

**UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION**

**Complaint of Michael Mabee)
Related to Mandatory Reliability Standards)
in the Texas Grid Collapse of 2021)**

Docket No. _____

COMPLAINT

Submitted to FERC on February 28, 2021

Introduction

I am a private citizen who conducts public interest research on the security of the electric grid because I recognize the absolutely vital role of this infrastructure in powering every one of the nation's 16 critical infrastructures and in undergirding not just the well-being but the very survival of our modern society. I am also a resident of Texas and was adversely impacted by the February 15, 2021 Texas grid collapse.

I am filing this complaint under 16 U.S. Code § 824o(d)(5)¹ and 16 U.S. Code § 824o(e)(3)² because, the Texas blackout on February 15, 2021 demonstrates that either:

- 1) The mandatory reliability standards were not followed, or,
- 2) The mandatory reliability standards were ineffective.

Request for Investigation

I request that the Commission issue a public notice of this Complaint pursuant to 18 CFR § 385.206(d), investigate this Complaint and issue an appropriate order to the Electric Reliability Organization ("ERO") to correct deficiencies.

¹ "The Commission, upon its own motion ***or upon complaint***, may order the Electric Reliability Organization to submit to the Commission a proposed reliability standard or a modification to a reliability standard that addresses a specific matter if the Commission considers such a new or modified reliability standard appropriate to carry out this section." [Emphasis added.]

² "On its own motion ***or upon complaint***, the Commission may order compliance with a reliability standard and may impose a penalty against a user or owner or operator of the bulk-power system if the Commission finds, after notice and opportunity for a hearing, that the user or owner or operator of the bulk-power system has engaged or is about to engage in any acts or practices that constitute or will constitute a violation of a reliability standard." [Emphasis added.]

Background of Texas Grid Collapse of 2021

On February 11, 2021, the Electric Reliability Council of Texas (ERCOT) issued a press release warning that "Extreme cold weather expected to result in record electric use in ERCOT region."³ (This press release is attached as Exhibit A.) The press release advised:

"This statewide weather system is expected to bring Texas the coldest weather we've experienced in decades," said ERCOT President and CEO Bill Magness. "With temperatures rapidly declining, we are already seeing high electric use and anticipating record-breaking demand in the ERCOT region."

On February 14, 2021, ERCOT issued another press release: "Grid operator requests energy conservation for system reliability."⁴ (This press release is attached as Exhibit B.) The press release advised:

"We are experiencing record-breaking electric demand due to the extreme cold temperatures that have gripped Texas," said ERCOT President and CEO Bill Magness. "At the same time, we are dealing with higher-than-normal generation outages due to frozen wind turbines and limited natural gas supplies available to generating units. We are asking Texans to take some simple, safe steps to lower their energy use during this time."

On February 15, 2021, ERCOT issued a third press release: "ERCOT calls for rotating outages as extreme winter weather forces generating units offline - Almost 10,000 MW of generation lost due to sub-freezing conditions."⁵ (This press release is attached as Exhibit C.) The press release, in its entirety, advised:

AUSTIN, TX, Feb. 15, 2021 – The Electric Reliability Council of Texas (ERCOT) entered emergency conditions and initiated rotating outages at 1:25 a.m. today.

About 10,500 MW of customer load was shed at the highest point. This is enough power to serve approximately two million homes.

Extreme weather conditions caused many generating units – across fuel types – to trip offline and become unavailable.

There is now over 30,000 MW of generation forced off the system.

"Every grid operator and every electric company is fighting to restore power right now," said ERCOT President and CEO Bill Magness.

Rotating outages will likely last throughout the morning and could be initiated until this weather emergency ends.

³ Available at: <http://www.ercot.com/news/releases/show/224996>

⁴ Available at: <http://www.ercot.com/news/releases/show/225151>

⁵ Available at: <http://www.ercot.com/news/releases/show/225210>

Impact on the People of Texas

The reality on the ground in Texas was a little less sterile than “10,500 MW of customer load was shed.”⁶

People died. Critical infrastructures were impacted.

Over 4,000,000 customers lost power during two days of subfreezing temperatures. Many lost power for longer. The picture on the right is the temperature at 5:21 a.m. on February 16, 2021 when many of us in Texas had already been without power for over 24 hours. The Houston Chronicle reported⁷ that day that:

Harris County has seen more than 300 carbon monoxide poisoning cases as temperatures bottomed out Monday in Houston and the state’s electricity grid failed, sending people scrambling for heat sources. That includes 90 carbon monoxide poisoning calls to the Houston Fire Department and 100 cases in Memorial Hermann’s emergency rooms.

Desperate people, who depended on the electric grid, tried any means they could find to keep their families from freezing – sometimes with catastrophic results. According to the article:

Several people have already died seeking warmth. A woman and an 8-year-old girl died from suspected carbon monoxide poisoning in Sharpstown, while a man and a 7-year-old boy were taken to a nearby hospital in critical condition. Three children and their grandmother died in a Sugar Land house fire after using the fireplace to heat their home.

The Wall Street Journal reported on February 23, 2021 that “Officials are still counting fatalities from hypothermia, carbon monoxide, other factors as some experts warn accurate total might never be known.”⁸ The article reported:

The failure of the state’s electrical grid during the weeklong cold snap left more than four million Texans without electricity and heat, many for days on end in subfreezing temperatures. Many residents also lost access to water, and 14.6 million were ordered to boil water to make it safe to drink.

...



⁶ In fact, Mr. Magness later testified to the Texas State Legislature that 20,000 MW was shed.

⁷ Houston Chronicle. “Harris County is slammed with 300+ carbon monoxide cases - and many are kids.” March 16, 2021. Available at: <https://www.houstonchronicle.com/news/houston-texas/health/article/Memorial-Hermann-sees-60-carbon-monoxide-15954216.php>

⁸ Wall Street Journal. “Full Death Toll From Texas Storm Could Take Months to Determine.” February 23, 2021. Available at: <https://www.wsj.com/articles/full-death-toll-from-texas-storm-could-take-months-to-determine-11614107708>

An 11-year-old boy was found frozen in his bed, his family told the Houston Chronicle. A grandmother and three grandchildren died in a house fire as they were trying to stay warm, the Chronicle also reported. At least six deaths occurred near the Abilene area, local media reported, including a patient who couldn't get medical treatment due to a lack of water and three elderly men who were found dead in subfreezing homes.

A copy of this Wall Street Journal article is attached as Exhibit D.

Impact on Texas Critical Infrastructures

Presidential Policy Directive 21 (PPD-21) "Critical Infrastructure Security and Resilience"⁹ identifies the 16 critical infrastructures in the U.S. and mandates that:

The Federal Government shall work with critical infrastructure owners and operators and SLTT [state, local, tribal, and territorial] entities to take proactive steps to manage risk and strengthen the security and resilience of the Nation's critical infrastructure, considering all hazards that could have a debilitating impact on national security, economic stability, public health and safety, or any combination thereof.

The Texas grid collapse beginning on February 15, 2021 adversely impacted critical infrastructures. Many people may have never heard of PPD-21, but this is what the failure of the critical infrastructures looks like to the people with no power trying to survive in subfreezing temperatures:



Bread aisle, Kroger's Fort Worth, TX
February 18, 2021



Water aisle, Kroger's Fort Worth, TX
February 18, 2021

⁹ Available at: <https://fas.org/irp/offdocs/ppd/ppd-21.pdf>



Egg case, Kroger's Fort Worth, TX
February 18, 2021



Milk case, Kroger's Fort Worth, TX
February 18, 2021

Here is another example of what critical infrastructure impact looks like to the actual people suffering through it:



QT Gas Station, Lake Worth, TX
February 19, 2021

In addition to the food, agriculture and transportation sectors, the collapse of the water infrastructure has been well covered in press articles.¹⁰ Millions in Texas were under “boil water” orders as the water infrastructure was impacted by the collapse of the grid and many had no water at all. Firefighters watched helplessly as homes burned and they lacked the water to fight the fires.¹¹

Some people froze in their homes and those that survived struggled for food and water when the critical infrastructures collapsed along with the Texas electric grid.



This is what the failure of electric reliability standards looks like. People dead, homes destroyed, critical infrastructures failing and the economy severely impacted.¹² (Photo credit: Bexar-Bulverde Volunteer Fire Department.)

Lessons Learned from 2011 and 1989 Texas Blackouts Ignored

In 2021 we find, as Yogi Berra once said, “It’s déjà vu all over again.” Almost exactly 11 years prior to the collapse of the Texas grid in February of 2021, a very similar thing happened in February 2011. And before that, another similar blackout occurred in December of 1989. While the causes of the 2021 Texas grid collapse are still under investigation, many similarities between the three tragic incidents are apparent.

The Austin American-Statesman reported¹³ on February 18, 2021:

¹⁰ NBC News. “Texas water shortage adds to power crisis as new winter storm moves in.” February 17, 2021.

<https://www.nbcnews.com/news/us-news/texas-contending-water-nightmare-top-power-crisis-n1258208>

¹¹ New York Times. “A Texas apartment building burned while firefighters scrambled for water.” February 19, 2021

<https://www.nytimes.com/2021/02/19/us/san-antonio-fire-hydrants-water.html>

¹² Foundation for Resilient Societies. “Causes and Costs of ERCOT Load Sheds in February 2021.” February 24, 2021 (Preliminary).

https://www.resilientsocieties.org/uploads/5/4/0/0/54008795/ercot_load_shed_causes_and_costs_preliminary_feb_25_2021.pdf

¹³ Austin American-Statesman / USA Today. “Winter storm blackouts plagued Texas in 2011, too.

Recommendations made afterward went unenforced.” February 18, 2021.

<https://www.usatoday.com/story/news/nation/2021/02/18/state-energy-winter-protections-lacking-reports-have-suggested/4490501001/>

Failing power plants, rolling blackouts and a spike in demand as Texas is hijacked by a harsh February winter snowstorm – this was the scenario exactly a decade ago as blackouts rolled through Texas.

A post-mortem at the time – including a key finding that state officials recommended but did not mandate winter protections for generating facilities – has renewed relevance as Texas is roiled by a record storm that has left millions without power for at least three days amid plunging temperatures.

A combination of those 2011 findings, as well as reports from the state grid operators that generators and natural gas pipelines froze during the current calamity and Austin American-Statesman interviews with current and former utility executives and energy experts, ***suggest a light regulatory touch and cavalier operator approach involving winter protections of key industrial assets.***

(Emphasis added.)

While it appears that a lot of lessons were learned from the 2011 Texas blackout, it also appears that few steps were taken to harden the Texas grid against a similar event in the future (i.e., the 2021 Texas blackout).

According to an August 2011 Joint report of the Federal Energy Regulatory Commission (FERC) and the North American Electric Reliability Corporation (NERC)¹⁴:

Between February 1 and February 4, a total of 210 individual generating units within the footprint of the Electric Reliability Council of Texas, Inc. (ERCOT), which covers most of Texas, experienced either an outage, a derate, or a failure to start. The loss of generation was severe enough on February 2 to trigger a controlled load shed of 4000 MW, which affected some 3.2 million customers. On February 3, local transmission constraints coupled with the loss of local generation triggered load shedding for another 180,000 customers in the Rio Grande Valley in south Texas.

(A copy of this report is attached as Exhibit E.) It is important to note, that prior to the 2011 Texas blackout, there had been another blackout in 1989 which bears striking similarities to 2011 and 2021. The Joint FERC/NERC report noted:

The experiences of 1989 are instructive, particularly on the electric side. In that year, as in 2011, cold weather caused many generators to trip, derate, or fail to start. The PUCT investigated the occurrence and issued a number of recommendations aimed at improving winterization on the part of the generators. These recommendations were not mandatory, and over the course of time implementation lapsed. Many of the generators that experienced outages in 1989 failed again in 2011.¹⁵

¹⁴ Federal Energy Regulatory Commission and the North American Electric Reliability Corporation. “Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011.” August 2011. <https://www.ferc.gov/sites/default/files/2020-05/ReportontheSouthwestColdWeatherEventfromFebruary2011Report.pdf>

¹⁵ id. Page 10.

Benjamin Disraeli famously said: “What we learn from history is that we do not learn from history.” In the present context, the people of Texas have suffered blackouts in 1989, 2011 and 2021 – all bearing remarkable – and preventable similarities. All having at least something to do with the lack of winterization of equipment and ill-preparedness for extreme cold weather.

In 2011, the regulators were comparing the 2011 blackout to 1989. On April 11, 2011, The Austin American Statesman reported¹⁶:

The report from the Public Utility Commission of Texas is clear in its analysis of what went wrong:

“The winter freeze greatly strained the ability of the Texas electric utilities to provide reliable power to their customers. Record and near-record low temperatures were felt throughout the state resulting in a significantly increased demand for electrical power.

“At the same time that demand was increasing, weather-related equipment malfunctions were causing generating units to trip off the line.” As a result, it noted, the state suffered widespread rolling blackouts and “near loss of the entire ERCOT electric grid.”

ERCOT is still the Electric Reliability Council of Texas. But the PUC report wasn’t analyzing the power outages that hit a large swath of Texas when temperatures plunged this past February. The report is dated November 1990 and is referring to the record freeze of late December 1989.

The PUC has a single remaining copy of it in its library north of the Capitol.

The report referred to in the article is Public Utility Commission of Texas report: “Electric Utility Response to the Winter Freeze of December 21 to December 23, 1989.”¹⁷ (A copy of this report is attached as Exhibit F.)

The 2011 blackout caused a flurry of investigations, hearings, reports and public outrage. Multiple Hearings, Investigations, Reports — and ultimately inaction.

On February 26, 2021 the Houston Chronicle reported¹⁸:

A decade ago, after an Arctic cold spell knocked out power and left millions of Texans shivering in the dark, the Public Utility Commission’s enforcement apparatus swung into action. Their aim: punish the companies that had promised but failed to deliver electricity in an emergency.

Specialists contracted by the state agency worked with an enforcement team the utility commission created four years earlier. More recently, it had added lawyers whose only job was

¹⁶ Austin American Statesman. “February power blackouts across Texas echoed 1989 failures, state report shows.” April 11, 2011. <https://www.statesman.com/article/20110411/NEWS/304119704>

¹⁷ Available at: <https://lrl.texas.gov/scanned/archive/1990/15303.pdf>

¹⁸ Houston Chronicle. “‘Muzzled and eviscerated’: Critics say Abbott appointees gutted enforcement of Texas grid rules.” February 26, 2021. <https://www.houstonchronicle.com/politics/texas/article/critics-abbott-power-grid-rules-texas-deadly-storm-15982421.php>

to pursue wrong-doing. The energy companies eventually paid fines and settlements totaling hundreds of thousands of dollars for failing to prepare for the extreme weather.

Two weeks ago, history repeated. Millions of residents were left without power and water in below-freezing temperatures. The damage far exceeded the 2011 storm. Nearly a third of the grid's power plants went offline. Dozens of deaths have been attributed to the event, with a full accounting yet to come.

But the enforcement tools that worked to hold companies accountable for the 2011 failures had been removed under Gov. Greg Abbott's appointees on the utility commission. Hearst Newspapers reported last week that commissioners in November cut ties with the Texas Reliability Entity — the specialists hired — leaving state regulators without an external independent reliability monitor.

Four months before that, the governor's commissioners had also disbanded the Oversight & Enforcement Division. The head attorney was told he no longer had a job; nine other team members were reassigned throughout the utility commission.

Several pending cases were dropped. According to commission records, by the end of 2020 the number of enforcement cases had fallen 40 percent.

The 2011 Joint FERC/NERC report noted:

On February 14, the Federal Energy Regulatory Commission (FERC) initiated an inquiry into the Southwest outages and service disruptions. The inquiry had two objectives: to identify the causes of the disruptions, and to identify any appropriate actions for preventing a recurrence of the disruptions. FERC stated it was not at that time initiating an investigation into whether there may have been violations of applicable regulations, requirements or standards under FERC's jurisdiction, and that any decisions on whether to initiate enforcement investigations would be made later. Consequently, while this report describes actions which in some cases appear to warrant further investigation, it does not reach any conclusions as to whether violations have occurred.

It seems nobody wants to tell the industry to fix grid security issues in Texas, thus they do not get fixed. This regulatory inaction is causing deaths, impacts to the critical infrastructures, and economic loss — it is unacceptable.

The 2011 Texas blackout was followed by many promises but little action. The Electric Reliability Council of Texas (ERCOT) made many promises, including "ERCOT will be an active participant in the discussion related to the adequate weatherization of generation units."¹⁹

In 2021, It doesn't seem that this "discussion" was fruitful.

One of the Key Findings in the FERC and NERC Joint 2011 report was:

¹⁹ ERCOT "Review of February 2, 2011 Energy Emergency Alert (EEA) Event." February 14, 2011. http://www.ercot.com/content/meetings/board/keydocs/2011/0214/Review_of_February_2,_2011_EEA_Event.pdf

During the February event, temperatures were considerably lower (15 degrees plus) than average winter temperatures, and represented the longest sustained cold spell in 25 years. Steady winds also accelerated equipment heat loss. However, such a cold spell was not unprecedented. The Southwest also experienced temperatures considerably below average, accompanied by generation outages, in December 1989. Less extreme cold weather events occurred in 2003 and 2010. ***Many generators failed to adequately apply and institutionalize knowledge and recommendations from previous severe winter weather events, especially as to winterization of generation and plant auxiliary equipment.***

(Emphasis added.)

Recommendations related to extreme cold weather and winterization in the FERC and NERC Joint 2011 report have apparently not been heeded. Similar recommendations of the Public Utility Commission of Texas after the 1989 Texas blackout were also not heeded.

The Foundation for Resilient Societies has done a preliminary analysis on the costs of the 2021 blackout versus the cost of mitigation.²⁰ These data demonstrate that it would have cost substantially less to mitigate the 2021 disaster than the disaster has actually cost us. To paraphrase the old adage, “an ounce of prevention is cheaper than a pound of disaster.” And yet we continue in this cycle of inaction and disaster. 1989. 2011. 2021.

Somebody is going to have to pay for this disaster. The taxpayers or the ratepayers. Unfortunately, I am both so I will pay. But perhaps I shouldn’t complain. Many people have paid for these disasters in 1989, 2011 and 2021 with their lives.

I implore the Commission: Stop asking and recommending. It is time to direct NERC and Texas RE to take action. Violators of reliability standards must be held accountable and we must make sure that this cycle of blackouts, deaths, critical infrastructure impacts and damage to the economy stops.

²⁰ Foundation for Resilient Societies. “Causes and Costs of ERCOT Load Sheds in February 2021.” February 24, 2021 (Preliminary).
https://www.resilientsocieties.org/uploads/5/4/0/0/54008795/ercot_load_shed_causes_and_costs_preliminary_feb_25_2021.pdf

If we were not prepared for a known incoming weather event, are we prepared for other events?

I conducted an analysis of the reported electric disturbance events between 2010 and 2020 from the Department of Energy OE-417 Electric Disturbance Reports.²¹ (I have attached a copy of my analysis as Exhibit G.)

According to my analysis, 52.6% of OE-417 disturbance reports filed nationwide in the last decade are weather related.

Interestingly, 70.9% of the disturbances reported in the Texas RE region are weather related. The Commission needs to ask why this difference exists and whether mandatory reliability standards are either being followed or are effective.

If we are not adequately prepared for a weather event that is forecast well in advance, such as the 2021 Texas grid collapse, are we ready for other threats?

Mike Rogers, former chairman of the House Intelligence Committee, recently noted in an article entitled “Why America would not survive a real first strike cyberattack today”²²:

The only thing that prevented the Russians from launching a destructive malware attack or inserting malicious code was the Russians themselves. They could have caused a major disruption across our government and private sector networks, changing or deleting data, planting viruses, or simply turning off the networks.

Restarting the systems and deleting the offending code alone is not a solution. In 2016, the Ukrainian electricity grid was targeted by the Russians and, until this day, the country is still finding and removing vulnerabilities left behind by Moscow.

All NERC Regions		
Events From 2010-2020	Total	%
Weather	961	52.6%
Cyber Attack	37	2.0%
Physical Attack	721	39.5%
Fuel Supply Deficiency	74	4.1%
Equipment	15	0.8%
Natural Disaster	14	0.8%
Wildfire	5	0.3%
Generation Interruption	17	3.4%
Transmission Interruption	113	22.8%
Distribution Interruption	9	1.8%
Operations	185	37.3%
Islanding	67	13.5%
Load Shed	30	6.0%
Public Appeal	65	13.1%
?	10	2.0%
Total OE-417 Reports	2323	
Cause Known from OE-417	1827	
Cannot Determine Cause	496	

Texas RE Only		
Events From 2010-2020	Total	%
Weather	83	70.9%
Cyber Attack	3	2.6%
Physical Attack	28	23.9%
Fuel Supply Deficiency	3	2.6%
Equipment	0	0.0%
Natural Disaster	0	0.0%
Wildfire	0	0.0%
Generation Interruption	4	7.1%
Transmission Interruption	17	30.4%
Distribution Interruption	2	3.6%
Operations	11	19.6%
Islanding	1	1.8%
Load Shed	0	0.0%
Public Appeal	21	37.5%
?	0	0.0%
Total OE-417 Reports	173	
Cause Known from OE-417	117	
Cannot Determine Cause	56	

²¹ See: <https://michaelmabee.info/oe-417-database/>

²²Rogers, Mike. “Why America would not survive a real first strike cyberattack today.” February 22, 2021. <https://thehill.com/opinion/cybersecurity/539826-we-would-not-survive-true-first-strike-cyberattack?rl=1>

If we are unable to prepare our electric grid and its dependent critical infrastructures from a cold snap that we see coming over a week away, it begs the question: Are we prepared for a cyberattack?²³ Are we prepared for a coordinated physical attack?²⁴ Are we prepared for a major geomagnetic disturbance (GMD) event? Are we prepared for an electromagnetic pulse (EMP) attack? Are we prepared for other extreme weather events?

Relief Sought

1. The Federal Energy Regulatory Commission should direct the North American Electric Reliability Corporation (NERC) and its regional entity, Texas Reliability Entity, Inc. (Texas RE) to conduct a comprehensive investigation into whether reliability standards were followed by all entities registered with Texas RE who had any involvement in the Texas grid collapse of February 15, 2021.
2. If the North American Electric Reliability Corporation (NERC) and its regional entity, Texas Reliability Entity, Inc. (Texas RE) determine that violations of reliability standards did not contribute to the Texas grid collapse of February 15, 2021, then the Federal Energy Regulatory Commission should direct the North American Electric Reliability Corporation (NERC) to improve the reliability standards to prevent catastrophic power outages such as this from occurring in the future.

Respectfully submitted,



Michael Mabee

Attachments: 18 CFR § 385.206 Compliance Information
Draft Notice
Exhibits A-G

²³ The Commission dismissed my complaint about inadequate supply chain cyber security CIP standards on October 2, 2020. Docket Number EL20-46-000.

²⁴ The Commission dismissed my complaint about inadequate physical security CIP standards on June 9, 2020. Docket Number EL20-21-000.

18 CFR § 385.206 Compliance Information

I Michael Mabee, hereby state the following:

18 CFR § 385.206(b) Contents. A complaint must:

(1) Clearly identify the action or inaction which is alleged to violate applicable statutory standards or regulatory requirements;

- Contained in Complaint

(2) Explain how the action or inaction violates applicable statutory standards or regulatory requirements;

- Contained in Complaint

(3) Set forth the business, commercial, economic or other issues presented by the action or inaction as such relate to or affect the complainant;

- A widespread power outage in Texas on February 15, 2021 caused the loss of life and substantial damage to the economy.

(4) Make a good faith effort to quantify the financial impact or burden (if any) created for the complainant as a result of the action or inaction;

- A widespread power outage in Texas on February 15, 2021 caused the loss of life and substantial damage to the economy.

(5) Indicate the practical, operational, or other nonfinancial impacts imposed as a result of the action or inaction, including, where applicable, the environmental, safety or reliability impacts of the action or inaction;

- A widespread power outage in Texas on February 15, 2021 caused the loss of life and substantial damage to the economy.

(6) State whether the issues presented are pending in an existing Commission proceeding or a proceeding in any other forum in which the complainant is a party, and if so, provide an explanation why timely resolution cannot be achieved in that forum;

- I am unaware of any public FERC docket which addresses the Texas Power Outage of 2021.

(7) State the specific relief or remedy requested, including any request for stay or extension of time, and the basis for that relief;

- Contained in "Relief Sought" section of Complaint.

(8) Include all documents that support the facts in the complaint in possession of, or otherwise attainable by, the complainant, including, but not limited to, contracts and affidavits;

- Attached as exhibits to the Complaint

(9) State

(i) Whether the Enforcement Hotline, Dispute Resolution Service, tariff-based dispute resolution mechanisms, or other informal dispute resolution procedures were used, or why these procedures were not used;

- N/A

(ii) Whether the complainant believes that alternative dispute resolution (ADR) under the Commission's supervision could successfully resolve the complaint;

- N/A

(iii) What types of ADR procedures could be used; and

- N/A

(iv) Any process that has been agreed on for resolving the complaint.

- N/A

(10) Include a form of notice of the complaint suitable for publication in the Federal Register in accordance with the specifications in § 385.203(d) of this part. The form of notice shall be on electronic media as specified by the Secretary.

- Draft Notice Attached

(11) Explain with respect to requests for Fast Track processing pursuant to section 385.206(h), why the standard processes will not be adequate for expeditiously resolving the complaint.

- N/A

18 CFR § 385.206(c) Service. Any person filing a complaint must serve a copy of the complaint on the respondent, affected regulatory agencies, and others the complainant reasonably knows may be expected to be affected by the complaint. Service must be simultaneous with filing at the Commission for respondents. Simultaneous or overnight service is permissible for other affected entities. Simultaneous service can be accomplished by electronic mail in accordance with § 385.2010(f)(3), facsimile, express delivery, or messenger.

- A copy of this Complaint will be sent electronically to the Electric Reliability Organization ("ERO") and the Texas Reliability Entity, Inc. simultaneously with my filing with the Commission.

Respectfully submitted,



Michael Mabee

Draft Notice

**UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION**

Complaint of Michael Mabee
Related to Mandatory Reliability Standards
in the Texas Grid Collapse of 2021

Docket No.

NOTICE OF COMPLAINT

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Take notice that on [date filed], pursuant to section 215(d) of the Federal Power Act, 16 U.S.C. 824o(d) and Rule 206 of the Federal Energy Regulatory Commission's (Commission) Rules of Practice and Procedure, 18 CFR 385.206 (2019), Michael Mabee, (Complainant) filed a formal complaint alleging that the Texas grid collapse of February 2021 resulted from either: 1) The mandatory reliability standards were not followed, or, 2) The mandatory reliability standards were ineffective.

Complainant certifies that copies of the complaint were served on the contacts as listed on the Commission's list of Corporate Officials.

Any person desiring to intervene or to protest this filing must file in accordance with Rules 211 and 214 of the Commission's Rules of Practice and Procedure (18 CFR 385.211 and 385.214). Protests will be considered by the Commission in determining the appropriate action to be taken but will not serve to make protestants parties to the proceeding. Any person wishing to become a party must file a notice of intervention or motion to intervene, as appropriate. The Respondent's answer and all interventions, or protests must be filed on or before the comment date. The Respondent's answer, motions to intervene, and protests must be served on the Complainants.

The Commission encourages electronic submission of protests and interventions in lieu of paper using the "eFiling" link at <http://www.ferc.gov>. Persons unable to file electronically should submit an original and 5 copies of the protest or intervention to the Federal Energy Regulatory Commission, 888 First Street, NE, Washington, DC 20426.

This filing is accessible on-line at <http://www.ferc.gov>, using the "eLibrary" link and is available for review in the Commission's Public Reference Room in Washington,

DC. There is an “eSubscription” link on the web site that enables subscribers to receive email notification when a document is added to a subscribed docket(s). For assistance with any FERC Online service, please email FERCOnlineSupport@ferc.gov, or call (866) 208-3676 (toll free). For TTY, call (202) 502-8659.

Comment Date: 5:00 pm Eastern Time on (insert date).

Kimberly D. Bose,
Secretary.

Exhibit A

**Complaint of Michael Mabee Related to
Mandatory Reliability Standards
in the Texas Grid Collapse of 2021**



News Release

February 11, 2021

Extreme cold weather expected to result in record electric use in ERCOT region

Consumers can stay current on grid conditions by downloading the ERCOT app and following ERCOT on Twitter

AUSTIN, TX, Feb. 11, 2021 – The Electric Reliability Council of Texas (ERCOT) is expecting record electric use as a result of the extreme cold temperatures that have already reached much of the ERCOT region.

"This statewide weather system is expected to bring Texas the coldest weather we've experienced in decades," said ERCOT President and CEO Bill Magness. "With temperatures rapidly declining, we are already seeing high electric use and anticipating record-breaking demand in the ERCOT region."

Consumers can monitor grid conditions in real time by following ERCOT on Twitter (@ERCOT_ISO) and/or by downloading the ERCOT mobile app available on Google Play and in the Apple Store.

On Monday, Feb. 8, ERCOT issued an Operating Condition Notice (OCN) for extreme cold weather expected in the ERCOT region Thursday, Feb. 11 through Tuesday, Feb. 16. Subsequently, ERCOT issued an Advisory on Feb. 10 and a Watch on Feb. 11 for extreme cold weather. A Watch is the third level of communication issued by the ERCOT control room in anticipation of potential tight grid conditions.

Generators have been asked to take necessary steps to prepare their facilities for the expected cold weather, which includes reviewing fuel supplies and planned outages and implementing winter weatherization procedures. The grid operator is also working with transmission operators to minimize transmission outages that could reduce the availability of generation or otherwise impact the ability of the system to serve demand.

Based on the current load forecast, and if temperatures continue to decline, ERCOT could set a new all-time winter peak demand record Monday morning, Feb. 15. The current winter peak demand record is 65,915 MW set on Jan. 17, 2018 between 7 and 8 a.m.

###

The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to more than 26 million Texas customers -- representing about 90 percent of the state's electric load. As the independent system operator for the region, ERCOT schedules power on an electric grid that connects more than 46,500 miles of transmission lines and 680+ generation units. It also performs financial settlement for the competitive wholesale bulk-power market and administers retail switching for nearly 8 million premises in competitive choice areas.

ERCOT is a membership-based 501(c)(4) nonprofit corporation, governed by a board of directors and subject to oversight by the Public Utility Commission of Texas and the Texas Legislature. Its members include consumers, cooperatives, generators, power marketers, retail electric providers, investor-owned electric utilities, transmission and distribution providers and municipally owned electric utilities.

Contact

media@ercot.com

512-275-7432

Exhibit B

**Complaint of Michael Mabee Related to
Mandatory Reliability Standards
in the Texas Grid Collapse of 2021**



News Release

February 14, 2021

Grid operator requests energy conservation for system reliability

AUSTIN, TX, Feb. 14, 2021 – The Electric Reliability Council of Texas (ERCOT) is asking consumers and businesses to reduce their electricity use as much as possible Sunday, Feb. 14 through Tuesday, Feb. 16.

"We are experiencing record-breaking electric demand due to the extreme cold temperatures that have gripped Texas," said ERCOT President and CEO Bill Magness. "At the same time, we are dealing with higher-than-normal generation outages due to frozen wind turbines and limited natural gas supplies available to generating units. We are asking Texans to take some simple, safe steps to lower their energy use during this time."

Here are some tips to reduce electricity use:

- Turn down thermostats to 68-degrees.
- Close shades and blinds to reduce the amount of heat lost through windows.
- Turn off and unplug non-essential lights and appliances.
- Avoid using large appliances (i.e., ovens, washing machines, etc.).
- Businesses should minimize the use of electric lighting and electricity-consuming equipment as much as possible.
- Large consumers of electricity should consider shutting down or reducing non-essential production processes.

Given the prolonged, below-freezing temperatures, conservation measures should be implemented safely and within reason.

ERCOT has the tools and procedures in place to maintain a reliable electric system during tight grid conditions. If power reserves drop too low, ERCOT may need to declare an Energy Emergency Alert, or EEA. Declaring an EEA allows the grid operator to take advantage of additional resources that are only available during scarcity conditions. There are three levels of EEA, and rotating outages are only implemented as a last resort to maintain reliability of the electric system.

Click [here](#) for more information on ERCOT's emergency procedures during tight grid conditions.

Click [here](#) for more information on the additional tools and resources available to ERCOT when it declares an EEA.

How to track electricity demand

- View daily peak demand forecast, current load and available generation on ERCOT.com.
- Follow ERCOT on Twitter (@ERCOT_ISO).
- Sign up for the ERCOT mobile app (available for download at the Apple App Store and Google Play).

Consumer assistance

Public Utility Commission of Texas Hotline – 1-888-782-8477

###

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Contact

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Exhibit C

**Complaint of Michael Mabee Related to
Mandatory Reliability Standards
in the Texas Grid Collapse of 2021**



News Release

February 15, 2021

ERCOT calls for rotating outages as extreme winter weather forces generating units offline

Almost 10,000 MW of generation lost due to sub-freezing conditions

AUSTIN, TX, Feb. 15, 2021 – The Electric Reliability Council of Texas (ERCOT) entered emergency conditions and initiated rotating outages at 1:25 a.m. today.

About 10,500 MW of customer load was shed at the highest point. This is enough power to serve approximately two million homes.

Extreme weather conditions caused many generating units – across fuel types – to trip offline and become unavailable.

There is now over 30,000 MW of generation forced off the system.

"Every grid operator and every electric company is fighting to restore power right now," said ERCOT President and CEO Bill Magness.

Rotating outages will likely last throughout the morning and could be initiated until this weather emergency ends.

###

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Exhibit D

**Complaint of Michael Mabee Related to
Mandatory Reliability Standards
in the Texas Grid Collapse of 2021**

U.S.

Full Death Toll From Texas Storm Could Take Months to Determine

Officials are still counting fatalities from hypothermia, carbon monoxide, other factors as some experts warn accurate total might never be known



Jackie Nguyen lost her three children along with their grandmother in a house fire in Sugar Land, Texas, during the severe weather that swept the state last week.

PHOTO: MARIE D. DE JESÚS/ASSOCIATED PRESS

By [Elizabeth Findell](#)

Updated Feb. 23, 2021 3:54 pm ET



Listen to this article

5 minutes

The harsh winter storm that hit Texas and other states last week has been blamed for dozens of deaths, though officials said that it would be weeks or months before the human cost of the freezing weather and utility crisis is known and that it might never be fully accurate.

The failure of the state's electrical grid during the weeklong cold snap left more than four million Texans without electricity and heat, many for days on end in subfreezing temperatures. Many residents also lost access to water, and 14.6 million were ordered to

boil water to make it safe to drink. Power had been restored in most of the state by Tuesday morning, but 7.5 million people in 204 counties remained under boil-water orders.

So far, nearly 80 people have died a result of the storm and its effects, according to the Associated Press.

SHARE YOUR THOUGHTS

Have officials responded effectively to the disaster in Texas? Why or why not? Join the conversation below.

An 11-year-old boy was found frozen in his bed, his family told the Houston Chronicle. A grandmother and three grandchildren died in a house fire as they were trying to stay warm, the Chronicle also reported. At least six deaths occurred near the Abilene area, local media reported, including a patient who couldn't get medical treatment due to a lack of water and three elderly men who were found dead in subfreezing homes.

Harris County, which includes Houston, has confirmed at least 15 hypothermia deaths and one fatal fall on ice, according to its forensics institute. Several others died from carbon-monoxide poisoning after taking unsafe measures to stay warm, according to the county's top executive. In Travis County, which includes Austin, the medical examiner's office is busy processing more than 80 cases from last week to determine causes of death, an official said.

Medical examiners don't determine the circumstances of a death. It will be up to officials such as constables and justices of the peace in each of Texas' 254 counties to investigate any recent deaths and decide whether they might have been related to the storm. Cases that local registrars flag as possibly storm-related will be referred to state epidemiologists to evaluate, said Chris Van Deusen, a spokesman for the Texas Department of State Health Services.

Calculating fatalities from any large-scale crisis is difficult, and totals can be unreliable, said Robert Jensen, chairman of Kenyon International Emergency Services, a London and Houston-based firm that has been hired to help count deaths after events such as Hurricane Katrina in Louisiana in 2005. Authorities there primarily counted bodies left

behind as floodwater receded, he said. In a case such as the storm in Texas, the reporting is likely to be based on local authorities' opinions.

‘Mass fatalities scare people, and they’re very political. I don’t think it’s intentionally misleading, it’s just a very screwed-up process.’

— Robert Jensen, chairman of Kenyon International Emergency Services, on calculating disaster deaths

“Every county will kind of do their own thing,” Mr. Jensen said. Individual officials will have to weigh factors such as whether a house fire or a carbon monoxide poisoning occurred because people were trying to stay warm, whether a car crash happened because of ice, or whether a lack of water or power caused an existing medical condition to flare or go untreated.

Mr. Jensen added that there is often little political will among state officials to standardize the process or to determine the true cost of a disaster.



Volunteers handed out water at an apartment complex in Dallas on Tuesday.

PHOTO: LM OTERO/ASSOCIATED PRESS

“Mass fatalities scare people, and they’re very political,” he said. “I don’t think it’s intentionally misleading, it’s just a very screwed-up process.”

Some lawsuits against the Electric Reliability Council of Texas, which manages the Texas energy grid, are seeking to link specific deaths to the storm. An attorney for Doyle Austin, a Houstonian whose family found him unresponsive—a week shy of his 96th birthday—

after two days without power and temperatures down to 11 degrees, said he died of hypothermia due to the storm.

An Ercot spokeswoman said it hadn't yet reviewed the lawsuits, but said it was confident the blackouts that occurred were the right decision to avoid a prolonged statewide blackout. "This is a tragedy," she said. "Our thoughts are with all Texans who have and are suffering due to this past week."

Mr. Austin worked in the Port of Houston all his life and played professional baseball in what were then called "Negro leagues" in the 1940s when teams were still segregated, said Larry Taylor, a Houston-based lawyer representing Mr. Austin's daughters, and a family friend. In his later years, Mr. Austin loved walking the neighborhood and playing dominoes and spades with his relatives.

"He was a hero to many of us in the family and community, as far as how he carried himself and what he was able to do in life and how he treated people," Mr. Taylor said.

Winter Storm Impact

States deal with the fallout from a major winter storm.

LIVES LOST

Full Death Toll Could Take Months to Determine

EXPLAINER

Why Texas Experienced Power Outages?

POWER

Texas Electric Bills Were \$28 Billion Higher Under Deregulation

AFTERMATH

Texas Grapples With Crushing Power Bills

INFRASTRUCTURE

A Grid Built for Heat, Not Cold

TECH PREP

Prep Your Tech for Power Outages

TAXES

IRS Postpones Tax Deadline For Texans

STORM RISKS

Desperate Families Take Risks to Stay Warm

Mr. Austin's death report is still unfinished, but Mr. Taylor said there is no question in his mind that the weather and utility crisis were to blame.

“I’m healthy, I’m fine, a traumatic freeze comes through, I lose power, my house is at freezing temperatures and I die,” he said. “There is no doubt in our minds that he died of hypothermia. We will eventually get more details, but it doesn’t take a rocket scientist to know.”

Write to Elizabeth Findell at Elizabeth.Findell@wsj.com

Appeared in the February 24, 2021, print edition as ‘Tallying Texas Deaths Could Take Months.’

Would you like more stories like this?

YES

NO

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Exhibit E

**Complaint of Michael Mabee Related to
Mandatory Reliability Standards
in the Texas Grid Collapse of 2021**



REPORT ON

OUTAGES AND CURTAILMENTS

DURING THE SOUTHWEST

COLD WEATHER EVENT

OF FEBRUARY 1-5, 2011

Causes and Recommendations

Prepared by the Staffs of the
Federal Energy Regulatory Commission
and the
North American Electric
Reliability Corporation



AUGUST 2011

Report on Outages and Curtailments During the Southwest Cold
Weather Event of February 1-5, 2011

Prepared by the Staffs of the Federal Energy Regulatory
Commission and the North American Electric Reliability
Corporation

Causes and Recommendations

August 2011

Table of Contents

I.	Introduction.....	1
II.	Executive Summary.....	7
III.	The Electric and Natural Gas Industries.....	13
IV.	Preparations for the Storm.....	49
V.	The Event: Load Shed and Curtailments.....	73
VI.	Causes of the Outages and Supply Disruptions....	139
VII.	Prior Cold Weather Events.....	169
VIII.	Electric and Natural Gas Interdependencies.....	189
IX.	Key Findings and Recommendations.....	195

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ATTACHMENTS

Acronyms

Glossary

Appendices

Task Force Members

Legislative and Regulatory Responses by the States

Categories of NERC Registered Entities

Electricity: How it is Generated and Distributed

Power Plant Design for Ambient Weather Conditions

Impact of Wind Chill

Winterization for Generators

Natural Gas: Production and Distribution

Natural Gas Storage

Natural Gas Transportation Contracting Practices

GTI: Impact of Cold Weather on Gas Production

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FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

I. Introduction

The southwest region of the United States experienced unusually cold and windy weather during the first week of February 2011. Lows during the period were in the teens for five consecutive mornings and there were many sustained hours of below freezing temperatures throughout Texas and in New Mexico. Low temperatures in Albuquerque, New Mexico ranged from 7 degrees Fahrenheit to -7 degrees over the period, compared to an average high of 51 degrees and a low of 26 degrees. Dallas temperatures ranged from 14 degrees to 19 degrees, compared to an average high of 60 degrees or above and average lows in the mid-to-upper 30s. Many cities in the region would not see temperatures above freezing until February 4. In addition, sustained high winds of over 20 mph produced severe wind chill factors.

Electric entities located within the Texas Reliability Entity, Inc. (TRE), the Western Electricity Coordinating Council (WECC), and the Southwest Power Pool (SPP) were affected by the extreme weather, as were gas entities in Texas, New Mexico and Arizona.

Between February 1 and February 4, a total of 210 individual generating units within the footprint of the Electric Reliability Council of Texas, Inc. (ERCOT), which covers most of Texas, experienced either an outage, a derate, or a failure to start. The loss of generation was severe enough on February 2 to trigger a controlled load shed of 4000 MW, which affected some 3.2 million customers. On February 3, local transmission constraints coupled with the loss of local generation triggered load shedding for another 180,000 customers in the Rio Grande Valley in south Texas. El Paso Electric Company (EPE), which is outside the ERCOT region, lost approximately 646 MW of local generation over the four days beginning on February 1. It implemented rotating load sheds on each of the days from February 2 through February 4, totaling over 1000 MW and affecting 253,000 customers. The Salt River Project Agricultural Improvement and Power District (SRP), located in Arizona, lost 1050 MW of generation on February 1 through February 2 and shed load of 300 MW, affecting approximately 65,000 customers. The New Mexico communities of Alamogordo, Ruidoso, and Clayton lost approximately 26 MW of load, affecting a little over 21,000 customers, when Public Service Company of New Mexico (PNM) experienced localized transmission failures, although these were largely unrelated to the extreme weather.

In total, approximately 1.3 million electric customers were out of service at the peak of the event on February 2, and a total of 4.4 million were affected over the course of the event from February 2 through February 4.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Natural gas customers also experienced extensive curtailments of service during the event. These curtailments were longer in duration than the electric outages, because relighting customers' equipment has to be accomplished manually at each customer's location. Local distribution companies (LDCs) interrupted gas service to more than 50,000 customers in New Mexico, Arizona and Texas; New Mexico was the hardest hit with outages of over 30,000 customers in areas as widespread as Hobbs, Ruidoso, Alamogordo, Silver City, Tularosa, La Luz, Taos, Red River, Questa, Española, Bernalillo and Placitas.

In the wake of these events, the Arizona Corporation Commission, the Public Regulation Commission of New Mexico, the Public Utilities Commission of Texas (PUCT), the Texas Railroad Commission (TRC), the New Mexico state legislature and the Texas state legislature all initiated inquiries or investigations. The PUCT directed TRE, the regional entity authorized by the North American Electric Reliability Corporation (NERC) to cover the ERCOT region, to investigate the decisions and actions ERCOT took in initiating the rolling blackouts.

On February 7, 2011, NERC announced that it would work with the affected Regional Entities to prepare an event analysis that would examine the adequacy of preparations for the event and identify potential improvements and lessons learned. NERC also stated it would review electric and natural gas interdependencies, in light of the shift toward a greater reliance on natural gas to produce electricity.

On February 14, the Federal Energy Regulatory Commission (FERC) initiated an inquiry into the Southwest outages and service disruptions. The inquiry had two objectives: to identify the causes of the disruptions, and to identify any appropriate actions for preventing a recurrence of the disruptions. FERC stated it was not at that time initiating an investigation into whether there may have been violations of applicable regulations, requirements or standards under FERC's jurisdiction, and that any decisions on whether to initiate enforcement investigations would be made later. Consequently, while this report describes actions which in some cases appear to warrant further investigation, it does not reach any conclusions as to whether violations have occurred.

From the beginning of their inquiries into the causes of the outages and disruptions, the staffs of FERC and NERC have cooperated in their data gathering and analysis. On May 9, FERC and NERC announced their staffs would create a joint task force to combine their separate inquiries. This report is a product of that effort.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The inquiry performed by the joint task force was far-reaching. Noted below in summary form are some of the steps taken by the task force to develop its understanding of the electric and natural gas disruptions that were experienced in the Southwest in early February.

Scope of Data Reviewed

The task force received approximately 54 GB of data through data requests issued to entities in both the electric and natural gas industries, conducted numerous follow-up calls and meetings, and issued follow-up requests to discuss questions raised by the data responses.

For the electric industry, the task force issued 122 data requests to generator operators, transmission operators, balancing authorities, and a reliability coordinator. The task force also utilized event analysis information which NERC and the affected Regional Entities received from 79 registered entities (72 from TRE, four from WECC and three from SPP). Additional event information was received through a request for information issued by NERC and Regional Entities to those entities affected by the extreme weather event. For the gas industry, the task force issued 92 data requests to pipelines (interstate and intrastate), storage facilities, gas processing plants, producers, and public utilities.

The data compiled by the task force focused on the causes of the outages and curtailments during the February cold weather event, critical entities' preparations for the forecasted cold weather and their performance in connection with the rolling blackouts and natural gas curtailments, and any lessons learned that could be applied in the future. As part of its analysis, the task force also reviewed historical data and recommendations compiled during past cold weather events in Texas and elsewhere in the Southwest, to determine whether the 2011 event was unprecedented or whether entities might have been better prepared to deal with it.

Electric Facility Site Visits

Staff from FERC and NERC, together with representatives of TRE and WECC, conducted site visits with various entities involved in the outages, toured facilities and conducted interviews with operations personnel, compliance personnel and company executives. The task force visited ERCOT, four transmission operators in ERCOT, and 15 generators in ERCOT (including coal, natural gas, and wind units); two generators in WECC; and two balancing authorities in WECC. During the generator site visits the task force toured the units, viewing any equipment that led to trips, derates, or failures to start; viewed winterization measures; and discussed maintenance and winterization processes,

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

fuel supply and market participation. During visits to the balancing authorities and transmission operators, the task force toured control centers and discussed the progression of the events, including specifics on load forecasting, market mechanics, system operations, load shedding and load restoration. The task force also discussed transmission system winterization and load shedding procedures with the transmission operators.

Natural Gas Meetings

The task force conducted numerous meetings with various entities from the gas industry to discuss the curtailments and shortages experienced in early February and the specifics of the entities' winter operations. These meetings included operations and regulatory personnel from two interstate pipelines doing business in Texas, New Mexico, Arizona, Colorado, and California; one LDC/intrastate pipeline located in New Mexico; one LDC from Arizona; and one intrastate pipeline located in Texas. The meetings focused on the companies' preparations for the storm, communications among LDCs, pipelines, marketers, and producers about unfolding events, system operations, underlying causes of the gas supply problems, and lessons learned. In most instances, interviews led to supplemental data requests that provided additional information about the events. The task force also held numerous telephone conferences with companies in the pipeline, LDC, processing and production sectors, both to gather information and to clarify information received in response to data requests.

Outreach Meetings

Task force staff conducted outreach meetings with the following industry associations and groups: the Electric Power Supply Association, the American Gas Association, the Independent Petroleum Association of America, the Texas Pipeline Association, the Interstate Natural Gas Association of America, the Natural Gas Supply Association, the Edison Electric Institute, the National Rural Electric Cooperative Association, the American Public Power Association, and the (ERO) Southwest Outage Advisory Panel. The task force shared its preliminary findings and recommendations on a non-public basis with members of these organizations in order to obtain feedback and, with respect to the recommendations, input as to their practicality and feasibility. The feedback and input provided by these organizations was considered and in a number of instances reflected in the findings and recommendations included in this report.

Coordination with State Inquiries

The task force also reviewed materials acquired in the course of inquiries into the event conducted by legislative bodies and regulatory commissions. The

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

task force followed legislative and regulatory hearings in Arizona, New Mexico and Texas and reviewed transcripts, testimony and webcasts from the proceedings.

Through contacts with state regulatory agencies, staff was able to review responses to data requests issued by those bodies to ensure that the task force was in possession of all potentially relevant materials. Task force staff also monitored legislative efforts taken in response to the February outage, including conferring with sponsors of pertinent legislation concerning, among other things, the anticipated impacts of their proposals. The task force tracked the bills throughout the legislative process. In addition, as regulatory agencies moved forward with their inquiries into the outage, task force staff reviewed draft and final copies of all relevant reports.

The task force also collaborated with ERCOT's Independent Market Monitor (IMM), which conducted an inquiry into potential market manipulation during the event at the request of the PUCT. Task force staff conducted calls with the IMM to discuss market conditions and reviewed its written assessment of the market impacts from the event. The task force also contacted the TRC regarding gas curtailment matters, submitted written questions about the TRC's activities in connection with the event, and reviewed all information the TRC collected concerning the event.

To assist in its analysis of the materials received, the task force commissioned one outside consultant's study to examine impacts of the cold weather event on gas production, reviewed studies conducted on behalf of regulatory and other bodies, and prepared extensive in-house studies by staff analysts.

This report documents the information received by the task force and presents the task force's conclusions as to the causes of the electric outages and natural gas curtailments that occurred during the February 2011 event. It is divided into several sections, beginning with an overview of the electric and natural gas industries that provides background for the event, discusses the event itself and prior cold weather events in the region, and ends with a summary of key findings and recommendations. Also included are a list of acronyms, a glossary, and a number of appendices which treat in fuller detail many of the matters mentioned in the body of the report.

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II. Executive Summary

The arctic cold front that descended on the Southwest during the first week of February 2011 was unusually severe in terms of temperature, wind, and duration of the event. In many cities in the Southwest, temperatures remained below freezing for four days, and winds gusted in places to 30 mph or more. The geographic area hit was also extensive, complicating efforts to obtain power and natural gas from neighboring regions.

The storm, however, was not without precedent. There were prior severe cold weather events in the Southwest in 1983, 1989, 2003, 2006, 2008, and 2010. The worst of these was in 1989, the prior event most comparable to 2011. That year marked the first time ERCOT resorted to system-wide rolling blackouts to prevent more widespread customer outages. In all of those prior years, the natural gas delivery system experienced production declines; however, curtailments to natural gas customers in the region were essentially limited to the years 1989 and 2003.

Electric

Going into the February 2011 storm, neither ERCOT nor the other electric entities that initiated rolling blackouts during the event expected to have a problem meeting customer demand. They all had adequate reserve margins, based on anticipated generator availability. But those reserves proved insufficient for the extraordinary amount of capacity that was lost during the event from trips, derates, and failures to start.

In the case of ERCOT, where rolling blackouts affected the largest number of customers (3.2 million), there were 3100 MW of responsive reserves available on the first day of the event, compared to a minimum requirement of 2300 MW. But over the course of that day and the next, a total of 193 ERCOT generating units failed or were derated, representing a cumulative loss of 29,729 MW. Combining forced outages with scheduled outages, approximately one-third of the total ERCOT fleet was unavailable at the lowest point of the event. These extensive generator failures overwhelmed ERCOT's reserves, which eventually dropped below the level of safe operation. Had ERCOT not acted promptly to shed load, it would very likely have suffered widespread, uncontrolled blackouts throughout the entire ERCOT Interconnection.

ERCOT also experienced generator outages in the Rio Grande Valley on February 3, again due to the cold weather. This area is transmission constrained,

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

and the loss of local generation led to voltage concerns that necessitated localized load shedding.

Spot prices in ERCOT hit the \$3,000 per MWh cap on February 2, the worst day of the event. Given the high demand and the huge loss of generation, this was not a surprising development. In fact, very high prices are an expected response to scarcity conditions, one that is built into ERCOT's energy-only market. ERCOT's IMM reviewed market performance during the event and found no evidence of market manipulation.

EPE and SRP likewise suffered numerous generator outages, necessitating load shed of 1023 MW in EPE's case, and 300 MW in SRP's case. As with ERCOT, many of these generators failed because of weather-related reasons.

A number of entities within SPP also experienced outages during the event. In their case, however, load shedding was not required, principally because the utilities were able to purchase emergency energy from other SPP members. One other utility in the Southwest, PNM, experienced blackouts, but these were localized and the result of transmission outages that were mostly unrelated to the weather.

The actions of the entities in calling for and carrying out the rolling blackouts were largely effective and timely. However, the massive amount of generator failures that were experienced raises the question whether it would have been helpful to increase reserve levels going into the event. This action would have brought more units online earlier, might have prevented some of the freezing problems the generators experienced, and could have exposed operational problems in time to implement corrections before the units were needed to meet customer demand.

The February event underscores the need to have sufficient black start units available, particularly in the face of an anticipated severe weather event. In ERCOT's case, for instance, nearly half of its black start units were either on scheduled outage at the time of the event or failed during the event itself, jeopardizing the utility's ability to promptly restore the system had an uncontrolled, ERCOT-wide blackout occurred.

The majority of the problems experienced by the many generators that tripped, suffered derates, or failed to start during the event were attributable, either directly or indirectly, to the cold weather itself. For the Southwest as a whole, 67 percent of the generator failures (by MWh) were due directly to weather-related causes, including frozen sensing lines, frozen equipment, frozen water lines, frozen valves, blade icing, low temperature cutoff limits, and the like. At least

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

another 12 percent were indirectly attributable to the weather (occasioned by natural gas curtailments to gas-fired generators and difficulties in fuel switching).

Low temperatures returned to the region on February 10. In fact, ERCOT set a new winter peak that day. But no load shedding proved necessary, largely because the temperatures were not quite as cold or sustained as those of the previous week, the winds were less severe, and many of the repairs and protective measures taken by the generators on February 2 remained in place.

Natural Gas

Problems on the natural gas side largely resulted from production declines in the five basins serving the Southwest. For the period February 1 through February 5, an estimated 14.8 Bcf of production was lost. These declines propagated downstream through the rest of the gas delivery chain, ultimately resulting in natural gas curtailments to more than 50,000 customers in New Mexico, Arizona, and Texas.

The production losses stemmed principally from three things: freeze-offs, icy roads, and rolling electric blackouts or customer curtailments. Freeze-offs occurred when the small amount of water produced alongside the natural gas crystallized or froze, completely blocking off the gas flow and shutting down the well. Freeze-offs routinely occur in very cold weather, and affected at least some of these basins in all of the six recent cold weather events in the Southwest with the possible exception of 1983, for which adequate records are not available. During the February event, icy roads prevented maintenance personnel and equipment from reaching the wells and hauling off produced water which, if left in holding tanks at the wellhead, causes the wells to shut down automatically. The ERCOT blackouts or customer curtailments affected primarily the Permian and Fort Worth Basins and caused or contributed to 29 percent (Permian) and 27 percent (Fort Worth) of the production outages, principally as a result of shutting down electric pumping units or compressors on gathering lines.

Processing plants suffered some mechanical failures, although most of their shortfalls resulted from problems upstream at the wellhead. The production declines, coupled with increased customer demand, reduced gas volume and pressure in the pipelines and in those limited storage facilities serving the Southwest. These entities in turn were unable in some instances to deliver adequate gas supplies to LDCs.

When LDCs suffer declines in gas pressure on their systems, they must reduce the amount of gas being consumed to prevent pressures from falling so low that their entire systems might fail. As a result of the high gas demand and the

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

falling pressures on their systems, four LDCs in New Mexico, Arizona and Texas were forced to curtail retail service or were unable to supply gas to all customers. These curtailments or outages affected more than 50,000 customers in those states, including the cities of El Paso in Texas; Tucson and Sierra Vista in Arizona; and Hobbs, Ruidoso, Alamogordo, Silver City, Tularosa, La Luz, Taos, Red River, Questa, Española, Bernalillo, and Placitas in New Mexico. In contrast to the relative ease of restoring electric service, restoration of gas service was complicated by the necessity to have LDC crews manually shut off gas meters and then relight pilot lights on site.

Winterization

Generators and natural gas producers suffered severe losses of capacity despite having received accurate forecasts of the storm. Entities in both categories report having winterization procedures in place. However, the poor performance of many of these generating units and wells suggests that these procedures were either inadequate or were not adequately followed.

The experiences of 1989 are instructive, particularly on the electric side. In that year, as in 2011, cold weather caused many generators to trip, derate, or fail to start. The PUCT investigated the occurrence and issued a number of recommendations aimed at improving winterization on the part of the generators. These recommendations were not mandatory, and over the course of time implementation lapsed. Many of the generators that experienced outages in 1989 failed again in 2011.

On the gas side, producers experienced production declines in all of the recent prior cold weather events. While these declines rarely led to any significant curtailments, electric generators in 2003 did experience, as a result of gas shortages, widespread derates and in some cases outright unit failure. It is reasonable to assume from this pattern that the level of winterization put in place by producers is not capable of withstanding unusually cold temperatures.

While extreme cold weather events are obviously not as common in the Southwest as elsewhere, they do occur every few years. And when they do, the cost in terms of dollars and human hardship is considerable. The question of what to do about it is not an easy one to answer, as all preventative measures entail some cost. However, in many cases, the needed fixes would not be unduly expensive. Indeed, many utilities have already undertaken improvements in light of their experiences during the February event. This report makes a number of recommendations that the task force believes are both reasonable economically and which would substantially reduce the risk of blackouts and natural gas curtailments during the next extreme cold weather event that hits the Southwest.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Electric and Gas Interdependency

The report also addresses the interdependency of the electric and natural gas industries. Utilities are becoming increasingly reliant on gas-fired generation, in large part because shale production has dramatically reduced the cost of gas. Likewise, compressors used in the gas industry are more likely than in the past to be powered with electricity, rather than gas. As a result, deficiencies in the supply of either electricity or natural gas affect not only consumers of that commodity, but of the other commodity as well.

Gas shortages were not a significant cause of the electric generator outages experienced during the February 2011 event, nor were rolling blackouts a primary cause of the production declines at the wellhead. Both, however, contributed to the problem, and in the case of natural gas shortfalls in the Permian and Fort Worth Basins, approximately a quarter of the decline was attributed to rolling blackouts or customer curtailments affecting producers.

The report explores some of the issues relating to the effects of shortages of one commodity on the other, including the question of whether gas production and processing facilities should be deemed “human needs” customers and thus exempted or given special consideration for purposes of electric load shedding. However, any resolution of the many issues arising from electric and natural gas interdependency must be informed by an examination of more than one cold weather event in one part of the country. For that reason, the report does not offer specific recommendations in this area, but urges regulatory and industry bodies to explore solutions to the many interdependency problems which are likely to remain of concern in the future.

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III. The Electric and Natural Gas Industries

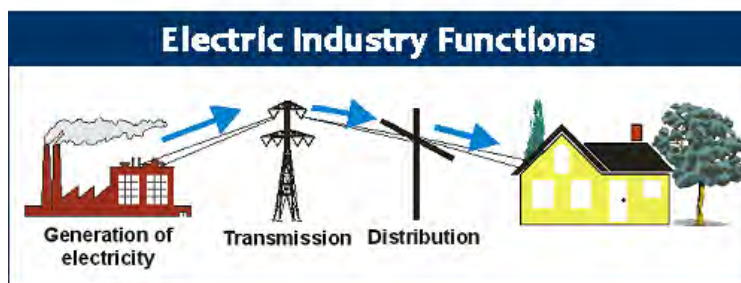
Electricity and natural gas are two of the most essential commodities for the conduct of modern life. However, the industries that produce electricity and natural gas and deliver these commodities from their points of production to consumers differ greatly from one another, as do the regulatory schemes governing them. This section provides an overview of the electric and natural gas industries, their market structures, and the regulatory authorities under which they operate, focusing particularly on the southwest region of the country. This background will be useful in understanding the causes of the outages and curtailments experienced during the first week of February 2011, the actions taken by the entities affected, and the recommendations the task force is suggesting to prevent a recurrence of the widespread service disruptions.

A. The Electric Industry

This subsection describes the structures under which electricity is generated and transmitted, the regulation of electric service providers, and the characteristics of the electricity markets found in the Southwest. A more detailed description of how electricity is produced, transmitted and delivered can be found in the appendix entitled “Electricity: How it is Generated and Distributed.”

Overview of Electric Power Production and Delivery

The electric power industry is comprised of three separate functions: generation, transmission, and distribution. These are depicted in the figure below.

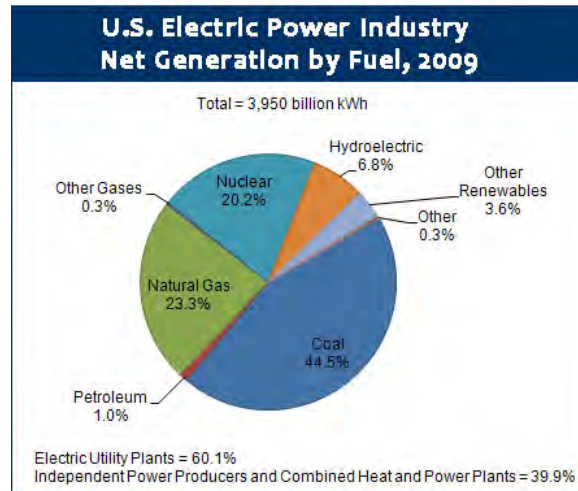


Source: EIA

Most of the power produced in the United States uses coal, natural gas, or nuclear fission as the energy source to produce steam or other hot combustion gas that turns a turbine and thereby creates electricity. The figure below shows the fuel source percentages for electricity produced in the US in 2009, with the majority of electricity coming from fossil fuels (coal and natural gas totaling a 68

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

percent share). While wind and solar energy have experienced fairly rapid growth over the past several years, renewable fuels (including hydroelectric generation's seven percent share) accounted for about 11 percent of the electricity generated in the United States in that year. Wind generation is more common in the Southwest than in most other regions; its share of total generation is about 3.8 percent.¹



Sources: EIA, Form EIA-923, "Power Plant Operations Report."

Generating units typically fall into three categories: base load, intermediate, and peaking units. Base load units, usually coal-fired or nuclear, have a relatively low operating cost and have fairly slow or expensive ramping rates.² These units are seldom cycled on and off, and are instead scheduled to cover the base levels of projected load. Peaking units, which are generally gas-fired, can be started up very quickly and have relatively expensive operating costs. Accordingly, they are generally last in the dispatch order and are used to cover seasonal (and sometimes daily) peak load levels. Intermediate plants fall somewhere in between base load and peaking with respect to operating characteristics, start-up times, and capacity factors.³

Generating plants produce power at a relatively low voltage level, so the power must be "stepped up" to a higher voltage in order to be more efficiently

¹ United States Energy Information Administration (EIA), *Electric Power Monthly*, Table 6 - Total Renewable Net Generation by Energy Source and State, 2009 (released August 2010) and *Electric Power Annual*, Figure 2.1 – U.S. Electric Industry Net Generation by State, 2009 (released November 2010, revised January and April 2011).

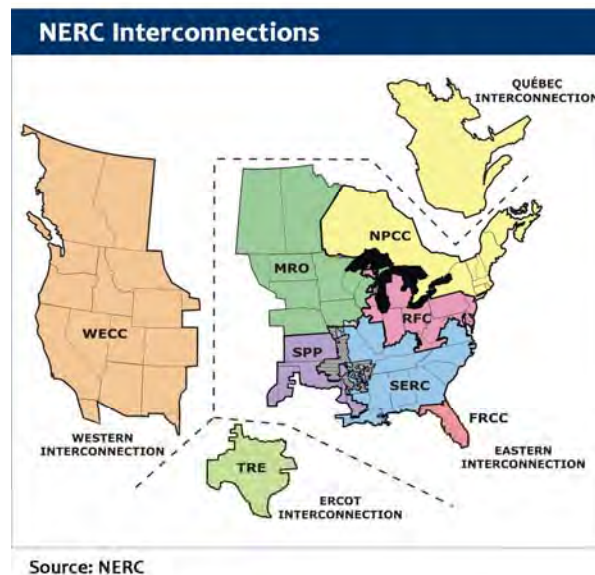
² "Ramping" refers to the generator's ability to produce more or less power on request.

³ "Capacity factor" refers to the ratio of average generation to the capacity rating of an electric generating unit for a specified period (expressed as a percentage).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

transmitted to its ultimate point of use. Energy is carried at these higher voltages over transmission lines (usually between 138 kV and 765 kV) to load centers, where voltage is then stepped back down to a distribution level for delivery to end-use customers. While distribution lines are generally considered to be those operating at 69 kV and below,⁴ some industrial end-use customers may take service at transmission-level or intermediate-level voltages.

Virtually all of the transmission system in the continental United States is operated as an alternating current (AC) system, although the West and a few other areas make use of some direct current (DC) lines for long-haul transportation of power or for system stability. DC ties are also used to provide limited connectivity between the three electrically independent grids currently found in the United States: (1) the Eastern Interconnection, which covers the eastern two-thirds of the United States and contiguous parts of Canada; (2) the Western Interconnection, which covers the western third of the United States, the Canadian provinces of Alberta and British Columbia, and a small portion of Baja California Norte, Mexico; and (3) ERCOT, which covers most of the state of Texas. (A fourth interconnection, the Quebec Interconnection, is located wholly in Canada.)



⁴ The bulk electric system, which constitutes transmission as opposed to distribution, has been described by FERC as those facilities operating at 100 kV or above except for defined radial facilities, with exemptions for those facilities not necessary for operating the interconnected transmission network. *Revision to Electric Reliability Organization Definition of Bulk Electric System*, Order No. 743, 75 Fed. Reg. 72,910 (Nov. 26, 2010), 133 FERC ¶ 61,150 (2010), *order on reh'g*, Order No. 743-A, 134 FERC ¶ 61,210 (2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Within each interconnection, power generally flows freely across the entire grid. An imbalance of generation versus demand that is significant enough to cause instability on one utility's system can ultimately affect the stability of all systems operating in that interconnection.⁵

Evolution and Regulation of the Electric Industry

Under part II of the Federal Power Act,⁶ FERC has jurisdiction over the rates, terms and conditions of wholesale sales of electric energy and transmission services in interstate commerce that are provided by jurisdictional entities (which generally excludes electric cooperatives and federal or state entities, including municipal utilities). Notably, wholesale electric energy sales and transmission services provided wholly within ERCOT are not considered to be interstate under the Federal Power Act, and are therefore not subject to FERC jurisdiction. States generally regulate retail sales of electric energy and distribution services, although publicly-owned and member-owned entities (such as electric cooperatives and municipal utilities) may be exempt from direct state regulatory oversight. In Texas, the PUCT exercises jurisdiction over wholesale sales of energy and the provision of transmission services wholly within the ERCOT footprint.

Historically, all three of the electric sector functions (generation, transmission, and distribution) were provided by one vertically-integrated utility, which was typically granted a monopoly franchise by states to serve retail customers within a given geographic area. While wholesale sales or exchanges of electric energy did occur between utilities, utilities historically planned their systems, both generation and transmission, to serve their own native peak load requirements.

Entities Providing Electric Services in the United States

The electric sector in the United States is made up of a variety of entities, including investor-owned utilities, publicly-owned utilities (including municipal utilities, public utility districts, and irrigation districts), member-owned utilities (generally rural electric cooperatives), Federal electric utilities, and
(cont'd)

⁵ See generally U.S.-Canada Power System Outage Task Force, Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations at 5-10 (April 2004) (2003 Blackout Report), available at <http://www.ferc.gov/industries/electric/indus-act/reliability/blackout.asp#skipnav> (last visited Aug. 2, 2011).

⁶ 16 U.S.C. § 824 et seq.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

independent power producers. Investor-owned utilities (IOUs) are private entities that were historically vertically-integrated, *i.e.*, owning generation, transmission and distribution assets. However, in states with restructured electric markets, many IOUs were required or strongly incentivized to divest or spin-off their generation assets, and now own only transmission and distribution assets as part of the utility company. Based on 2007 data from the United States Energy Information Administration, IOUs serve about 71 percent of the retail customers in the country. Publicly-owned electric utilities and electric cooperatives have generally been exempted from state restructuring initiatives, and have not been required to offer customer choice or to divest generation assets. There are approximately 2,000 publicly-owned utilities in the United States (which own about 9 percent of the installed generating capacity) and over 880 electric cooperatives (which own approximately 4 percent of the installed capacity).

Since the 1970s, a number of changes occurred to alter this traditional, vertically-integrated model. In 1978, Congress created a class of non-utility generators called qualifying facilities (QFs), and in 1992 created a class of independent generators called Exempt Wholesale Generators. This legislation opened the door not only for independent owners to develop generating plants in multiple regions, but also for utilities to develop generating plants in regions outside their service territory.⁷

FERC took a number of steps to further encourage the development of a competitive wholesale market for generation, including by (1) authorizing generation owners to sell wholesale power at market rates if they can demonstrate that they lacked market power in the relevant market; and (2) requiring transmitting utilities to provide open access transmission service for the delivery of power to wholesale customers on terms and conditions comparable to the transmission service the utilities provided themselves in serving their native load customers.⁸

⁷ Energy Policy Act of 1992, Pub. L. No. 102, 486.

⁸ Promoting Wholesale Competition Through Open Access Non-Discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, Order No. 888, FERC Stats. & Regs. ¶ 31,036 (1996), *order on reh'g*, Order No. 888-A, FERC Stats. & Regs. ¶ 31,048, *order on reh'g*, Order No. 888-B, 81 FERC ¶ 61,248 (1997), *order on reh'g*, Order No. 888-C, 82 FERC ¶ 61,046 (1998), *aff'd in relevant part*

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

FERC also encouraged the formation of Independent System Operators (ISOs)⁹ and Regional Transmission Organizations (RTOs).¹⁰ ISOs/RTOs serve a number of functions critical to operation of the wholesale market within a given region, including control and operation of the transmission grid, operation of real-time and day-ahead markets, and transmission system planning.¹¹ Not all regions in the United States have adopted an ISO/RTO structure, although they may rely on other power pool structures. The map below shows the footprint of the nine ISOs or RTOs currently operating in the US and Canada.

sub nom. Transmission Access Policy Study Group v. FERC, 225 F.3d 667 (D.C. Cir. 2000), *aff'd sub nom.* New York v. FERC, 535 U.S. 1 (2002) (Order No. 888).

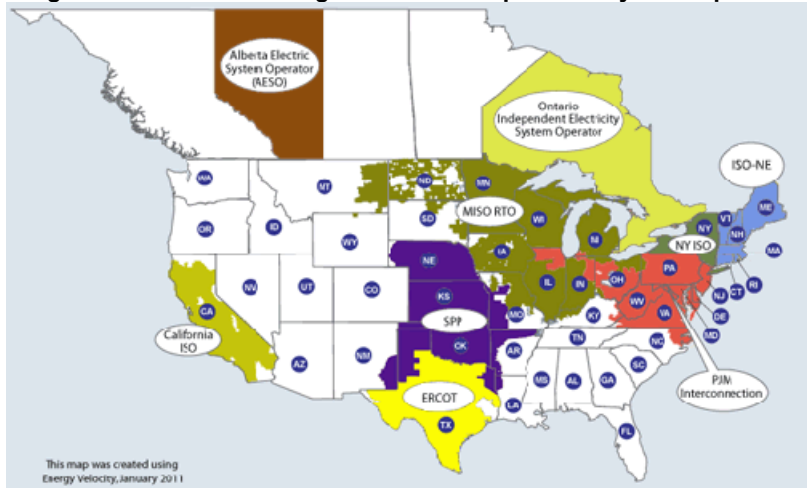
⁹ ISOs grew out of Order No. 888, issued in 1996, as a means of satisfying FERC's requirement that jurisdictional utilities provide non-discriminatory access to transmission services. Order No. 888, FERC Stats. & Regs. ¶ 31,036 at 31,730; and *Regional Transmission Organizations*, Order No. 2000, FERC Stats. & Regs. ¶ 31,089 (1999), *order on reh'g*, Order No. 2000-A, FERC Stats. & Regs. ¶ 31,092 (2000), *aff'd sub nom. Pub. Util. Dist. No. 1 of Snohomish County, Washington v. FERC*, 272 F.3d 607 (D.C. Cir. 2001).

¹⁰ In 1999, as part of Order No. 2000, FERC created and sought to encourage the voluntary formation of Regional Transmission Organizations to oversee electric transmission and ancillary services and transmission planning services across a broader territory. ISOs and RTOs perform similar functions, but RTOs are only recognized as such if they meet FERC's minimum characteristics and minimum functions as set out in Order No. 2000. In addition, ISOs tend to be smaller in geographic size, or are not subject to FERC jurisdiction. See "The Value of Independent Regional Grid Operators: A Report by the ISO/RTO Council," *available at* <http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/Value_of_Independent_Regional_Grid_Operators.pdf>. Order 2000: *Regional Transmission Organizations*, Order No. 2000, FERC Stats. & Regs. ¶ 31,089 (1999), *order on reh'g*, Order No. 2000-A, FERC Stats. & Regs. ¶ 31,092 (2000), *aff'd sub nom. Pub. Util. Dist. No. 1 of Snohomish County, Washington v. FERC*, 272 F.3d 607 (D.C. Cir. 2001).

¹¹ See Order No. 888, FERC Stats. & Regs. ¶ 31,036 at 31,730 (1996).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Regional Transmission Organizations/Independent System Operators



In markets where an ISO/RTO has been approved, the ISO/RTO is generally responsible for dispatching generating units based on hourly energy prices offered by the generation owner or other energy marketer. Initially, these competitive wholesale markets were structured to reflect only energy products and ancillary services,¹² with no compensation for the provision of capacity¹³ and no corresponding obligation on the part of generators to offer into a specific market.¹⁴ Many of the markets have undergone modifications over time, including

¹² Ancillary services support the reliable operation of the transmission system as it moves electricity from generating sources to retail customers, and in RTO or ISO-based markets are generally procured through a mechanism or market separate from the energy market. Ancillary services typically include regulation, synchronized or spinning reserves, non-spinning reserves, and black-start services. Among ERCOT's various categories of ancillary services are responsive reserve service (RRS) and non-spinning reserve service (NSRS). RRS are operating reserves intended to help control the frequency of the system. NSRS are reserves intended to cover the uncertainties in forecasting load and wind power output.

¹³ Capacity (or installed capacity) refers in this context to the maximum kW or MW of output offered into a capacity market and required to be available except as otherwise provided by the relevant market rules. Payments by load serving entities for capacity are made regardless of whether energy is actually provided, as long as the relevant availability requirements are met. Penalties are generally imposed if a supplier fails to meet the availability requirements or otherwise provide energy when called upon.

¹⁴ After an offer is accepted in a given energy or ancillary services market, the generator or its marketer has the obligation to deliver the energy or to cover the real-time cost of replacement if the generator experiences a forced outage or derate. In addition, even in an energy-only market, certain generators that are deemed essential for reliability (often referred to as reliability must-run generators or RMRs), are paid an amount above the base energy payments to ensure that the unit remains operational and available; these generators are subject to some form of penalty if the unit is not available as provided for under the market rules or specific RMR contract.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

implementation of day-ahead markets, virtual bidding,¹⁵ nodal pricing,¹⁶ and separate capacity markets.

Energy-Only Markets versus Capacity Markets

In an energy-only market, load serving entities purchase energy on an hourly basis (even if secured or scheduled on a day-ahead or forward basis), and are generally also required to cover minimum ancillary services requirements, including voltage support, regulation, and spinning or non-spinning reserves. These load-serving entities are not obligated to secure capacity to cover their projected peak loads going forward, and generators can only recover their capital costs through payments for hourly energy and ancillary services.

In markets with capacity-based payments, load serving entities are responsible for procuring capacity (including adequate reserves) to cover their peak loads. In the Northeast, capacity prices are set through forward capacity markets, and while generators receive the benefit of a more predictable revenue stream, they must also accept certain obligations to ensure that their unit is available and offered into the energy market when needed, or face penalties for failure to do so.

Reliability Oversight by FERC, NERC and Regional Entities

In 1968, following the extensive 1965 blackout in the Eastern United States and Canada, members of the electric utility industry formed a voluntary council (NERC)¹⁷ to coordinate regional planning for the industry and develop operating

¹⁵ A form of transaction where buyers and sellers place trades based on differences between day-ahead prices and real-time prices. Virtual bidding is intended to improve market efficiency as real-time and day-ahead prices converge.

¹⁶ Nodal pricing uses the locational marginal price (LMP, or the cost of supplying the next megawatt of load) at each specific electric location or bus. In a completely unconstrained system, the nodal price will be the same at each node on the system. When transmission constraints occur, the nodal price will reflect the cost of dispatching generating units out of economic merit order in order to serve load within the constrained area. Nodal pricing allows for separate energy prices at each bus, while zonal pricing sets a locational price for much larger, pre-established zones.

¹⁷ The council was originally named the National Electric Reliability Council, but the name was later changed to North American Electric Reliability Council to reflect Canadian

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

guides and voluntary standards and practices to protect the reliability of the interconnected system.¹⁸ While efforts were undertaken in the 1990s to require adherence to NERC reliability policies and guidelines, mandatory reliability standards were not adopted in the United States until Congress passed the Energy Policy Act of 2005 (EPAct 2005). That act required FERC to certify an independent Electric Reliability Organization (ERO) tasked with developing and enforcing such mandatory reliability standards.¹⁹

Pursuant to EPAct 2005, FERC certified NERC as the ERO on July 20, 2006.²⁰ Under implementation procedures adopted by FERC, NERC is permitted to delegate a portion of its responsibilities for enforcement and for regional standards development to Regional Entities, which NERC in turn oversees. NERC has provided such delegated authority to eight Regional Entities in the United States and Canada, each of which has primary authority for enforcement in the regions shown below.²¹

member participation, and changed again to North American Electric Reliability Corporation in 2007 to reflect its new role as the independent Electric Reliability Organization. *See NERC Company Overview: History*, <http://www.nerc.com/page.php?cid=17|11>.

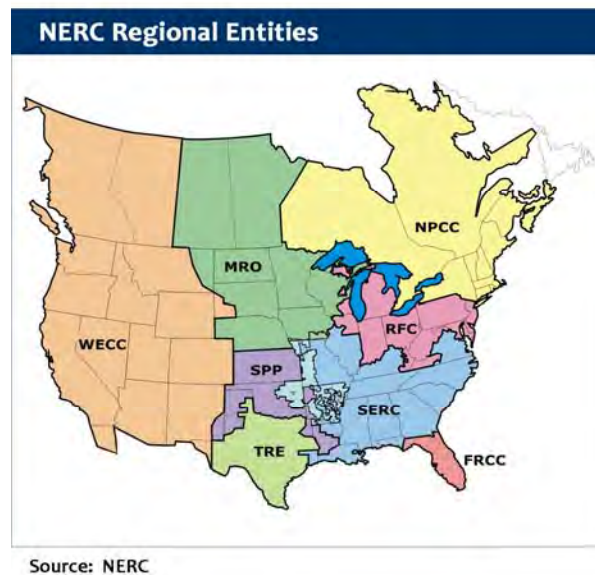
¹⁸ Responsibility for the voluntary standards and operating guidelines was originally given to the North American Power Systems Interconnection Committee (NAPSIC, formed earlier in the 1960s). NAPSIC later became part of NERC. *Id.*

¹⁹ *See* Energy Policy Act of 2005, Pub. L. No. 109-58. The renewed efforts to adopt mandatory reliability standards that prompted this section of the Energy Policy Act came in response to the Northeastern blackout of August 14, 2003, and to the recommendations made in a report prepared by a joint US-Canada task force that reviewed the causes of the blackout. *2003 Blackout Report* at 3 (adopting as its first recommendation: “Make reliability standards mandatory and enforceable, with penalties for noncompliance.”)

²⁰ *N. Am. Elec. Reliability Corp.* 116 FERC ¶ 61,062 (2006).

²¹ The eight Regional Entities operating under delegated authority from NERC are Florida Reliability Coordinating Council, Midwest Reliability Organization, Northeast Power Coordinating Council, ReliabilityFirst Corporation, SERC Reliability Corporation, Southwest Power Pool Regional Entity, Texas Reliability Entity, and Western Electric Coordinating Council.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



Under Section 215 of the Federal Power Act, NERC must submit its proposed Reliability Standards to FERC for approval before they may become mandatory and enforceable. In order to approve a Reliability Standard, FERC must find that it is just, reasonable, not unduly discriminatory or preferential, and in the public interest, after giving due weight to the technical expertise of the ERO.²² In addition, while the ERO has the authority to propose a penalty for violation of a Reliability Standard following notice and opportunity for a hearing, that penalty may only take effect after it has been filed with FERC. FERC can exercise the option to review, set aside, or modify the penalty, on its own motion or on application by the entity subject to the proposed penalty.²³ FERC also has the authority, on its own motion or on complaint, to order compliance with a Reliability Standard or to impose a penalty for violation of a Reliability Standard.²⁴

In Order No. 693, FERC approved the first set of 83 Reliability Standards, which became enforceable on June 18, 2007.²⁵ NERC maintains a Compliance

²² 16 U.S.C. § 824o(d)(1) and (2).

²³ *Id.* at § 824o(e)(1) and (2).

²⁴ *Id.* at § 824o(e)(3).

²⁵ NERC and the Regional Entities may assess penalties for non-compliance with the Reliability Standards. In order for such a penalty to take effect, NERC must file a notice of penalty with FERC. Each penalty determination is subject to FERC review. In the absence of an application for review or action by FERC, each penalty filed by NERC is affirmed by operation of law after 30 days.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Registry that identifies all entities subject to compliance with the approved Reliability Standards. Users, owners and operators of the bulk power system are required to register with NERC under the appropriate functional categories, and each Reliability Standard designates each category of entity to which it applies. Currently, there are over 1900 registered entities subject to the Reliability Standards (a number of entities are counted more than once as they are registered under more than one category). The categories of registered entities are set out in the appendix entitled “Categories of NERC Registered Entities.”

Registered entities are required to report the occurrence of defined bulk power system disturbances and unusual occurrences to the appropriate Regional Entity and to NERC. The Regional Entity and/or NERC in turn undertakes various levels of analysis to determine the causes of the events, assure tracking of corrective actions to prevent recurrence, gather information needed to assess compliance, and provide lessons learned to the industry. The event analysis process also provides input for training and education, reliability trend analysis efforts and Reliability Standards development, all of which support continued reliability improvement. Under NERC’s field trial of its event analysis program, the February 2 and February 3 event was classified as a category 4 event due to the overall significance and impact of the event (loss of over 5,000 MW but less than 10,000 MW of load or generation). Based on the scope of the needed analysis, and the fact that it impacted multiple regions, NERC determined that the event review should be coordinated at the NERC level.

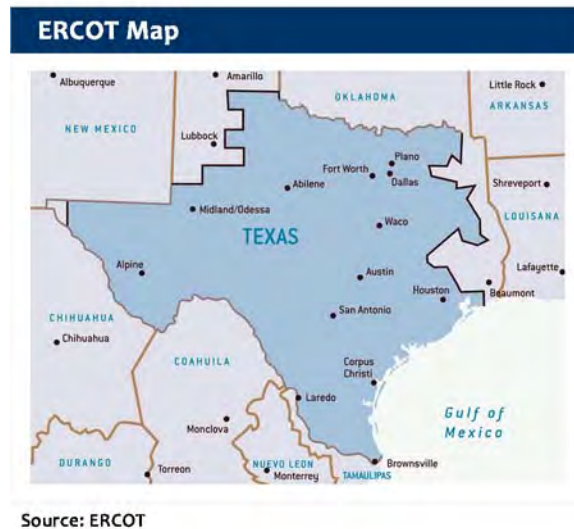
Southwest Electricity Markets, Pools and Reserve Sharing Groups

The Southwest contains two ISO/RTOs (ERCOT and SPP), and a number of vertically integrated utilities that are located within the WECC region. These are described below.

ERCOT

The Electric Reliability Council of Texas (ERCOT) is an ISO that covers approximately seventy-five percent of the landmass within Texas, excluding the El Paso area, part of the northern panhandle, and part of the region east of Houston. ERCOT manages access to the transmission system within its footprint and operates the Texas energy and ancillary services markets (it does not have a capacity market).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



ERCOT schedules power over 40,500 miles of transmission lines and is responsible for the dispatch of more than 550 generating units.²⁶ It was founded in 1970 as one of the NERC regional reliability coordination councils, and is currently the registered balancing authority for 85 percent of the electric load in Texas.²⁷ When it became an ISO in 1996 it undertook a number of new responsibilities, including operation of the wholesale competitive electricity market. When Texas restructured its electric industry in 2002, implementing customer choice for most retail customers and requiring divestiture of generation by IOUs, ERCOT also undertook administration of customer switching for those retail customers in Texas that can choose their electric service provider.

ERCOT is a summer-peaking region, and experienced its highest peak demand to date (68,294 MW) on August 3, 2011. Generation in ERCOT is fairly diverse in terms of fuel sources. Natural gas represented the highest percentage of installed capacity in 2009 (at 59 percent), but coal and nuclear power combined to provide over 50 percent of the energy produced for that year.²⁸

ERCOT operates as a functionally separate interconnection, although it has five asynchronous ties with other interconnections.²⁹ Three of the ties allow

²⁶ For ERCOT background, *see generally* ERCOT 2009 Annual Report, *available at* <http://www.ercot.com/content/news/presentations/2010/2009%20ERCOT%20Annual%20Report.pdf>.

²⁷ ERCOT is also registered in NERC's Compliance Registry as an interchange authority, planning authority, reliability coordinator, resource planner, and transmission service provider. In addition, it also partners with other transmission operators in Texas and in that capacity is listed as a "coordinated functional registration."

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

exchanges with Mexico (through the Comisión Federal de Electricidad, or CFE): the Laredo Variable Frequency Tie, the South Tie (also called Eagle Pass), and the Railroad Tie, the latter located near McAllen, Texas. Two of the ties allow exchanges with the Eastern Interconnection through SPP: the North Tie, located near Oklaunion, Texas, and the East Tie, located near Mt. Pleasant, Texas. The maximum amount of energy that can be imported on all the ties is 1090 MW (approximately 2.3 percent of ERCOT's 2010/2011 forecasted winter peak), with most of that attributable to the ties to the Eastern Interconnection.³⁰

ERCOT originally employed a zonal market design, under which the region was divided into pricing zones and all generators within a zone received the same price for the power they provided. It shifted to a nodal market design in December 2010, under which prices are assessed at points (nodes) where electricity enters or leaves the grid. The settlement price at each node is referred to as the locational marginal price (LMP). A nodal market design allows for more precise price signals and greater dispatch efficiencies than a zonal market design, and permits direct assignment of congestion costs through the more granular locational marginal prices.

Under its previous zonal market, ERCOT had no day-ahead energy market (although ancillary services were procured on a day-ahead basis to ensure sufficient capacity would be available). Under its current nodal market, ERCOT has a day-ahead energy market, which is co-optimized with ancillary services.

ERCOT has an energy-only market, as opposed to both an energy market and a capacity market. Capacity markets are used to address resource adequacy concerns; typically, a planning reserve margin is established to maintain reliability goals, and the ISO/RTO imposes capacity obligations on load-serving entities that are met through bilateral contracting or a centralized capacity market. In contrast, an energy-only market relies on energy price signals to spur investment in new generation. Thus, by design, ERCOT's energy-only market would be expected to

²⁸ ERCOT reported the following percentage fuel mix of installed capacity in 2009, in declining order: (1) natural gas, 59 percent; (2) coal, 22 percent; (3) wind, 11 percent; (4) nuclear, 6 percent; and (5) hydroelectric and biomass, 2 percent. ERCOT reported the following percentages for energy produced for 2009: (1) natural gas, 42 percent; (2) coal, 37 percent; (3) nuclear, 14 percent (4) wind, 6 percent; and (5) hydroelectric and biomass, 1 percent. ERCOT 2009 Annual Report at 2.

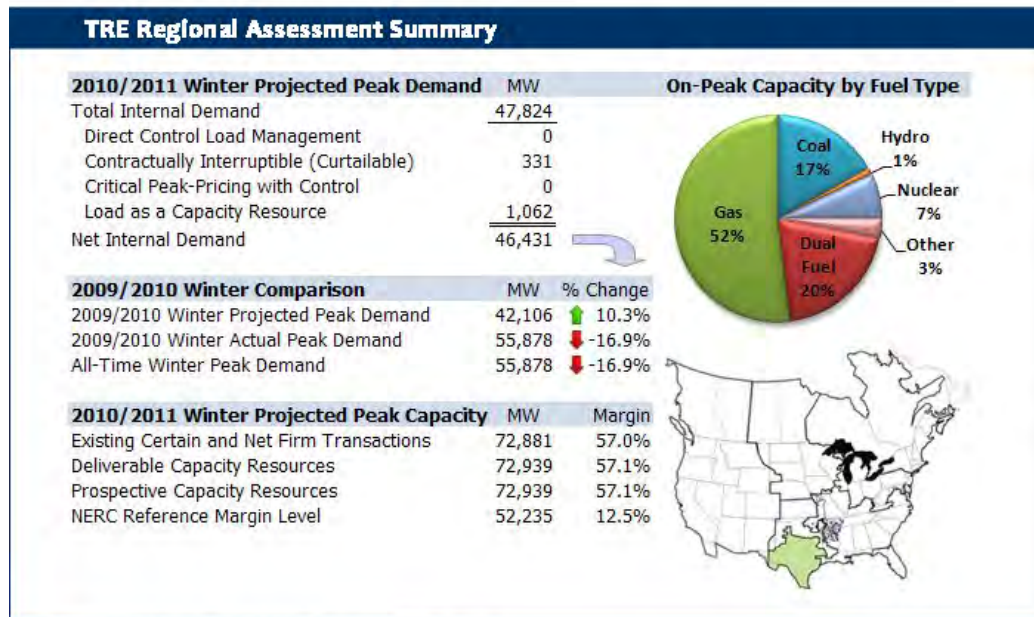
²⁹ Four are DC interties and one is a variable frequency transformer (VFT) inter-tie.

³⁰ The maximum MW that can be imported on each of the ties (actual limits may vary based on real-time conditions) is as follows: North, 210 MW; East, 600 MW; South/Eagle Pass, 30 MW; Railroad, 150 MW; and Laredo, 100 MW.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

result in higher prices during times of scarcity and produce more volatile prices in general than do dual energy and capacity markets. These price signals are intended to encourage investment in energy resources, such as new generation plants, demand response, and energy efficiency, to meet growing demand.

NERC's regional assessment summary for TRE, which includes the ERCOT control area, for the winter of 2010/2011 is presented in the following chart.³¹



Source: NERC Winter Reliability Assessment 2010/2011

WECC Region and Southwest Reserve Sharing Group

WECC is the largest geographically of the eight NERC Regional Entities, with responsibility for coordinating and promoting system reliability throughout the Western Interconnection. WECC's service territory covers Alberta and British Columbia, the northern part of Baja California in Mexico, and all the states in between, constituting an area of about 1.8 million square miles.

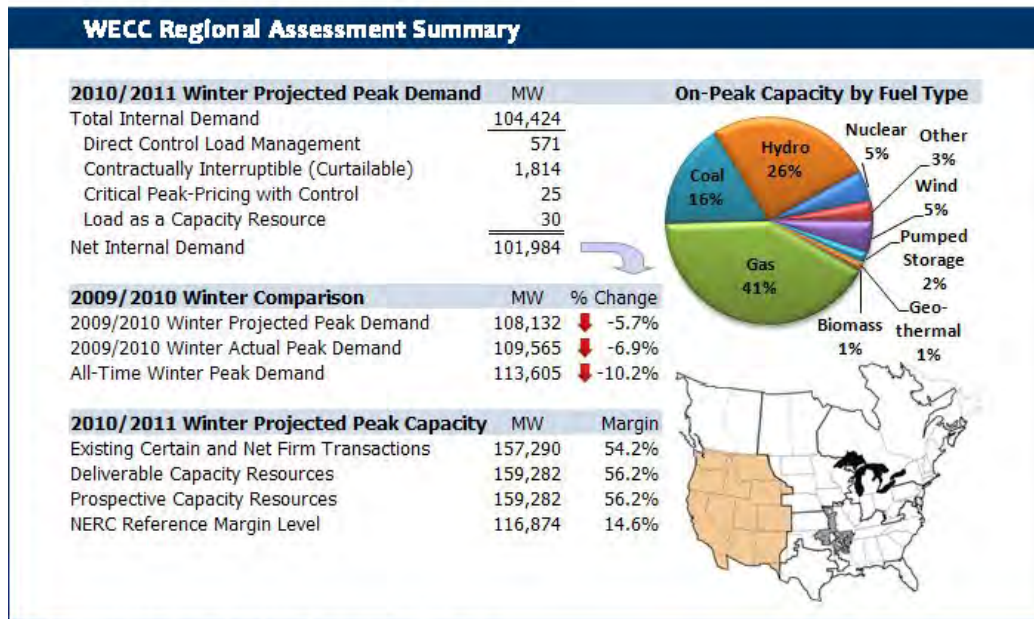
WECC's bulk power system generally transfers energy over long transmission lines from remotely located generators to load centers. The lack of redundant transmission facilities demands a high level of operational scrutiny in order to maintain correct voltages and power flows on the many stability limited transmission paths that exist in the Western Interconnection.

³¹ NERC 2010/2011 Winter Reliability Assessment, available at http://www.nerc.com/files/2010_Winter_Assessment_Final_Posted.pdf.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

WECC has registered 34 balancing authorities;³² 52 transmission operators, and 3 reserve sharing groups. The California Independent System Operator (CAISO) is the only balancing authority in the Western Interconnection that operates as an ISO or RTO.

NERC's regional assessment summary for WECC for the winter of 2010/2011 is presented in the following chart.³³



Source: NERC Winter Reliability Assessment 2010/2011

Two of the entities that experienced rolling blackouts during the February event, SRP and EPE, are located in the WECC region. SRP, one of Arizona's largest utilities, is vertically integrated and a subdivision of the State of Arizona. Serving over 933,500 retail customers, SRP's eleven main generating stations, combined with numerous smaller facilities, have a peak retail load of over 6400 MW, and serve a 2,900 square mile area. SRP is registered with NERC for all bulk power system functions except interchange authority, reliability coordinator, and reserve sharing group.

³² NERC defines "balancing authority" as the responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within the BA area, and supports interconnection frequency in real-time.

³³ NERC 2010/2011 Winter Reliability Assessment.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

EPE is a vertically integrated electric utility providing generation, transmission, and distribution service in west Texas and southern New Mexico. EPE serves approximately 372,000 customers over a 10,000 square mile service territory via five major generating stations, including three stations local to El Paso, Texas. It has a native peak load of 1616 MW. Like SRP, EPE is registered with NERC for all bulk power system functions except interchange authority, reliability coordinator, and reserve sharing group.

Both SRP and EPE participate in the Southwest Reserve Sharing Group (SRSG), which provides for the sharing of contingency reserves among its participants pursuant to a Participation Agreement. SRSG was formed in 1998 as the successor to an earlier pool, and has participants in Arizona, New Mexico, southern Nevada, part of southern California and El Paso, Texas. SRSG is a NERC Registered Entity, and administers certain requirements related to disturbance control and emergency operations standards. Its participants are obligated to carry reserves in accordance with a contractual formula, and to provide power within a certain time frame to other participants experiencing a disturbance on their systems.

Southwest Power Pool

SPP is both an RTO and a NERC Regional Entity responsible for the enforcement of Reliability Standards within its region. SPP had its origins in 1941, when eleven regional power companies formed the pool in order to ensure sufficient electric service to aluminum plants needed for the war effort. The pool remained intact after the war and was a founding member of NERC in 1968. SPP implemented operating reserve sharing arrangements among its members in 1991, and became a FERC-approved RTO in 2004.

SPP covers a 370,000 mile area that includes all or portions of nine states: Nebraska, Kansas, Oklahoma, Missouri, Arkansas, Louisiana, Texas, New Mexico, and Mississippi.³⁴ SPP operates 48,930 miles of transmission lines, and has a coincident peak demand within its reliability coordinator³⁵ footprint of approximately 55,000 MW.

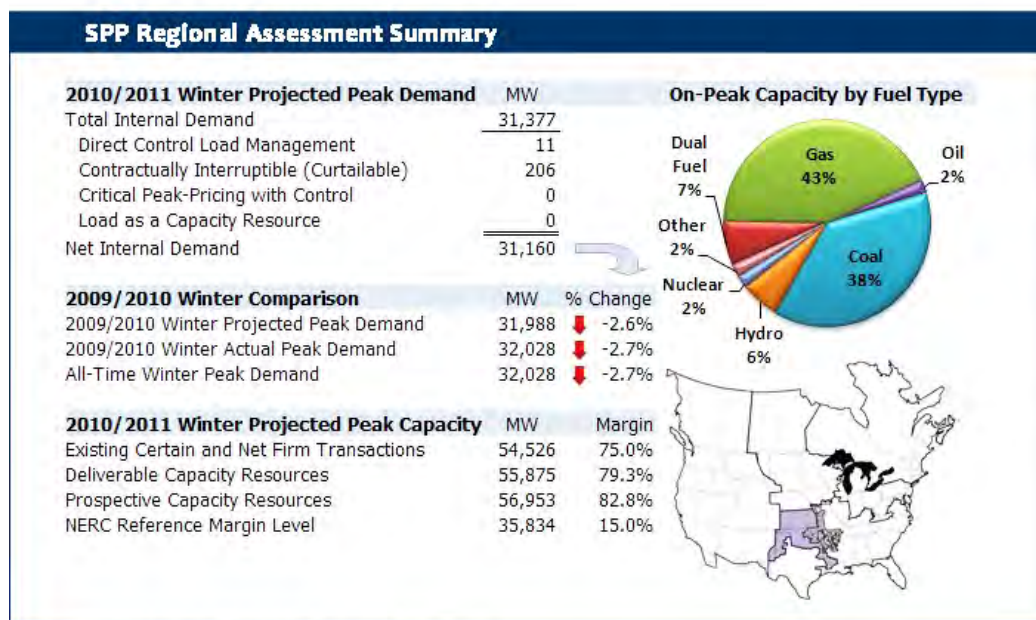
³⁴ SPP actually has five “footprints,” with differing membership and oversight functions, as (1) a NERC Regional Entity; (2) a reserve sharing group; (3) a reliability coordinator area (29 balancing authorities and transmission owners, including certain balancing authorities in SERC and the Midwest Reliability Organization); (4) an RTO (with 15 balancing authorities); and (5) an energy imbalance services (EIS) market region (with 15 balancing authorities). *See* <http://www.spp.org/section.asp?pageID=28> (last visited Aug. 2, 2011).

³⁵ NERC defines “reliability coordinator” as the entity that is the highest level of authority responsible for the reliable operation of the bulk power system, has the wide area view

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

At present, SPP's market operations are relatively limited, currently allowing participants to buy and sell energy in real time and to settle out any energy scheduling imbalances based on the real-time market price. SPP does not currently operate a separate market for reserves but is working to implement a new integrated marketplace that includes a day-ahead energy and operating reserves market.³⁶

NERC's regional assessment summary for SPP for the winter of 2010/2011 is presented in the following chart.³⁷



Source: NERC Winter Reliability Assessment 2010/2011

of the bulk power system, and has the operating tools, processes and procedures, including the authority to prevent or mitigate emergency operating situations in both next-day analysis and real-time operations. The RC has the purview that is broad enough to enable the calculation of interconnection reliability operating limits, which may be based on the operating parameters of transmission systems beyond any Transmission Operator's vision.

³⁶ Unlike California, Texas, and the Northeast, most of the states SPP covers have not undertaken a broad restructuring of the electric industry through retail access and/or mandatory unbundling of generation from transmission and distribution. Accordingly, most utilities operating within SPP's footprint still supply a large portion of their customers' electricity needs through their own generation and do not need to access the market to do so.

³⁷ NERC 2010/2011 Winter Reliability Assessment.

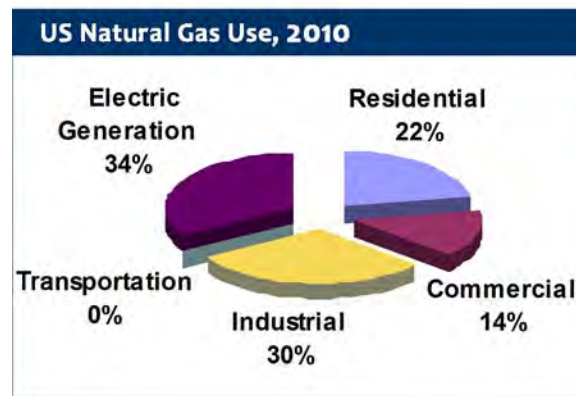
FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

B. The Natural Gas Industry

This subsection provides an overview of the manner in which natural gas is produced and delivered, the jurisdictional structures applicable to the industry, and the various producers and pipelines located in the Southwest. A detailed description of the geology and physics of natural gas production and delivery can be found in the appendix entitled “Natural Gas: Production and Distribution.”

Overview of Natural Gas Production and Delivery

Natural gas is a fossil fuel, formed through the decomposition of organic matter found in underground geological formations. It is a significant source of energy representing 25 percent of the United States energy consumption. In 2010, approximately 22 percent of gas consumption was used for residential heating and cooking, 14 percent for commercial use, 30 percent for industrial processes, 34 percent for electric generation, and less than one percent for transportation.³⁸

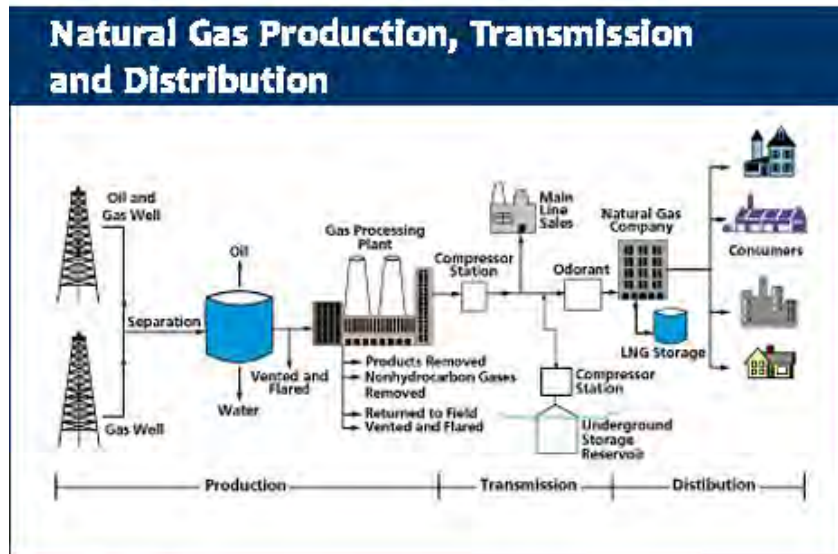


Source: EIA

The delivery framework for natural gas includes production, separation of fluids at or near producing wells, natural gas liquids (NGL) processing, pipeline transmission, storage, and finally distribution by an LDC. The following chart is a simplified schematic of this framework.

³⁸ EIA, *Natural Gas Consumption by End Use*, http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm (last visited Aug.27, 2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



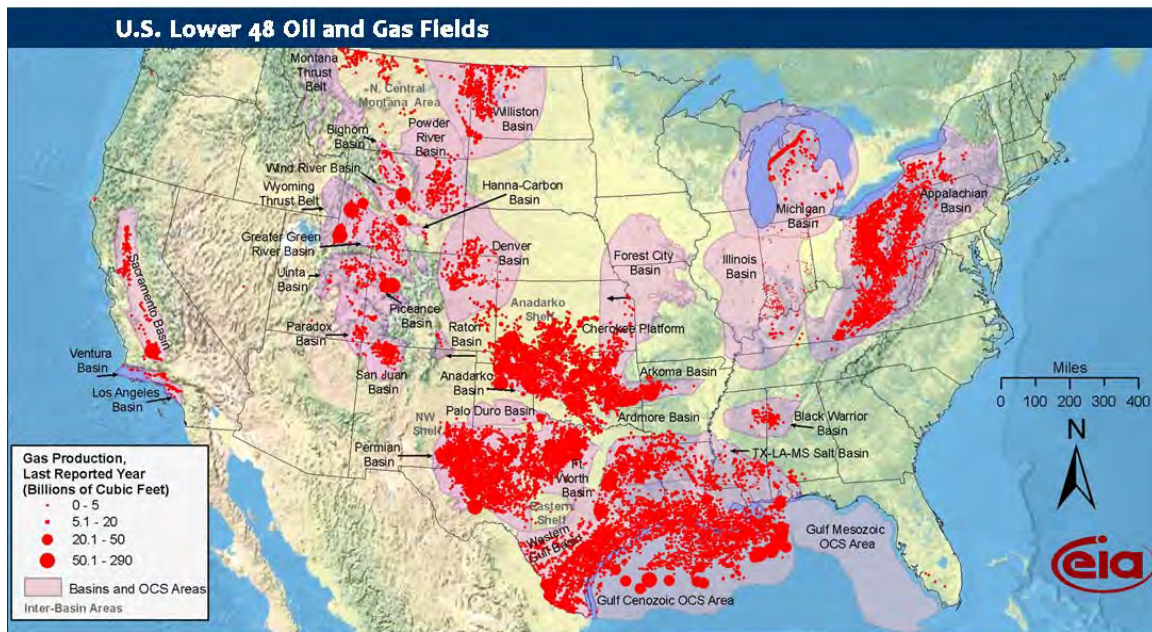
Source: EIA

Natural gas is often produced in locations distant from demand centers. The Energy Information Agency estimates that in 2009 there were 493,100 gas wells in the United States. The majority of these wells were located in the Gulf Coast, Southwest and the Appalachian Basin. The five states with the largest number of wells that year were Texas, 93,507; Pennsylvania, 57,356, West Virginia, 50,602; New Mexico, 44,784, and Oklahoma, 43,600.³⁹ The following chart shows production basins and the concentration of reported natural gas production.⁴⁰

³⁹ EIA, *Natural Gas, Number of Producing Wells*, http://www.eia.doe.gov/dnav/ng/ng_prod_wells_s1_a.htm (last visited Aug.2, 2011).

⁴⁰ EIA, *Gas Production in Conventional Fields*, http://www.eia.gov/oil_gas/rpd/conventional_gas.pdf (last visited Aug. 2, 2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



Source: EIA based on data from HPDI, IN Geological Survey, USGS, April 8, 2009

Major oil companies and large independent companies account for a substantial portion of the gas production in the United States. In the first half of 2009, the five largest producers and their daily production were as follows: BP, Inc, 2.33 Bcf per day; Anadarko Petroleum Corporation, 2.33 Bcf per day; XTO Energy, Inc., 2.29 Bcf per day (acquired by ExxonMobil in 2010); Chesapeake Energy Corporation, 2.21 Bcf per day; and Devon Energy Corporation, 2.13 Bcf per day. These producers together accounted for approximately 20 percent of United States production.⁴¹

In the Southwest, production takes place at the many thousands of wellheads located throughout the basins. The wellhead consists of equipment on top of the well that is used to manage flows of oil and gas, often produced together, arising from the underground formations. The high pressure gas in formations is lighter than air and will often rise on its own through the wellhead to surface pipes. In other gas wells, as well as oil wells with associated natural gas, flow requires lifting equipment. Typical lifting equipment consists of the “horse head” or conventional beam pump. The pumps are recognizable by the distinctive shape of the cable feeding fixture, which resembles a horse's head.⁴² They are

⁴¹ Reuters, <http://www.reuters.com/article/2009/12/14/xto-exxon-natgas-producers-idUSN1420089920091214>; and EIA, http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FPD_mmc_f_a.htm. “Bcf” refers to a billion cubic feet.

⁴² *Well Completion*, NATURALGAS.ORG, http://www.naturalgas.org/naturalgas/well_completion.asp (last visited Aug. 2, 2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

often called “pumpjacks” and are seen throughout west Texas and southeastern New Mexico. The following two photographs are of a wellhead and a pumpjack.



Wells and lift equipment are monitored on a daily basis and maintained by oil and gas company employees, who are often referred to as “pumpers” or “gaugers.” Their responsibilities include reporting malfunctions and spills, and ensuring that field processing equipment is operational and that production is correctly measured. Onshore gaugers may drive many miles per day to monitor dozens of wells.

Processing Natural Gas

The natural gas used by consumers consists almost entirely of methane. However, produced gas often contains other hydrocarbons such as ethane, propane, butane, pentanes and liquids such as condensates. It may also include water vapor, hydrogen sulfide (H₂S), carbon dioxide, helium, nitrogen, and other compounds. Some field processing occurs near production wells to remove the water and condensates, but complete processing usually occurs at a gas processing plant. Natural gas processing plants remove other hydrocarbons to produce what is known as “pipeline quality” dry natural gas that meets the heating content and other restrictions necessary for the safe operation of pipeline and distribution company facilities. The removed hydrocarbon NGLs are sold separately.

Natural gas is transported to processing plants⁴³ typically through small-diameter and low-pressure gathering pipelines. There were an estimated 20,552

⁴³ More than 500 processing plants operated in the United States in 2004 with 166, or over 31 percent, in the state of Texas. EIA, *Natural Gas Processing: The Crucial Link Between Natural Gas Production and Its Transportation to Market*, (Jan. 2006), http://dnr.louisiana.gov/assets/docs/oilgas/productiondata/ngprocess_20060131.pdf.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

miles of gathering system pipelines in the United States in 2009.⁴⁴

After gathering and processing, interstate and intrastate transmission pipelines transport gas to LDCs (as well as to directly attached users such as power plants). Within the United States, the pipeline network delivers gas to 65 million residential, commercial, industrial, and power generation customers. It includes at least 210 gas pipeline systems with a total of more than 300,000 miles of transmission pipelines.⁴⁵ The pipeline system also includes more than 1,400 compressor stations, 11,000 delivery points, 5,000 receipt points, and 1,400 interconnection points.⁴⁶

Pipeline companies monitor and control gas flow with computerized supervisory control and data acquisition (SCADA) systems, which provide operating status, volume, pressure, and temperature information. In addition to real-time monitoring, the SCADA system may enable a pipeline to start and stop some facilities remotely.⁴⁷

The following map shows the breadth and integrated nature of the natural gas transmission grid.⁴⁸

⁴⁴ U.S. Dep't of Transp. Pipeline & Hazardous Materials Safety Admin., *Natural Gas Transmission, Gas Distribution, and Hazardous Liquid Pipeline Annual Mileage*, (Jun. 30, 2011), <http://www.phmsa.dot.gov/portal/site/PHMSA/menuitem.ebdc7a8a7e39f2e55cf2031050248a0c/?vgnextoid=036b52edc3c3e110VgnVCM1000001ecb7898RCRD&vgnnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnnextfmt=print>.

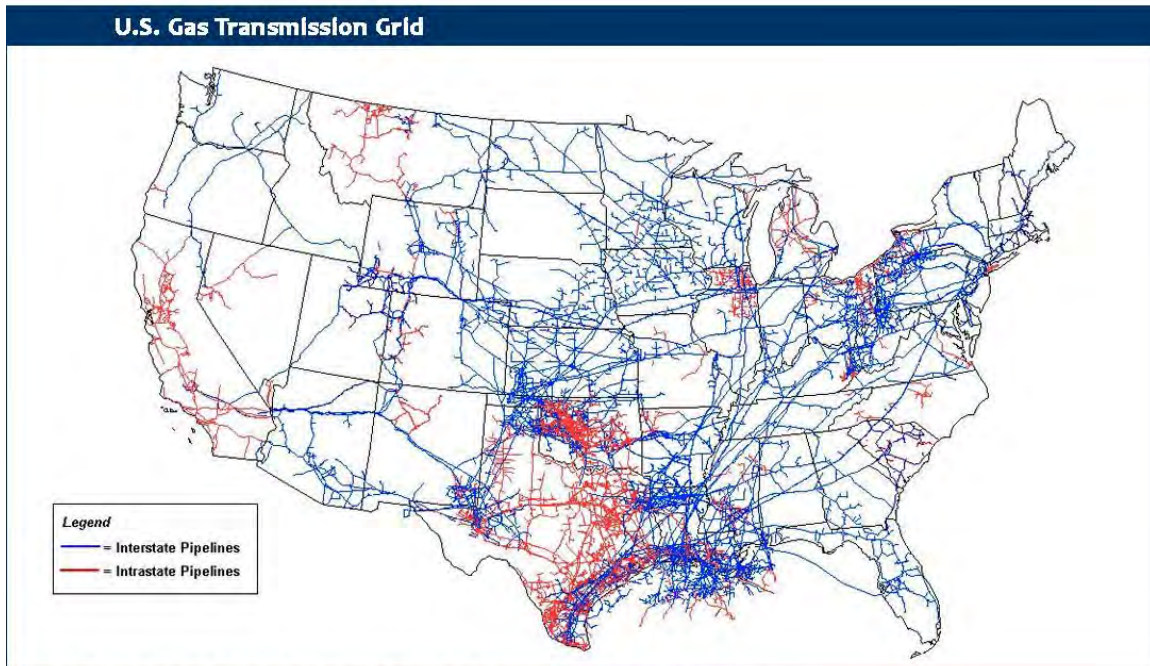
⁴⁵ Am. Gas Assn., *About Natural Gas*, <http://www.aga.org/Kc/aboutnaturalgas/Pages/default.aspx> (last visited Aug. 2, 2011). These pipelines are high pressure systems and operate at 500 to 1,800 psi. The lines are usually 20 inches to 42 inches in diameter. <http://www.naturalgas.org/naturalgas/transport.asp>.

⁴⁶ EIA, *About U.S. Natural Gas Pipelines-Transporting Natural Gas* (June 2007), http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/fullversion.pdf (EIA: About U.S. Natural Gas Pipelines).

⁴⁷ INGAA, *Supervisory and Data Acquisition (SCADA)*, <http://www.ingaa.org/cms/33/1339/109/134.aspx> (last visited Aug. 2, 2011).

⁴⁸ EIA: About U.S. Natural Gas Pipelines.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



Source: EIA, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

To meet higher gas demand at various times of the year, gas is stored underground in depleted oil and gas reservoirs, aquifers or caverns formed in salt beds.⁴⁹ Storage facilities may be interstate and regulated by FERC, or intrastate and non-jurisdictional. There are over 390 underground storage facilities in the United States,⁵⁰ of which approximately 205 are under FERC jurisdiction.⁵¹ Depleted oil and gas reservoirs account for 87 percent of the total FERC jurisdictional storage capacity, with salt caverns (3 percent) and aquifers (10 percent) accounting for the rest.⁵² A detailed discussion of the types of storage facilities and their characteristics is included in the appendix entitled “Natural Gas Storage.”

⁴⁹ EIA, *Natural Gas Explained: Delivery and Storage of Natural Gas*, http://www.eia.doe.gov/energyexplained/index.cfm?page=natural_gas_delivery (last updated June 8, 2011).

⁵⁰ EIA, *The Basics of Underground Storage*, http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/storagebasics/storagebasics.html (last updated Aug. 2004).

⁵¹ <http://www.ferc.gov/EventCalendar/Files/20060615103625-A-3-TALKING-PTS.pdf>.

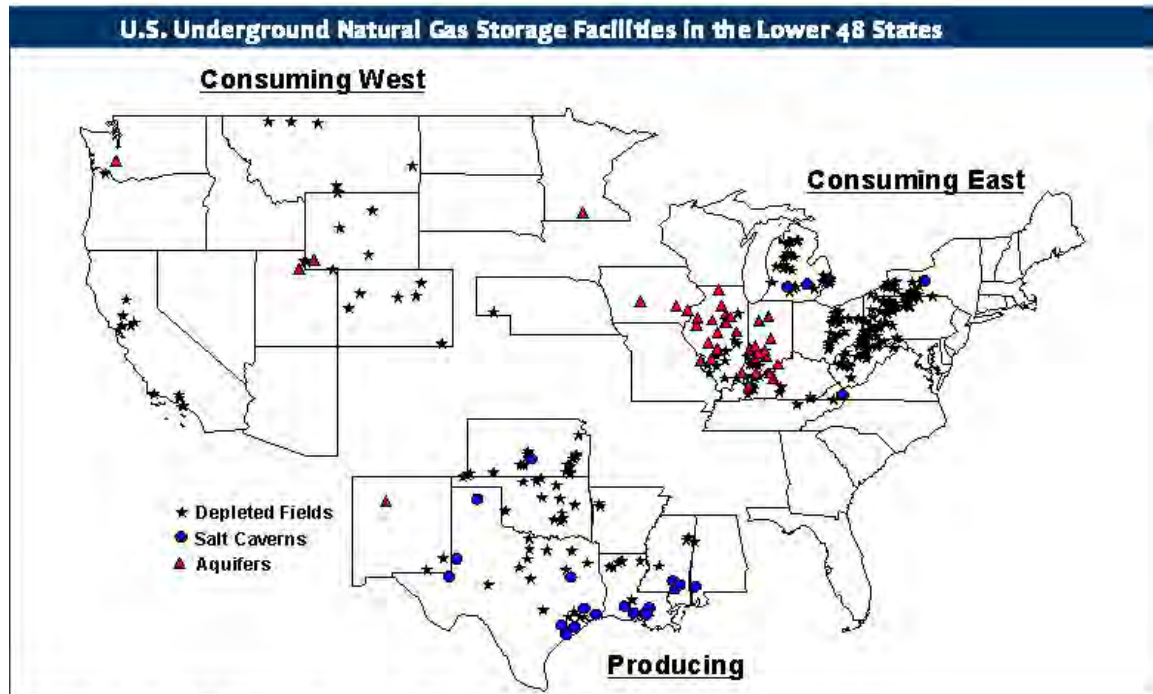
⁵² <http://www.ferc.gov/industries/gas/indus-act/storage/fields.asp>.

Gas Storage Facilities

- Depleted reservoirs consist of porous and permeable underground formations (average of 1,000 to 5,000 feet deep). The gas is divided into two categories, working or top gas, which can be withdrawn, and cushion or base gas, needed as permanent inventory to maintain adequate reservoir pressure and deliverability rates. Gas is generally withdrawn in the winter heating season and injected during the summer, although the demand for gas in summer months is increasing due to an increase in gas-fired generating plants. This type of storage facility can be used for both system supply and peak day demand.
- Aquifer storage fields are bounded partly or completely by water-bearing rocks. They have a high cushion gas requirement, generally between 50 to 80 percent. They also have high deliverability rates and, similar to depleted reservoirs, gas is generally withdrawn in the winter season and injected in the summer season.
- Salt cavern facilities use solution mining to recover minerals in underground salt deposits (salt domes or salt formations). Salt caverns usually operate with only about 20 to 30 percent cushion gas. Working gas can be recycled multiple times per year. Salt cavern storage has high deliverability and injection capabilities and is used for short peak day deliveries. Salt caverns are more expensive to construct due to the increased capital cost associated with leaching and mining the salt.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The following figure shows the location of United States storage facilities.⁵³



Source: EIA, EIA GasTran Geographic Information System Underground Storage data Base.

Natural Gas Regulation

Natural gas production is not comprehensively regulated, and no government agency monitors daily production activity. However, some aspects of production are subject to regulation; gas-producing states monitor well drilling and permitting, and in Texas, for instance, the TRC has jurisdiction over oil and gas wells located in the state and over persons owning or engaged in drilling oil and gas wells located in the state.⁵⁴ Congress deregulated the price on natural gas at the wellhead.⁵⁵ FERC does not regulate natural gas producers, but does provide

⁵³ EIA, *The Basics of Underground Storage*, http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/storagebasics/storagebasics.html.

⁵⁴ Among the matters covered by the TRC are space and density of drilling; prevention of waste; approval of water flood permits; location exceptions; intrastate pipelines; environmental and safety aspects of production, including well plugging; regulation of the injection of carbon dioxide into reservoirs; and maintenance of well records including logs, maps and production reporting. Jack M. Wilhelm, Texas Land Institute, *What Every Landman Should Know about the Railroad Commission of Texas* (2005), available at <http://blumtexas.tripod.com/sitebuildercontent/sitebuilderfiles/wilhelm.pdf>.

⁵⁵ Natural Gas Wellhead Decontrol Act, Pub L. No. 101-60, 103 Stat. 157 (1989).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

that producers have not unduly preferential or discriminatory access to transportation on jurisdictional pipelines, and that no undue treatment bias is exercised with respect to transportation services and gas quality standards. Retail natural gas sales to consumers are regulated by state public utility commissions, not by FERC.

FERC's jurisdiction over the transportation of natural gas,⁵⁶ which also includes the provision of natural gas storage services, begins when the gas is delivered to an interstate pipeline and continues until the gas is delivered to the wholesale purchaser, absent some intervening transaction which renders the activity exempt from federal jurisdiction under the Natural Gas Act (NGA) or the Natural Gas Policy Act of 1978 (NGPA). While generally the activities of intrastate pipelines and LDCs are exempt from FERC jurisdiction, when those entities engage in the transportation of natural gas in interstate commerce or the wholesale sales for resale of natural gas, their activities are subject to FERC jurisdiction.

FERC's responsibilities include:

- Issuance of certificates of public convenience and necessity to construct and operate interstate pipeline and storage facilities, and oversight of the construction and operation of pipeline facilities at United States points of entry for the import or export of natural gas.
- Regulation of transportation and sales for resale in interstate commerce that are not first sales.
- Regulation of the transportation of natural gas as authorized by the NGPA and the OCSLA (Outer Continental Shelf Lands Act).
- Regulation of liquefied natural gas facility siting.
- Regulation of the abandonment of jurisdictional facilities and services.
- Establishment of rates and terms and conditions for jurisdictional services.

Pipelines publish FERC-approved tariffs that pertain to services, terms of conditions and rates for gas transportation. The North American Energy Standards Board (NAESB) provides business standards for the pipelines in areas such as the scheduling of pipeline transportation.

⁵⁶ FERC also has NGA jurisdiction over sales for resale of natural gas that are not deemed first sales. A first sale does not include the sale by an interstate pipeline, intrastate pipeline, or LDC, or affiliate thereof, unless such sale is attributable to volumes of their own production.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Most interstate pipelines no longer offer sales services. The two broad categories of transportation service on an interstate pipeline are firm and interruptible transportation, subject to specified exceptions such as force majeure clauses. (The pipeline companies sell transportation, not the gas itself, which almost always is purchased separately from the producer by the shipper.) Firm transportation is characterized by a reservation of capacity. Shippers customarily pay a charge for the reservation of guaranteed capacity rights on the pipeline and a separate usage charge; pipeline firm rates thus include cost recovery of pipeline facilities in addition to recovery of variable transportation costs such as fuel. Interruptible service rates are usage charges that are derived from the firm service rates. There is no reservation of capacity under interruptible service, and capacity is provided to a shipper only to the extent it is available.⁵⁷

Prior to the deregulation of wellhead gas prices and open access transportation established under Commission Order No. 436 in 1985 and Order No. 636 in 1992, producers typically sold gas to both intrastate and interstate pipelines; these entities in turn sold the gas to LDCs that delivered the gas to end users. With the issuance in 1992 of Order No. 636, the Commission required interstate pipelines to unbundle their services to separate the transportation of gas from the sale of gas. Thus, today most interstate pipelines do not engage in the buying and selling of natural gas except for operational purposes.

Order No. 636 further required interstate pipelines to set up informational postings to show available pipeline capacity and to ensure that all participants have access to available capacity. Additionally, holders of the firm capacity can, through capacity release, resell those rights on a temporary or permanent basis.

Natural Gas Marketing

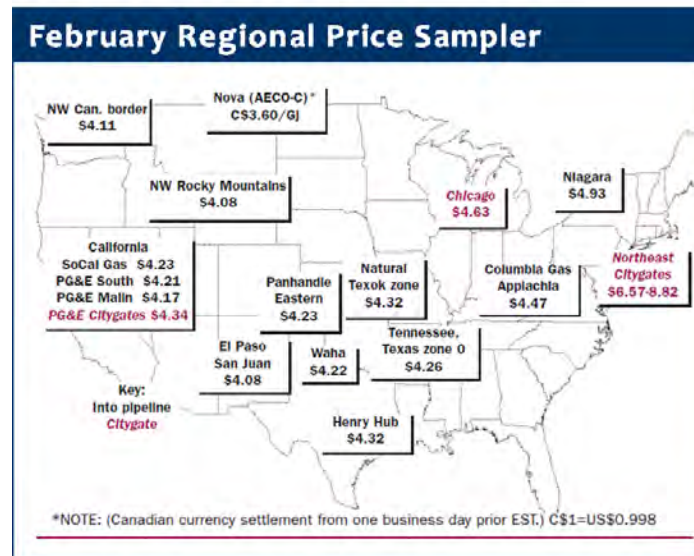
Natural gas marketing mushroomed after the opening of access to pipeline capacity. Producers and marketers, in conjunction with the deregulation of wellhead gas, were granted blanket authorization to make sales at market rates. Marketers may now be affiliates of producers, pipeline companies, or local utilities, or be separate business entities unaffiliated with any other industry players. Marketers may also be associated with financial institutions. Marketing natural gas typically includes ensuring secure supplies and arranging for pipeline

⁵⁷ Pipeline Knowledge and Development, *The Interstate Natural Gas Transmission System: Scale, Physical Complexity and Business Model* (August 2010), available at www.ingaa.org/File.aspx?id=10751.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

transportation, storage and accounting. Marketers also trade financial instruments to hedge commodity price risk and to speculate.⁵⁸

For illustrative purposes, the following map depicts the February 2011 price for some regional gas trading hubs.⁵⁹ Waha and El Paso San Juan, shown on the map, are trading prices respectively applicable to the San Juan and Permian Basins. These two basins are important Southwest supply areas and figured prominently in the weather event of February 1-5.



Source: Platts Inside FERC's Gas Market Report February 2011

LDCs often make the final sale and transfer of gas to retail consumers. Unlike the interstate pipeline companies, many LDCs provide bundled sales and delivery services, although some may provide delivery services only. Many commercial and industrial customers contract for their own supply and purchase only transportation service from the LDC. There are more than 1,200 LDCs in the United States. LDCs can be stand-alone gas utilities, combination electric-gas utilities, or parts of integrated energy companies. The largest LDC is Southern California Gas Company (SoCalGas) with more than 20 million customers, followed by Pacific Gas and Electric Company and Atmos Energy Corporation.

⁵⁸ *Natural Gas Distribution*, NATURALGAS.ORG., <http://www.naturalgas.org/naturalgas/marketing.asp> (last visited Aug. 2, 2011).

⁵⁹ PLATTS INSIDE FERC'S GAS MARKET REPORT (Feb. 2011). Reprinted with permission of Platts.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Natural gas distribution companies typically deliver smaller volumes through smaller diameter pipes and at lower pressures than pipeline companies with systems that end at an individual household or place of business. Compressor stations are generally smaller than those found on the larger pipeline systems. Natural gas traveling through distribution pipelines will often be at a pressure as low as 3 psi to 0.25 psi at the customer's meter.⁶⁰

Natural Gas Production in the Southwest

Texas and New Mexico are both prolific producers of natural gas, while Arizona has negligible production. In January 2011, Texas produced 31 percent of total United States production and New Mexico produced 6.2 percent.⁶¹

Texas and New Mexico contain a number of natural gas basins. The most significant of these with respect to the outages and curtailments experienced during the February cold weather event are the Permian, San Juan, and Fort Worth Basins.⁶² Together, these three basins are responsible for almost 18 percent of total United States natural gas production.

The San Juan Basin straddles the Colorado and New Mexico border in the Four Corners region, and is a leading coal bed methane producing area. The basin is approximately 270 miles wide and covers over 4,000,000 acres.⁶³ Production is approximately 2.99 Bcf per day. The Permian Basin is located in West Texas and Southeastern New Mexico. It underlies an area approximately 250 miles wide and 300 miles long,⁶⁴ and produces on average 2.52 Bcf per day. The Fort Worth Basin contains the Barnett Shale Formation, with one of the largest producible

⁶⁰ *Natural Gas Distribution*, NATURALGAS.ORG, <http://www.naturalgas.org/naturalgas/distribution.asp> (last visited Aug. 2, 2011).

⁶¹ In 2009, U.S. dry gas production was 20,580 billion cubic feet (Bcf) or 56.4 Bcf per day. Texas produced 17.5 Bcf per day on and off shore, and New Mexico produced 3.5 Bcf per day. EIA, *Natural Gas Withdrawals and Production*, http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGM_mmc_f_m.htm (last visited Aug. 15, 2011).

⁶² Other onshore basins in the region include East Texas, the Gulf Coast and South Texas.

⁶³ La Plata Cnty. Energy Council, *Gas Facts: San Juan Basin Map*, <http://www.energycouncil.org/gasfacts/sjbmap.htm> (last visited Aug. 2, 2011).

⁶⁴ Charles D. Vertrees, *Handbook of Texas Online: The Permian Basin*, TEX. STATE HISTORICAL ASSN., <http://www.tshaonline.org/handbook/online/articles/ryp02> (last visited Aug. 2, 2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

reserves of any natural gas field in the United States.⁶⁵ The basin produces 4.83 Bcf per day.⁶⁶

Gas processing companies in the San Juan, Permian and Fort Worth Basins include DCP Midstream Partners, L.P., Enterprise Products Partners L.P., Williams Partners, L.P., Southern Union Gas Services, and Frontier Energy, L.L.C.

Natural Gas Pipelines in the Southwest

Intrastate gas pipelines in Texas comprise 45,000 miles out of the 58,600 total miles of gas pipeline in the state. This intrastate network delivers much of the region's natural gas, including deliveries to many large refining and petrochemical facilities, numerous electric generating facilities, and pipeline interconnects.⁶⁷ The largest intrastate pipelines in Texas are Enterprise Texas Pipeline LLC (8,750 miles) and the Energy Transfer Partners L.P. (8,800 miles). Other large systems include Atmos Pipeline – Texas (6,162 miles) and the Kinder Morgan Pipeline's Texas Intrastate Natural Gas Group (5,900 miles). Together these pipelines provide for transmission from west Texas supply and market hubs such as Waha, and for gas production in south Texas to the Houston Ship Channel, Katy Hub, the Dallas-Forth Worth area and other markets. Intrastate pipelines have expanded significantly due to increased demand for capacity to transport natural gas from the Barnett Shale Formation in the Fort Worth Basin south to the Katy area or out of the state. The following map shows the Texas intrastate pipeline grid.⁶⁸

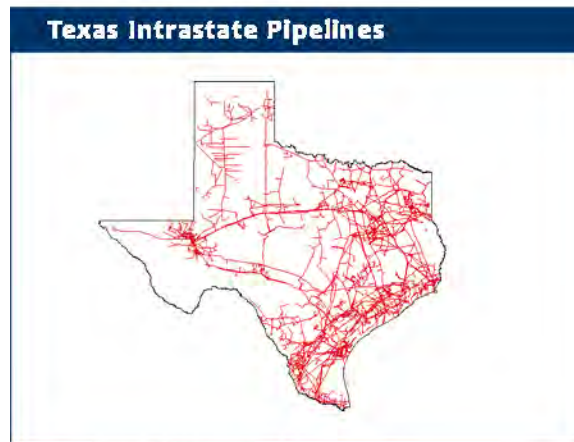
⁶⁵ The Perryman Group, *Bounty from Below: The Impact of Developing Natural Gas Resources Associated with the Barnett Shale on Business Activity in Fort Worth and the Surrounding 14-County Area*, at 5 (May 2007), available at http://www.barnettshaleexpo.com/docs/Barnett_Shale_Impact_Study.pdf. The Barnett Shale is one of the most significant onshore natural gas fields in North America, with thousands of wells producing hundreds of billions of cubic feet of natural gas each year. Production has risen sharply over the past several years as a result of improvements in recovery techniques.

⁶⁶ Staff's analysis based on supporting data, display reports and data warehouse on file with Bentek Energy LLC (unpublished); See also *Market Alert: Deep Freeze Disrupts U.S. Gas, Power, Processing*, Bentek Energy LLC, Feb. 8, 2011, at 2-6; additional materials were also obtained from natural gas pipelines.

⁶⁷ EIA, *Natural Gas Pipelines in the Southwest Region*, http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/southwest.html (last visited Aug. 2, 2011).

⁶⁸ EIA, *About U.S. Natural Gas Pipelines - Transporting Natural Gas: Intrastate Natural Gas Pipeline Segment*, http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/intrastate.html (last visited Aug. 2, 2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



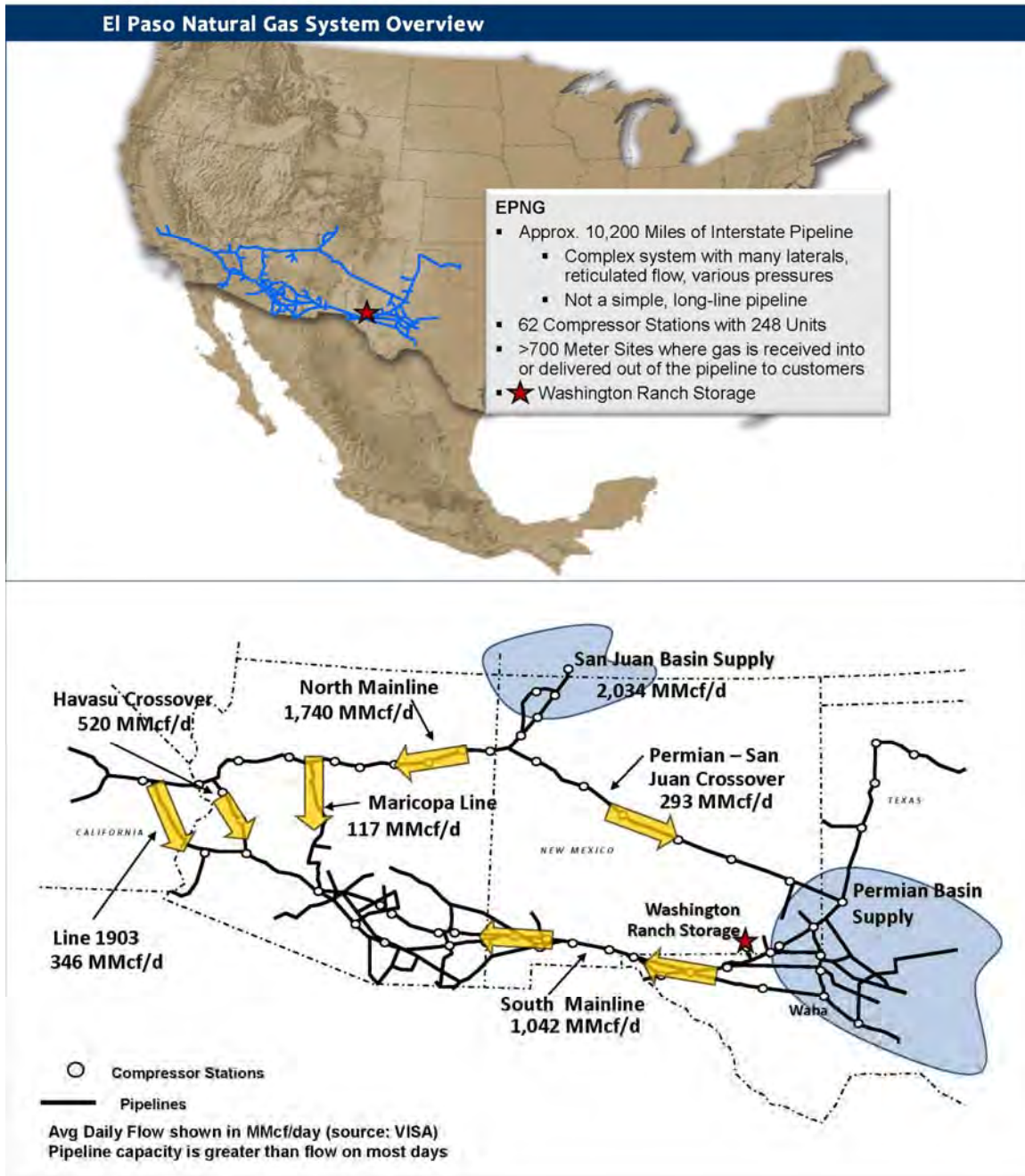
Source: Energy Information Administration

New Mexico and Arizona are supplied largely by two interstate transmission pipelines, Transwestern Pipeline Company, LLC (Transwestern) and El Paso Natural Gas Company (El Paso). These pipelines transport natural gas primarily from the San Juan and Permian Basins to the western regions of the United States. (The many other interstate pipelines that operate in Texas tend to transport gas to the Midwest and Northeast.)

A brief description of these two interstate pipeline systems follows.

El Paso owns a transmission delivery system consisting of approximately 10,200 miles of pipeline. It is a complex, highly networked pipeline system with many laterals and interconnections, operating at a variety of flows and pressures. It includes 62 compressor stations and more than 700 meter sites where gas is delivered. It has 53 delivery meters to New Mexico Gas Company (NMGC), 216 meters to Southwest Gas Corporation (Southwest Gas), and 28 meters to Texas Gas Service. The system also includes the Washington Ranch Storage Field, one of the two storage facilities in the area between west Texas and the Arizona-California border.

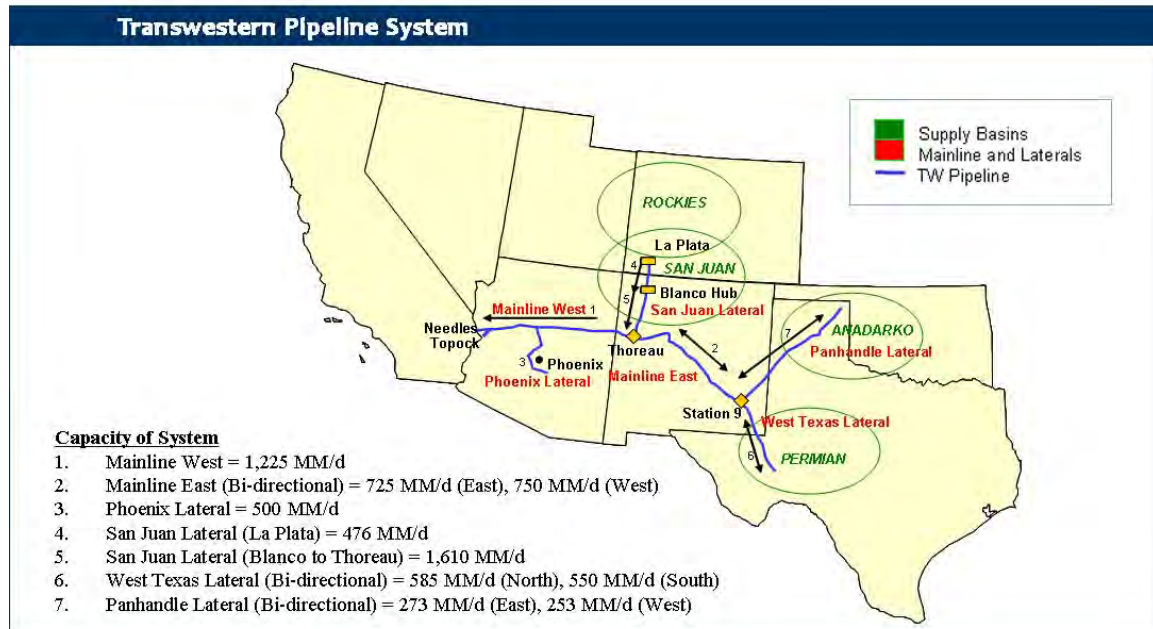
FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



Source: El Paso Natural Gas Company

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Transwestern has approximately 2,700 miles of pipeline and 26 compressor stations. Its mainline capacity flowing west is 1,225 MMcf/day, and its San Juan Lateral capacity is 1,610 MMcf/day.⁶⁹



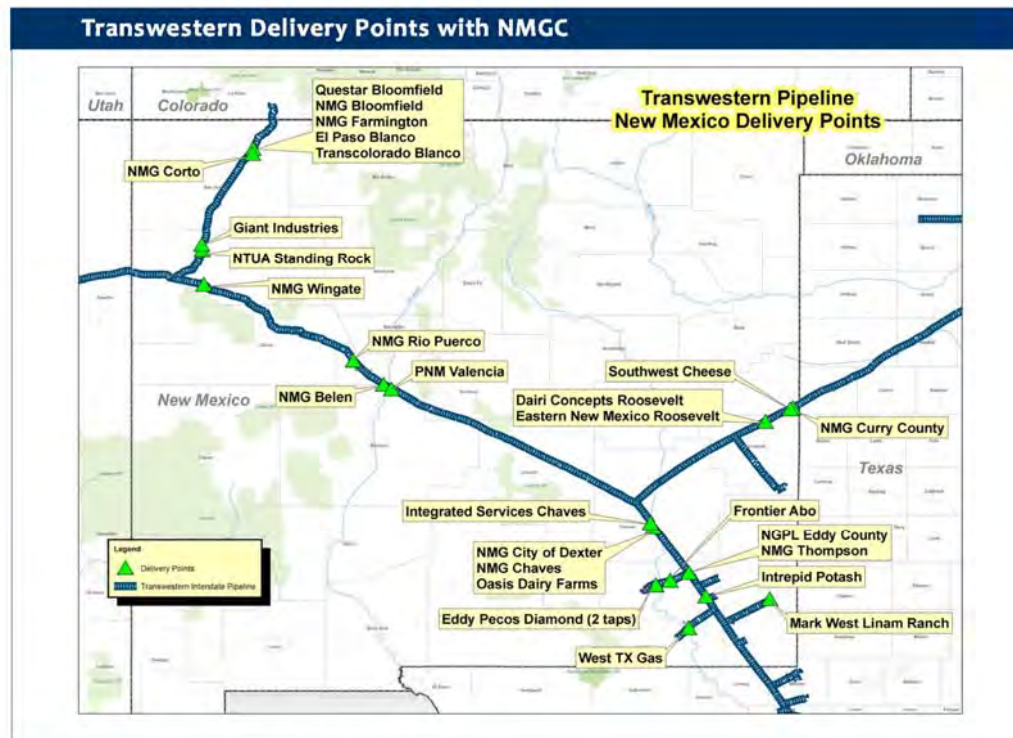
Source: Transwestern Pipeline Company, LLC

Transwestern has at least ten delivery points with NMGC.⁷⁰ In terms of flow volumes, the most significant of these during the February cold weather event was the NMG Rio Puerco, as shown in the following map.

⁶⁹ Throughout the report, MMcf refers to a million cubic feet, and Mcf to a thousand cubic feet.

⁷⁰ http://www.energytransfer.com/ops_interstate.aspx, and materials provided by Transwestern Pipeline Company, LLC to the task force.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



These two pipeline companies, Transwestern and El Paso, are the interstate providers to those LDCs that experienced customer curtailments or outages in February 2011. Those LDCs are:

- New Mexico Gas Company, headquartered in Albuquerque. It provides gas service to more than 500,000 customers and maintains approximately 12,000 miles of natural gas pipelines.⁷¹
- Southwest Gas Corporation, providing gas service to more than 1.8 million residential, commercial and industrial customers in Arizona, Nevada and portions of California.⁷²
- Texas Gas Service, the third largest natural gas distribution company in Texas. It provides gas to more than 603,000 customers in Austin, El Paso, and Rio Grande Valley areas as well as Galveston, Port

⁷¹ New Mexico Gas Company, *About Us*, http://www.nmgco.com/about_us.aspx (last visited Aug. 2, 2011).

⁷² Southwest Gas Corporation, *Profile of Southwest Gas*, <http://www.swgas.com/about/aboutus/index.php> (last visited Aug. 2, 2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Arthur, Weatherford and several communities in the Permian Basin and the Texas panhandle.⁷³

- Zia Natural Gas Company, which provides gas service to over 35,000 customers in five New Mexico counties, serving primarily residential and small commercial users. In Lincoln County, where the city of Ruidoso experienced gas outages during the February event, Zia obtains gas from a direct interconnection to the El Paso Natural Gas pipeline.

Natural Gas Storage Facilities in the Southwest

There are two major natural gas storage facilities in the Southwest:

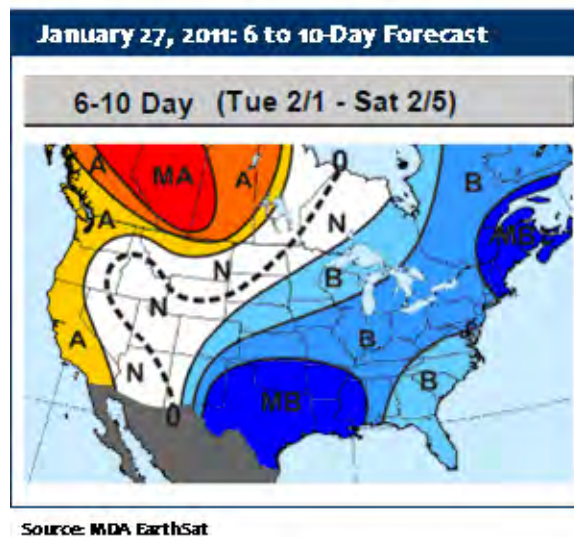
- **Washington Ranch Storage Field**, part of the El Paso system, is located in Eddy County, New Mexico, approximately nine miles southwest of Whites City. This facility has a working storage capacity of slightly more than 47.6 bcf and a maximum daily withdrawal capacity of 250,000 Mcf.
- **Chevron Keystone Storage Facility**, owned by Chevron Corporation, is located in Winkler County, in west Texas near Midland. This is a salt cavern facility with 6.38 Bcf of working gas. Its maximum daily injection capability is 200,000 Mcf and its maximum daily withdrawal capacity is 400,000 Mcf. It has interconnects to Transwestern, El Paso and the Northern Natural Gas Company's pipeline systems.

⁷³ Texas Gas Service, *Profile*, <http://www.texasgasservice.com/en/About.aspx> (last visited Aug. 2, 2011).

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IV. Preparations for the Storm

A severe arctic cold front hit the central and northeastern United States and southern Canada on February 1, 2011, and lasted for several days. It was dubbed the “Groundhog’s Day Blizzard of 2011.”⁷⁴ The front was not unexpected. About a week prior to the event, long-range forecasts predicted an outbreak of very cold temperatures for the first week of February, with wind, ice, and snow from Texas to Mississippi. Arctic air was expected to extend southward to the Gulf Coast by February 2, bringing daytime highs to as low as 30 degrees below normal. Sustained winds of 20-25 mph, with higher gusts, were also anticipated.⁷⁵



[Color legend: N is normal, B is below normal, MB is much below normal, and SB is strong below normal.]⁷⁶

⁷⁴ National Oceanic and Atmospheric Administration National Climatic Data Center (NCDC), *State of the Climate: Global Hazards for February 2011* (March 2011), <http://www.ncdc.noaa.gov/sotc/hazards/2011/2#winter>.

⁷⁵ Weather data used in this section is drawn from NCDC data. Raw land-based observation data was obtained at <http://www.ncdc.noaa.gov/oa/land.html>. Quality controlled local climatological data was obtained at <http://cdo.ncdc.noaa.gov/qclcd/QCLCD?prior=N>. Additional data, unless otherwise noted, is drawn from materials provided to the task force by BAs, transmission operators, generators, producers, processing plants, pipelines and LDCs.

⁷⁶ EarthSat is a private forecasting service used by many entities in the energy industry and by the Commission in connection with its market monitoring efforts.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

A. Weather Conditions During the Event

Actual weather conditions between February 1 and 5, 2011 turned out to be largely as predicted by the National Weather Service's long-range forecasts. However, actual temperatures were a few degrees lower than forecasted, especially in west Texas and New Mexico. In some places, temperatures did not rise above freezing until February 4. Low temperatures in Albuquerque ranged from -7 degrees to 7 degrees over the four-day period, in Midland from 6 degrees to 12 degrees, and in Dallas from 13 degrees to 19 degrees.⁷⁷

As the storm hit during the early morning hours of Tuesday, February 1, temperatures in the western-most cities of the Southwest plummeted dramatically. Daily highs at Albuquerque and Dallas fell 20 degrees (to 28 degrees and 39 degrees respectively) from the previous day, while at Midland the recorded high was 30 degrees, which was 43 degrees below that of the previous day. Houston's temperatures started out on February 1 at 70 degrees, but by 7:00 AM had dropped to 45 degrees.

The wind profile was also changing dramatically. Wind speeds had rarely exceeded 10 mph the preceding day, but by the morning of February 1 Albuquerque was experiencing sustained wind speeds of 20 mph (representing a wind chill index of 4 degrees), with gusts to 27 mph. Winds in Midland hovered around 20 mph and gusted to over 30 mph. Light snow began falling in both cities around midnight. It was also windy in Dallas on February 1, with speeds of up to 25 mph and gusts between 20 and 40 mph.

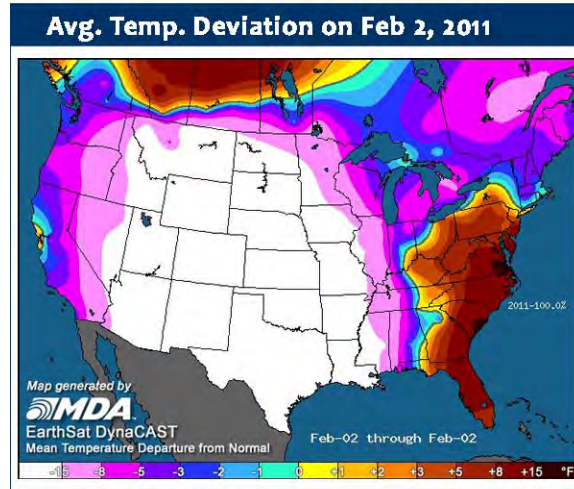
Conditions worsened at all locations through the day, and by midnight temperatures were extremely low. Albuquerque was at 4 degrees, with continuing high winds and snow. Temperatures at Midland were 14 degrees and at Dallas 16 degrees. The cold air finally hit Houston late in the day, with temperatures of 27 degrees and winds of 14 mph, although without precipitation.

By Wednesday, February 2, early morning conditions had become severe. In Albuquerque, the temperature at 8:00 AM was 1 degree, almost 40 degrees below the average for that date, and the wind was blowing at 26 mph. Temperatures in El Paso and Midland hovered around 10 degrees for much of the day, with wind speeds of 15 mph. El Paso set a record low for the day of 6 degrees at 5:00 AM, and recorded the third coldest day in 38 years. In fact, February 2 turned out to be one of the coldest days on record in the last 25 years across the state of Texas, with average temperatures well below freezing and only

⁷⁷ All temperatures in this report are in degrees Fahrenheit.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Brownsville escaping severe conditions (with average temperatures of about 35 degrees). Significant winds accompanied the frigid temperatures, with wind chill factors dropping the perceived temperatures to -6 degrees in Dallas and 6 degrees in Austin.



Source: MDA EarthSat

On Thursday, February 3, weather conditions began to marginally improve in some areas, although in Albuquerque and El Paso it would rank as the coldest day in 38 years. Albuquerque, Midland and El Paso were still experiencing highs near 15 to 20 degrees, but the winds had begun to diminish. From Dallas to San Antonio, temperatures moderated about 5 to 10 degrees, but wind speeds remained high.

On Friday, February 4, conditions improved across the region. Temperatures in the western cities finally rose above freezing, and in a few of the eastern-most cities rose above 40 degrees. Nonetheless, during the early morning hours, El Paso hit a low of 3 degrees before reaching a high of 37 degrees, ranking the day as the city's second coldest in 38 years. Four to six inches of snow fell in the Dallas Metropolitan area, causing cancellation of more than 300 flights at Dallas airports just as fans were arriving for the Super Bowl.

Cold weather hit the region again on February 9 and February 10. The coldest temperatures were seen on February 9, when El Paso recorded a low of -2 degrees, and Midland a low of 7 degrees. Daily highs, however, were in the 30s and 40s. Other cities saw lows dip into the 20s and teens, with high temperatures rising into the 40s and 50s.

There is no question that the cold and windy weather during this first week of February was both sustained and severe. Just how severe, when compared to

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

prior storms, is examined in the section of this report entitled “Prior Cold Weather Events.”

B. Preparations for the Storm: Electric

Three balancing authorities in the Southwest shed load during the cold weather event: ERCOT, SRP and EPE. (PNM lost some 26 MW of load as well, although this was the result of localized transmission issues largely unrelated to the storm). Customers in ERCOT were affected the most, by a large margin. ERCOT shed 4000 MW of load, affecting 3.2 million customers, on February 2. It shed another 300 MW on February 3, affecting 180,000 customers. In comparison, SRP shed 300 MW of load, affecting 65,000 customers, and EPE shed a little over 1000 MW of load, affecting 253,000 customers.⁷⁸

The preparations for the storm taken by these three entities are discussed below.

ERCOT

Going into the winter season of 2010/2011, ERCOT had substantial reason to believe it could meet its projected demand with available generation and imports. ERCOT’s peak demand for the winter of 2010/2011 was forecasted to be 47,824 MW, with the peak anticipated to occur in January.⁷⁹ (This forecasted peak was 11 percent higher than the forecasted peak for the previous winter.⁸⁰) To meet that peak demand, ERCOT had projected generation capacity plus imports of 72,881 MW.⁸¹ Thus, for planning purposes, ERCOT could anticipate a

⁷⁸ In the case of ERCOT, these numbers represent the amount of load the transmission providers were directed to shed. Actual load shed was somewhat higher (5411.6 MW on February 2 and 459.5 MW on February 3), for reasons discussed in the section of this report entitled “The Event: Load Shed and Curtailments.”

⁷⁹ NERC, *2010/2011 Winter Reliability Assessment*, at 16 (Nov. 2010), available at http://www.nerc.com/files/2010_Winter_Assessment_Final_Posted.pdf. NERC prepares its reliability assessments based on data and information submitted by the applicable Regional Entity, which in ERCOT’s case is TRE.

⁸⁰ ERCOT modified the forecasting models because it had experienced extreme cold weather in January of 2010, with load tracking notably higher than forecasted.

⁸¹ Resources listed in the NERC 2010-2011 Winter Reliability Assessment consisted of available generation (72,500 MW) and net firm imports (381 MW), and did not include generating units which were known well in advance to have scheduled maintenance outages spanning the expected peak load period. Demand was calculated based on a 50/50 load forecast (47,824 MW), meaning the forecast is expected to be exceeded five years out of every ten.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

comfortable reserve margin of 57 percent. This percentage compares favorably with NERC's reference reserve margin for ERCOT of 13 percent, considered by NERC to be the base level required for reliability.⁸²

The estimated demand for the season included only firm load, and therefore did not include ERCOT's two categories of contractually curtailable load: Load Resources (formerly designated as Load Acting as a Resource, or LaaR), which may be automatically disconnected when system frequency drops below a prescribed threshold (totaling 1062 MW as of February 2); and Emergency Interruptible Load Service (EILS), which permits curtailment prior to firm load shedding (totaling 331 MW as of February 2).

Although ERCOT seemingly had a generous reserve margin going into the winter of 2010/2011, the reserve margin cited did not take into account planned outages that were not yet known at the time of the forecast. ERCOT is a summer-peaking system, and the high summer temperatures and demand often extend into what would be considered shoulder seasons in more northerly regions. For that reason, it is not unusual for generators in ERCOT to schedule maintenance outages in February. ERCOT does not have the authority to prohibit generators from scheduling such outages or from taking them as scheduled, unless the outage is scheduled eight days or less before the outage date, or the outage would keep ERCOT from meeting applicable Reliability Standards or its own Protocol requirements.⁸³ At most, pursuant to its Protocols, ERCOT can ask generators to refrain from taking a scheduled outage if it believes it may need the generator's output. ERCOT also does not have authority under its Protocols to require generators that are on planned outage to come back into service early (assuming the generator is even in a condition to do so). Nor are there any market mechanisms to compensate generators for any costs associated with delaying or coming back early from a scheduled outage.

Despite these potential limitations, ERCOT was far from being generation deficient for winter 2010/2011 seasonal planning purposes. Nor, as will be seen, did it appear to be deficient going into the storm itself. A little background is needed to put in context the generation that ERCOT thought it would be able to call upon during the storm.

⁸² NERC 2010/2011 Winter Reliability Assessment at 16.

⁸³ ERCOT Nodal Protocols § 3.1 (Nov. 20, 2010), *available at* <http://www.ercot.org/mktrules/nprotocols/2010/index>. ERCOT is considering revising this provision to permit it to deny an outage request if it is scheduled 90 days or less from the outage date.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

ERCOT uses proprietary forecasts (performed both on a seasonal and daily basis) to predict its load.⁸⁴ ERCOT used those weather forecasts, coupled with historical and other information, to gauge expected customer demand during the approaching event. A task force review of ERCOT's forecasts determined that they accurately predicted the February storm conditions, and in some cases their weather estimates were even slightly more accurate than those of the National Weather Service.

ERCOT then compared the anticipated demand⁸⁵ against its generation capacity, both for purposes of scheduling power in the day-ahead market and for determining whether it would meet reliability and reserve requirements. For operating purposes, ERCOT's Protocols include a responsive reserve requirement (also referred to as Physical Response Capability, or PRC) of 2300 MW. The primary purpose of the responsive reserves is to restore system frequency to 60 Hz within the first few minutes after the system experiences a significant frequency deviation. The 2300 MW amount is based on a 1988 study that determined the reserves that would be needed to prevent the shedding of firm load upon the simultaneous loss of the two largest generation resources in the ERCOT region.⁸⁶ (Actual online responsive reserves at any given time typically exceed the 2300 MW requirement.⁸⁷)

ERCOT Protocols

The ERCOT protocols set forth the procedures and processes used by ERCOT and its market participants for the orderly functioning of the ERCOT system and market. They contain
(cont'd)

⁸⁴ ERCOT relies on Telvent DTN and Pattern Recognition Technologies (PRT) for the weather data used in its load forecasts.

⁸⁵ ERCOT's load forecast projected loads of 52,673 for February 1 and 57,436 for February 2.

⁸⁶ This is a more conservative measurement than that required by NERC Reliability Standard BAL-002-0 R3, which sets a "contingency reserve" requirement to cover the loss of the single largest contingency on a Balancing Authority's or Reserve Sharing Group's system (N-1), not the loss of the two largest contingencies. Because ERCOT is not synchronously linked with other interconnections, a larger reserve amount than N-1 is required to maintain proper frequency response.

⁸⁷ ERCOT's daily morning report listed responsive reserves of 4196 MW for February 1 and 5944 MW for February 2, projected for the peak hours of those days.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

policies for scheduling, operations, planning, reliability, and settlements, as well as ERCOT's rules, guidelines, procedures, and standards. The protocols are developed and amended through stakeholder committees for approval by the ERCOT Board of Directors. Once approved at ERCOT, the protocols are submitted to the PUCT for final approval. In addition to its task of enforcing the FERC-approved Reliability Standards, TRE is responsible for compliance monitoring and enforcement of the ERCOT Protocols.

In addition to the responsive reserve requirement, ERCOT must meet a non-spinning reserve requirement.⁸⁸ These reserves are intended to address the risks of load uncertainty and wind power output variability. For February 2011, the non-spinning reserve requirement was set at 2000 MW. (The sources counted for non-spinning reserves are not included in the calculation of available resources for purposes of meeting the responsive reserve requirement of 2300 MW.⁸⁹)

Notwithstanding the fact that 11,566 MW of generation were on scheduled outage as of February 1,⁹⁰ ERCOT had more than 3100 MW of responsive

⁸⁸ Non-spinning reserves in ERCOT are generation resources capable of being ramped to a specified output level within thirty minutes and running at that level for at least one hour, or Load Resources that are capable of being interrupted within thirty minutes after being asked for interruption and remaining de-energized for at least one hour.

⁸⁹ Wind resources, which are forecasted on an hourly basis, are also not included in the calculation of available resources for purposes of meeting the responsive reserve requirement. One of the most significant differences between the NERC Winter Assessment and ERCOT operations is how wind power is handled. The NERC Winter Assessment assigns a fixed average output of 8.7 percent of nameplate rating as "existing-certain" generation capacity. For the 9317 MW of installed wind capacity (aggregate nameplate rating) in ERCOT, this amounts to 811 MW. Operations, on the other hand, utilizes wind power forecasts derived from highly localized wind speed forecasts, which provide wind power output values for each of the upcoming 48 hours. The forecasts are re-run hourly and the results updated accordingly, yielding a "rolling" 48 hour look-ahead. ERCOT's Current Operating Plan (COP) for wind power uses a conservative estimate which has an 80 percent chance of being met or exceeded, and already takes into account any equipment outages, either scheduled or forced. On the morning of February 2, the aggregate COP for wind power peaked at about 5200 MW at 3:00 AM and decreased steadily each hour down to 3500 MW at 8:00 AM. The actual wind power output followed the same downward trend, but fell short off the COP numbers anywhere from 400 MW to 1000 MW, depending on the specific hour. (This snapshot picture exhibits the variability of wind power.)

⁹⁰ This number grew to 12,413 MW on February 2; however, the additional units might have been ones that experienced forced outages on February 1 and then transitioned into scheduled outages.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

reserves available throughout the entire 24 hours of that day, running as high as 5600 MW in the early morning and again during the mid-afternoon hours. This exceeded the responsive reserve requirement of 2300 MW by a comfortable amount.⁹¹

Thus, on paper, ERCOT had reason to believe it had ample generation going into the storm.⁹² As it turned out, the large number of generator outages, derates and failures to start that occurred on February 1 and February 2 would reduce that margin below acceptable levels.

Aside from determining it had sufficient operating reserves listed as available, ERCOT took other steps to prepare for the storm. On January 31, ERCOT issued an Operating Condition Notice (OCN) to its market participants, advising them of the expected cold front. On February 1, it issued another OCN at 2:45 AM and an Advisory at 9:05 AM. ERCOT also reported to the PUCT that it was expecting temperatures in the teens to the low 20s and maximum temperatures near or below freezing, with anticipated impacts on 50 percent or more of its major metropolitan areas.⁹³

Notices and Emergency Declarations

The ERCOT Protocols set out three types of preliminary notices to be issued by ERCOT to inform market participants of a potentially adverse operating condition, including extreme weather conditions such as hurricanes and protracted periods of below-freezing temperatures. The type of notice is determined based on the time available for the market to respond before an emergency condition may occur.

(cont'd)

⁹¹ On February 2, responsive reserves would hover in the range of 2700 MW to 3300 MW in the early morning hours, dropping to around 3000 MW at 4:30 AM and then plummeting rapidly.

⁹² In addition to the outages already underway, three planned generation outages were scheduled to begin during the time period covered by the anticipated storm. ERCOT requested one of these generators to delay the outage, as discussed later in the report.

⁹³ ERCOT did not provide any further market notices or indications of projected capacity shortages until 3:00 AM on February 2, when it issued an OCN and an Advisory reporting that reserves were below 3000 MW. These notices, as well as the other actions that took place on February 2, are discussed in the following section of this report entitled “The Event: Load Shed and Curtailments.”

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- Operating Condition Notice -- issued to inform participants of a possible future need for more resources due to conditions that could affect system reliability; allows ERCOT to confer with transmission providers and participants regarding the potential for adverse reliability impacts and contingency preparedness when adverse weather conditions are expected.
- Advisory -- issued when conditions are developing or have changed such that more ancillary services will be needed, or when weather or conditions require more lead-time than the normal day-ahead market allows; allows ERCOT to increase ancillary services requirements above the quantities originally specified in the day-ahead market, and to require information from participants regarding their fuel capabilities for the next seven day period.
- Watch -- issued when additional ancillary services are needed in the current operating period, or when forced outages or abnormal operating conditions have occurred or may occur that require operating with transmission security violations; allows ERCOT to instruct transmission owners to reconfigure ERCOT system elements to improve reliability in ERCOT; and allows ERCOT to take steps to procure additional regulation services, RRS services, and non-spinning services.

ERCOT issues the fourth level of Notice, an Emergency Notice, when it cannot maintain minimum Reliability Standards or meet its Protocol requirements during the operating period or is otherwise in an unreliable condition. Depending on the severity level, ERCOT may take additional steps to resolve the system emergency, including relaxing transmission constraints, issuing public appeals for conservation, deploying Load Resources and EILS resources, and requiring firm load shedding.

Between January 28 and January 31, ERCOT cancelled, withdrew, or delayed planned outages on ten 345 kV transmission lines, 27 138 kV transmission lines, two 345/138 kV auto-transformers and one 138/69 kV transformer (outage cancellation rules differ as between transmission and generation). On January 31, ERCOT requested one generating unit (Mountain Creek SES Unit 8 at 568 MW) to begin start-up due to its long start-up lead time, and requested another unit (Lake Hubbard SES Unit at 397 MW) to convert from natural gas to fuel oil in anticipation of possible gas curtailments.⁹⁴ ERCOT reports that it did not request any generators to return early from scheduled

⁹⁴ Texas Reliability Entity, *Event Analysis Report – Feb.2, 2011 EEA-3 Event* at 16 (Apr. 15, 2011) (TRE Report).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

outages, nor did it request any generators to defer scheduled outages that were slated to start during the cold weather event.⁹⁵

In the afternoon of January 31, ERCOT decided to adjust its load forecast to factor in the potential effect of the high winds that had been predicted (ERCOT's forecasts do not normally factor in wind chill effects). ERCOT made a manual adjustment to its load forecast for the remainder of February 1 and for February 2, adding 4000 MW.

The storm hit on February 1. Beginning at approximately 12:00 PM on that day, power plants across Texas experienced problems due to the cold weather. These included freezing instrumentation, freezing pipes, freezing drain lines, natural gas curtailments, and natural gas pressure reductions due to high usage.⁹⁶ Between noon and midnight on February 1, two large coal units and 18 natural gas units tripped or failed to start for varying periods of time. Another six natural gas units and 13 wind plants were derated during this period. As of midnight on February 1, unavailable generation capacity in ERCOT (not counting scheduled outages) reached 6022 MW.⁹⁷

In addition to the generation scheduled for February 2 by its economic dispatch model, ERCOT committed 24 additional generating units, totaling 3400 MW, through its reliability unit commitment (RUC) process.⁹⁸ By midnight, all available generation had been instructed to run on February 2.

⁹⁵ ERCOT did discuss with generators deferring scheduled outages planned for the February 10 period, when cold weather was again anticipated. Some of those scheduled outages were postponed.

⁹⁶ TRE Report at 7. The details of the types and causes of the forced outages experienced during the February 1-5 weather event are discussed in detail in the section of this report entitled "Causes of the Outages and Supply Disruptions."

⁹⁷ This is a net cumulative number; that is, if a failed unit came back online, it is not counted as unavailable.

⁹⁸ ERCOT initially committed 13 units through the RUC process on February 1, to be deployed on February 2; it later cancelled six of those unit commitments, leaving a net value of 2049 MW in additional generation as of midnight on February 1. At 3:03 AM on February 2, ERCOT committed 19 units through its RUC process, totaling 1351 MW. Unit generation added on both days through the RUC process for February 2 deployment totaled 3400 MW.

ERCOT's RUC Process

After ERCOT completes the run of its day-ahead market, which matches buy and sell offers for energy and ancillary services for the following operating day, ERCOT runs a Day-Ahead Reliability Unit Commitment (DRUC) study to ensure that sufficient capacity is available to serve load. For each hour of the following day, the DRUC examines whether sufficient resources have been committed, through Day-Ahead awards or as otherwise reflected in each resource's Current Operating Plan (COP), to meet the forecasted load for each hour. If ERCOT determines that any additional resources are needed, it can physically commit those resources for the hours needed, with certain payment levels guaranteed to the resources when ordered to run.

ERCOT runs the DRUC study in the afternoon prior to the operating day studied. Hourly RUC (HRUC) studies are run thereafter, comparing resources and load for each hour remaining in the DRUC period and reflecting any changes in resource commitments (such as forced outages or modified COPs) or other changes in system conditions since the DRUC was run.

The RUC process takes into account resources committed in the Day-Ahead market, resources self-committed in the COPs, and resources committed to provide ancillary services. The RUC process can also recommend decommitment of resources where transmission constraints are not otherwise resolvable. ERCOT can order any available resource to come online as part of the RUC process.

If a resource is selected by the RUC, the resource will at a minimum be made whole for its startup and minimum-energy costs. However, if the energy revenues received during the RUC-commitment period are greater than these guaranteed costs, the resource may be subject to a "clawback" under certain conditions.

Could or should ERCOT have done more to prepare for the event? ERCOT procedures specifically include provisions for severe cold weather operations.⁹⁹ In anticipation of severe cold weather, ERCOT may issue an OCN, Advisory, Watch, or Emergency Notice. These various alerts allow ERCOT to react to potential operating conditions by: reviewing planned and existing outages; determining if more lead-time is needed for generating resources to meet their commitments than the normal day-ahead market allows; determining if additional ancillary services are required; ordering on additional units; and increasing staffing. Under the

⁹⁹ ERCOT Operating Procedure Manual: Shift Supervisor Desk § 7.5 (July 18, 2011), available at <http://www.ercot.org/mktrules/guides/procedures/>. Severe cold weather is defined by expected temperatures in the mid to low 20 degree range with expected maximum temperatures near or below freezing, impacting 50 percent or more of major metropolitan areas.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

various alerts, ERCOT's RUC Operator may also confer with transmission operators and QSEs¹⁰⁰ regarding preparedness, fuel capabilities, the need to reconfigure system elements, or to vary from market timing deadlines.¹⁰¹

In anticipation of the event, ERCOT arguably could have better utilized these tools to prepare for the severe cold weather, particularly by increasing ERCOT's responsive reserves well in advance of its decision late on February 1 to schedule all available units for the next day.¹⁰² As events proved, the extensive generator outages substantially exceeded ERCOT's reserves, and would have done so even if the reserves had been substantially larger in number. But this was not known by ERCOT going into the event. Furthermore, if generating units had been online and running, they would have been better able to withstand freezing temperatures,¹⁰³ a consideration ERCOT might have factored into its decision-making process.

Another strategy that might have improved generator response would have been the use of pre-warming techniques.¹⁰⁴ ERCOT does not currently have the authority to require generators to engage in these actions, but if generators had done so, they might have prevented some of the extensive freezing problems that developed. Running quick start units prior to their scheduled start time could also

¹⁰⁰ A "Qualified Scheduling Entity" (QSE) is a market participant qualified by ERCOT as a resource entity or a load serving entity, for purposes of communications with ERCOT and the settling of payments and charges.

¹⁰¹ ERCOT Operating Procedure Manual, Reliability Unit Commitment Desk, Section 6.1 (July 20, 2011), *available at* <http://www.ercot.com/mktrules/guides/procedures/>.

¹⁰² ERCOT Protocols formerly required it to increase its spinning reserves by an amount at least equal to its responsive reserves during cold weather alerts. *See* Elec. Reliability Council of Tx., *ERCOT Operating Guide No. 12* (May 1989). ERCOT advised the task force that this protocol had been changed to account for the variability of wind power. ERCOT now carries non-spinning reserves continuously rather than only during peak hours, as was its former practice. ERCOT stated its belief that the continuous availability of non-spinning reserves serves virtually the same purpose as the former practice of doubling the spinning reserves.

¹⁰³ The use of a generating unit's own radiant heat to prevent freezing is discussed in the section of the report entitled "Key Findings and Recommendations."

¹⁰⁴ For conventional gas steam units, pre-warming can be accomplished by establishing a fire in the boiler to produce warming steam for the turbine while it is on turning gear. This keeps metal temperatures warm enough to prevent freezing in piping and instrumentation lines and helps bring lubricating and hydraulic oils up to proper operational temperatures. Combustion turbines can run at full speed no-load operation for short periods of time prior to start up, in order to warm vital parts, instrumentation, and lubricating oils.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

have identified problems before the output of the units was needed, giving them time to make corrections.¹⁰⁵

Had ERCOT and the generators undertaken these additional measures, it is possible that fewer generating units might have failed. ERCOT might still have been forced to shed load, but the extent of the load shed might well have been reduced. Every generator that could have escaped failure on February 1 and February 2 would have improved the situation for Texas consumers.

ERCOT Generators

Most generators in ERCOT's footprint reported having employed freeze protection measures to protect their facilities. These measures generally fell into two categories: physical readiness and operational readiness.

To prepare physical facilities for the cold weather, generators variously reported that they installed portable heaters to maintain ambient air temperature, added extra insulation to exposed components, installed temporary windbreaks to exposed areas, drained non-essential water systems, and determined that the water in essential water systems was circulating.

Some generators also reported adjusting their operations to adapt to the cold weather. They called in more operating and maintenance staff, increased the frequency of operator rounds, performed checks of freeze protection panels and heat tracing circuits, and added windbreaks. Plant staff also tested emergency equipment, added fuel to heaters and emergency generators, stocked extra supplies of fuels as well as food and other emergency items in case deliveries were disrupted, and prepared sleeping arrangements for employees if roads became impassable. Some generators utilized pre-operational warming during the event.¹⁰⁶

Despite these reports of having taken steps to prepare for the cold weather event, many generating units in ERCOT failed to perform or suffered derates after

¹⁰⁵ On February 1 and 2, approximately 19 simple cycle and combined cycle units in ERCOT tripped for non-weather related causes and were restored within two hours. Many of the simple cycle and combined cycle unit trips occurred immediately during start-up sequences or very soon after synchronization.

¹⁰⁶ On February 10 as well, some generators utilized pre-operational warming for that day's cold weather snap. At least five generators kept their units running, started units earlier or took other measures to keep from having a "cold start." These generators credited these strategies for their improved performance on that date.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

the storm hit. And they failed, in the majority of cases, because of weather-related problems. The various generator outages and their causes are examined in the section of this report entitled “Causes of the Outages and Supply Disruptions.”

Salt River Project

SRP is a vertically integrated utility and owns its own generation, transmission, and distribution facilities. Its preparations for inclement weather therefore needed to encompass all three functions. In terms of its forecasting, SRP uses an Artificial Neural Network Short-Term Load Forecaster model, which projects control area loads. This model incorporates SRP’s own meteorologist’s weather forecast as well as hourly historical load data. SRP reported that while weather on February 2 matched its weather forecasts, its load forecast was lower than actual load demands. The disparity, however, was within five percent.

SRP has generating facilities located throughout central and northern Arizona. Winter temperatures tend to be mild in and around the Phoenix Valley but can be noticeably colder in the more remote areas where the company’s two coal burning facilities are located. SRP reports that it carries out preventative maintenance for facilities that have winterization equipment, which generally consists of heat tracing¹⁰⁷ and insulation. Gas-fired generating plants in and around the Phoenix valley use winterization equipment to protect against expected conditions, while hydro generating facilities are almost exclusively contained inside protected buildings. SRP’s coal generating facilities at the Coronado and Navajo stations have winterization systems that consist mostly of heat tracing and insulation. SRP advised the task force that every year in the fall, planners for the Coronado and Navajo stations develop work orders to inspect and test these winterization systems to verify they are working properly, and that during the winter months, staff conduct weekly winterization and freeze protection equipment checks.

SRP’s immediate preparations for the February event were limited. It did not issue a cold weather alert in advance of the storm.¹⁰⁸ SRP reports that management at the Navajo Generating Station did inform its operators at the beginning of shifts that cold weather was approaching, and inquired if there was anything the employees needed to help them do their job. SRP does not employ a

¹⁰⁷ Heat tracing refers to the application of a heat source to pipes, lines, and other equipment.

¹⁰⁸ Indeed, the only alert the SRP Balancing Authority provided to generators was a “Capacity Alert,” indicating that maintenance and operations activities on all operating generating units were to be stopped.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

formal checklist of activities that should be carried out prior to a winter storm, and the company reported that the Operations and Maintenance Group at the Navajo Generating Station did not take any formal actions to prepare the station for the anticipated severe weather. However, SRP informed the task force that the group did hold meetings at which the need for staff to frequently check the generating equipment for potential weather-related problems was emphasized.

El Paso Electric

Like SRP, EPE is a vertically integrated utility. It reported to the task force that at the beginning of the winter of 2010/2011, as at the beginning of every winter, it took steps to winterize its generating facilities. This winterization included verifying that heat tracing was properly functioning, as well as making sure insulation was properly installed.

EPE also reported that it verified that the equipment in its substations, the part of the transmission and distribution system most susceptible to cold temperature extremes, could withstand the expected cold temperatures.

On January 31, 2011, EPE initiated preparations for the anticipated severe weather, which included verifying winterization of generation, transmission and distribution facilities, reviewing system operations plans, checking on the availability of fuel, preparing for potential pipeline constraints, and placing employees on call as needed during the weather event. The Systems Operations group requested EPE's Power Marketing and Fuels group to keep additional generation online. In response, the Power Marketing and Fuels group made arrangements to leave on Rio Grande Unit 6, to continue with the start-up of Newman Units GT-3 and GT-4, and verified the ability of Newman Unit 3 to operate on fuel oil.

In contrast to some other areas in the region, EPE reported that actual weather during the event was more severe than forecasted (and significantly colder than historical temperatures). For February 2, EPE reported that the actual high temperature in El Paso was 15 degrees compared to a forecasted high of 37 degrees, and the actual low temperature was 6 degrees compared to a forecasted low of 14 degrees. The forecasted high for February 3 was 30 degrees, compared to an actual high of 18 degrees, and the forecasted low was 14 degrees, compared to an actual low of 1 degree. For February 4, the last day of the freeze event in EPE's service territory, the forecasted high of 43 degrees compared to an actual high of 37 degrees, and a forecasted low of 21 degrees compared to an actual low of 3 degrees. EPE did not report the exact location for its temperature statistics, but presumably they occurred in the west Texas and New Mexico regions.

C. Preparations for the Storm: Natural Gas

Varying levels of preparation for the February cold front were employed by the producers, processing plants, interstate pipelines, intrastate pipelines, and LDCs that together make up the natural gas delivery chain. Depending on the type of facility, preparations included at least one, if not several of the following items: monitoring the weather, increasing staffing, methanol injection, pigging, insulation, tarps, heat tracing, building line pack¹⁰⁹ in pipelines by injecting more gas, over-purchasing gas supplies and enhancing winterization equipment. For the most part, facilities began their preparations by either Sunday, January 30 or Monday, January 31.

This section describes the preparations taken by individual companies in west Texas, the Texas panhandle, north Texas and New Mexico and by the LDCs in Arizona and New Mexico.

Producers

As discussed in detail in the section of this report entitled “Causes of the Outages and Supply Disruptions,” the difficulties encountered by LDCs in trying to meet customer demand stemmed principally from supply declines in the basins, and secondarily from problems encountered at processing plants. The preparations for the cold weather event taken by producers is therefore of special interest.

Of the 15 producers who provided information to the task force on this issue, all reported that they had used winterization techniques of one sort or another. The following table shows by basin the numbers of producers that used one of or more of the listed methods.

¹⁰⁹ Line pack refers to the volume of gas in the system at any given point in time.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

	PERMIAN	SAN JUAN	FORT WORTH	EAST TEXAS	TEXAS GULF
Methanol Injection or Drip	✓✓✓✓✓✓✓✓	✓✓✓	✓✓✓✓✓✓	✓✓✓✓✓✓✓✓	✓✓✓✓✓✓✓✓
Increased Pigging or Clearing of Liquids	✓✓✓	✓	✓✓	✓	✓
Tarps or Cold Weather Barriers	✓	✓✓		✓✓	✓✓
Increased Hauling of Fluid	✓✓	✓	✓✓✓	✓✓✓	✓✓
Heated Anti-Freeze		✓			
Heat Trace	✓	✓✓	✓	✓✓✓✓	✓
Hot Oil Trucks	✓				
Insulation	✓✓✓	✓	✓✓	✓✓	
Burial of Lines	✓				
Heat Lamps or heaters	✓✓	✓			✓

A short description of some of these techniques gives a fuller picture of the actions the producers reported having taken:

- Methanol (an anti-freeze type solution) injection or drip is a common practice for freeze protection of wellbores and pipelines. The methanol is injected into the gas stream by chemical injection pumps or enters the pipeline by methanol drips and effectively lowers the freeze point of the gas. Also, separators (used to separate liquids such as oil from the natural gas) may be filled with heated antifreeze to prevent freezing.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- Pigging refers to the practice of using pipeline inspection gauges or “pigs” inside a pipeline to perform various operations without stopping the flow of gas. Pigging operations are conducted on a year-round basis as needed to keep pipelines in working flow conditions. During cold weather their deployment can be increased to remove liquids that might be prone to freezing.
- Cold weather barriers are a relatively simple weather precaution involving the erection of wind walls around certain compressors to block cold winds that exacerbate freezing conditions. Wrapping and insulating surface equipment, injection lines, supply valves, water lines and other locations may also help prevent freezing and the stoppage of fluid flow.
- Hauling oil and produced water from storage tanks is a necessary part of the production process, since tanks that are not emptied can trigger fail safe shut-in devices that will automatically shut down the well. Prior to cold weather, and in anticipation of trucks not being able to reach the facilities, the tanks may be emptied to reduce the likelihood of automatic shut-off.
- Heat can prevent freezing problems; if the gas is never allowed to reach freezing temperatures, ice cannot form. However, heat application involves expensive equipment and requires additional fuel. Heat is also a potential hazard as it can provide an ignition point for the gas. Nonetheless, heat systems can be very effective for a localized freezing problem, and include heating blankets, catalytic heaters, fuel line heaters, or steam systems. Coupling heat systems with insulation is a common technique for protecting flow lines in northern climates.
- Hot oil trucks may be utilized to thaw out flow lines. Typically the hot oil truck will be filled with water, which is then heated and directly sprayed onto lines at risk of freezing.

As it turned out, the various measures producers described as having employed to prepare for the projected cold weather proved inadequate; a substantial number of wells in the affected basins suffered freeze-offs, which had a significant effect on production during the February cold weather event.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Processing Plants

Individual processing plants reported making anywhere from minimal to extensive preparations. Their winterization included:

- Making equipment checks;
- Adding 24-hour staff and adding to nighttime crews;
- Installing insulation;
- Confirming that heat trace equipment was operational;
- Placing tarps as wind breaks and to capture heat;
- Draining water from cooling systems and fluids from piping low points;
- Coordinating with upstream gathering;
- Reviewing past winter events; and
- Installing hot oil heaters.

A representative sampling of processing plant preparations follows.

The Crosstex Energy-affiliated Silver Creek natural gas processing plant in Weatherford, Texas processes Barnett Shale production from the Fort Worth Basin. In preparation for the weather event, operating personnel reportedly performed checks on all equipment, confirmed that all heat trace equipment was turned on prior to the storm, installed tarps on critical equipment, and drained all air supply low points. (Despite these precautions, the plant did experience a shut down of a steam boiler due to a freezing amine/water mixture.)

Enbridge Energy Company, Inc. operates processing plants in east Texas and in north Texas. Generally speaking, operations in both the east Texas and north Texas plants continued in a routine manner prior to the storm.

Energy Transfer Corporation (Energy Transfer) owns and operates the La Grange processing plant in east Texas and the Godley processing plant in north Texas. As part of its general preparation for cold weather at the La Grange plant, Energy Transfer wrapped air regulators and hung tarps around vessels. In late January, an extra operator was placed on duty. With regard to the Godley plant, Energy Transfer had previously installed louvers on all amine still overhead condensers¹¹⁰ to assist in cold weather operations. A hot oil heater had also been installed in a still condenser to prevent freezing. In addition, prior to the February weather event, Energy Transfer insulated condenser piping at two plants.

¹¹⁰ The term “amine still overhead condensers” refers to a piece of equipment used to remove the acid gases from the natural gas stream.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

MarkWest Energy Partners has two processing plants in Texas. The company reported that both processing facilities are equipped to run during extreme cold weather and that no additional maintenance, insulation or heat tracing was performed prior to the February cold weather event.

Williams Midstream has four processing facilities, the Markham Cryogenic processing plant in Matagorda County, Texas; the Milagro treating plant in San Juan County, New Mexico; the William FS Kutz (Kutz) processing plant in San Juan County, New Mexico; and the Lybrook processing plant in Rio Arriba County, New Mexico. The company reported that the Milagro plant and related facilities are designed to operate in cold weather. Nevertheless, it is standard practice at the plant to check heat tracing controls and piping insulation in the fall months. For the February event, preparations consisted of round-the-clock staffing for certain facilities and adding staffing for the night crew. Standard winter preparation at the Kutz plant reportedly includes coordination with upstream gathering, draining of water cooling systems, placing catalytic heaters into service, installation of wind barriers and group review of past events. In January and February 2011, additional contractor personnel were provided for night operations and additional heat wagons were placed based on needs. The Lybrook plant had also addressed winter preparation prior to 2011 by upgrading and inspecting piping, tracing, and insulation, and by making repairs to hot oil pumps.

Pipelines

Pipelines also prepared for the anticipated cold snap. Typical preparations for both interstate and most intrastate pipelines included:

- Maintaining higher than normal line pack;
- Optimizing compressor operations;
- Enhancing internal communication such as cold weather operational meetings;
- Increasing availability of personnel;
- Cancelling scheduled maintenance where possible; and
- Communicating with customers.

Interstate Pipelines

Individual interstate pipelines reportedly took the following preparations:

EL Paso prepared for the forecasted colder weather by maintaining higher than normal line pack throughout the weekend of January 29 and January 30. (El

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Paso considers line pack volumes between 7,200 MMcf and 7,800 MMcf at any given point in time to be in the normal range; at line pack quantities below 7,200 MMcf or above 7,900 MMcf, El Paso generally considers its system to be at or approaching stressed operational conditions.) On Monday afternoon, January 31, El Paso began gas withdrawals from its Washington Ranch Storage Facility, reaching the field's maximum withdrawal rate by the morning of February 1. This was done to compensate for gas supply underperformance in the San Juan and Permian Basins.

Natural Gas Pipeline Company of America (NGPL) uses its Texas facilities to receive gas in Texas and redeliver that gas to markets in the upper Midwest. For February 1 through February 3, NGPL put in place a severe weather operating procedure that provided for management of cold, high winds, ice and snow. This procedure included conferences and communications involving the managers of the gas control and commercial groups of impacted NGPL facilities. Additional actions reportedly taken by the gas control group included adjusting pipeline pressures to meet anticipated load increases, manning facilities on an around-the-clock basis, and carrying out operating procedures designed to keep facilities from freezing.

Transwestern began operating its compression stations to maximize pressures in New Mexico in advance of the cold weather event.

ANR Pipeline Company (ANR) has no facilities in New Mexico, Arizona or California, and only limited facilities in Texas, which are located in the northeast corner of the Texas panhandle (this is the southern-most part of ANR's Southwest Area). To prepare for and respond to operating concerns and ongoing and expected weather events, ANR conducted daily morning operations meetings. An additional "cold weather" operational meeting specifically addressed the week of February 1. ANR reported reduced horsepower at all its Southwest Mainline compressor stations to help flow gas south into the Texas area if scheduled supply decreased, with the aim of maintaining adequate line pack and constant pressures in Texas and Oklahoma.

Intrastate Pipelines

Intrastate pipelines in general employed many of the same preparations as did the interstate pipelines. Reported examples are provided below.

Atmos Pipeline –Texas began building line pack on January 31, and advised shippers to be in hourly and daily balance effective 9:00 AM on February 1. This action assisted with maintaining line pack. Electric generation customers

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

were advised that deliveries would be limited to Tier 3¹¹¹ beginning at 9:00 AM on February 1. Third-party interruptible storage customers were advised that they would be limited to 50 percent withdrawals effective February 1 at 9:00 AM.

Energy Transfer Partners reported ensuring that critical stations were staffed, spare compressors were placed on standby, line pack was increased, and all scheduled maintenance was postponed.

Enterprise Products Partners reported closely monitoring nominations. Staffing coverage was extended in addition to employees' normal schedules. Operations were also reviewed for potential service adjustments that might be required, although none were anticipated.

The Kinder Morgan Texas Pipes' natural gas pipeline operations and gas control group initiated the Kinder Morgan Gas Pipelines' severe weather operating procedure, designed to manage facilities in the event of severe cold, high winds and frozen precipitation. The procedure prescribes conferences and communications among managers and the gas control and commercial groups, and these communications began several days prior to the cold weather event. The gas control group also adjusted pipeline pressures in anticipation of increased load. In the field, some facilities were reportedly staffed around-the-clock, and procedures were put in place to keep facilities from freezing.

Local Distribution Companies

Each of the four LDCs that curtailed customers during the February weather event reported making preparations. They monitored weather forecasts before the event and revised their load forecasts upward. They also increased their purchases of gas to accommodate increased demand and to compensate for freeze-offs, and communicated with suppliers and the pipelines about pending conditions. As conditions worsened, these communications became more frequent.

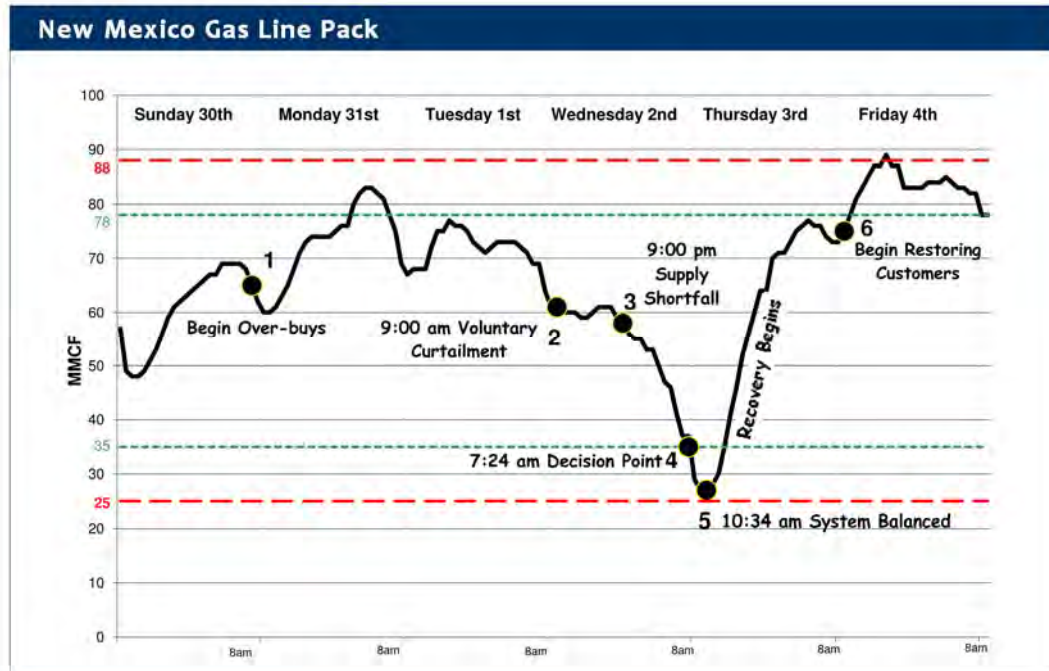
New Mexico Gas Company packed transmission lines with extra gas, and confirmed that the storage facility it accesses was positioned for withdrawals. Additional gas was purchased for the expected increased demand and in anticipation of freeze-offs. From February 1 through February 3, NMGC had, for each respective day, pre-purchased 36 percent, 55 percent, and 62 percent more gas than its forecasted need. NMGC issued an Alert to all transportation customers concerning the weather forecasts. Given the severity of the anticipated

¹¹¹ Tier 3 restrictions applying to electric generating units limit the amount of natural gas the units can take.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

storm, at 9:00 AM on February 2, NMGC began requesting that large industrial and commercial customers throughout the state voluntarily reduce or curtail their gas usage. In total, NMGC reported contacting 39 customers, asking for voluntary curtailment.

The following is a chart of NMGC's line pack, juxtaposed with its preparation events.



Source: New Mexico Gas Company

Southwest Gas monitored current weather forecasts on January 30 and January 31, which indicated colder temperatures were expected for southern Arizona. On February 1, a scheduled meeting of engineering and technical services personnel was expanded to include discussions concerning cold weather preparations and system monitoring.

Zia Natural Gas Company (Zia), after observing the dramatically dropping temperatures forecasted for February 1 through February 4 for the state of New Mexico, contacted its primary supplier on January 30 to discuss its supply and receipt options. On February 1, Zia discussed maximum volumes that could be nominated on its pipeline transportation contract.

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V. The Event: Load Shed and Curtailments

When the storm hit the Southwest on February 1, both electric and natural gas facilities began experiencing outages and other production difficulties. These difficulties escalated and ultimately led to load shedding by three electric balancing authorities and service curtailments by four gas LDCs, beginning on February 2. The unfolding events that led to these disruptions, and the conduct of the load shedding and curtailments, are described in this section.

A. Electric

ERCOT, SRP and EPE all engaged in load shedding during the cold weather event. Other electric entities in the area, although they experienced generation losses, were able to avoid load shedding (with the exception of PNM, which experienced some small, localized load loss from transmission issues). Each affected utility's actions are discussed separately below. (All times referenced are expressed in local time.)

ERCOT

ERCOT's required responsive reserve level is 2300 MW.¹¹² This is the amount that ERCOT has determined to be necessary on its system to ensure that the system will maintain frequency and voltage stability; that thermal and voltage limits will remain within applicable ratings; and that there will be no loss of demand, curtailment of firm transfers, or cascading outages.¹¹³ If reserves drop below specified amounts, ERCOT is required by its Protocols to take actions to bring them up again, including the shedding of load.

ERCOT has specified in its Protocols certain triggering events that require taking action to prevent the uncontrolled loss of firm load. In doing so, it has patterned its emergency alert protocol on the Reliability Standard that prescribes

¹¹² As discussed in the section of this report entitled "Preparations for the Storm," this amount was based on a 1988 study designed to determine the amount of reserves needed to prevent shedding of firm load if ERCOT's two largest contingencies occurred.

¹¹³ This minimum level of reserves is based on an N-2 criterion, a more conservative requirement than that required by the FERC-approved Reliability Standard BAL-002-0 R3.1, which requires that "as a minimum, the Balancing Authority or Reserve Sharing Group shall carry at least enough Contingency Reserve to cover the most severe single contingency." ERCOT's N-1 largest single contingency would be the loss of a nuclear-powered generating unit at the South Texas Nuclear Project, rated at 1354 MW.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

an energy emergency alert procedure.¹¹⁴ Both the Reliability Standard and the ERCOT Protocol categorize these triggering events into three levels, Levels 1, 2, and 3; ERCOT further subdivides Level 2 into 2A and 2B.

ERCOT had to make decisions throughout the morning of February 2 regarding the declaration of these various emergency alert levels and actions. That was particularly so with respect to Level 3, which requires the shedding of firm load.

Energy Emergency Alerts

Reliability Standard EOP-002-2.1 prescribes the use of an energy emergency alert (EEA) procedure when a load serving entity is unable to meet its customers' expected energy requirements. These energy emergencies are declared by the load serving entity's reliability coordinator, and are categorized by level of severity:

- EEA 1 - For conditions where all available resources are committed to meet firm load and reserves, all non-firm sales have been curtailed, and the entity is still concerned about sustaining its operating reserves.
- EEA 2 - For conditions when the entity is no longer able to meet expected energy requirements, and is designated an Energy Deficient Entity.

The entity is to do the following, as time permits:

Public appeals to reduce demand,
Voltage reduction,
Interruption of non-firm loads,
Demand-side management, and
Utility load conservation measures.

Other entities are to provide emergency assistance as appropriate and available.

- EEA 3 - For conditions when the energy available to the Energy Deficient Entity is only accessible with actions taken to increase transmission transfer capabilities.

At this point, firm load interruption is imminent or in progress.

(cont'd)

¹¹⁴ See Reliability Standard EOP-002-2.1 (Capacity and Energy Emergencies).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

ERCOT:

ERCOT has particularized this emergency energy alert system to the requirements of its own system. It is required under its Protocols to perform certain actions upon the occurrence of distinct triggering events. These are as follows:

Level / Triggering Event / System Operations Actions

- EEA 1 Less than 2300 MW of Reserves:
Use capacity available from DC ties, dispatch uncommitted units.
- EEA 2A Less than 1750 MW of Reserves:
Deploy Load Resources (LR); begin block-load transfers of load to neighboring grids.
- EEA 2B To maintain system frequency at 60 Hz or reserves trending downward or not available:
Deploy Emergency Interruptible Loads (EILS) if available.
- EEA 3 To maintain system frequency at 59.8 Hz or greater:
Instruct transmission operators to shed load via rotating outages in blocks of 100 MW.

As discussed in the preceding section of this report, “Preparations for the Storm,” severe weather conditions on February 1 precipitated numerous forced generator outages within ERCOT’s footprint. By midnight on February 1, 6022 MW of generation capacity was unavailable due to weather-related forced outages and derates, and conditions worsened overnight.

Generation Shortfalls on February 2

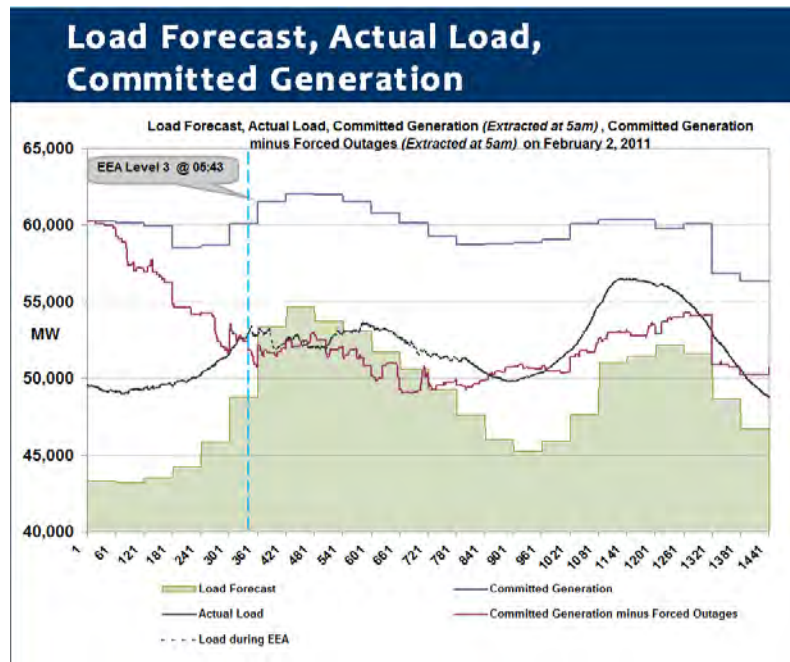
By 3:00 AM on February 2, responsive reserves had dropped below 3000 MW. ERCOT issued both an OCN and an Advisory to market participants, notifying them of the severe weather and the falling reserve level.¹¹⁵ It followed this communication with an emailed report to the PUCT about the falling reserves.

¹¹⁵ The communication steps taken by ERCOT appear to be consistent with its Operating Guidelines and Protocols. However, a number of transmission providers have stated they could have been better prepared to implement their required load shed if they had had more information about ERCOT’s deteriorating system status much earlier during the overnight period of February

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

At 4:30 AM, ERCOT operators instructed deployment of 1840 MW of non-spinning reserves, principally combustion turbines. (Non-spinning reserves require 30 minutes or longer to come on-line or to ramp up to their next block of power output.) Ten of the units, or a total of 669 MW of capacity, were unable to respond, many because they failed to start. By 5:08 AM, reserves had dropped below 2500 MW, and ERCOT issued a Watch.

ERCOT calculates its operating reserves on a real-time basis by comparing metered demand with its available generation resources. At the same time generation was dropping off during the morning of February 2, demand was rising. The cold weather and winds were placing extraordinary demands for power on the system, and load was running consistently higher than had been forecasted for the day. In fact, at 5:20 AM the demand was 2760 MW higher than on any other day in the history of the ERCOT region at that hour, and was rapidly climbing.¹¹⁶ The following chart, prepared by TRE, compares actual demand with forecasted demand.



Source: TRE

The actual peak demand for the day, which typically occurs in the morning around 8:00 AM, was artificially skewed downward because of the load shed. The

1 to February 2. They would have liked to have received such information as soon as ERCOT began seeing a high number of forced generator outages.

¹¹⁶ Potomac Economics, Ltd., *Investigation of the ERCOT Energy Emergency Alert Level 3 on February 2, 2011*, at 3 (April 21, 2011) (Potomac Report), available at http://www.puc.state.tx.us/files/IMM_Report_Events_020211.pdf.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

IMM (Potomac Economics, Ltd.), the market monitor for ERCOT, estimated that the demand that would have materialized absent any load reductions or curtailments would have peaked at 59,000 MW, just after 7:00 AM.¹¹⁷ This estimate suggests that the high demands already being placed on the system in the early morning hours would likely have continued to escalate.

At 5:09 AM, reserves dropped below 2300 MW, the triggering event for ERCOT's declaration of an EEA 1 (although it was not declared, presumably because events were moving so swiftly). At 5:20 AM, responsive reserves had dropped below 1750 MW, and ERCOT issued an EEA 2A. It also deployed 888.5 MW of Load Resources, with 881.7 MW responding. Load Resources are counted as responsive reserves and, as such, their deployment reduces ERCOT's responsive capability. In this case, however, two factors worked to offset this reduction:

- The dropping of 881.7 MW of load increased the margin between generation and load, and ERCOT allowed a fraction of this increase to be allocated to responsive reserves. (The fraction ERCOT allots is typically 20 percent, but varies based on the specific generation online at any given time.)
- The Load Resources were being deployed over a 10-minute interval during which some additional generation was actually coming online, despite all the problems on the system.

As a result of these factors, for a short time while Load Resources were being deployed, responsive reserves actually increased by about 200 MW. It was not long, however, before additional forced outages and derates of generation, combined with the normal pick-up of morning demand, again decreased the level of responsive reserves.¹¹⁸

At 5:26 AM, ERCOT deployed RRS reserves, a form of interruptible load, which briefly raised the reserve level to above 1400 MW.

¹¹⁷ Potomac Report at 3-5. The estimate was based on several factors, including the actual load and rate of load increase prior to the implementation of the first load curtailments, the load shape on similar days, and ERCOT load forecasts produced just after 3:00 AM on the morning of February 2.

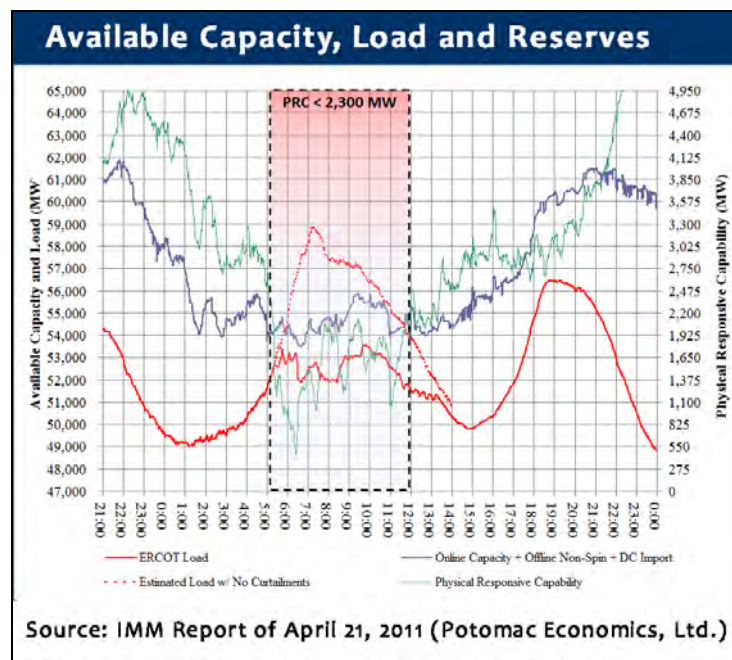
¹¹⁸ Responsive reserves would ultimately fall to a low point of 447 MW at 6:25 AM, after the load shed had already begun.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

More units, however, continued to trip off-line. Responsive reserves briefly dipped below 1354 MW (the N-1 contingency reserve level required for safe operation of the system) twice before 5:40 AM. At that time, the responsive reserves dropped below the N-1 contingency level for an extended 73 minute period.¹¹⁹

At 5:43 AM, ERCOT declared an EEA 3 and began the process of shedding load.

The following graph¹²⁰ indicates the relationship between ERCOT's available capacity, loads and reserves throughout the day.



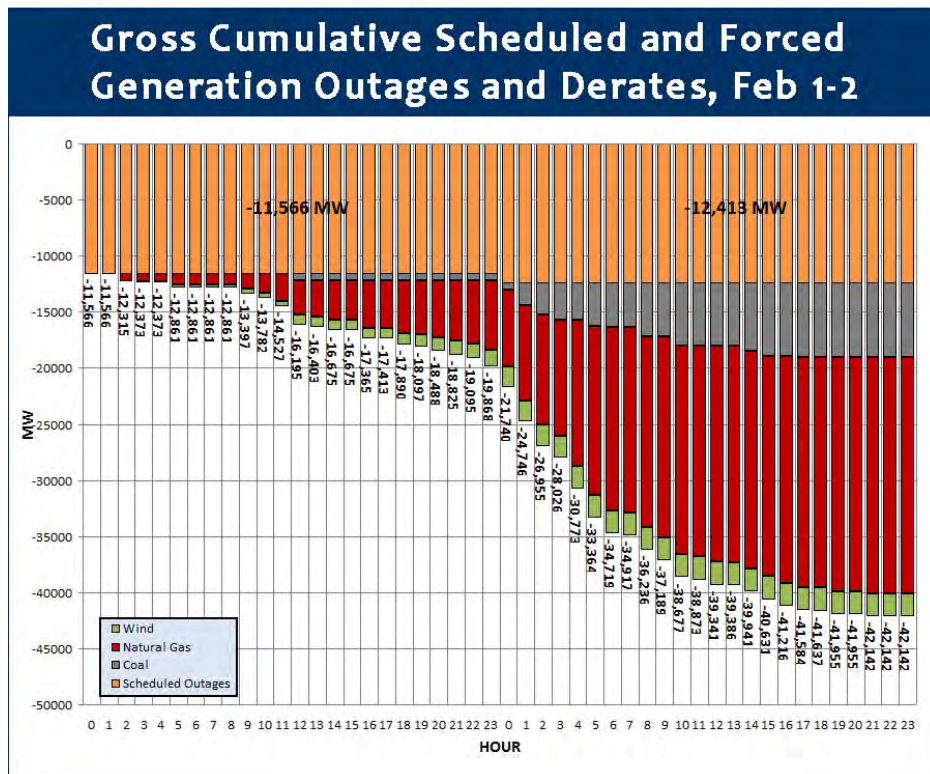
Counting both February 1 and February 2, a total of 193 generating units in ERCOT tripped, had derates, or failed to start, representing a loss of 29,729 MW of capacity.¹²¹ At the lowest point of available generation, which occurred at 6:12

¹¹⁹ There were six times during the morning of February 2 when ERCOT's response reserves fell below 1354 MW. Those times are: 5:23-5:29 AM, 5:31-5:32 AM, 5:40-6:52 AM, 7:11-7:30 AM, 8:39-8:52 AM, and 10:58-11:15 AM, for a total of two hours and 14 minutes, with the longest interval 73 minutes. (Calculation of the time periods includes the beginning and ending minutes.)

¹²⁰ Potomac Report at 6.

¹²¹ This is a gross cumulative number; a unit is counted as having failed regardless of whether it came back online at some point during the event. This measurement gives an

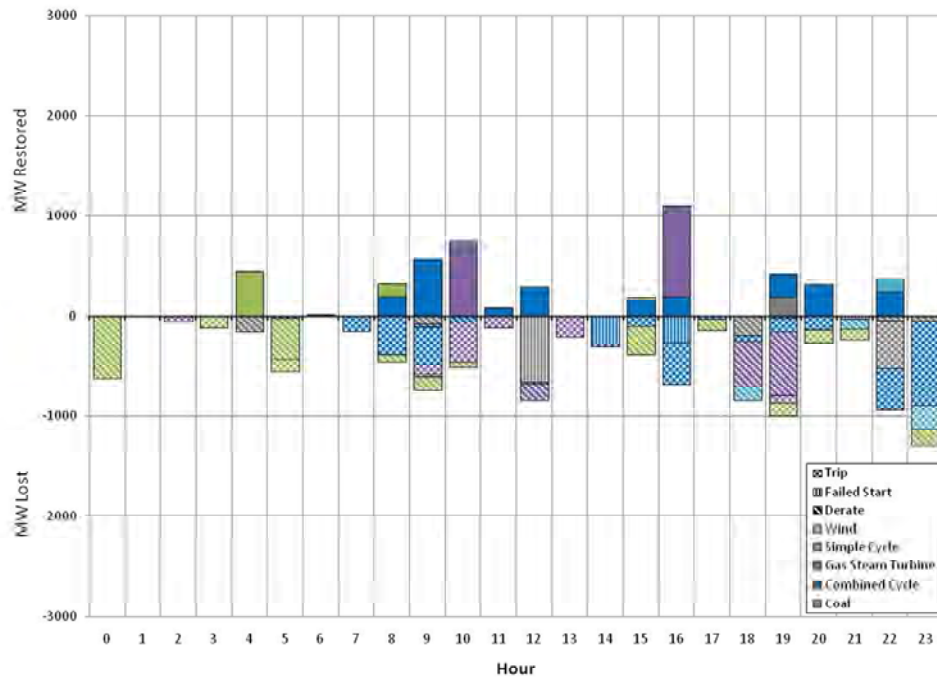
FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



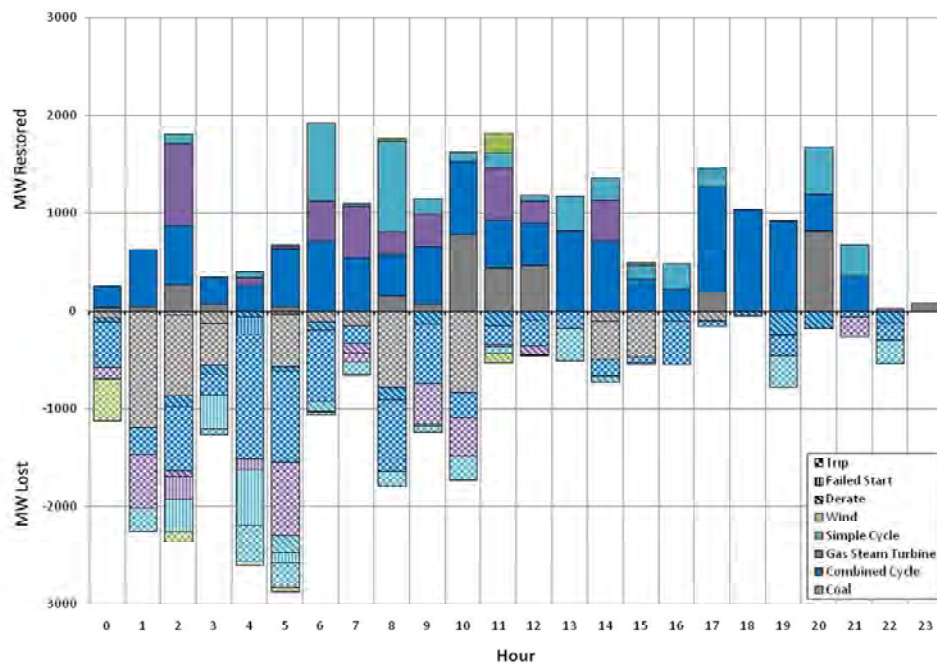
The task force has also prepared charts for February 1 and February 2 that depict, hour by hour, the MWs that failed and the MWs that were restored, both by fuel type and by type of failure (trip, derate, or failure to start). These charts give a running picture of the fluctuations in available capacity, by fuel type, at any given point in time throughout the event.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Capacity Fluctuations by Fuel Type on Feb. 1, 2011



Capacity Fluctuations by Fuel Type on Feb. 2, 2011



The various reasons for the outages, derates and failures to start that occurred during the event (the majority of which were weather-related, either

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

directly or indirectly) are discussed in the following section of this report entitled “Causes of the Outages and Supply Disruptions.”

Adjusted Wind Power Capacity

The capacity of a wind power installation is typically reported on a “nameplate” basis, with the nameplate value representing what the facility can produce when the actual wind speed is optimum for the particular turbine design. When a wind farm is offline on a scheduled or forced outage, the capacity unavailable to the system is also typically reported on a nameplate basis; the same is true for partial outages, which are reported as derates (collectively, nameplate outage value).

The actual wind speed, however, is seldom sufficient to produce full nameplate output simultaneously throughout ERCOT. Therefore, the nameplate outage values must be adjusted downward to realistically represent the impact of outages and derates of individual wind facilities.

Adjusted Outages and Derates

The total installed wind power nameplate capacity in ERCOT is 9321 MW. If the aggregate nameplate outage values reported during February 1 and February 2 are subtracted from this 9321 MW total, nameplate available values are obtained on an hourly basis. Dividing the actual measured aggregate wind power output for any given hour by the nameplate available value for the same hour produces a percentage output that reflects how strongly the wind is blowing compared to full-output levels. Over the course of February 1 through February 2, that percentage varied from 40 to 75 percent (which is atypically high). To determine adjusted outage values, the percentage for any given hour is applied to the nameplate outage value for that same hour. For example, if the reported nameplate outage value for the 5:00 AM hour was 3200 MW, and the percentage output was 50 percent, the adjusted outage value is 1600 MW. This value more realistically represents the additional wind power that would have been supplied to the ERCOT grid had it not been for the wind farm outages and derates.

Although this method does not take into account the fact that the wind speed at a specific location where a forced outage has occurred may or may not correlate with the average value, any errors at individual locations should tend to offset one another. The method also assumes that the reports of forced outages and derates were made on a timely basis, which may or may not have been the case.

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FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Adjusted Capacity

NERC used 8.7 percent of nameplate capacity in calculating the contribution of wind power to existing generation in its 2010-2011 Winter Assessment of the TRE region. This is a planning number that has merit for the seasonal overview, but is not applicable to the high wind conditions of February 1 through February 2. Therefore, in determining the wind power capacity in ERCOT for purposes of this inquiry, the task force multiplied the total installed capacity of 9321 MW by the percentage of output actually achieved by those facilities that remained in service, compared to nameplate capacity. The resulting adjusted capacity represents what the total wind power output would have been in ERCOT had there not been any outages or derates during February 1 through February 2. Since the percentage varies with the wind speed, adjusted capacity values were calculated hourly. At 8:00 AM on February 2, the percentage of output vs. nameplate was 57 percent, yielding an adjusted capacity of 5313 MW ($0.57 \times 9321 \text{ MW}$). This number was then used as wind power's contribution to the total generation fleet. Counting all units, both online and off, that total came to 79,658 MW for the 8:00 AM hour. (Since the adjusted capacity value changes hourly based on wind speed, so too will the numerical size, in MWs, of the total generation fleet.)

The Load Shed Decision

Load shedding is implemented to correct an electrical power imbalance if load exceeds supply and system operators cannot bring the system back into balance through other measures. Load shedding may be used to reduce an overload condition (such as when thermal limits on a transmission line are exceeded), to recover from an under-frequency condition, or to return voltage to a normal level. The operation can be manual (operator-initiated) or automatic (relay-initiated), depending on how quickly the frequency is decaying or the voltage is falling. For slowly declining frequency or voltage issues, the manual option is usually chosen. For rapidly declining frequency or voltage, the automatic option will respond without operator intervention.

ERCOT utilized operator-initiated load shedding on February 2, which preserved the system's ability to implement automatic load shedding had system conditions continued to deteriorate. Had ERCOT not instituted manual load shedding, automatic under-frequency load shedding would have been a last resort before a possible system collapse. Manual load shedding also helped raise the frequency levels, preventing damage to generator turbines.

The task force considered the question of whether ERCOT's decision to manually shed load prevented more extensive blackouts than were experienced as a result of the load shed itself. While a definitive answer would require extensive

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

modeling and data inputs, the task force concluded, based on the information available, that ERCOT's declaration of an EEA 3 probably prevented widespread, uncontrolled blackouts throughout the ERCOT Interconnection. Because ERCOT operates as a functionally separate interconnection from its neighboring Eastern and Western Interconnections and is linked only by asynchronous ties, the blackouts would not have propagated further.¹²⁴

Frequency Response and Automatic Under-Frequency Load Shedding

Frequency as a measure of the reliability status of a power system can be likened to pulse or heart rate as a measure of human health. It provides a key indicator of the overall integrity of operations. Maintaining frequency requires balancing a system's aggregate generation output to load moment-to-moment. It also requires having sufficient reserves available at all times to withstand the sudden loss of the largest generator on the system, in order to instantaneously make up for the loss of power and thus reestablish balance.

In spite of the enormous amount of generation that was forced off line in successive waves in ERCOT on February 1 and February 2, especially during the overnight and early morning hours between the two days, the overall frequency response of the system was not problematic during the event. Nonetheless, the need to maintain frequency to prevent a collapse of the system was the fundamental driving force behind ERCOT's decision to shed firm load.

Because ERCOT is not synchronously connected to either the Eastern or Western Interconnections, all frequency response must come from internal resources. And because ERCOT is smaller than the other interconnections, the loss of a generator results in a steeper frequency decline, necessitating a more robust frequency response. For this reason, in 1988 ERCOT established a minimum responsive reserve requirement of 2300 MW, based on an N-2 criterion covering the loss of the two largest generators in ERCOT (one nuclear-powered unit and the next largest unit on the system). This is a larger reserve than the N-1 criterion required by Reliability Standard BAL-002-0 R3.1. On the morning of
(cont'd)

¹²⁴ NERC has prepared a study on the reliability implications of the February cold weather event entitled "Analyses of Reliability Impacts on the Bulk Power System." The study discusses the impacts on the WECC Interconnection of the events in SRP, EPE, and PNM, and presents an analysis of frequency response performance during the event by the Eastern Interconnection and the ERCOT Interconnection. NERC plans to make the study publicly available.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

February 2, 2011, the largest single contingency was an online nuclear-powered generating unit with a capability of 1354 MW.

ERCOT maintains and closely monitors its responsive reserve levels (also referred to by ERCOT as its Physical Response Capability, or PRC), to comply both with its own 2300 MW criterion and with the 1354 MW minimum criterion.

ERCOT relies on demand side load resources to provide up to 50 percent (1150 MW) of its 2300 MW responsive reserve requirement. These resources automatically disconnect when the frequency declines to 59.7 Hz. The purpose of the responsive reserves, both generation and load, is to arrest frequency declines before they reach 59.3 Hz (the trigger threshold for the first block of automatic under-frequency load shedding (UFLS)), and to restore frequency to 60 Hz within a few minutes following an event. Should either generation or load resources be deployed manually by system operators, they are no longer available to provide frequency response.

Between 5:15 AM and 1:20 PM on February 2, responsive reserves dropped below the 2300 MW N-2 criterion three separate times, of varying durations. Ultimately, responsive reserves dropped below the 1354 MW N-1 criterion. This occurred six separate times between 5:23 AM and 11:15 AM, for a combined total of 134 minutes, with the longest interval being 73 minutes. During the times when responsive reserves were below 1354 MW, had the largest generator tripped, reserves would have been insufficient to reestablish the balance between generation and load. The result would have been an inexorable decline in frequency which, when it reached 59.3 Hz per second, would have triggered the first block of automatic under-frequency load shedding, which would have dropped five percent of the system load, or roughly 2600 MW.

Even though the under-frequency load shedding would have tripped automatically, this response would have taken out firm load and would be in addition to any firm load that operators may have already shed, starting with the first directive ERCOT issued at 5:43 AM. Depending on the particular circumstances surrounding the moment of activation of the automatic under-frequency load shedding, it is possible that an overvoltage condition could have occurred in one or more localized areas, that frequency could have significantly overshoot the 60 Hz norm, or that other electrical perturbations could have developed that would have resulted in the tripping of even more generation. Only a detailed dynamic simulation could answer the question as to how widespread the February 2 blackout would have been had the automatic under-frequency load shedding been triggered.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

ERCOT's Black Start Capability

If the load shed had not prevented an ERCOT-wide blackout, the outages would not only have been more widespread, they might have been of a much longer duration. The task force reviewed the state of ERCOT's black start units to determine whether they could have promptly brought the system back had a collapse occurred. "Black start" refers to restarting the system after a major portion of the electrical network has been de-energized, and generators that have black start capability are those that can be started independently and without external power.

ERCOT has 15 primary and six alternate black start generators. During the event, roughly half of these generators were unavailable: two (totaling 97 MW of capacity) were on planned outage; four (totaling 141 MW) failed to start due to the extreme cold weather; three (totaling 423 MW) tripped offline after starting due to freezing equipment; and one (26 MW) tripped offline due to natural gas fuel curtailment. Had a total blackout of the ERCOT system occurred, the unavailability of 10 of ERCOT's 21 (primary and alternate) black start resources, comprising 687 MW out of a total 1150 MW of black start capacity, could have jeopardized ERCOT's ability to promptly restore the system.

The Load Shed Process

ERCOT accomplishes a controlled load shed by issuing directives to its transmission providers,¹²⁵ ordering the load shed to proceed in defined blocks of power (each transmission provider being responsible for its allocated share of the total). On February 2, ERCOT issued its first load shed directive at 5:43 AM and its third and last at 6:23 AM. In total, it directed that 4000 MW be shed.

ERCOT began load restoration at 7:57 AM, and firm load was fully restored at 1:07 PM.

¹²⁵ "Transmission provider" is a generic term. ERCOT uses "transmission service provider" to mean an entity that owns or operates transmission facilities to transmit electricity and provide transmission service on the ERCOT grid. NERC uses different terminology to describe the various types of transmission providers, including "transmission service provider," "transmission operator," and "transmission owner." (The definitions of these terms can be found in the appendix entitled "Categories of NERC Registered Entities.") Under NERC terminology, ERCOT is the only "transmission service provider" for its Interconnection. To avoid confusion, the term "transmission provider" will be generally used in the narrative portions of this report to refer to any of those various categories of entities who provide transmission service and who were directed to shed load and took the necessary actions to do so (including load shedding both within and outside of ERCOT).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The actual load shed process and eventual restoration of the system to an EEA 0 state¹²⁶ proceeded as follows:

ERCOT issued its first instruction at 5:43 AM, ordering a load shed of 1000 MW. Shortly thereafter, ERCOT also deployed 384.2 MW of Emergency Interruptible Load Service, ERCOT's form of demand response.¹²⁷

At 6:04 AM ERCOT directed the transmission providers to shed an additional 1000 MW of load. In the next second, 6:05 AM, ERCOT's frequency dropped to 59.576 Hz, its lowest point during the event.

At 6:23 AM ERCOT issued its third and last load shed directive, directing the transmission providers to shed an additional 2000 MW. This resulted in a total load shed directive of 4000 MW.

As the transmission providers were implementing ERCOT's directives to shed load, additional generation became unavailable; between 5:45 and 6:30 AM, 18 generating units tripped offline, were derated, or failed to start, totaling 1643 MW of output. (During this same time, 12 units came back online, totaling 774 MW.)

At 6:25 AM, ERCOT's reserve level dipped to 447 MW, its lowest point of the day.

At 6:59 AM, ERCOT issued a media appeal for energy conservation. This was the first notification to the public of the problems ERCOT was experiencing on its system.¹²⁸

At 7:57 AM, ERCOT issued its first load restoration directive, beginning with a 500 MW block. Three seconds later, a combined cycle unit loaded at 77

¹²⁶ "EEA 0" signifies a normal state of operation.

¹²⁷ While some EILS customers failed to reduce load as contracted (thus exposing themselves to potential penalties), others responded with a load reduction in excess of their contracted amount. The net result was that total EILS load reduction fell short of obligated levels on February 2 in only one fifteen-minute interval.

¹²⁸ ERCOT has acknowledged that it could improve its communications with the general public, which it suggests could be accomplished through use of an automated system for contacting the media, deployment of representatives to meet with the media, and through designation of supplemental communications staff to answer phone inquiries during a period of emergency.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

MW tripped offline, causing reserve levels to again fall below 1354 MW. However, ERCOT did not shed any additional load.

At 8:22 AM, ERCOT directed the transmission providers to restore another 500 MW block of shed load. ERCOT would issue six more load restoration directives over the course of the next several hours, completing the process at 1:07 PM.¹²⁹

At 8:53 AM, ERCOT deployed an additional 83.5 MW of EILS, at which point reserves increased above the 1354 MW limit.

At 9:25 AM, ERCOT called all QSEs and instructed them not to take any resources offline unless so instructed.

Additional units, including an 849 MW coal unit, continued to trip offline. At 10:58 AM, reserves again dropped below the 1354 MW limit. This situation lasted until 11:15 AM.

At 12:12 PM, ERCOT reported to the QSEs that the Texas Commission on Environmental Quality (TCEQ) had issued a waiver for certain air permitting requirements that might otherwise have prevented generators from producing power during the emergency. (The TCEQ's actual communication did not mention a waiver, but rather indicated it would exercise its "enforcement discretion.")

At 1:57 PM, ERCOT recalled RRS Block 2 Load Resources (463 MW).

At 2:01 PM, ERCOT returned to a state of EEA 2B.

At 2:55 PM, ERCOT recalled RRS Block 1 Load Resources (437 MW).

At 3:14 PM, ERCOT returned to a state of EEA 2A. Reserve levels rose to approximately 2900 MW.

At 7:15 PM, ERCOT set a record winter peak demand of 56,480 MW.

On February 3, at 10:00 AM, ERCOT declared a state of EEA 0 and recalled all EILS loads.

¹²⁹ Directives were issued in 500 MW blocks at 9:25 AM, 11:39 AM, 12:04 PM, 12:25 PM, 12:49 PM, and 1:07 PM.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Summing every transmission provider's peak load shed amount (which did not occur at the same time), the cumulative load shed on February 2 was 5411.6 MW. The largest amount of load shed at one point in time (8:02 AM) was 4947.9 MW.¹³⁰

The load shed process by ERCOT's transmission providers is discussed below.

Conduct of the Load Shed by ERCOT's Transmission Providers

ERCOT communicated its oral dispatch instructions to shed load via hotline calls. The percentage of the total requirement that is to be shed by each transmission provider is based on the transmission provider's previous year peak load, as reported to ERCOT.¹³¹ Under ERCOT's Nodal Operating Guides, transmission providers have 30 minutes to shed their required share of load if the curtailment is implemented remotely by SCADA system, and one hour if implemented by dispatch of personnel into the field to manually disconnect feeders.¹³²

Load Shed Program Design

Each transmission provider in ERCOT is responsible for determining how load will be shed in order to meet its load shed obligation.¹³³ The larger transmission providers interviewed by the task force make use of automated systems for shedding load. All transmission providers interviewed pre-designated feeders or blocks that are available for manual load shed. Transmission providers generally take into account the following factors in setting up their load shed system:

¹³⁰ Based on TRE data supplied to the task force. (This number does not include Greenville, for which comparable data was not available. Adding 8.8 MW for Greenville would bring the total to 4956.7 MW).

¹³¹ See ERCOT Nodal Operating Guides: Emergency Operation § 4.5.3(5) (July 1, 2011), available at <http://www.ercot.com/mktrules/guides/noperating/cur>.

¹³² *Id.* at § 4.5.3(7)(a)-(b). These time frames do not apply if the load shed directive exceeds 1000 MW, as was the case for ERCOT's last load shed instruction on Feb. 2, 2011. *Id.* at § 4.5.3(7)(c).

¹³³ Actual implementation of load shedding is carried out at the distribution level, which may be done through a separate division of the transmission provider or through a separate, affiliated entity (e.g., a member distribution cooperative of a generation and transmission cooperative). This extra layer of communication appears to have caused some delay in the initiation of the load shed process in at least some cases.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

1. Minimizing customer disruptions through target outage rotation periods. Transmission providers interviewed utilize a load-shed scheme with a targeted rotation period between 15 minutes at the low end and 30-45 minutes at the high end. During the February 2 event, transmission providers reported difficulties maintaining a short (15-minute) rotation period over the course of the morning, as ERCOT raised their load shed obligation to the highest levels most transmission providers had experienced. Transmission providers reported having to go through their rotation schedule multiple times, and some transmission providers expressed concern that a limited number of customer groups had to carry a disproportionate amount of the load-shed burden.¹³⁴
2. Avoidance of feeders or lines reserved for under-frequency load shedding (UFLS) requirements. All transmission providers interviewed indicated that UFLS blocks¹³⁵ are not generally included as available feeders for manual load shedding under their load shed procedures. However, one transmission provider discovered during the February 2 load shed event that some lines designated as available for manual load shed were also designated for UFLS. Except for this one overlap in blocks, the transmission providers interviewed were able to fully meet their load-shedding obligations while maintaining the required 25 percent of load reserved for UFLS. There were no reported instances of automatic under-frequency trips during the February 2 event.
3. Exemptions for critical customers. Transmission providers utilize a variety of approaches for identifying critical customers or loads that are either exempt from rolling outages or are given a higher priority for preservation of service. Customers that typically receive some form of exemption or higher priority include hospitals, airports, and

¹³⁴ TRE Report at 41; materials provided to the task force by transmission operators.

¹³⁵ Distribution service providers in ERCOT are required to set up relays to automatically trip load as frequency falls, as follows: (1) at 59.3 Hz, a minimum of 5 percent of load must trip; (2) at 58.9 Hz, an additional 10 percent of load must trip; and (3) at 58.5 HZ, an additional 10 percent of load must trip, *i.e.*, the distribution service providers must have at least 25 percent of its load available for UFLS. (This is independent of any manual load shedding directives.) ERCOT Nodal Operating Guides Section 2: System operations and Control Requirements at 2.6.1(1) and (2). Some transmission providers use these same blocks of load for automatic under-voltage protection. (Note that NERC uses the term “distribution provider” to describe this type of entity. This report will use the term “distribution service provider” throughout to avoid confusion.)

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

other facilities that may affect public safety, such as police stations.¹³⁶ Some transmission providers interviewed indicated that they have a process for checking with gas customers for possible critical loads, such as gas compressor facilities without backup generation. But most acknowledged that the process for identifying “critical” gas facilities could be better standardized or otherwise improved.

4. Exemption of large loads and networks needed for system stability. Major downtown areas are generally exempted from the load shed plan, as cutting off service to these heavily networked systems could affect system stability. Large, high-voltage industrial loads are also generally not available for manual load shedding due to system stability concerns.¹³⁷

After taking into account UFLS blocks, critical/exempt customers, and other load that is not appropriate for manual load shedding, the interviewed transmission providers indicated that they had between 30 percent and 70 percent of their total load available for manual load shedding.

Experience on February 2, 2011

The transmission providers’ overall load shed response (in MW) was beyond the minimum required by ERCOT and was adequate to protect system frequency.

Most of the larger transmission providers interviewed were able to shed load within a few minutes of receiving each ERCOT directive, and utilized some form of automated system for shedding load. These systems were designed to

¹³⁶ The State of Texas also requires transmission providers and distribution service providers to provide notification of interruptions or suspensions of service under certain conditions (set out in their retail delivery tariffs) to customers that meet the criteria for designation as a Critical Load Public Safety Customer (hospitals, police stations, fire stations, and critical water and wastewater facilities), Critical Load Industrial Customer, Chronic Condition Residential Customer, or Critical Care Residential Customer. 16 TEX. ADMIN. CODE § 25.497 (2011).

¹³⁷ Some of these high-voltage industrial loads may be under contract as Emergency Interruptible Load Service (EILS) or providing ancillary services (RRS) as Non-Controllable Load Resources (NCLR). *See* TRE Report at 42-44. In such case, those resources would be (and were) called upon by ERCOT through the relevant QSE (at 5:49 for EILS and at 5:20 for NCLR), something that is not communicated to or controlled by the transmission providers or distribution service providers.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

look at actual load on the feeders in real time, and were designed to rotate customer blocks by restoring service feeder-by-feeder as the pre-determined rotation period expired. These systems were also designed to ensure that the total curtailment obligation is maintained or exceeded at all times, by restoring a given feeder only *after* another feeder or feeders with off-setting load have been dropped in the next block. At least one of the automated systems in use during the event was designed to take into account cold load pickup prior to restoration of feeders,¹³⁸ and therefore may have generated a greater reported level of over-shedding for limited periods of time during the rotation process.¹³⁹

Other transmission and distribution service providers used less sophisticated methods for shedding load during the event, including having a dispatcher record load amounts prior to dropping a given block to calculate the total amount to be reported to ERCOT as having been shed, and using color-coded circuit maps to select lines to be shed.

All but four transmission providers were able to meet or exceed their load shed obligations within 30 minutes of each oral dispatch instruction from ERCOT. Three of the four transmission providers did meet their full load shed obligations at a later point in time. The fourth transmission provider contended that it had not received the dispatch instruction.

Effect of Load Shed on Gas Delivery or Supply

At approximately 8:00 AM on February 2, ERCOT notified all transmission providers that gas companies were reporting low gas pressures, and requested that they confirm that no gas company feeds were included in their

¹³⁸ Cold load pickup is a phenomenon that takes place when a distribution circuit is re-energized following an extended outage of that circuit. Cold load pickup is a composite of two conditions: inrush and loss of load diversity. *Cold Load Pickup Issues: A Report to the Line Protection Subcommittee of the Power System Relay Committee of the IEEE Power Engineering Society*, May 16, 2008, § 2.1, at 3, available at http://www.pes-psrc.org/Reports/Cold_Load_Pickup_Issues_Report.pdf.

¹³⁹ One transmission provider's automated system includes an expectation of a 60 percent increase in load on any feeder coming off of its pre-determined outage period, and therefore requires that feeders in the next block must cover the expected increase before the first feeder can be restored. That transmission provider did report peak load shed amounts well above its requirement (about 49 percent over the required amount at one point), but attributed the reported over-shedding to several factors in addition to the cold load pickup assumptions used, including (1) restoration failure of a certain percentage of breakers; and (2) loads that did not come back on-line until manually re-set, including certain gas compressors.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

outage rotation feeders.¹⁴⁰ At 9:25 AM, as part of its third directive to restore 500 MW of load, ERCOT requested that transmission providers serving west Texas concentrate their restoration efforts in that region due to concerns about the impact of the outages on gas compressor facilities. At 10:45 AM, ERCOT notified some transmission providers that gas compressor stations in two west Texas counties were still without power, and requested that service be restored to those counties as soon as possible.¹⁴¹ In addition, some transmission providers reported additional requests from ERCOT about restoring power to specific gas facilities or regions, but noted that ERCOT did not appear to have reliable or current information as to which transmission or distribution service provider was providing electric service to those facilities.

The task force found that transmission providers currently have only limited information on overall system conditions in ERCOT, and in real-time can typically see nothing more than ERCOT's responsive reserve (PRC) levels and the status of generators connected to the transmission provider's own system. Many transmission providers indicated that they could perform better with respect to load shedding, particularly in increasing staffing and providing notice to the public, if they are able to get information about deteriorating system conditions from ERCOT earlier in the process.

Some transmission providers indicated they are already working on improvements to their public notification protocols, and believe that certain sensitive loads (including loads with back-up generation) could have benefitted from earlier notification of potential outages.

The task force also found that transmission providers with annual training programs, particularly those that require use of hands-on simulations or drills, tended to perform well during the February 2 load shedding event. Transmission providers with less frequent training, or that fail to simulate expected conditions during a load shed event, tended to have more problems with timely implementation of the required curtailment. Automated systems for shedding load may be helpful for larger transmission providers, but do not appear to be necessary

¹⁴⁰ One transmission provider reported that, upon receiving ERCOT's notice, it restored power to facilities believed to be compression facilities; these were later determined to be regulator stations, for which restoration of power would not affect pipeline pressure.

¹⁴¹ ERCOT directed one transmission provider to restore power to five specific counties in north/central Texas due to concerns about affected gas facilities, which restoration could only be done by working outside the automated outage rotation system to identify each feeder or circuit serving those counties.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

for successful implementation of a load shed program under ERCOT's current time requirements for implementation.

Price Effects of the Cold Weather Event

As discussed in the section of this report entitled "The Electric and Natural Gas Industries," ERCOT is an energy-only market. This type of market relies on scarcity pricing to provide price signals for the addition of needed resources. ERCOT transitioned from a zonal market to a nodal market in December 2010, and as part of its preparation for that transition, adopted rules in 2006 that included a Scarcity Pricing Mechanism that relaxed the then-existing system-wide cap of \$1,000 per MWh. ERCOT did this by gradually increasing the cap in accordance with a defined schedule to \$1,500 per MWh on March 1, 2007, to \$2,250 per MWh on March 1, 2008, and finally to \$3,000 per MWh on February 1, 2011, two months after the implementation of the nodal market and, as it happened, on the day before the severe weather impacts caused ERCOT to shed load.¹⁴²

The rapidly dwindling supply of generation on February 2 created a scarcity event and, not surprisingly, caused prices to spike. By 4:55 AM, prices had reached a sustained level of \$3,000 per MWh.¹⁴³

These high prices, coupled with the fact they occurred the day after the price cap had been raised to \$3,000 per MWh, fueled speculation that market manipulation may have been a factor. Such speculation was probably exacerbated by certain instances of past high prices, as well as two studies finding the existence of market power in the ERCOT markets.

In 2001, prices rose to the \$1,000 per MWh cap on the first day of operation of ERCOT's pilot zonal market.¹⁴⁴ During the winter storm of February 2003, high prices of \$990 per MWh in the balancing market and \$967 per MWh in the ancillary service market were later determined to have been partially caused by "hockey stick bidding."¹⁴⁵ According to two studies evaluating behavior in the

¹⁴² Potomac Report at 15.

¹⁴³ *Id.* at 20.

¹⁴⁴ The Steering Committee of Cities Served by Oncor and the Texas Coalition for Affordable Power, *The Story of ERCOT: The Grid Operator, Power Market & Prices under Texas Electric Deregulation*, at 32 (Feb. 2011), available at <http://tcaptx.com/downloads/THE-STORY-OF-ERCOT.pdf>.

¹⁴⁵ Public Utility Commission of Texas, *Report to the 79th Texas Legislature: Scope of Competition in the Electric Market in Texas*, January 2005, at 32, available at http://www.puc.state.tx.us/industry/electric/reports/scope/2005/2005scope_elec.pdf. Hockey stick bidding

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

ERCOT balancing market, large firms were found to have exercised unilateral market power between 2001 and 2003.¹⁴⁶ And in March of 2008, two days after the market cap rose to \$2,250 per MWh, prices hit the cap for three consecutive 15-minute intervals.¹⁴⁷

Given these historical events, suspicions concerning the causes of the high prices on February 2 were understandable. The Executive Director of the PUCT directed the IMM for ERCOT, Potomac Economics, Ltd., to investigate whether there was any evidence of market manipulation or market power abuse.

In its April 21 report to the PUCT, the IMM concluded there had not been any market manipulation during the cold weather event on February 2. The IMM further concluded that the ERCOT real-time and day-ahead markets operated efficiently, and that the shortage conditions were properly accompanied by scarcity level pricing, a phenomenon consistent with ERCOT's energy-only market design.¹⁴⁸

The IMM reached its conclusion by examining whether there had been any economic or physical withholding. The IMM's test for economic withholding was to determine whether energy had not been produced when the capacity would have been economic, given the prevailing price. Since all available capacity was being utilized when prices spiked, the IMM concluded there had been no economic withholding.¹⁴⁹ The IMM's test for physical withholding was to determine whether resources were made unavailable that were actually capable of providing energy and were economic at prevailing market prices. This determination

involves offers of a small, expendable quantity of energy or capacity well in excess of its marginal cost, which can set the marginal clearing price at times of short-term demand when all offers must be accepted. See Daniel Hurlbut, Keith Rogas, and Shmuel Oren, *Protecting the Market from "Hockey Stick" Pricing: How the Public Utility Commission of Texas is Dealing with Potential Price Gouging*, THE ELEC. J., April 2004, at 26-27.

¹⁴⁶ Ali Hortacsu & Steven L. Puller, *Understanding Strategic Bidding: A Case Study of the Texas Electricity Spot Market* (June 2007), <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.73.9947&rep=rep1&type=pdf>; Ramteen Sioshansi & Shmuel Oren, *How Good are Supply Function Equilibrium Models: An Empirical Analysis of the ERCOT Balancing Market*, 31(1) J. REG. ECON. 1 (2007).

¹⁴⁷ Eric S. Schubert, Shmuel Oren & Parviz Adib, *Achieving Resource Adequacy in Texas Via an Energy-Only Electricity Market*, in *ELECTRICITY RESTRUCTURING: THE TEXAS STORY* 70, 92 (L. Lynne Kiesling & Andrew N. Kleit, eds., AEI Press, 2009).

¹⁴⁸ Potomac Report at 1-2, 8.

¹⁴⁹ *Id.* at 8-9.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

required a review of the causes of outages and derates. After conducting this review, the IMM found no evidence that the outages and derates were caused by anything other than the physical inability of the generators to produce power.¹⁵⁰

The IMM observed that the scope of the outages and derates was widespread in geography, generating unit type, and by class of market participant.¹⁵¹ It also observed that those market participants that were able to operate their generation fleet at greater than 90 percent availability during the morning of February 2 were financially successful that day, and the market participants affected by significant generation outages were unprofitable.¹⁵² Furthermore, those market participants that lost significant generating capacity and were unprofitable on February 2 did not achieve gains on February 3 that significantly exceeded the previous day's losses, despite high day-ahead prices.¹⁵³ These findings suggested to the IMM that market participants had every incentive to offer their units' capacity into the market, had they been physically able to do so.

Based both on the IMM's study and on the task force's independent evaluation of the causes of the generator outages, there does not appear to be evidence that the high prices on February 2 were the result of market manipulation. Rather, they appear to be the natural result of scarcity pricing in an energy-only market.

Rio Grande Valley Event: February 3-4

In addition to the ERCOT-wide load shed on February 2, ERCOT experienced more localized difficulties on February 3 and February 4 that necessitated local load shedding. The area affected was the southernmost tip of Texas along the Rio Grande River, designated as the Lower Rio Grande Valley (LRGV).

The weather in the LRGV is typically mild. Temperatures in February for Brownsville, the largest city in the LRGV, average a high of 72 degrees and a low of 53 degrees. For February 2011 as a whole, Brownsville had a high of 90

¹⁵⁰ *Id.* at 12.

¹⁵¹ *Id.* at 10.

¹⁵² *Id.* at 14.

¹⁵³ *Id.*

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

degrees; on February 3, however, the high reached only 36 degrees, with a low of 28 degrees.¹⁵⁴

Load in the LRGV generally exceeds available local generation, making the area dependent on imports. The Rio Grande Valley import capability consists of a group of five elements, three 138 kV and two 345 kV transmission lines, owned and operated by American Electric Power (AEP), that allow for the import of energy into the LRGV area. The Rio Grande Valley import limit is a contingency import limit based on the loss of either of the two series compensated 345 kV lines that transmit electricity into the LRGV. The contingency limit is 1200 MW, with economic redispatch occurring at 1100 MW. This limit was exceeded for short periods during the evening hours of February 2, and for over 30 consecutive hours beginning on February 3 and concluding on February 4.

Two types of events can trigger load shedding to prevent an uncontrolled loss of load: under-frequency and under-voltage. Under-frequency load shedding is designed to rebalance load and generation within an electrical island following a system disturbance. Under-voltage load shedding is designed to prevent local area voltage collapse. While the ERCOT-wide February 2 event was the result of under-frequency concerns, the issue in the LRGV was one of under-voltage. Had the entities in the LRGV not implemented manual load shedding on February 3, a subsequent contingency could have resulted in the activation of automatic under-voltage load shedding.

On February 3, the LRGV area hit an all-time winter peak demand of 2734 MW.¹⁵⁵ A total of 829 MW of local generation was on scheduled outage that day, and the picture was further complicated by the loss of the three Frontera units, totaling 486 MW. The two Frontera combustion turbines CTG-1 and CTG-2 tripped due to frozen control equipment pneumatics at 9:47 PM and 9:59 PM, respectively, followed by the steam turbine CTG-3 at 10:00 PM. The import limit of 1200 MW had already been exceeded, beginning at 6:23 AM. When the three Frontera units tripped in rapid succession, the import level rose to 2074 MW (172.8 percent of the limit of 1200 MW). Additionally, the bus voltages at some substations dipped to 91 percent to 93 percent of nominal, which is outside the normal AEP Texas operating voltage range of 95 percent to 105 percent nominal. (The automatic under-voltage load shedding system in the LRGV activates when the voltage declines to 90 percent for three seconds.)

¹⁵⁴ Weather Underground, *Almanac for Brownsville*, http://www.wunderground.com/history/airport/KBRO/2011/2/3/Daily_History.html.

¹⁵⁵ Texas Reliability Entity, *Event Analysis: February 3-4, 2011 Lower Rio Grande Valley Load Shed Category 2f.1 Event* at 4 (April 15, 2011) (LRGV Event Analysis Report).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The transmission providers for the LRGV area are AEP, Public Utilities Board of Brownsville (BPUB), and the South Texas Electric Cooperative (STEC). AEP had previously developed a procedure with ERCOT, STEC, and BPUB that specified the load allocation for any necessary manual load shed in the event of the loss of one of the 345 kV transmission lines. The entities decided to use that plan for this event, even though it was not caused by the loss of a line but rather by the loss of Rio Grande Valley generation. AEP initiated the load shedding and the three entities each manually shed their portion of the target 300 MW load shed, beginning the process at 10:06 PM on February 3.¹⁵⁶ The maximum actual load shed of 459.5 MW occurred at 10:59 PM. (Power was fully restored to most customers in the early morning hours of February 4.)

Approximately 115,000 customers were affected by the rolling blackouts, with AEP contributing 60 percent of the load shed obligation and BPUB and STEC each contributing 20 percent. The task force determined that load shedding was executed well by all three entities and the required levels of load shedding were reached within ERCOT's specified 30-minute period. The entities attempted to rotate the load shed through different circuits, but due to the size of the allotments of BPUB and STEC relative to their total load, as well as the number of critical loads on their systems, the rotation periods for each circuit of load shedding were longer than desired and more frequent than during the ERCOT-wide load shed of February 2.

Some of the transmission providers in the LRGV region expressed concerns about communications with ERCOT. AEP initiated the first phase of the load shed and then requested ERCOT to notify the other transmission providers to shed their portion, as opposed to ERCOT directing the simultaneous shedding of load. As a result, AEP proceeded alone for the first phase of the load shed. The transmission providers also observed that a public announcement made by ERCOT on February 3, advising customers that further outages appeared unlikely, did not accurately reflect the situation in the LRGV and complicated the conduct of their localized load shed.

The task force concluded that in order to prevent similar problems in the future, additional generation or transmission lines are needed to reinforce the LRGV area. This is in accord with ERCOT's Regional Planning Group analysis, which concluded that there is a need for transmission or market solutions in the LRGV to meet forecasted load beyond 2014.¹⁵⁷ AEP Service Company has

¹⁵⁶ LRGV Event Analysis Report at 20.

¹⁵⁷ *Lower Rio Grande Valley (LRGV) 345 kV Project Analysis*, ERCOT (May 13, 2011), http://www.ercot.com/content/meetings/rpg/keydocs/2011/0513/ERCOT_Lower_Rio_Grande_Valley_345_kV_Project_Analysis.pdf.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

proposed a new 345 kV transmission line from the Laredo area into the LRGV; however, improvements at this time are in the early planning stages.

February 10, 2011

In analyzing the implications of the February 2 blackouts, it is instructive to compare that day with February 10, when ERCOT did not shed either firm or interruptible load despite setting a new winter peak.¹⁵⁸ Cold weather was again expected on that day, and actual temperatures in the ERCOT region averaged a low of 19 degrees with a 12 degree wind chill. (This compares to a low on February 2 of 19 degrees with wind chill of 4 degrees; however, low temperatures during the earlier event were more persistent, remaining in the low twenties for four days with wind chills between 10 and 14 degrees.) The average high temperature in the ERCOT region on February 10 was over 42 degrees (compared to an average high between February 2 and February 5 that remained below freezing).

ERCOT avoided service interruptions on February 10 largely because there were far fewer forced outages. ERCOT reports that 11 units, totaling 2160 MW of generation, were forced offline at some point during the day. The biggest difference between February 2 and February 10 was the number of units forced offline on February 2 just during the early morning hours. The cumulative net outages on that morning exceeded 14,700 MW,¹⁵⁹ whereas for the entire day on February 10, only 2160 MW were forced offline. The equivalent total outages for the entire day of February 2 was 21,400 MW, a ten-fold difference.

The majority of the forced outages in ERCOT on February 2 were weather-related, while on February 10, few were weather-related (those few were the result of frozen valves, a frozen transmitter and automatic temperature cut-offs at some wind farms). Representative causes of forced outages on February 10 included control issues, a condensate pump that was out of service, the loss of a vacuum pump, a low head level in a cooling lake, frozen valves, low gas header pressure, and a boiler tube leak.

There appear to be three reasons ERCOT was not forced to shed load on February 10: repairs made and protective measures taken during the event of February 2 remained in place; the temperatures on February 10 were not quite as

¹⁵⁸ The peak of 57,915 MW occurred at 7:15 AM.

¹⁵⁹ “Cumulative net outages” subtracts out those units that were successfully brought back online.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

cold and the cold temperatures were of shorter duration; and the wind chill was, in the main, not as severe.

In interviews with the task force, generator operators mentioned that on or after the earlier event they had installed wind breaks, including tarps or enclosures, added portable heaters or heat lamps, repaired or added insulation, and repaired or added heat tracing. One generator changed its procedures for monitoring the reliability of its heat tracing. Some generators also continued their increased level of staffing to address freeze protection issues, and others changed elements of their control logic to prevent units from automatically tripping.

Some of the vulnerabilities identified and addressed the week before included re-routing piping or moving vulnerable equipment, correcting transformer oil levels at wind farms, and adding freeze-resistant chemicals. At least five generators kept units running, started units earlier or took other measures to keep from having a cold start. After so many static sensor and other lines froze the week before, some units left water lines draining, or took other measures to keep water flowing.

The storm on February 10 was concentrated in Oklahoma and northern Texas, unlike the more widespread storm of February 2. Temperatures by and large were somewhat less severe, especially during the day when they rose above freezing. A number of generator operators told the task force that the difference in temperatures and the shorter duration of the cold spell on February 10 were significant factors in the improved performance of their units.

Lastly, the wind chill in some areas was not as extreme on February 10 as during the preceding week. Some generator operators cited the lower wind speed as a significant factor in their improved performance, an assessment with which ERCOT concurred.¹⁶⁰

Salt River Project

ERCOT was not the only entity in the Southwest that was forced to shed load during the storm of February 1 through February 5. SRP shed 300 MW of load on February 2, affecting 65,000 customers. However, only some of the generation losses leading to SRP's load shed were weather-related.

¹⁶⁰ Of special interest to wind units was the absence of precipitation that would ice their turbine blades. Several wind farm operators mentioned this absence as a factor in their improved performance.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

SRP's problems began at 6:54 PM on February 1, when Unit 1 at the Navajo Generating Station (NGS) in Page, Arizona, tripped offline.¹⁶¹ Page was experiencing colder than average temperatures, reaching a high of 36 degrees and a low of 17 degrees, and facing average wind speeds of 10 miles per hour. NGS Unit 1 tripped due to these freezing conditions when a sensing line leading to a waterwall pressure transmitter froze. The trip resulted in a loss of 330 MW of generation for the SRP balancing authority area.¹⁶²

In response to the trip, SRP called on the SRSG for assistance and imported its allowed amount of 170 MW. It also deployed 80 MW of spinning reserves and curtailed 48 MW of interruptible load. At 8:10 PM, SRP restored the interruptible load.

To make up for the loss of NGS Unit 1, SRP's system operator scheduled Santan Generating Station (SGS) Unit 6, a 275 MW combined cycle unit (consisting of a combustion turbine and a steam turbine), to start at 5:00 AM on February 2 (it had not been included in SRP's day-ahead plan). Understanding that it might need additional generation on February 2, SRP also decided to keep SGS Unit 5, a 570 MW unit, online for the following day.

On February 2, SRP's difficulties resumed at 2:56 AM, when Coronado Generating Station (CGS) Unit 2, which is coal-fired, tripped offline due to a non-weather related mechanical problem with its coal pulverizers. Although the unit was running at only 130 MW at the time of the trip, it was scheduled for its full 389 MW output for the morning peak. The loss of CGS Unit 2 also tripped Coronado 500 kV breakers 945 and 948.

SRP lost another 75 MW at 3:20 AM, when Unit 4 at the Four Corners Power Plant (FC) tripped due to control valve problems (all 750 MW of the unit was lost, of which SRP has a ten percent share). The FC unit trip was weather-related and occasioned by frozen sensing lines. SRP dispatched SGS Units 1, 2, 5 and 6 to replace the loss of FC Unit 4 for the morning peak.

SRP was able to close the Coronado 500 kV breaker 945 at 4:21 AM, and brought Coronado 2 back online. Shortly thereafter, at 5:07 AM, SRP dispatched SGS Units 1 and 2 at 90 MW each to meet increasing system loads, and at 5:15 AM ramped SGS Unit 6 to 236 MW.

¹⁶¹ Details are based on information provided to the task force by SRP.

¹⁶² NGS Unit 1 is a 750 MW unit that is owned by the Salt River Project, U.S. Bureau of Reclamation, Los Angeles Department of Power & Light, Arizona Public Service, NV Energy, Inc., and Tucson Electric Power. SRP has a 21.7 percent ownership in the unit. NGS Unit 2, discussed below, has the same ownership structure and total output.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

At 5:18 AM, SRP dispatched duct firing on SGS Units 5&6.¹⁶³ A few minutes later, at 5:22 AM, the SGS Unit 6 steam turbine tripped, although the unit's combustion turbine was able to continue supplying generation. The steam unit had an output of 80 MW. At this time, SRP system operators told the generator operators at SGS that they needed the steam turbine back online as quickly as possible. The system operators were not aware, and were not advised by the generator operators, that in order to get the steam turbine back online, the combustion turbine would have to be ramped down significantly. Between 5:22 AM and 5:44 AM, as a result of the ramping down of the combustion turbine, the output of SGS Unit 6 was reduced from 159 MW to 15 MW.

SRP experienced a flurry of activity between 5:22 AM and 6:00 AM. After the loss of the SGS Unit 6 steam turbine, SRP dispatched the Mormon Flat Hydro (MFH) Unit 2 to come online at 50 MW, interrupted 38 MW of instantaneous interruptible load, and at 5:30 AM dispatched Horse Mesa Hydro (HMH) Units 1, 2 and 3, for a total of 30 MW additional generation. SRP's system operators also directed its merchant group to purchase 100 MW for the 7:00-8:00 AM hour. At 5:31 AM, SRP called on MFH Unit 1 for 10 MW, and also requested that a large interruptible customer drop 100 MW of 10-minute interruptible load. At this point SRP's reserves were diminishing, and SRP used the interruptible load to increase its spinning reserves.

At 5:39 AM, SRP was able to bring SGS Unit 2 online at 92 MW, and at 5:40 AM, SRP's merchant group called on another interruptible customer to drop 29 MW of contracted interruptible load in the 6:00-7:00 AM hour. However, Tucson Electric Power contacted SRP at the same time to report that it had lost Springerville Unit 3, which diminished SRP's available capacity by another 25 MW. At 5:44 AM, SRP determined that SGS Unit 6 would not be able to return to service, resulting in a total loss of 236 MW of capacity.

SRP was able to bring on SGS Unit 2 online at 40 MW at 5:45 AM, and SGS Unit 1 at 40 MW at 5:57 AM. At 6:00 AM on February 2, SRP system load was running at 3557 MW, which was 161 MW higher than its day-ahead schedule.

At 6:02 AM, SRP dispatched Units 4, 5, and 6 at the Agua Fria Generating Station (AFGS), at approximately 70 MW each, to recover reserves and meet forecasted load. SGS Unit 2 also reached full load of 100 MW at this time. Two minutes later SRP dispatched Kyrene Generating Station (KGS) Units 5 and 6, at 60 MW each. Unit 6 was brought online at 6:11 AM and Unit 5 at 6:14 AM. SRP

¹⁶³ Duct firing is a process involving additional burners being fired for a heat recovery steam generator (HRSG) to increase steam production and output. The output of the burners combines with the hot exhaust gas from the gas-fired turbines to create steam.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

dispatched the 41 MW KGS Unit 4 at 6:08 AM and HMH Units 1, 2 & 3 at 10 MW each at 6:09 AM. At this point all available SRP generating units were dispatched, and SRP purchased an additional 100 MW to begin at 6:20 AM.

SRP issued a Capacity Alert at 6:17 AM. (A Capacity Alert is an internal alert telling operators in the balancing authority that SRP believes that if another unit were to trip, the balancing authority would have trouble recovering.) A Capacity Alert is a precursor to a NERC EEA-1.

Five minutes later, NGS Unit 2 tripped due to frozen waterwall pressure sensing lines. The trip resulted in the loss of 350 MW for the SRP balancing authority area, and constituted the event that triggered load shedding. In response to the NGS Unit 2 trip, SRP again called on SRSB for assistance and was supplied with 128 MW, 82 MW less than anticipated. EPE, a neighboring balancing authority experiencing its own difficulties, told SRP that it could not deliver the assistance it was obligated to provide under the SRSB Agreement.

Immediately after the NGS Unit 2 tripped at 6:22 AM, SRP's system operator determined, based on the information available to him, that the remaining reserve and emergency assistance was insufficient to recover SRP's ACE in a timely manner.¹⁶⁴ The operator concluded that 300 MW of firm load needed to be shed to insure stable operations of the bulk electric system should additional generation trip offline. The system operator contacted its reliability coordinator, WECC's LRCC (Loveland Reliability Coordination Center), to notify it of the impending load shed. At 6:24 AM LRCC directed SRP (as transmission provider) to shed 300 MW. At the same time, KGS Units 5 and 6 reached full load of 62 MW each, and SRP's merchant group purchased 190 MW for the 7:00-8:00 hour.

At 6:29 AM, SRP called on the last of its 10-minute interruptible load, curtailing 136 MW. At the same time, SRP's distribution service provider initiated its rotating load shed program. Once initiated, load shed is to take place within one minute; however, SRP's distribution service provider encountered problems, requiring five full minutes to initiate the sequence. At 6:31 AM, LRCC declared an EEA 3 for SRP, which was seven minutes after SRP had initiated the shedding of 300 MW of load.

SRP reports that the 300 MW load shed event affected approximately 65,000 customers.

¹⁶⁴ ACE, or area control error, refers to the instantaneous difference between a balancing authority's net actual and scheduled interchange with other balancing authorities, taking into account the effects of frequency bias and correction for meter error.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Immediately after the load shed was initiated, SRP's ACE returned to normal. At this time SRP also restored its reserves to meet its SRSG reserve requirement. At 6:34 AM, Springerville Unit 3 tripped offline due to high furnace pressure, cutting 75 MW of generation (although this did not affect SRP's operations).

AFGS Units 4, 5 and 6 remained online and ramping to full load, and at 6:34 AM SRP's system operator instructed the distribution service provider to restore 100 MW of firm load. However, instead of restoring only the 100 MW, the distribution service provider mistakenly restored all 300 MW of the load that was shed. At 6:45 AM, the distribution service provider realized its mistake and, without further instruction, shed 200 MW of the load that had been restored. Prior to the second load shed of 200 MW, SRP's ACE had returned to normal.

At 6:52 AM, KGS Unit 4 came online and began ramping to full load, and the system operator directed the restoration of another 100 MW of shed load. At 6:55 AM, SGS Unit 6 returned to service and a minute later the system operator directed that the final 100 MW of shed load be restored. By 6:57 AM, approximately a half-hour after the initial load shed, SRP was able to restore service to its customers.¹⁶⁵ At 7:05 AM, LRCC declared a return to an EEA 0 condition effective as of 6:59 AM.

El Paso Electric Company

During the cold weather event, EPE experienced forced outages of all but one generator in its El Paso area fleet. Because of the significant loss of its local generation (six out of seven operational units) and the resulting loss of dynamic reactive support, EPE was limited in the amount of generation that could be imported on its transmission system.¹⁶⁶

With limited import capability and limited local generation, EPE had to operate its system in such a way as to prevent cascading due to voltage instability. It was therefore necessary for EPE to reduce loads in its service area by manual load reduction. Load shedding occurred four times between February 1 and

¹⁶⁵ Although SRP had directed that all load be restored at this time, some of the distribution service provider's breakers would not close, leaving 4000 customers without service until 9:43 AM.

¹⁶⁶ EPE utilizes WECC Path 47 to import power from Palo Verde and Four Corners. The capability of this path is limited by post-contingency voltages. EPE can also utilize the Eddy DC tie in New Mexico to help regulate the flows on Path 47 by importing up to approximately 200 MWs from Southwestern Public Service (SPS) to the East.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

February 4, totaling up to approximately 1023 MW and affecting 253,000 customers. Two of the load shed events occurred on February 2, one on February 3 and one on February 4 (all due to voltage instability concerns).

The four-day sequence of events is set forth below.¹⁶⁷

Tuesday, February 1, 2011

On February 1, an arctic air mass moved in across the Las Cruces and El Paso area. Temperatures hovered in the low 40s between midnight and 4:00 AM, but dropped as the wind changed direction. The temperature dipped below freezing at approximately 8:51 AM and then plummeted into the middle teens by the late evening hours. Maximum temperature for the day was 43 degrees and the minimum was 14 degrees.

As the colder air moved in, gusty winds picked up in the late evening, measuring up to 26 mph at the El Paso International Airport. These gusts, combined with air temperatures in the middle teens, produced wind chill values below zero. The peak wind gust reached on February 1 was 43 mph (during the 1:00 AM hour).

Timeline of Events

- At 6:34 PM, the Coyote-Dell City 115 kV line tripped (reportedly as a result of gunshot damage to a conductor).
- At 8:07 PM, the first of EPE's gas-fired generators, Newman No. 3, tripped (loss of 40 MW).¹⁶⁸
- At 10:15 PM, Rio Grande No. 6 tripped (loss of 50 MW).
- At 10:15 PM, system controllers contacted LRCC, EPE's reliability coordinator, and advised it of the loss of local generation.
- At 10:52 PM, system controllers requested that interruptible loads be interrupted due to the extreme weather conditions and the loss of local generation.

¹⁶⁷ Details are based on information provided to the task force by EPE.

¹⁶⁸ The various causes of EPE's unit trips are discussed in the following section of the report, entitled "Causes of the Outages and Supply Disruptions."

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- At 11:45 PM, the Copper Generator was brought online.

Wednesday, February 2, 2011

The air temperature continued to drop during the morning of February 2, falling from 13 degrees at 1:00 AM to 8 degrees by 8:00 AM. Temperatures moderated during the afternoon, reaching 15 degrees. On February 2, the maximum temperature was 15 degrees (45 degrees below normal) and the minimum temperature was 6 degrees.

The maximum temperature for the day was the coldest maximum (high) temperature ever recorded in El Paso, Texas. A few wind gusts up to 24-26 mph occurred around mid-day. This, combined with the frigid air temperatures, produced wind chill values of -9 to -10 degrees. The peak wind speed reached on February 2 was 26 mph.

Timeline of Events

- At 12:10 AM, Newman 5 GT3 tripped.
- At 12:26 AM, Newman 5 GT4 tripped.
- At 1:49 AM, Rio Grande No. 8 tripped.
- At 1:53 AM, system controllers contacted LRCC, which declared an EEA 1.
- At 2:02 AM, EPE purchased power from SPS; the Eddy DC tie was opened and ramped to 100 MW.
- At 2:27 AM, a switching order was given by the system controller to synchronize PNM's Luna Energy Facility (Luna) to the grid, permitting the transmittal of power EPE had purchased from PNM.
- At 3:17 AM, Newman Generator No. 4 GT1 tripped.
- At 3:20 AM, Four Corners Unit No. 4 tripped.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- At 5:07 AM, the HVDC terminal at the Eddy DC Tie experienced a runback¹⁶⁹ from 100 MW to 48 MW.
- At 5:12 AM, system controllers again contacted LRCC, and the EEA level was heightened to EEA 2. This Alert advised other utilities that EPE was placing its load management procedures in effect due to its energy deficient condition. Actions taken pursuant to this Alert included public appeals to reduce demand, made through media announcements, and other demand-side management procedures.
- At 6:28 AM, the Coyote-Dell City 115 kV line was restored.
- At 7:12 AM, the Newman No. 4 steam turbine (ST) tripped, and the Newman-Butterfield 115 kV line opened at Newman (tripping the line).
- At 7:16 AM, the Newman No.4 GT2 unit tripped. With the loss of Newman No.4 GT2, the Copper unit was the only local unit remaining online that could supply dynamic reactive support (it was producing 55 MW of power).
- At 7:22 AM, system controllers initiated load shedding in order to balance load with generation and maintain voltage stability. Area load was at 982 MW at the time, and approximately 170 MW of firm load was shed.
- At 7:23 AM, EPE again contacted LRCC and EPE's EEA status was increased to an EEA 3. This alert advised other utilities that EPE had implemented firm load interruptions.
- At 7:55 AM, system controllers saw that Luna had lost approximately 130 MW of generation. Another 103 MW of load was shed, with load stabilizing at 710 MW.
- At 8:16 AM, Luna ramped up to 235 MW.
- At 9:51 AM, the combustion turbine portion of PNM's Afton combined cycle generator was placed online (the steam turbine portion of this generator experienced problems and remained unavailable throughout the

¹⁶⁹ "Runback" is a manually or automatically controlled decrease in output designed to protect against loss of thermal transfer capability or transient angle instability.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

event). EPE made arrangements to obtain power from that unit on an hourly basis.

- At 12:17 PM, controlled load shedding ended, with load at 977 MW.
- At 12:19 PM, LRCC was contacted and EPE's EEA alert level was decreased to EEA 2.
- At 6:04 PM, the terminal at the Eddy DC tie tripped (opening the Amrad-Eddy 345 kV line).
- At 6:11 PM, load shedding resumed, and continued for approximately two hours and 45 minutes. Load shed amounts varied between 100 and 250 MW during this period.
- At 6:15 PM, EPE contacted LRCC, which again placed EPE under EEA 3 status.
- At 8:58 PM, load shedding terminated because of reduced load demand. EPE contacted LRCC, which changed the EEA alert level back to an EEA 2.
- At 11:04 PM, the Eddy DC tie (and the Amrad-Eddy 345 kV line) resumed operation. (According to SPS, operating agent for the DC Terminal, the tie had tripped due to loss of thyristors.¹⁷⁰)

Thursday, February 3, 2011

The lowest temperatures of the event were experienced in the El Paso area during the morning of February 3, 2011. Temperatures remained in the single digits from midnight through 10:00 AM, slowly climbed into the teens during the late morning, and reached a maximum of 18 degrees at 2:51 PM. The high temperature for the day was 18 degrees, and the low was 1 degree. (The high temperature was 43 degrees below normal, and the low was 34 degrees below normal). The peak wind speed reached on February 3 was 20 mph. The combination of frigid air temperatures and wind speeds produced wind chill values from midnight to 11:00 AM of -10 to -17 degrees.

¹⁷⁰ A thyristor is a semiconductor with an anode, a cathode and a gate. Thyristors have the ability to switch high voltages and withstand reverse voltages, and are used in switching applications, especially in AC circuits, for AC power control, and overvoltage protection for power supplies.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Timeline of Events

- At 3:45 PM, PNM's Afton CT tripped.
- At 4:23 PM, PNM put the Afton CT back online.
- At 5:00 PM, as the evening load increased, LRCC was contacted, and EPE's alert status was elevated to EEA 3.
- At 5:30 PM, controlled rotating load shedding resumed for just over five hours. During this period, the load shed amounts varied between 100 MW and 250 MW.
- At 6:52 PM, Newman 4 GT1 was brought online.
- At 7:20 PM, Newman 4 GT1 tripped.
- At 9:32 PM, Newman 4 GT1 returned online.
- At 10:30 PM, Newman 4 GT2 was brought online.
- At 10:30 PM, EPE terminated the controlled rotating load shedding.
- At 10:40 PM, LRCC lowered the EEA level to Alert Level 2.

Friday, February 4, 2011

On February 4, although skies were clear and winds relatively calm, temperatures were as low as 3 degrees during the early morning hours. By late morning, temperatures moderated, reaching the middle 20s by 12:00 PM. The temperature continued to rise during the afternoon, and the high for the day was 37 degrees. Winds, with speeds under 10 mph, were generally light and variable in direction. The low for the day was 3 degrees. (The maximum air temperature was 24 degrees below normal and the minimum air temperature was 32 degrees below normal).

Timeline of Events

- At 2:02 AM, Newman 4 GT2 tripped.
- At 2:04 AM, Newman 4 GT1 tripped.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- At 3:17 AM, PNM's Luna steam turbine tripped.
- At 3:23 AM, one Luna gas turbine dropped from 90 MW to 11 MW.
- At 3:51 AM, the Luna steam turbine was brought back online and slowly ramped up.
- At 6:30 AM, LRCC issued an EEA Level 3 for EPE. With Copper again as the only local unit online, controlled rotating load shedding of between 100 MW and 250 MW resumed.
- At 6:49 AM, Newman 4 GT2 was brought online.
- At 12:05 PM, the controlled rotating load shedding ended.
- At 12:12 PM, the RC changed EPE's alert status to an EEA Level 2.
- At 3:57 PM, Newman 5 GT4 unit was brought online and remained stable at 50 MW.
- At 5:12 PM, the Rio Grande 8 unit was brought online.

Due to the added generation, which provided the necessary dynamic reactive support, no controlled rotating load shedding was required for the Friday night peak load period or thereafter during the event.

Saturday, February 5, 2011

- At 4:07 PM, Newman 5 GT3 came online.
- At 4:30 PM, LRCC modified EPE's alert status to an EEA Level 1.

Sunday, February 6, 2011

- At 9:46 AM, LRCC decreased EPE's alert status to an EEA Level 0.

Public Service Company of New Mexico

PNM set a new record winter system demand during the February cold weather event and experienced outages on some of the generating units it owns,

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

co-owns, or from which it purchases power.¹⁷¹ PNM was generally able to meet its system load requirements and also to provide energy assistance to another utility. On February 3, however, PNM was forced to implement a localized rolling blackout in the Alamogordo and Ruidoso areas in southern New Mexico, and experienced an outage in the town of Clayton in northeastern New Mexico.

In the Alamogordo and Ruidoso areas, the February 3 rolling blackout was implemented at 5:21 AM by the PNM Distribution Operations Center, as a result of a transmission line outage. The PNM Amrad to Alamogordo 115 kV transmission line locked out due to a failed conductor clamp, a condition that was apparently unrelated to the weather. As a result, the Las Cruces to Alamogordo 115 kV transmission line, owned by Tri-State Generation and Transmission Association, Inc. (Tri-State), became overloaded and required load relief from PNM and Tri-State. PNM implemented its share of the load curtailment by sequential curtailment of two separate feeder lines. Approximately 20,207 customers were affected, with an estimated load loss of up to 22.1 MW. All circuits were fully restored at 8:08 AM.

The outage in Clayton began at 5:03 AM as a result of the outage of a Tri-State 69 kV transmission line that serves PNM's Van Buren substation, located in Clayton. A static wire, stretched by the extremely cold weather, snapped and fell on one of the phases of the line, interrupting service to the town. All service was restored at 6:54 AM. The estimated load lost was 3.7 MW.

Southwest Power Pool

SPP also experienced severe weather conditions over much of its footprint during the February cold weather event. However, none of its entities was forced to shed load. Three BAs within SPP declared varying levels of EEAs due to tripping or derating of generating resources or deficiencies in natural gas supply. In one instance, SPS requested an EEA 1 following the trip of a 250 MW gas-fired generating unit. SPS had all of its available resources in use and issued public appeals for energy conservation. In a second instance, Oklahoma Gas & Electric Company (OG&E) experienced multiple generation losses on February 2 and February 3, and requested four separate EEA 2 declarations during the week. It was unable to meet its energy commitments to the reserve sharing group run by SPP. In the last instance, Sunflower Electric Cooperative (Sunflower) requested an EEA 3 on February 2 following the loss and subsequent derating of a large coal

¹⁷¹ Generating units affected, to a greater or lesser degree, included Four Corners Unit 4, Reeves Unit 1, Reeves Unit 3, Delta Person CT, Valencia, Afton, LGS Units 1 and 2, and Luna Unit 2.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

generating unit. The failure to start of a gas-fired combustion turbine aggravated the situation, which continued until the afternoon of February 3. During this period, Sunflower was unable to meet its energy commitments to the SPP reserve sharing group. However, following declaration of the EEA 3, Sunflower obtained sufficient transmission service to purchase energy and was able to meet its own firm energy commitments, thereby avoiding the need to shed load.

In SPS's case, its purchases over the Blackwater Tie (a connection between the Western and Eastern Interconnections) were lost between 9:00 AM and 10:00 AM on February 2, due to capacity emergencies in the Western Interconnection. SPS replaced this purchase with a 100 MW purchase from Public Service Company of Colorado, importing it over the Lamar Tie (another one of the connections between the Western and Eastern Interconnections). SPS ultimately increased this purchase to 210 MW, and was later also able to make limited purchases through the Blackwater Tie.

Notwithstanding SPS's transactions over the ties, the majority of the purchases made by the energy-deficient utilities within SPP were made from other SPP entities. Thus, even if SPP had been separated from its neighbors by asynchronous ties, as is ERCOT, it probably would not have had to shed load during the February event. This suggests that the problems ERCOT experienced did not directly relate to its functionally separate interconnection status, but rather to the ability and preparedness of the generators within its footprint to operate as scheduled during the severe weather conditions.

B. Natural Gas

The extreme cold experienced in early February 2011, particularly on February 2 and February 3, caused widespread production declines. These reductions were typically the result of freeze-offs,¹⁷² mostly at wellheads but also in nearby processing plants. To a lesser extent, other equipment reliability issues contributed to the problems, both at the wellhead and at processing and treating facilities. The rolling power blackouts in ERCOT also played a role in the Fort Worth Basin, as did customer curtailments in the Permian Basin. These supply reductions had adverse effects all the way down the delivery chain.¹⁷³

¹⁷² A "freeze-off," as described earlier, occurs when water produced alongside the natural gas crystallizes or freezes, completely blocking off the flow and shutting down the well.

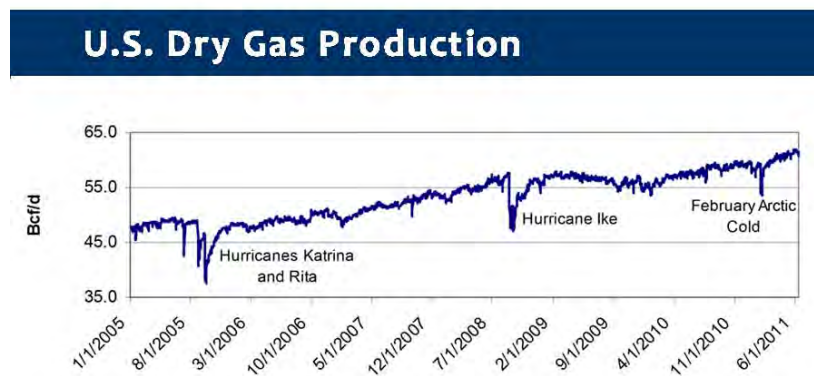
¹⁷³ Unless otherwise noted, the entity-specific data was obtained from materials submitted to the task force by producers, processing plants, pipelines, and LDCs.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

This subsection summarizes the supply shortfalls resulting from production declines in the basins, discusses the resulting reduced gas volumes and pressures experienced by the pipelines, and ends with a detailed examination of the retail curtailments made by LDCs in the affected states of New Mexico, Arizona, Texas, and California.

Producing and Processing Facilities

The reductions in supply experienced during the cold weather event were comparable in magnitude to production shut-ins during hurricanes. The following chart illustrates this point.

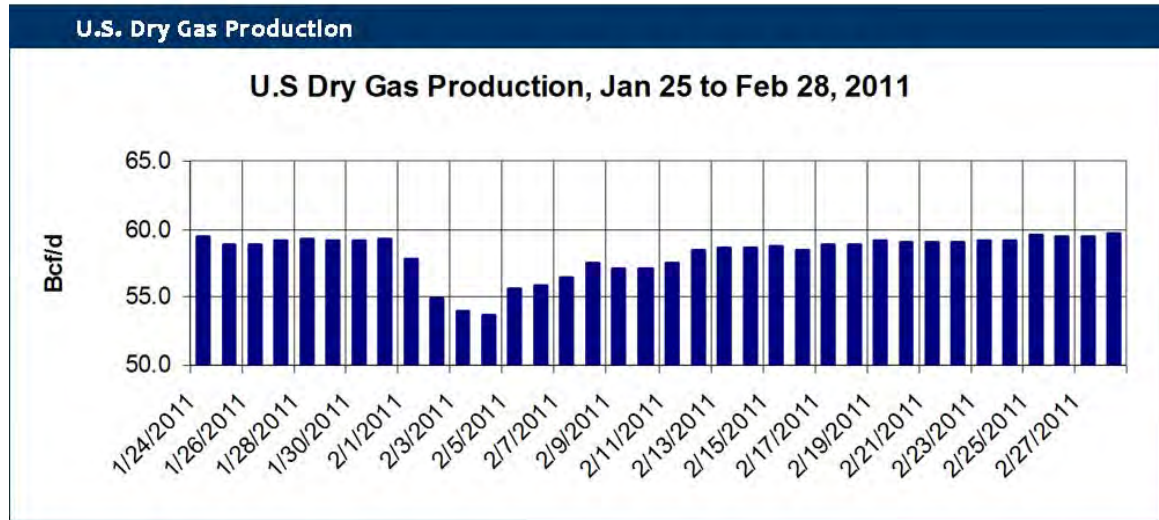


Source: Task Force chart based on Bentek data

Relative to average dry gas production of 59.22 Bcf per day on January 31, 2011, Bentek estimates that production in the first week of February declined by 5.55 Bcf per day, a reduction of 9.4 percent. The decline began on February 1 and reached its lowest level on February 4.¹⁷⁴

¹⁷⁴ Data is based on task force analyses using supply and demand history from Bentek.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



Of the 5.55 Bcf per day decline during the first week in February, 79 percent, or 4.36 Bcf per day, occurred in production basins in Texas and New Mexico (where production declined by 21 percent). Both the San Juan Basin in northern New Mexico and the Permian Basin in west Texas and southeastern New Mexico tend to experience production declines with low temperatures, and the February event was no exception. The declines in these basins, together with the large increases in demand, were almost exclusively responsible for the gas curtailments in Texas, New Mexico and Arizona.¹⁷⁵

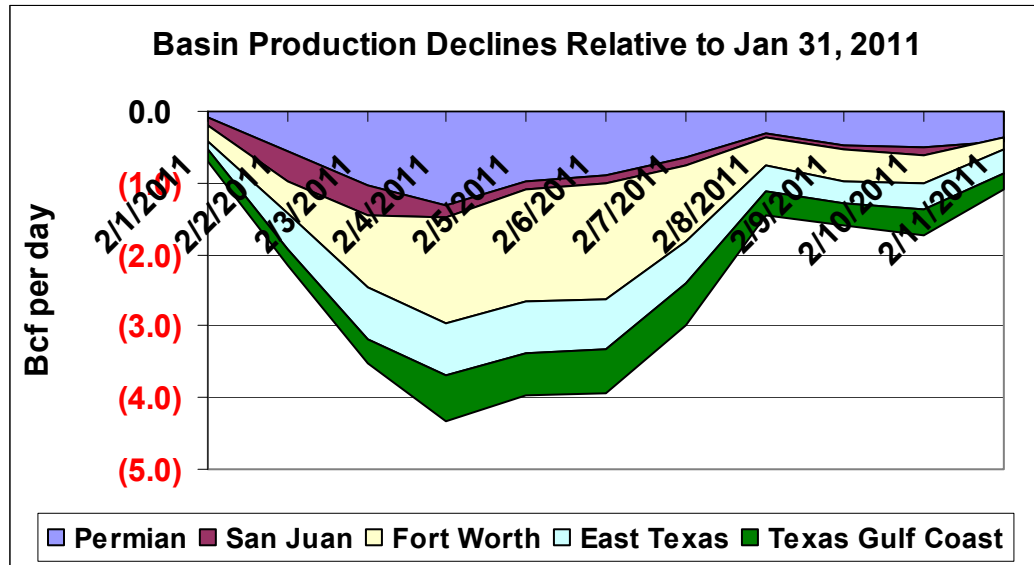
This weather event was so extreme that production freeze-offs were experienced not only in the San Juan and Permian Basins, but throughout Texas and as far south as the Gulf Coast. Based on scheduled pipeline receipts, the task force estimates that production in the Fort Worth Basin declined by 1.63 Bcf per day compared to the last week of January, 2011; East Texas Basin production declined by 0.72 Bcf per day; and Gulf Coast Basin production declined by 0.65 Bcf per day.¹⁷⁶ The shortfalls in these additional Texas basins, while not directly a cause of the natural gas curtailments, did contribute to fuel-related electric

¹⁷⁵ Production declined by 0.43 Bcf per day in the San Juan Basin and by 1.31 Bcf in the Permian Basin, based on task force analyses of Bentek supporting data, pipeline receipts and flow data from El Paso and Transwestern.

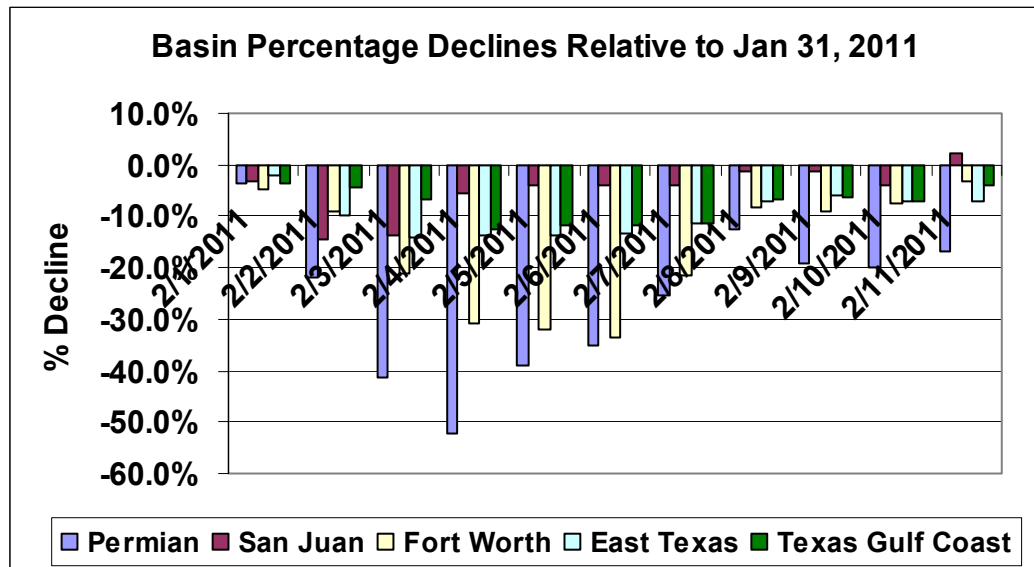
¹⁷⁶ Staff's analysis based on supporting data, display reports and data warehouse on file with Bentek (unpublished); see also *Market Alert: Deep Freeze Disrupts U.S. Gas, Power, Processing*, Bentek Energy LLC, Feb. 8, 2011, at 2-6; materials submitted to the task force by pipelines. Note that basin level production reductions may not be equal to the total February 4 reduction as not all basin level maximum reductions occurred on February 4.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

generation failures in ERCOT. The following charts demonstrate absolute and percentage declines by production basin.



Source: Task Force chart based on Bentek data



Source: Task Force chart based on Bentek data

The causes of these production declines are examined in detail in the following section of this report, entitled “Causes of the Outages and Supply Disruptions.”

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

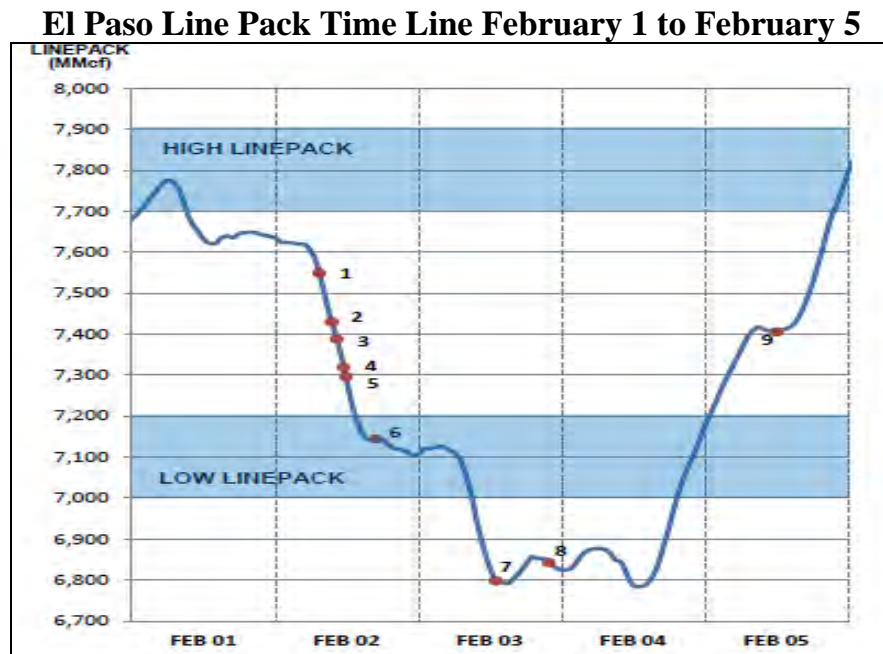
Effects on the Pipelines and Storage Facilities

At the same time that gas supplies flowing into the pipelines were reduced, shippers requested increased volumes of gas. The reduced supply relative to higher deliveries (a situation known as a draft condition) resulted in lower line pressures and reduced line pack, which for most pipelines began on February 2.¹⁷⁷

Between February 1 and February 4, pipelines responded to this draft condition through a variety of approaches. To the extent possible, deliveries to shippers were met by relying upon line pack. Pipelines with storage used increased withdrawals to build line pack. El Paso, for instance, used its Washington Ranch Storage Field to support its south system when gas supplies failed to arrive.

El Paso

The effect of the draft conditions on El Paso's line pack is depicted in the following graph (the numbered dots reference various occurrences on El Paso's system during the cold weather event):



Source: El Paso Natural Gas Company

¹⁷⁷ Generally by February 4, line pressures and line pack began rising again, as the previous day's scheduled receipts were received into the system. By February 5, line pack grew to a level above that prevailing on February 1.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

El Paso system demand increased from 3,416 MDth¹⁷⁸ on January 31 to 3,675 MDth on February 2. For the same period, supply from all sources, including pipeline interconnects, decreased from 3,264 MDth to 3,040 MDth. As supply decreased and demand increased, El Paso used line pack to attempt to maintain deliveries. As a result, line pack fell from almost 7.8 Bcf on February 1 to approximately 6.8 Bcf at 2:00 PM on February 3.

As line pack fell, pipeline pressure on the western edge of the system dropped below 600 pounds per square inch gauge (psig). Pressure on the east side of the system had already dropped below 600 psig, as of 12:00 noon on the previous day. At 10:51 PM on February 3, El Paso issued a low pressure force majeure announcement, suspending its contract obligations and declaring that operating pressure on portions of its system could not sustain contract levels.

Pipeline Communications

Interstate pipelines issue a variety of communications and directives to shippers and, pursuant to FERC regulations (18 CFR §284.12 (2011)), post critical notices to describe strained operating conditions, to issue operational flow orders and, when applicable, to make force majeure announcements. Most intrastate pipelines provide similar information and instructions to shippers, either by posting or direct communications.

Critical notices describe situations when the integrity of the pipeline system is threatened. A critical notice will specify the reasons for and conditions making issuance necessary, and also state any actions required of shippers. Operational integrity may be determined by use of criteria such as the weather forecast for the market area and field area; system conditions consisting of line pack, overall projected pressures at monitored locations, and storage field conditions; facility status (defined as horsepower utilization) and availability; and projected throughput versus availability, for capacity and supply.

Operational flow orders (OFO) are used to control operating conditions that threaten the integrity of a pipeline system. (Individual pipeline companies may have other names for operational flow orders such as alert days, performance cut notices or an emergency strained operating condition.) OFOs request that shippers balance their supply with their usage on a daily basis within a specified tolerance band. An OFO can be system-wide or apply to selected points. Failure by a shipper to comply with an OFO may lead to penalties. Pipelines may also

(cont'd)

¹⁷⁸ “MDth” is a thousand dekatherms.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

limit services such as parking and lending of natural gas, no-notice (the provision of natural gas service without prior notice to the pipeline), interruptible storage and excess storage withdrawals and injections.

Force majeure, if authorized by the pipeline's tariff, is a declaration of the suspension of obligations because of unplanned or unanticipated events or circumstances not within the control of the party claiming suspension, and which the party could not have avoided through the exercise of reasonable diligence.

Based on data responses to task force inquiries, the number of companies making use of these various communications and directives for weather-related reasons in the Southwest during the first week of February is as follows:

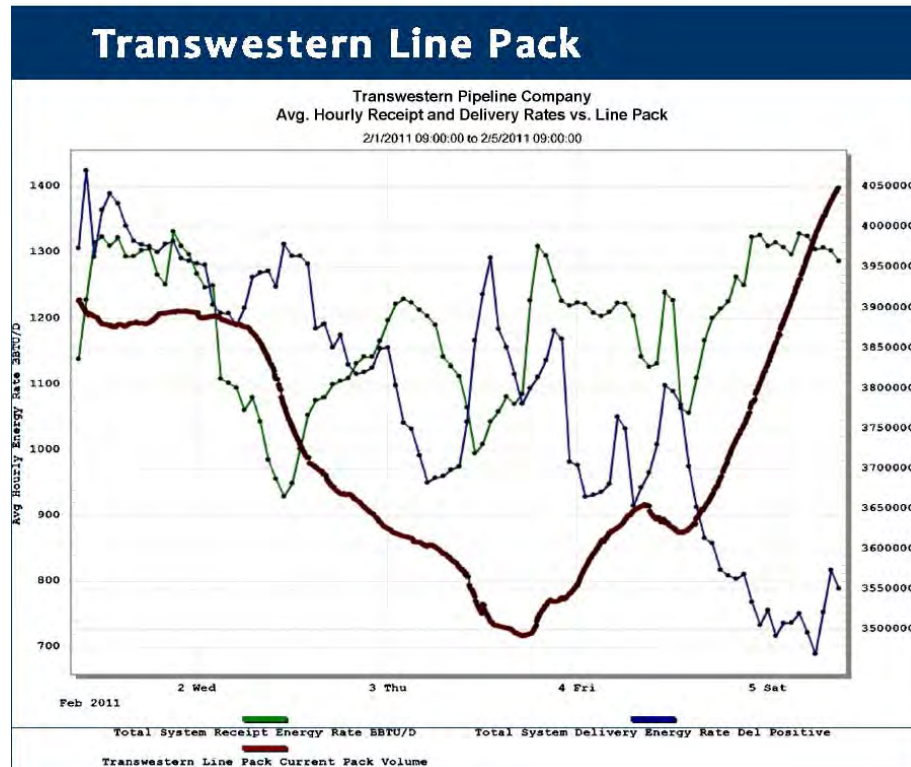
Type of Pipeline	Number of Data Responses	Number of Companies With a Critical Notice	Number of Companies With an OFO	Number of Companies Declaring Force Majeure
Interstate	24	6	3	1
Intrastate	21	5	5	3

El Paso Natural Gas issued a force majeure declaration on February 3, stating that it had experienced system operating pressure on portions of its mainline and some laterals that could not sustain contract levels. The other interstate pipeline most affected by the supply shortfalls, Transwestern, did not declare a low pressure force majeure.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Transwestern

The effect of the draft conditions on Transwestern's line pack is depicted in the following graph.



Source: Transwestern Pipeline Company, LLC

Scheduled deliveries on Transwestern from January 31 to February 2 increased from 1,426 MDth to 1,526 MDth. Supplies dropped by approximately 400 MDth by midday on February 2; however, Transwestern continued to make scheduled deliveries from line pack. Accordingly, line pack decreased from 3.9 Bcf on February 1 to a low of 3.5 Bcf on February 3. Transwestern, unlike El Paso, did not declare a low pressure force majeure.¹⁷⁹

New Mexico Gas Company

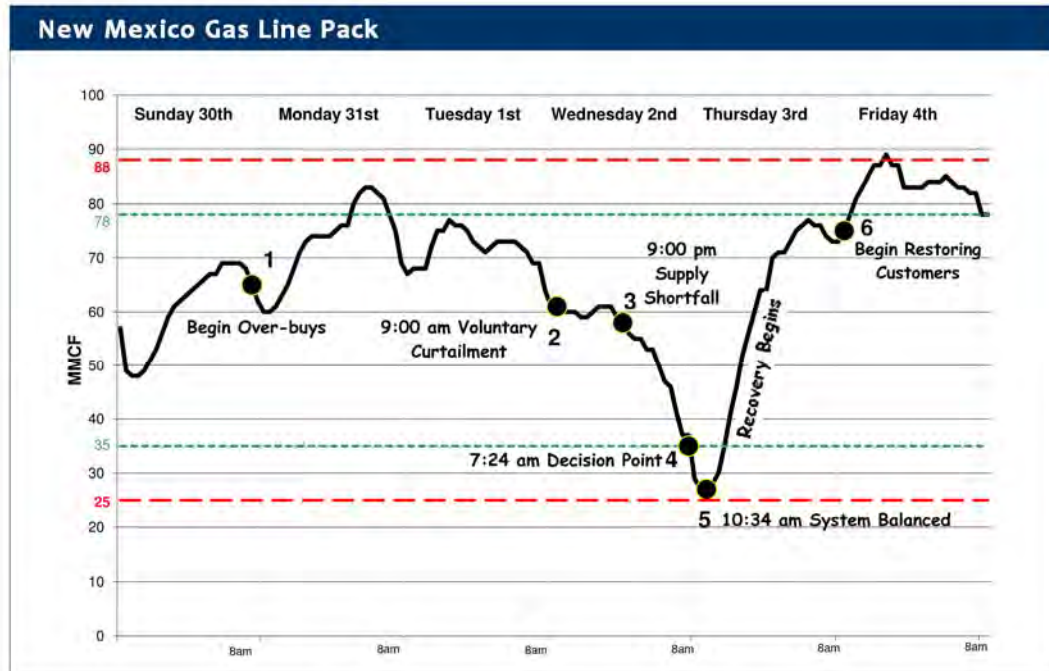
NMGC also experienced significant line pack problems on its distribution system. On January 31, NMGC bought additional supply for its north segment and its south/remotes segment, for delivery on the following day. On February 2,

¹⁷⁹ By midday on February 3, pressures and line pack were beginning to increase, and on February 4, NMGC's line pack was over 4 Bcf.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

NMGC contacted 39 large industrial and commercial customers, requesting them to reduce or curtail their gas usage. By 9:00 PM on February 2, NMGC reported to supplying pipelines that pre-ordered gas was not being delivered as scheduled.

The effect of events on NMGC's line pack is depicted in the following graph.



Source: New Mexico Gas Company

The vast majority of the shortages experienced on NMGC's north segment on February 2 and 3 was attributable to supply failures at the Transwestern Rio Puerco and El Paso's Wingate interconnection points. An NMGC representative has stated that the failure of Transwestern to deliver scheduled flows of 127,454 MMBtu on February 2 and 146,438 MMBtu on February 3 "was devastating to NMGC and its customers."¹⁸⁰

Transwestern responded by observing that it scheduled much greater volumes of gas at Rio Puerco than NMGC historically flowed (and equal to the amount nominated by NMGC and other shippers to the point). NMGC was unable to flow all of the scheduled volumes, suggesting there were difficulties on NMGC's system in taking away the gas from the Rio Puerco delivery point. On February 2,

¹⁸⁰ Transcript of Testimony of Tommy Sanders at 13, In the Matter of an Investigation into New Mexico Gas Co.'s Curtailments of Gas Deliveries to New Mexico Consumers, NMPRC (Mar. 17, 2011) (No. 11-0039-UT).

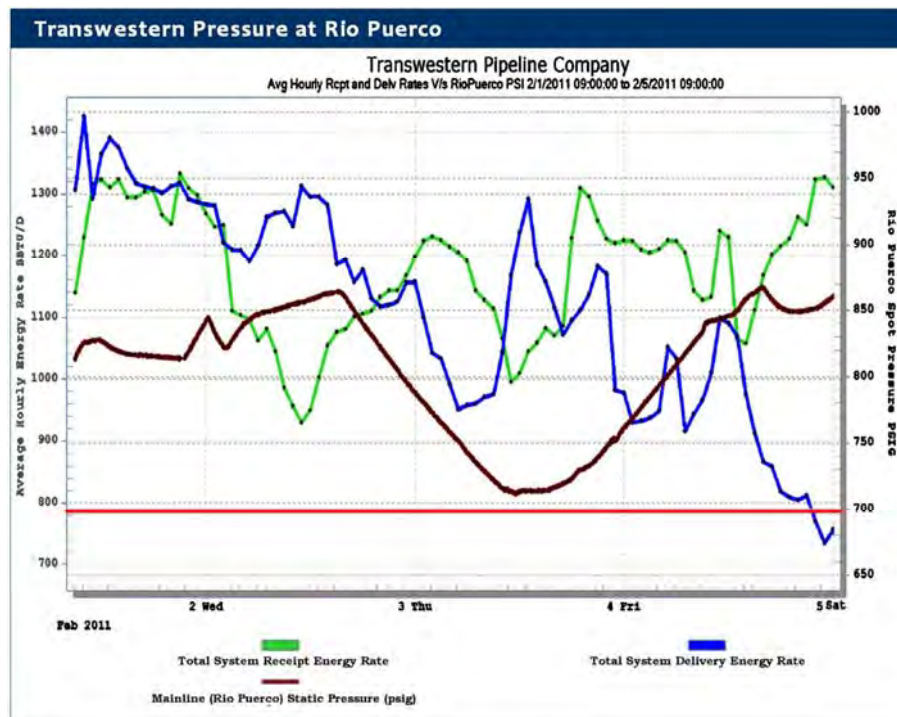
FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

for example, Transwestern scheduled 305,000 MMBtu/d and NMGC took 182,000; on Feb. 3 Transwestern scheduled delivery of 298,000 MMBtu/d at Rio Puerco, and NMGC took 128,000.

NMGC also reported lower pipeline pressure than those on which it typically relies. On an average winter day in the north segment, pressure ranges from 800 to 900 pounds per square inch atmosphere (psia) at Rio Puerco. The average pressures were lower during the week of January 31 and, from February 1 to February 4, the loss of pressure caused NMGC to experience significant pressure losses on its own system. For example, the interstate pipeline pressure at NMGC's interconnection at Rio Puerco fell to a low of 724 psia from a normal operating pressure of 850 psia.

Notwithstanding this decline in pressure, Transwestern's contractual obligation with respect to pressures at Rio Puerco (as opposed to its typical operating pressures) is 700 psia, and Transwestern reports that pressure never fell below that obligation.

The following chart provided by Transwestern depicts the pressure at Rio Puerco (fluctuating brown line) relative to contractually obligated pressure (non-fluctuating red line), total receipts (green line) and deliveries (blue line) on the Transwestern system. According to the chart, pressure did not fall below the contractual obligation of 700 psia.



Source: Transwestern Pipeline Company, LLC

Coordination Among Pipelines to Address Supply Problems

Flows between and among pipelines through redirected supplies and incremental transactions at least partially alleviated supply shortage conditions during the first week of February, 2011. These flows were the result of active coordination among the involved counterparties to address shortfalls. The redirection of gas came too late to avoid the curtailments in New Mexico and Arizona that occurred on February 2 and February 3. However, in the Texas intrastate markets, the increased purchases of gas at pipeline interconnects was an important factor in maintaining pressure in the Dallas-Fort Worth area and also served to move gas east to west in response to reduced supply at Waha.

Changes in gas deliveries do not occur instantly. Operation Balancing Agreements (OBA) contractually specify how gas imbalances between flows and scheduled amounts are to be managed. (Interstate pipelines are obligated by FERC regulations to have OBAs at interconnects with other interstate pipelines and with intrastate pipelines). These agreements enabled counterparties to make operational changes and revise nominations.

Chevron Keystone Storage Facility

In addition to the pipelines, at least one storage facility experienced weather-related difficulties. These difficulties, however, stemmed not from freeze-offs upstream, but from the rolling blackouts on ERCOT's system and from the facility's own operational problems.

The Chevron Keystone Storage Facility (Keystone), which has interconnections with El Paso, Transwestern, and Northern Natural Gas Company, was affected by two rolling blackouts on February 2, at 6:30 AM and 10:00 AM. It was shut down completely for six hours (from 6:30 AM to 9:30 AM and again from 10:00 AM to 1:00 PM).

Keystone remained at less than 100 percent capacity through February 6, due to line and equipment freeze-offs. Keystone declared force majeure at 9:00 AM on February 2. As a result, during the period February 2 through February 4, Keystone was unable to deliver 100 percent of nominated volumes to its three interconnecting pipelines. Keystone lifted the force majeure effective 9:00 AM on February 7.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Keystone's difficulties did not meaningfully contribute to the curtailments of natural gas customers, but they did affect supplies to gas-fired generators of EPE and SRP. (The failures of EPE's generating units stemmed from other causes,¹⁸¹ so they would not have been able to utilize the gas in any event; SRP was able to obtain gas from another source.) In order to estimate reduced output per customer, the task force prepared the following table, which compares customer scheduled deliveries with contractual withdrawal rights for the Keystone storage facility. It appears that on the coldest day, February 2, shortfalls were most significant not for NMGC, but for EPE, SRP and the two marketers Sequent and Tenaska.

Keystone Storage Scheduled Deliveries Relative to Contractual Rights

Total (MMbtu)	WD Rights	Scheduled Deliveries	2-Feb	3-Feb	4-Feb
Arizona Electric Power	(6,000)		-	(1,687)	(6,000)
Atmos Energy	(20,000)		(5,096)	(2,009)	(20,000)
BP Energy Company	(17,000)		(2,500)	(7,706)	(17,000)
El Paso Electric	(26,000)		-	(12,730)	(26,000)
New Mexico Gas	(140,000)		(140,000)	(140,000)	(52,510)
Salt River Project	(35,000)		(11,667)	(24,791)	(35,000)
Sequent Energy	(27,000)		(4,793)	(19,125)	(27,000)
Tenaska Marketing	(55,500)		(14,718)	(24,112)	(55,500)
Total	(326,500)	-	(178,774)	(232,160)	(239,010)

Natural Gas Curtailments to Retail Customers

The retail customer is the last link in the natural gas delivery chain, taking gas for home or business consumption from LDCs. LDCs receive their gas from interstate or intrastate pipelines at a delivery point called the "citygate." They distribute the gas through a large network of increasingly smaller diameter pipes to homes and businesses in the distribution area. LDC distribution networks operate at much lower pressures than transportation pipelines, but must maintain certain minimum pressures in order to deliver gas to end users. Some large LDCs use compressors to help maintain minimum delivery pressure, but others rely solely on pressure supplied by the upstream pipelines.¹⁸²

When receipt pressures from the pipelines fall, or when consumer demand for gas exceeds the volume being delivered to the citygate, gas pressure within the LDC network will decline correspondingly. In such instances, LDCs must reduce

¹⁸¹ The causes of the generating unit outages experienced by EPE are described in the following section of the report, entitled "Causes of the Outages and Supply Disruptions."

¹⁸² NaturalGas.Org, *Natural Gas Distribution*, <http://www.naturalgas.org/naturalgas/distribution.asp>.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

the amount of gas being consumed to prevent pressures from falling to the point where the entire system could fail. LDCs typically do this by first seeking voluntary curtailment from large users. If voluntary curtailment fails to stabilize gas pressure in the system, they will further reduce consumption by cutting off sections of the network, usually beginning with remote sections that would be the first to fail under strained conditions.¹⁸³

State Regulation of Curtailment

Arizona, New Mexico, Texas, and California all regulate curtailments by LDCs in their states, but generally grant LDCs a great deal of discretion in determining how curtailments are implemented.

In Arizona, for example, the Arizona Administrative Code directs utilities to file, as a part of their general tariffs, a procedural plan for handling severe supply shortages or curtailments.¹⁸⁴ The definitions of customer classes and the priority of curtailment are left to the utilities. Southwest Gas's Arizona curtailment rule places residential and other human needs customers at the highest service priority. Electrical generators are classified below that, at priority 2 or 3, depending on the amount of gas they consume.

New Mexico also requires LDCs to create and file a list of customer classifications prioritizing curtailments during a system emergency, but does not prescribe how customers should be ranked.¹⁸⁵ NMGC Original Rule 21 sets forth the company's curtailment priorities, assigning the highest priority to residential and other human needs end users, including suppliers of service to human needs customers.¹⁸⁶ Under the NMGC plan, electrical generators fall within this highest priority category. Zia gives the highest curtailment priority to residential and small commercial or industrial customers.¹⁸⁷

¹⁸³ Transcript of Testimony of Timothy A. Martinez at 15, In the Matter of an Investigation into New Mexico Gas Co.'s Curtailments of Gas Deliveries to New Mexico Consumers, NMPRC (Apr. 20, 2011) (No. 11-00039-UT).

¹⁸⁴ ARIZ. ADMIN. CODE § 14-2-308(H) (2010).

¹⁸⁵ N.M. CODE R. § 17.10.660.10(E)(1) (2011).

¹⁸⁶ N.M. Gas Co., Original Rule No. 21 IV (2009), *available at* <https://www.nmgco.com/Regs/Rule21.pdf>.

¹⁸⁷ Zia Natural Gas Co., Second Revised Rule 21 (C) (1997).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

In Texas, state law provides that the highest priority of service should be given to “residences, hospitals, schools, churches, and other human needs customers,” but LDCs have the authority to set their own priorities, which override the general provisions if the TRC approves the LDC’s plan. The TRC-approved plan of Atmos Energy, for example, classifies electric generators several levels below residential customers.¹⁸⁸ Texas Gas Service’s curtailment plan gives top priority to residential customers, ranking all commercial and industrial users below them.¹⁸⁹

The California Public Utility Commission allows LDCs to set curtailment priorities, subject to PUC approval, and it has specifically declined to mandate priority service for electric generators.¹⁹⁰ Both San Diego Gas & Electric Company (SDG&E) and SoCalGas assign the highest priority of service to all residential customers and to small core commercial customers (including some electric generators) that use less than 20,800 therms per month.¹⁹¹

Restoration of Gas Service Following a Curtailment

Restoration of gas service to residences following curtailment is a lengthy process that must be performed by trained, qualified personnel. The first step is to shut off each individual gas meter. The LDC’s distribution lines and lines from the meters to homes must then be purged of air and re-pressurized with gas. Once this is done, workers visit each home, inspect gas appliances for safety, open meter valves, relight pilot lights, and confirm that the appliances are operating safely. This can only be done when the customer is home, and if workers find that any appliances are not operating properly, service cannot be restored to that home until repairs have been made.

¹⁸⁸ *In re Curtailment Program of Lone Star Gas Co.*, Order No. 496, Docket No. 496 (Texas Railroad Comm’n Oct. 15, 1973).

¹⁸⁹ Curtailments, El Paso Texas Gas Service Area Gas Tariff, Third Revised, § 14.2.

¹⁹⁰ Pub. Util. Comm’n of Cal., Opinion Declining to Provide Service Priorities to Electric Generators in the Event of a natural Gas Shortage, No. 01-12-019 (2001), available at <http://docs.cpuc.ca.gov/published/Graphics/11821.pdf>.

¹⁹¹ Annual Notice, San Diego Gas & Electric, Information on Natural Gas Services and Programs (Feb. 26, 2010) (on file with author); *Continuity of Service and Interruption of Delivery Rule 23(B)*, SOUTHERN CALIFORNIA GAS CO. at 1, <http://www.socalgas.com/documents/business/23.pdf>. A therm is 100 MMBtu.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The February 2011 Curtailments

From February 2 through February 4, 2011, LDCs interrupted gas service to more than 50,000 customers in New Mexico, Arizona, and Texas. Areas affected included the cities of El Paso, in Texas (863 customers) Tucson (14,620) and Sierra Vista (4,596) in Arizona, and Hobbs (406), Ruidoso (50), Alamogordo (2,385), Silver City (290), Tularosa (1,445), La Luz (475), Taos (8,505), Red River (557), Questa (548), Española (12,367), Bernalillo (3,172), and Placitas (1,114) in New Mexico.

The New Mexico Curtailments and Outages

Zia Natural Gas Company

The city of Hobbs, in southeastern New Mexico, was the first to experience gas outages. Its LDC, Zia Natural Gas Company, receives gas from DCP Raptor Pipeline, LLC, (DCP) an intrastate pipeline that receives its supply from processing plant tailgates and wellheads. Zia serves approximately 11,000 retail customers in the Hobbs area.

On February 1, 2011, DCP fell behind for a two-hour period on deliveries to Zia because of wellhead freeze-offs and other supplier issues. However, the pipeline made arrangements with the Northern Natural Gas (NNG) pipeline to reverse the flow of gas at a DCP/NNG interconnect near Hobbs, making additional supplies available. Thus, according to both Zia and DCP, DCP's temporary supply shortage did not adversely affect customers in Hobbs.

At approximately 3:00 AM on February 2, an electrical blackout affected approximately 2,065 homes in the northeast area of Hobbs.¹⁹² Zia was not notified of the blackout until approximately 7:30 AM, but at 5:55 AM, the company received a low pressure alarm from a regulator station on the northeast end of the system. Personnel sent to the site reported that pressure was well below normal levels, and Zia immediately contacted DCP, which informed them that a plant had gone out of service due to a cold weather-related mechanical failure and that DCP was attempting to address the problem. The DCP plant in question did not return to service until February 6.

Zia reported that it was able to continue supplying gas to all its customers in Hobbs until approximately 7:30 AM that day, when electric power was restored. At that point, there was a surge in demand as gas appliances that had been unable

¹⁹² SPS is the city's electrical supplier.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

to operate without electricity simultaneously came back in service. Almost immediately, Zia began receiving calls from customers reporting that they had no gas or very low gas pressure. In all, 406 customers called in to report supply problems.

Zia believes the reason for the outages was the sudden surge in demand when electric power came back online, coupled with the low line pressures that resulted from the DCP plant outage. That morning, Zia began the process of relighting the primarily residential customers that were affected, and the company was able to restore all gas service by 10:00 PM the same day.

Zia customers in the Ruidoso, New Mexico area also lost gas service as a result of the cold weather events. During the early morning hours of February 3, the Ruidoso area experienced power outages that lasted until 8:00 AM. At the same time, receipt pressures from El Paso were declining.

At approximately 7:30 AM, Zia began receiving complaints of no gas or low gas pressure. Personnel sent to the area reported extremely low pressures, and did what they could to boost flow by bypassing regulator stations. Through a local radio station that was operating on backup power, the company asked the community to cut back on gas use. Pressures were critically low through most of the morning but began to rise just before noon. However, when electrical power was restored, there was a surge in demand that further strained the system. A total of 50 customers at the far reaches of the distribution system lost gas service that day, but their service was fully restored by the end of the working day.

According to Zia, it has no industrial or large load single customers; almost all of its customers are residential or small commercial users. Thus, it was not possible for Zia to reduce demand by curtailing large commercial accounts. Zia believes the Ruidoso outages were caused by high demand on the system, combined with low supply pressures and the surge in demand that occurred when power was restored.

New Mexico Gas Company

NMGC serves more than 500,000 retail customers in towns, pueblos, cities and rural areas throughout New Mexico. NMGC's distribution system is divided into two areas: (1) the north segment, serving the Albuquerque metropolitan area and communities to the north; and (2) the south/remotes segment, consisting of (a) the southeast system, which serves the towns of Roswell, Artesia, Carlsbad, Lovington, Eunice, and surrounding areas, and (b) remote locations, including Alamogordo, Silver City, Clovis, Portales, Tucumcari, Hatch, and Truth or Consequences. The north and the south/remotes segments are served by the

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Transwestern and EL Paso interstate pipelines and by other third-party pipelines. The remote locations that lost gas service during the period in question were supplied solely by El Paso.

NMGC: The North Segment

On February 2, 2011, NMGC personnel monitoring the company's north segment, which serves the Albuquerque metropolitan area and communities to the north, noted that gas volumes at the company's receipt points with El Paso and Transwestern were not increasing, indicating that much of the company's nominated gas was not being received. However, although line pack was decreasing, the system was still operating within sustainable limits. Based on additional gas purchases made during the day, the company expected pressures at receipt points to increase at 9:00 PM that night and at 8:00 AM the following morning.

As a precautionary measure, the company began telephoning large commercial users on the morning of February 2, seeking voluntary reductions of gas consumption. NMGC employees, working from a list of the company's 200 largest customers, placed phone calls or sent emails to points of contact on the list. Customers were informed that the company was expecting a gas shortage and that cutting back on gas usage was necessary to maintain service to home, hospitals, and other top priority consumers.

In some instances, large customers agreed to reduce their gas use, either by switching to alternative fuel supplies, lowering thermostats, or shutting down equipment or manufacturing processes. However, some of the customers (approximately 10 percent of those contacted) indicated that they could not or would not reduce their usage.

One of the large customers NMGC contacted was PNM, which operates two gas-fired generating plants in the Albuquerque area. Contacted at 9:42 AM on February 2, PNM responded by stating that no curtailment options were available to it, and that the plants would be increasing their gas consumption to meet power generation requirements.

In other instances, NMGC was unable to reach a point of contact for its large customers and could only leave messages requesting cutbacks or return calls. NMGC estimates that it was ultimately able to contact 30 percent of the top 200 users to request voluntary curtailment.

NMGC was expecting the supply problems to improve at 9:00 PM on February 2, because of the extra gas it had purchased. When line pressure did not

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

improve at that time, due to the inability of suppliers to put the purchased gas on the system, the company began contacting other pipelines and suppliers in an effort to purchase more gas.

During the early morning hours of February 3, NMGC personnel monitoring line pressure on the north segment, from both the company's gas control center and field locations, believed the system would have enough gas to meet the anticipated morning demand, based on the amount of gas that had been used the previous day. However, beginning at 7:12 AM, the demand for gas rose to unprecedented levels, even though temperatures were only slightly higher than the day before.¹⁹³

Even at this point, however, the company concluded that if pressures at receipt points began to rise at 8:00 AM, as expected based on the additional gas that had been purchased, they would be able to meet the increased demands on the system.

However, pressures continued to decline at 8:00 AM, leading NMGC to conclude that it was in immediate danger of losing the entire system and that they must immediately reduce demand by cutting off sections of the system. At around this time, the company also began receiving reports of no gas or low gas pressure in the Albuquerque area, further indicating that its system was near collapse.

Because NMGC needed to act quickly, and because the distribution systems in the larger metropolitan areas of Santa Fe and Albuquerque were not configured so as to allow curtailment of large numbers of customers by closing just a few valves, the company decided to curtail the areas served by the Taos mainline, which runs from the company's north-south mainline at Otowi junction, located approximately 80 miles north of Albuquerque. That line serves the communities of Española, Dixon, Taos, Questa, and Red River. The Otowi Junction valve was closed at 8:37 AM, cutting off service to those communities.

The company also curtailed two additional communities just north of Albuquerque by closing two valves that supplied the town of Bernalillo at 8:55 AM and 9:14 AM, and by closing one valve to the town of Placitas at 9:29 AM.

¹⁹³ NMGC told the task force that although temperatures were slightly warmer on the morning of February 3, compared to the previous morning, demand was nevertheless higher, despite NMGC's efforts to seek voluntary curtailment from large users, and despite appeals through the media for residential customers to conserve gas. NMGC does not know the reason for the increased demand.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

If pressures continued to decline, the next step anticipated by NMGC was curtailing sections of the Albuquerque metropolitan area. Curtailment options in that area were limited, however, because of the lack of shut off valves capable of curtailing a large block of customers at one time. The company nevertheless prepared for curtailments by sending a crew with a backhoe to two sections of pipeline that served 2,000 customers, with the intention of digging up the pipes and pinching them off.¹⁹⁴

At 9:20 AM, following discussions between NMGC and PNM about system conditions, PNM decided to switch its Delta Person (Cobisa) power plant from gas to backup fuel oil. PNM was unable to make the changeover because of a faulty valve, and as a result the plant went out of service and did not draw gas from the system for the duration of the cold weather event.

By 10:30 AM, pressure on the north segment had stabilized and had begun to increase. The restoration process was already underway at that point, as NMGC teams began shutting off meter valves to individual customers so that the lines could be purged and recharged.

NMGC: The South/Remotes Segment

On February 2, line pressure on El Paso's delivery pipeline to NMGC's south/remotes segment steadily declined, dropping below contract pressure¹⁹⁵ at approximately 10:00 AM. As the day progressed, NMGC personnel monitored line conditions and began considering the possibility that if conditions worsened, they would have to curtail certain areas.

At approximately 3:00 PM, NMGC started calling large customers on the south segment to ask them to voluntarily reduce their gas consumption. Some of the larger customers, such as Western New Mexico University, Silver City School System, and the Alamogordo School System, agreed to reduce usage, but two other large users -- Holloman Air Force Base and the White Sands Missile Range - - could not be reached that day, reportedly because the bases were closed because of the weather conditions and the contact persons were not present. (Holloman Air Force Base was successfully contacted the following day at approximately 1:00 AM, and agreed to reduce its usage at that time.)

¹⁹⁴ Transcript of Testimony of Doug Arney at 4, In the Matter of an Investigation into New Mexico Gas Co.'s Curtailments of Gas Deliveries to New Mexico Consumers,, NMPRC (Mar. 17, 2011) (No. 11-00039-UT).

¹⁹⁵ Contract pressure is the minimum gas pressure, measured in pounds per square inch, that a pipeline agrees to provide to a customer at a given delivery point.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Shortly before 5:00 PM on February 2, NMGC received notice from El Paso that line pressure was not expected to improve during the next 24 hours.

At 1:50 AM on February 3, NMGC began cutting off service to schools and non-essential government buildings in Alamogordo. At 2:36 AM, seeing that conditions were continuing to deteriorate, the company declared a system emergency on the south segment.

At 3:00 AM, NMGC cut off service to the communities of Tularosa and La Luz, which are located at the end of the NMGC distribution pipeline that serves Alamogordo. Line pressures continued to decline, however, and at 5:05 AM, the company shut off one section of Alamogordo. At 6:00 AM, the Alamogordo area experienced an electrical blackout. When electricity was restored at 8:00 AM, the resulting surge in demand for gas caused pressure to drop to zero on the southern part of the Alamogordo system, forcing NMGC to cut off that section as well. In all, more than 4,300 customers lost gas service in Alamogordo, Tularosa and La Luz, out of a customer base of approximately 15,000. By 9:25 AM, pressures in the Alamogordo area began to stabilize, and by 3:00 PM that day, the company began restoring service to curtailed areas.

Another community on the NMGC south/remotes segment that lost a portion of its gas service on February 3 was Silver City. According to NMGC, the Silver City distribution network lacked the capacity to meet the unprecedented demand for gas on February 2 and February 3, due to system limitations. NMGC stated that in 2007, it determined that the system's maximum operating pressure should be reduced from 40 psi to 30 psi for safety reasons. With that limitation, the system could not transport the volumes demanded by customers.

Although two large users in that area, the Silver City Consolidated School District and Western New Mexico University, agreed to curtail gas use on February 2, mitigating demand on the system to some extent, pressure continued to drop. NMGC curtailed a section of Silver City at approximately 6:00 AM the following day, February 3, in order to avoid total collapse of the system. Pressure began to recover by 11:00 AM, and restoration efforts began shortly thereafter. A total of 271 out of approximately 9,200 customers in the area lost gas service due to the curtailments.

NMGC has informed the task force that it is in the process of making improvements to the Silver City distribution system that should allow it to meet peak loads of the sort that occurred during the February event.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Restoration of Service

Closing individual gas meters, which is the first stage of restoring service, began shortly after NMGC cut off service on the morning of February 3. In some areas, NMGC personnel began shutting off meters within minutes of the curtailment. As restoration efforts got underway, the company sought additional help through its mutual assistance agreements with the American Gas Association and the Southern Gas Association, whereby member LDCs agree to help each other in emergency situations. That morning, NMGC asked other member LDCs by email and by conference call to send personnel to help them restore service in the affected areas. Out-of-state LDCs responded by sending qualified service personnel, who began to arrive the following day. NMGC also sought help from other New Mexico LDCs, and hired local contractors and plumbers to help restore service. Police, fire department, and National Guard personnel all eventually played roles in the effort to restore service.

Relighting continued through the weekend and into the following week, with a workforce of more than 700 persons participating. Service was restored to some areas as early as February 5, but the statewide relighting effort was not substantially completed until the following week, on February 10.

The Arizona Curtailments and Outages

Southwest Gas, a multistate LDC whose service areas include the cities of Tucson and Sierra Vista in Arizona, was forced to curtail service to parts of those cities on February 3 due to low pressures at receipt points with El Paso. After El Paso declared a system-wide Critical Operating Condition at 11:52 AM on February 2, due to declining line pack and drop offs in gas supply, Southwest Gas's management met at 1:00 PM to plan for increased monitoring of the distribution systems. Shortly thereafter, at about 2:00 PM, the company started calling large commercial customers to alert them to possible curtailments.

At 10:00 PM, as conditions on the El Paso pipeline continued to deteriorate, Southwest Gas concluded that it might be necessary to cut off some customers in order to preserve system operability. When pressures on the Sierra Vista system reached a critical stage at approximately 3:30 AM on February 3, the company identified several sections of the system that should be shut down to reduce demand. At approximately 6:30 AM, crews began closing valves in Sierra Vista and Tucson. Out of a total of 17,801 customers in Sierra Vista, 4,596 were shut off; out of a total of 279,362 customers in Tucson, 14,620 were shut off.

Starting at approximately 5:00 AM on February 3, the company began curtailing several large commercial customers, including an electric power plant in

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Tucson. Other commercial users voluntarily curtailed or reduced their use throughout the day.

By 8:30 AM, pressures began to stabilize and recover, and the restoration process was initiated. Southwest Gas brought in 130 employees from other divisions in California, Nevada, and Central Arizona to help with the relighting process, and service was fully restored on the afternoon of February 7, 2011.

The Texas Curtailments and Outages

Texas Gas Service (TGS) serves several communities in Texas, with a total of 616,462 residential, commercial, and transportation customers. The City of El Paso is one of those communities, and during the week in question it was the only city in Texas to experience gas curtailments, with 863 residential customers (out of approximately 231,000) losing service.

Gas is delivered to TGS by the El Paso and ONEOK WestTex Transmission, L.L.C. (ONEOK WestTex) pipelines. Beginning around February 2, TGS received cuts from its suppliers and had to make alternative arrangements to obtain gas for the anticipated cold weather demand, including buying compressed natural gas (CNG) for expedited delivery by tanker truck from Arizona. The company also experienced low delivery pressures from El Paso later that week. However, those factors were not responsible for the service disruptions that occurred. According to TGS, the El Paso system experienced unprecedented demand during the winter event, as much as 41 percent higher than the previous historical peak.¹⁹⁶ The company's distribution system was simply unable to handle that much volume.

Beginning on February 2, at approximately 8:00 AM, residential customers began reporting low pressures. Shortly thereafter, customers in low pressure areas of the system began losing service. TGS responded to each reported outage, and in some instances service was restored the same day. A total of 863 customers lost service during an approximately 24 hour period. Service was fully restored by February 5. The restoration process was hampered by icy road conditions, and by the fact that TGS workers could not restore service when customers were not at home.

In order to alleviate pressure on the system during the period of peak demand, TGS asked ten large transportation customers to reduce consumption at

¹⁹⁶ On February 3, 2011, TGS delivered 258,853 MMBtu to its customers in El Paso. The previous peak at that location was 184,088 MMBtu, in January 2007.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

approximately 10:00 AM on February 3. The company also restricted service to 36 commercial customers in areas that were experiencing low pressure, and on February 3, extended a gas main to boost pressures in one of the affected areas. In addition, TGS used two CNG tankers to help deal with low pressure issues. One was used to maintain service to a hospital, and the other was deployed to assist in the restoration process in one of the affected neighborhoods.

TGS plans to make additional system improvements to increase delivery capacity by extending gas mains in several areas that experienced low pressures during the period in question. The cost of these improvements is expected to total more than \$1.7 million and the company estimates that they will be completed by September 30, 2011.

The California Curtailments

SoCalGas and SDG&E are separate utility companies, both owned by Sempra Energy. SoCalGas serves approximately 20 million customers in Central and Southern California; SDG&E serves approximately 3.4 million customers in Orange and San Diego Counties, California. SoCalGas operates the natural gas transportation systems of both companies.¹⁹⁷

Beginning on January 31, 2011, SoCalGas monitored weather developments in the Southwest and was aware of the supply problems that had developed because of the severe cold weather. The company responded to supply shortfalls by increasing withdrawals from on-system storage and by purchasing operational gas to support the southern system, which cannot be served by storage gas. Delivery shortfalls were highest on February 2 and February 3. SoCalGas estimates that the net cost of the operational gas it purchased was \$3.81 million, representing the purchase price of the gas less the price at which SoCalGas was later able to sell it.

On the morning of February 3, the company issued a curtailment advisory to non-core (lower priority) customers, informing them that curtailments could occur. At 1:15 PM, due to the continuing severe weather and its effect on production, the company declared a system emergency and curtailed transmission service on its southern system for all interruptible and some firm non-core customers by limiting the amounts they could withdraw from the system.

SoCalGas curtailed 19 interruptible retail non-core and electric generator customers, and 40 firm non-core and electric generator customers. SDG&E

¹⁹⁷ Sempra Energy, *Our Companies*, <http://www.sempra.com/companies/companies.htm>.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

curtailed all its interruptible load and all its firm service to three electric generator customers. SoCalGas reported that its non-core customers and electric generator customers generally complied with curtailment limits during the emergency. When the CAISO informed the two companies that approximately 500 MW of total generation was needed from two of the curtailed electric generators in order to ensure reliable grid operations, SoCalGas and SDG&E adjusted the curtailments so that the two plants could provide the necessary generation.

Resumption of Production

Weather conditions moderated slightly in the Southwest on February 3 and improved further on February 4, rising above freezing for the first time in days. Although production did not return to pre-event levels for several weeks, consumer demand slackened with the warmer weather, and line pack and system pressure rose steadily on the interstate pipelines. As a result, El Paso issued a warning of a system pack condition on February 5, and declared a system -wide Strained Operating Condition for high line pack February 6, 2011.¹⁹⁸

Impacts of the Event on Natural Gas Prices

Gas prices responded to the winter weather and associated freeze-offs, although the increases were short-lived and not exceptionally dramatic. Some points in the midcontinent and southwest regions did post increases of approximately two dollars to three dollars per MMBtu, which were gains of 40 to 60 percent relative to February 1. West Texas prices were particularly strong with a basis at Waha of \$2.60 relative to Henry Hub.¹⁹⁹ Southern California prices at Ehrenberg and Needles also traded higher by \$1.77, reflecting upstream supply shortfalls.

The price gains in east Texas and south Texas were more muted, despite the freeze-offs extending to the Gulf Coast, and limited to \$0.50 to \$0.60 per MMBtu. The Houston Ship Channel, however, had an increase of almost \$1.57.

The NYMEX (New York Mercantile Exchange) futures contract was flat to declining for the week. Cash prices at Henry Hub increased by only \$0.29.

Most gains were gone by February 5, at which time warmer weather had returned. Prices on February 8 actually traded below those of February 1.

¹⁹⁸ Production figures from Bentek, supporting documentation for *Deep Freeze Disrupts U.S. Gas, Power, Processing* (Feb. 8, 2011); information provided to the task force by pipelines.

¹⁹⁹ Basis is the price differential between, in this case, Henry Hub and Waha.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The following table shows spot prices at a variety of locations for February 1 to February 8.²⁰⁰ Daily closing prices are also listed for the NYMEX March gas futures contract, which is based on delivery at Henry Hub. The NYMEX price was relatively unaffected by the spot price increases during February 1 to February 8, suggesting that traders viewed the increases as a temporary, weather-related event.

Spot Prices

Flow Date	1-Feb	2-Feb	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	8-Feb
Waha	\$ 4.47	\$ 4.79	\$ 5.80	\$ 7.30	\$ 4.76	\$ 4.76	\$ 4.76	\$ 4.25
El Paso-Permian	\$ 4.40	\$ 4.75	\$ 5.74	\$ 7.23	\$ 4.86	\$ 4.86	\$ 4.86	\$ 4.19
Transwestern-San Juan	\$ 4.35	\$ 4.66	\$ 5.73	\$ 6.40	\$ 4.49	\$ 4.49	\$ 4.49	\$ 4.11
El Paso-San Juan	\$ 4.30	\$ 4.51	\$ 5.77	\$ 6.52	\$ 4.51	\$ 4.51	\$ 4.51	\$ 4.10
East Texas, Carthage Hub	\$ 4.36	\$ 4.42	\$ 4.63	\$ 4.89	\$ 4.49	\$ 4.49	\$ 4.49	\$ 4.28
Houston Ship Channel	\$ 4.40	\$ 4.37	\$ 4.61	\$ 5.91	\$ 4.43	\$ 4.43	\$ 4.43	\$ 4.29
South Texas, Tennessee Zone 0	\$ 4.38	\$ 4.39	\$ 4.62	\$ 5.03	\$ 4.40	\$ 4.40	\$ 4.40	\$ 4.28
Oneok Oklahoma	\$ 4.49	\$ 5.31	\$ 7.06	\$ 6.28	\$ 4.59	\$ 4.59	\$ 4.59	\$ 4.40
SoCal Gas	\$ 4.40	\$ 4.50	\$ 5.47	\$ 6.17	\$ 4.52	\$ 4.52	\$ 4.52	\$ 4.22
Henry Hub	\$ 4.42	\$ 4.43	\$ 4.55	\$ 4.70	\$ 4.48	\$ 4.48	\$ 4.48	\$ 4.33
NYMEX Contract	\$ 4.42	\$ 4.35	\$ 4.43	\$ 4.34	\$ 4.31	\$ 4.31	\$ 4.31	\$ 4.10

The following table shows the basis for the same locations relative to cash prices at Henry Hub.

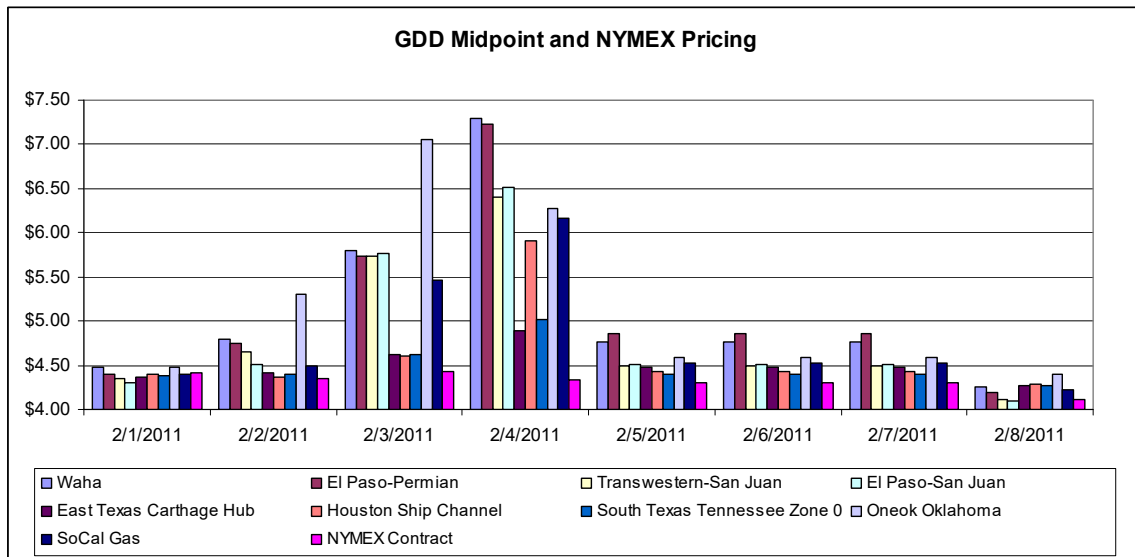
Basis

Flow Date	1-Feb	2-Feb	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	8-Feb
Waha	\$ 0.05	\$ 0.37	\$ 1.25	\$ 2.60	\$ 0.29	\$ 0.29	\$ 0.29	\$ (0.08)
El Paso-Permian	\$ (0.02)	\$ 0.32	\$ 1.19	\$ 2.53	\$ 0.38	\$ 0.38	\$ 0.38	\$ (0.14)
Transwestern-San Juan	\$ (0.07)	\$ 0.24	\$ 1.18	\$ 1.70	\$ 0.02	\$ 0.02	\$ 0.02	\$ (0.22)
El Paso-San Juan	\$ (0.12)	\$ 0.08	\$ 1.22	\$ 1.82	\$ 0.04	\$ 0.04	\$ 0.04	\$ (0.23)
East Texas Carthage Hub	\$ (0.05)	\$ 0.01	\$ 0.08	\$ 0.19	\$ 0.01	\$ 0.01	\$ 0.01	\$ (0.05)
Houston Ship Channel	\$ (0.01)	\$ (0.06)	\$ 0.06	\$ 1.21	\$ (0.05)	\$ (0.05)	\$ (0.05)	\$ (0.04)
South Texas Tennessee Zone 0	\$ (0.04)	\$ (0.04)	\$ 0.07	\$ 0.33	\$ (0.08)	\$ (0.08)	\$ (0.08)	\$ (0.05)
Oneok Oklahoma	\$ 0.07	\$ 0.88	\$ 2.51	\$ 1.58	\$ 0.12	\$ 0.12	\$ 0.12	\$ 0.07
SoCal Gas	\$ (0.02)	\$ 0.08	\$ 0.92	\$ 1.47	\$ 0.04	\$ 0.04	\$ 0.04	\$ (0.11)

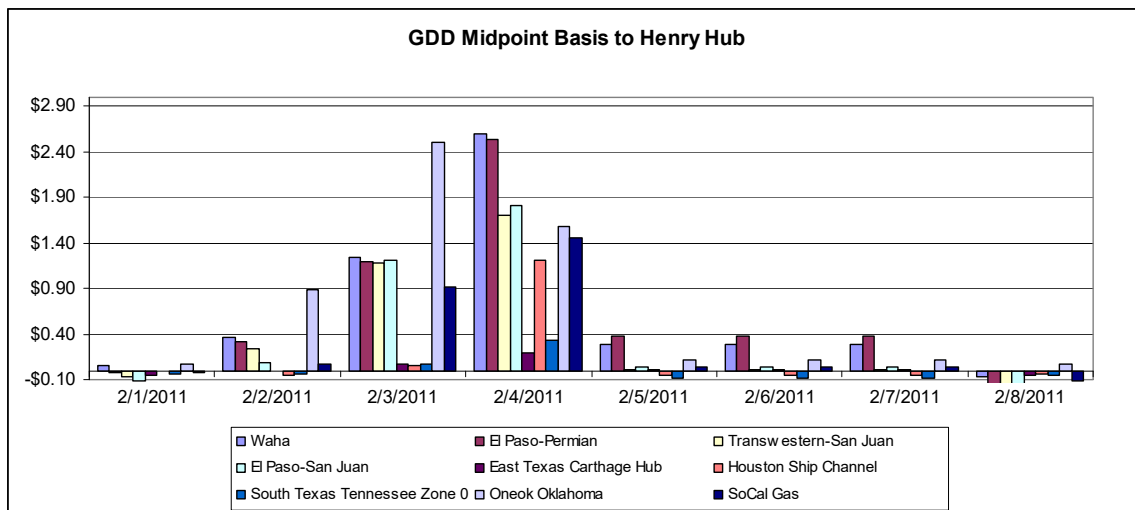
²⁰⁰ *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 1, 2011, at 1-2.; *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 2, 2011, at 1-2.; *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 3, 2011, at 1-2.; *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 4, 2011, at 1-2.; *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 5, 2011, at 1-2.; *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 6, 2011, at 1-2.; *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 7, 2011, at 1-2.; *Daily price survey (\$/MMBtu)*, Platts Gas Daily, Feb. 8, 2011, at 1-2. Reprinted with permission of Platts.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The following three charts show the absolute prices, basis, and price change of natural gas during the week of the event.

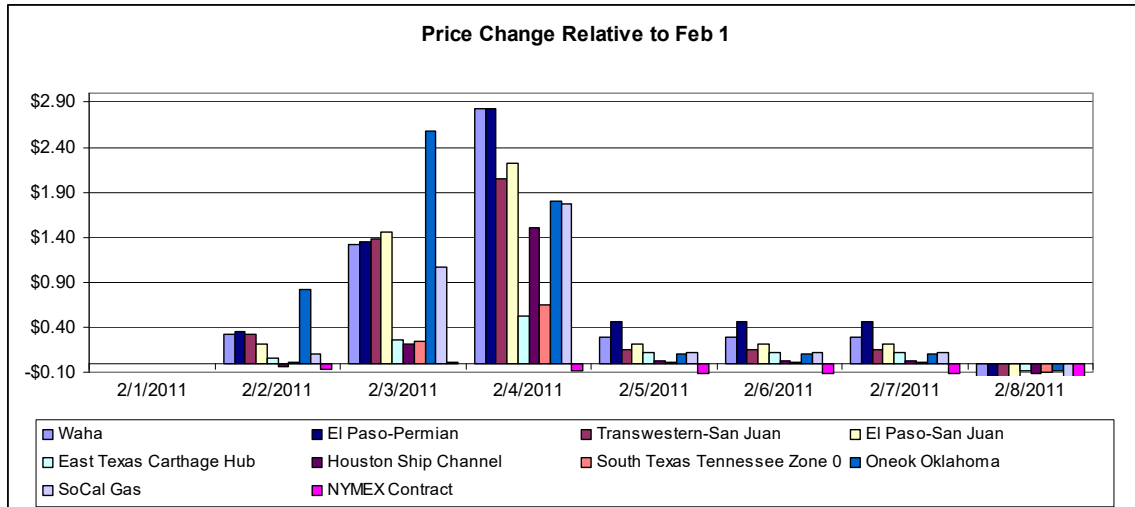


Source: Task Force analysis based on Platts data



Source: Task Force analysis based on Platts data

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



Source: Task Force analysis based on Platts data

The causes of the electric generator failures and the natural gas shortfalls described above are examined in the following section of this report, entitled “Causes of the Outages and Supply Disruptions.”

VI. Causes of the Outages and Supply Disruptions

The precipitating cause of the rolling blackouts experienced in Texas and Arizona during the February 2011 cold weather event was the large number of electric generator outages. The principal cause of the gas service curtailments experienced in several southwestern states was the production declines in the supply of natural gas, which led to volume and pressure reductions in the pipelines. The task force has analyzed in detail the causes of these outages and declines, and found that the majority of them were directly or indirectly related to the weather, particularly so with respect to production declines in the gas supply. This section of the report describes in detail those causes, both weather and non-weather-related.

While the storm itself was an uncontrollable event of force majeure, the question arises as to whether the facilities affected should have been better prepared to withstand the severe weather. Was the cold spell so unprecedented that the entities responsible for those facilities could not reasonably be expected to have taken preventative actions? Or did entities fail to take into account lessons that could have been learned from past cold weather events in the Southwest? These questions are addressed in the next section of this report, entitled “Prior Cold Weather Events.”

A. Electric

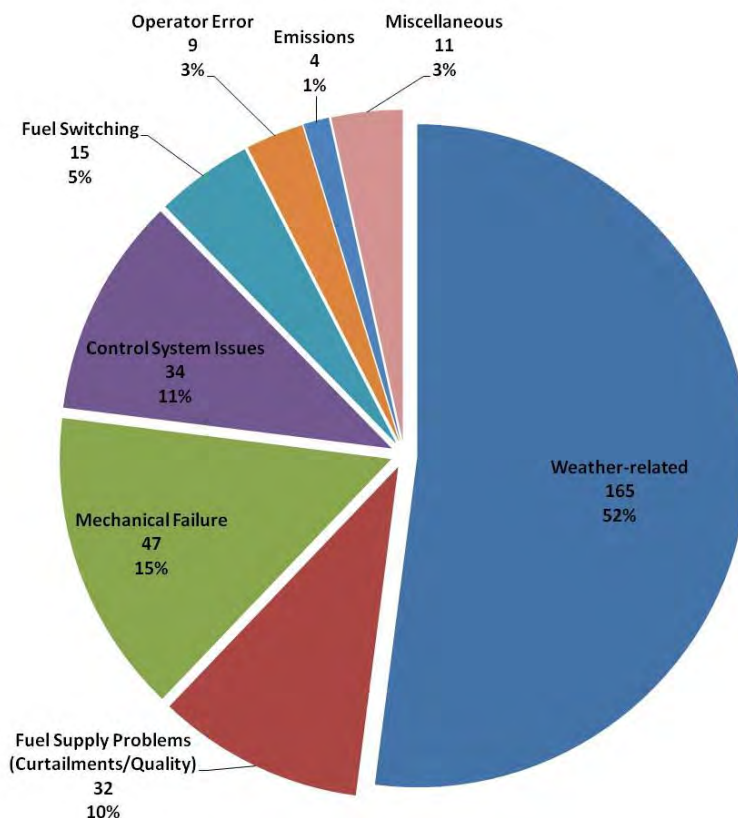
The rolling blackouts that utilities implemented during the cold weather event, which centered in Texas (ERCOT, EPE) and Arizona (SRP), were almost entirely the result of trips, derates, and failures to start of the generating units in those regions. The localized blackouts experienced by PNM in New Mexico, however, were caused by transmission trips. Units in Oklahoma and Kansas also experienced generator outages, but these did not result in blackouts.

The task force has analyzed these various generator outages to determine their underlying causes. By far, the most common cause of the outages was the cold weather, most commonly when sensing lines froze and caused automatic or manual unit trips. There were also several outages that were due to operator error or non-weather-related equipment failures. In a lesser number of cases, an interruption in the supply of natural gas prevented gas-fired units from providing power.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The following two charts²⁰¹ and supporting table depict the various causes of the trips, derates, and failures to start²⁰² for generating units throughout the Southwest, both by number of units and by MWhs.

Southwest - Number of Units Tripped, Derated, and Failed to Start - Feb. 1 - 5, 2011



Total Entries in Pie Chart: 317

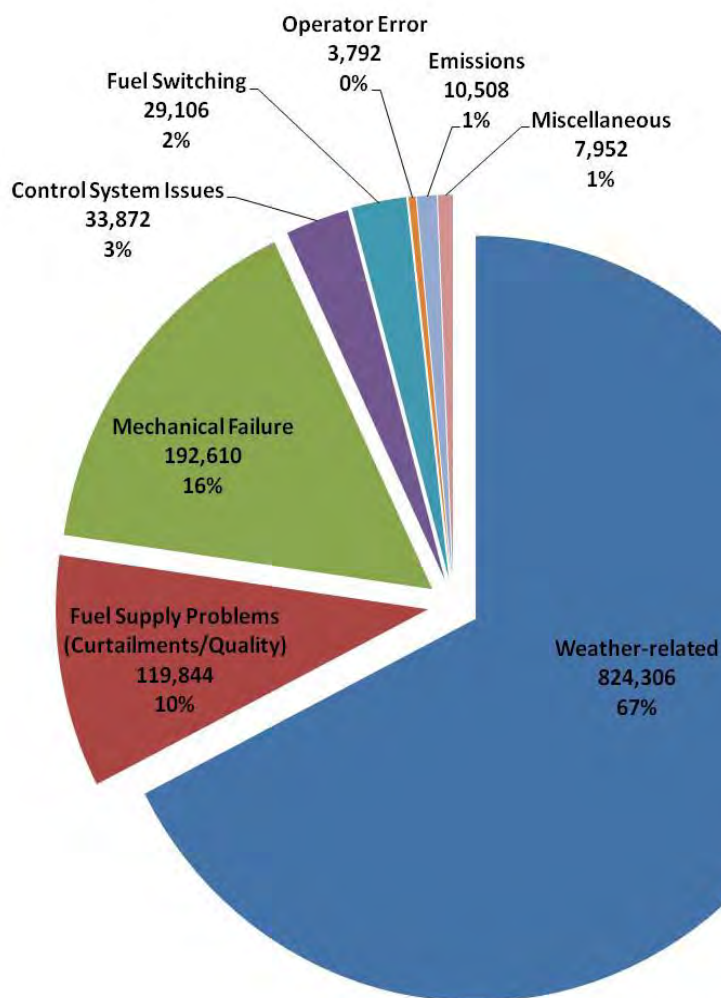
Total Number of Units Forced Out, Derated, or Failed to Start: 268

²⁰¹ Data includes generation in Texas (ERCOT and non-ERCOT), New Mexico, Arizona, and SPP. Units on the first chart are counted more than once if they failed multiple times from different causes (75 units failed on more than one occasion during the event); however, they are only counted once per cause. Data used in the preparation of this chart are drawn from materials submitted to the task force by balancing authorities and generators. Data throughout the section are drawn from materials submitted by transmission operators, generators, producers, processing plants, and pipelines.

²⁰² Trips totaled 167 units (30,376 MW), derates totaled 57 units (5024 MW), and failures to start totaled 44 units (4743 MW).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Southwest – MWh²⁰³ of Generation Unavailable - Feb. 1 - 5, 2011



Total MWh in Pie Chart*: 1.2 Million
Total MWh of Load Served in affected Southwest Areas: 6.7 Million
Generation unavailable as a percentage of Total MW-hours Load Served: 18%
*Total time period is 106 hours (Midnight going into Feb. 1 through 10 AM Feb. 5)

²⁰³ Megawatt hours were used for this chart to give an indication of the time impact of the outages, derates, and failures to start. (From an operator's perspective, a smaller unit out for a longer time might have a greater impact than a larger unit out for a short time, depending on the circumstances.) To capture this time factor, each instance of unavailable capacity was multiplied by the associated duration of the particular outage or derate and the results were summed.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Supporting Table (Southwest):

Cause	# of Unique Units	MWh
Total Frozen Sensing lines:	89	432,897
Frozen - Drum level sensing lines	48	150,000
Frozen - Other Sensing lines	41	282,896
Frozen Equipment (General)	21	153,393
Frozen Water lines	14	80,091
Frozen Valves	12	20,603
Blade Icing (Wind Turbines)	10	53,989
Low Temperature Limits (Wind Turbines)	17	80,389
Transmission Loss	2	2,944
Fuel Supply Problems (Curtailments/Quality)	32	119,844
Mechanical Failure	47	192,610
Control System Issues	34	33,872
Operator Error	9	3,792
Emissions	4	10,508
Fuel Switching	15	29,106
Miscellaneous	11	7,952

The large percentage of weather-related outages speaks in part to the design and construction of generating facilities in the Southwest. Unlike facilities in cold climates, generating stations in the Southwest are typically designed and constructed so that their boilers, turbines, and other auxiliary systems are exposed to ambient weather conditions. This design prevents heat build-up from occurring in the hot summer months. A more detailed discussion of generating plant design is contained in the appendix entitled “Power Plant Design for Ambient Weather Conditions.”

Sub-freezing temperatures can have adverse operational effects on generating stations if systems containing water do not have sufficient freeze protection, if pneumatic air systems do not have sufficient air drying capacity or freeze protection, or if equipment lubricants are not maintained above prescribed minimum temperatures. Generators with exposed elements typically employ a combination of heat tracing, insulation, wind breaks or enclosures, and heat sources to prevent freezing and to maintain minimum lubricant temperatures. Frozen sensing lines were a particular problem during the February cold weather event, when many generators automatically tripped offline due to faulty readings

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

from transmitters whose sensing lines froze (most notably steam drum²⁰⁴ level transmitters).

A detailed examination of the causes of the generator outages experienced within ERCOT, SRP and EPE during the February event, both weather and non-weather-related, is set forth below.

Generation Outages in ERCOT

As a preliminary matter, the task force categorized by age and fuel type the ERCOT units that failed, to determine whether there was any statistical indication that older units or units of a given fuel type were more prone to developing problems. With respect to age, no strong correlation was found. The failure percentage of units with in-service dates before 1981 (19 percent) was actually less than their percentage contribution to the ERCOT fleet as a whole (22 percent).²⁰⁵ The failure of units with recent in-service dates (between 2001 and 2010) represented 55 percent of the failures, which was slightly more than their contribution to the fleet as a whole (48 percent).

The results are more equivocal with respect to type of unit, where a more significant correlation was found with respect to combined cycle units. Otherwise, however, no significant correlation was found between failure and type of unit. Of ERCOT's combined cycle units, 48 percent failed, compared to their 35 percent of the total. For wind units, 16 percent failed, compared to their 15 percent of total units. For simple cycle units, 21 percent failed, compared to their 20 percent of total units. For gas-steam and coal units, the percentage that failed exactly matched their percentage contribution of total units (13 percent and 7 percent, respectively). Nuclear facilities account for only 1 percent of the total fleet, and no nuclear units failed.²⁰⁶

²⁰⁴ Steam drums are used in boilers (excluding once-through supercritical boilers) to take in a mixture of steam and water coming from the boiler's waterwall tubes. The drum separates the steam from the water by gravity and mechanical separation (such as baffles). The water level in the drum is controlled to keep water in the waterwall tubes and to prevent water carrying over into the steam section of the boiler. The drum also functions to remove solids from the steam.

²⁰⁵ This statistic and those immediately following are based on number of units, rather than on capacity. (Coal units, for instance, have a larger capacity contribution to the fleet as a whole than seven percent, which is their percentage contribution based on number of units.)

²⁰⁶ The totals do not add up to 100 percent because certain other facilities have not been taken into account, such as hydro facilities and storage facilities.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

For purposes of further analysis, the task force sorted by unit²⁰⁷ the ERCOT generator trips, derates, and failures to start into three broad categories: weather-related, non-weather-related, and fuel supply. (The weather-related category considers only failures directly related to the weather; problems of insufficient fuel supply as well as outages and derates resulting from fuel switching, although indirectly related to the weather, are listed separately.) Direct weather-related causes accounted for 52 percent of the total failures, non-weather-related causes for 40 percent, and problems with fuel supply for nine percent.²⁰⁸ Sub-categories within these major groupings, as well as specific examples of the various types of failures, are provided below.

ERCOT Weather-Related Outages and Derates

The task force identified the various specific causes for the trips, derates, or failed starts in ERCOT between February 1 and February 5 that were due directly to the cold weather.²⁰⁹ (Some of the other failures experienced by ERCOT generators, such as reduced supplies of natural gas, were indirectly related to the weather.) The task force has identified the specific causes of these weather-related failures, by number of units and number of MWs:

Cause	No. of Units Lost	MW Lost
Frozen Sensing Lines (Total)	68	15,255
Frozen Drum Level Sensing Lines	(43)	(9438)
Frozen Other Sensing Lines	(25)	(5817)
Frozen Equipment (General)	13	2942
Frozen Water Lines	12	1072
Frozen Valves	8	1501
Blade Icing (Wind Turbines)	10	709
Low Temperature Limits (Wind Turbines)	17	1237
Transmission Loss	2	89
Total Weather-Related	130	22,805

²⁰⁷ A unit that failed multiple times for different reasons is counted under each separate reason; if it failed multiple times for the same reason, it is counted once. That convention applies as well to the three charts detailing ERCOT's weather, non-weather, and fuel failures.

²⁰⁸ Numbers add up to slightly higher than 100 percent due to rounding.

²⁰⁹ The weather effects stemmed not only from the prolonged cold, but from high wind chill factors. Although typically thought of as applying to living beings, wind chill also more quickly cools inanimate objects, such as water pipes, bringing them down to the current air temperature. Wind also causes the loss of radiant heat, which otherwise can protect equipment from freezing. This phenomenon is discussed at more length in the appendix entitled "Impact of Wind Chill."

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

A sample of the ERCOT generating units that experienced weather-related failures, categorized by the specific cause of failure, provides some insight into the variety of concerns with which the generator operators had to contend during the event, and illustrates the complexity of the protections needed for generating plant systems.

- **Frozen Sensing Lines:** Instrumentation provides operational data necessary to monitor and control the generator's systems. Typically, sensing lines containing a standing water column sense changes in pressure and a transducer produces an electronic signal that is transmitted to instrumentation or controls. In sub-freezing temperatures, if freeze protection is not employed on critical unit systems, the water in the sensing lines freezes, causing faulty signals and subsequent unit trips or derates. During the February event, frozen sensing lines were the leading cause of outages, with steam drum sensing lines being the most prevalent (43 units tripped from this cause alone).
 - ✓ JK Spruce Unit 2, a 785 MW coal unit, tripped due to frozen sensing lines that caused a false high water level reading in the steam drum.
 - ✓ Ingleside Cogeneration lost two units due to frozen sensing lines. The lines were heat traced, but the ground fault interrupter breakers protecting the heat trace circuits tripped, resulting in a loss of 176 MW.
 - ✓ Another unit tripped due to frozen sensing lines on feedwater heater level controls. The freezing caused a high condensate level in a feedwater heater, which in turn incorrectly initiated a trip of the unit.
 - ✓ Non-drum sensing line failures included a unit whose vacuum system became erratic when the sensing line to the auxiliary steam pressure indication froze. Another unit tripped when the sensing lines to the rotor air cooler level transmitters froze.

Sensing Lines and Frozen Transmitters

There were many reports of frozen transmitters causing generating units to be forced offline during the cold weather event. In almost all cases, it was not the transmitters themselves that froze, but rather sensing lines filled with standing (non-flowing) water routed between the transmitters and the points the sensing lines are measuring.

(cont'd)

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Transmitters

The transmitter assemblies perform three distinct functions. First, they detect the difference in pressure between two water lines, typically with a diaphragm-type sensor that deflects in the direction of, or towards, the lower pressure. Second, they serve as transducers that translate the pressure difference into an electrical signal. Third, they boost or otherwise process the signal for transmitting to the plant's control room, generally using electronics.

Differential Pressure Measurement

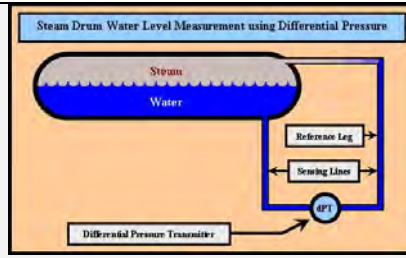
The technique of measuring the pressure difference (differential pressure) between two sensing lines filled with water has widespread application throughout power plants, especially in steam-powered generating units. This is due to the fact that differential pressure can be used to provide not just a measure of pressure itself, but also of water levels and flow rates. Significant applications include the following:

- **Pressure Measurement**
 - Between a boiler feedwater pump and the steam drum
- **Water Level Measurement**
 - In feedwater heater tanks
 - In the deaerator tank
 - In the steam drum
- **Water Flow Measurement**
 - Feedwater flow
 - Generator stator cooling water flow

Water Level Measurement

Differential pressure can be used to measure water level by virtue of the force of gravity, which results in greater pressure as the water level increases. This is akin to the hydraulic head resulting from water in an open reservoir, which is a measure of water pressure compared against standard atmospheric pressure. The method needs to be modified, however, to account for the fact that the space within a tank above the water is pressurized. Hence the use of differential pressure measurement, with one sensing line connected to the bottom of the tank to sense the water pressure, and the other to the top of the tank to sense the water vapor or steam pressure. The line at the top of the tank is known as the reference line. Even though the reference line connects to the top of the tank, which is above the water level, it will itself still fill up with water because the vapor/steam condenses in the line due to the much cooler ambient air temperature external to the tank.

(cont'd)



Water Flow Measurement

Differential pressure can be used to measure water flow by virtue of Bernoulli's principle: an increase in the speed of a flowing fluid is accompanied by a decrease in pressure. This increase in speed can be forced by placing a constriction such as an orifice plate or nozzle inside a pipeline, reducing its effective diameter. In order for the rate of flow in gallons per minute, for example, to remain the same, the velocity of the fluid must increase to make up for the fact that it is travelling through a smaller opening. This phenomenon is known as the Venturi effect. The higher velocity translates into lower pressure by Bernoulli's principle. Thus, measuring the differential pressure on either side of the constriction provides a measure of the rate of flow through the pipeline.

For exact flow measurement, the design and dimensions of the constriction are critical. In some cases, however, the concern lies more with changes in flow rate, indicative of blockages in the piping or overall flow path. This concern is important when strainers are used to filter out undesired particles from the fluid, especially in generator stator cooling systems. The strainers provide constriction to the water flow, resulting in a pressure difference. When the strainers are clogged, the pressure difference increases.

Steam flow can also be measured using the Venturi effect. But in that case, long sensing lines are not needed, as pressure immediately on either side of the orifice plate or nozzle is measured.

The Freezing Problem

Since differential pressure measurement requires gauging the difference in pressure between two separate sensing lines, if the water in either or both of those lines freezes, the measurement will be false. When a sensing line is plugged with ice, it cannot convey the intended water pressure to the transmitter location.

The fact that the water in the sensing lines is not flowing makes freezing all the more likely, and emphasizes the need for proper freeze protection methods such as insulation and heat tracing. Some sensing lines must run long distances through areas exposed to outdoor ambient air, which significantly exacerbates the risk of false readings.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- **Frozen Equipment (General):** Many other critical systems besides sensing lines experienced problems from the low temperatures. These included emissions systems, feedwater systems, control air systems, lubricating oil systems, and the like. Emissions systems sometimes rely on water, which is susceptible to freezing. Control air systems contain moisture-laden air; if the moisture is not removed, freezing can occur. Changes in the viscosity and properties of lubricants that are not kept at specified temperatures can adversely affect the operation of equipment.
 - ✓ Two units at one plant were derated when the NO_x water storage tank lines froze.
 - ✓ At a City of Garland unit, 78 MW were lost from a draft fan failure, which was caused by frozen damper controls and a resulting low air flow trip.
 - ✓ A wind facility lost six units when lubricating oil fell below the minimum operating temperature and automatically tripped the units.
- **Frozen Water Lines:** The condensate and boiler feedwater systems of steam-cycle generating units (coal, conventional gas, and combined cycle) utilize water from the condenser and add heat (through a series of feedwater heaters) and pressure (through condensate and boiler feedwater pumps) to increase cycle efficiency before the water enters the boilers. Piping, pressure vessels, and valves contained in these systems are susceptible to freezing, absent freeze protection measures. (This is especially true if the unit is offline at the onset of freezing temperatures.)
 - ✓ One facility lost a 160 MW unit when air compressor drains froze. Another unit was shut down because of high boiler “superheat” temperature when its superheat spray lines froze.
- **Frozen Valves:** The operation of valves can become sluggish when exposed to severe cold weather. Depending on the particular application of these components, sluggish valves can cause instability in the boiler or turbine controls, which can eventually lead to a unit trip.
 - ✓ Kiowa Power Partners attempted to free up a frozen valve and, in the process, shut the valve completely, cutting off steam to the turbine and tripping 307 MW of capacity.
 - ✓ Another generating unit experienced a frozen valve on a fuel gas temperature controller, which caused gas temperatures to become

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

erratic. A bypass valve on another unit's fuel gas temperature controller froze, preventing the unit from reaching full capacity for a period of time.

- **Blade Icing:** Blade icing caused problems for wind generators. Precipitation and condensation during cold weather can cause layers of ice to form on turbine blades, causing potential balancing, bearing, and other equipment problems (as well as safety problems resulting from “ice throws”).
 - ✓ Turkey Track Wind Energy lost 27 turbines and 40.5 MW of capacity during the event due to blade icing problems.
- **Low Temperature Limits:** Wind turbines are typically designed to operate within a designated range of temperatures, and have an automatic shutdown feature to protect their components if the range is exceeded. Although manufacturers offer a “cold weather package”²¹⁰ that allows a turbine to continue operating in colder temperatures, it does not appear that the package is used in the Southwest.
 - ✓ McAdoo Wind Energy suffered outages of 90 of its 100 turbines when the turbines, designed to shut down when the temperature drops below five degrees, performed as expected. Although McAdoo's turbines restarted automatically when the temperatures rose above the shutdown point, other units, such as Bull Creek Wind, did not come back online as temperatures rose.
- **Transmission Loss:** Generators can also be affected by external outages of transmission facilities.
 - ✓ At one generating plant, cold grease in a breaker appears to have caused slow clearing of the breaker, tripping six units.

²¹⁰ Press Release, General Electric, GE Energy's 2.5xl Wind Turbine Now Offers Extreme Cold Weather Capabilities for Challenging Applications in North America and Europe (Sept. 21, 2009), *available at* <http://www.genewscenter.com/content/Detail.aspx?ReleaseID=8415&NewsAreaID=2>.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

ERCOT Non-Weather-Related Outages and Derates

While the majority of the ERCOT generator failures during the February event were weather-related, other causes also played a part. This is not surprising, as on any given day generating units can and do experience problems. To determine whether the amount of non-weather-related failures during the February cold weather event was typical, the task force reviewed ERCOT's 2010 daily forced outage data. During that year, forced outages ranged from 900 MW to 6300 MW per day, averaging 3200 MW per day or 16,000 MW for a five-day period. Therefore, the task force concluded that the 14,386 MW of non-weather-related failures experienced by ERCOT generators between February 1 and February 5, 2011 were comparable to what might be expected over a normal five-day period.

The causes (other than fuel supply) of the non-weather-related outages between February 1 and February 5 included difficulties with mechanical equipment, control equipment, operator error, emissions limitations, and fuel switching failures. The task force identified six general categories of non-weather-related causes of generator trips, derates, and failed starts over these five days:

Cause	No. of Units Lost	MW Lost
Mechanical Failure	37	7588
Control System Issues	28	3624
Fuel Switching	12	909
Operator Error	9	980
Emissions	3	358
Miscellaneous	11	927
Total Non-Weather-Related	100	14,386

Representative problems within these categories are discussed below.

- **Mechanical Failure:** A number of generators experienced mechanical equipment problems that were not related to the cold weather. For instance, several had combustion turbines trip due to high exhaust temperature spreads, which is an indicator of internal problems with the combustion turbine (or with the thermocouple²¹¹). Another common combustion turbine problem encountered during the event was high blade path

²¹¹ Thermocouples are used to measure process temperatures and consist of two dissimilar metal wires soldered together at the tip, which produce an electrical current in response to temperature changes. Thermocouples can fall out of calibration over time or fail suddenly due to broken wires or damaged lead wire insulation.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

spread,²¹² which resulted in several more trips. Other trips, derates, and failures to start resulted from such problems as boiler and heat recovery steam generator leaks, plugged suction strainers on condensate pumps, improper boiler feed water pump oil pressure, gas pressure regulation issues (which were mainly resolved by the pipelines), and an assortment of gas turbine tuning issues.

- ✓ Greens Bayou CT 81 (54 MW) tripped due to a high combustible gas alarm, which was triggered by a leak in a coupling.
- ✓ San Miguel Unit 1 (395 MW) tripped due to a waterwall tube leak.
- **Control System Issues:** A prominent problem with control equipment appears to have been failed thermocouples. Control parameters, logic, and dynamics probes also resulted in several trips. Other problems included, but were not limited to, malfunctioning flame detectors and sheared air register pins,²¹³ loose wiring, a failed speed sensor, broken control linkages and faulty flow meter switches.
 - ✓ Deer Park CT 1 (195.5 MW) tripped due to a blade path temperature spread resulting from a failed sensor in the plant's distribution control system logic.
 - ✓ One facility experienced problems with its 46 relay,²¹⁴ which caused an outage. Another unit had a false indication of a ground fault on a generator rotor, which prompted the operator to take the unit offline.
- **Fuel Switching:** ERCOT has approximately 90 generating units with fuel switching capabilities, permitting them to switch from natural gas to an alternate fuel when natural gas is in short supply. (Generators may wish to switch fuel for other reasons as well, such as economics.) During the February event, 20 units attempted to switch from natural gas to their

²¹² Blade path spread is a measurement, utilizing thermocouples, designed to identify turbine exhaust temperatures. A temperature spread beyond allowable limits will initiate an alarm or a trip. However, the alarm or trip can also be triggered by a defective thermocouple, rather than by actual fuel problems or air cooling problems.

²¹³ The failed flame detectors and air register pins caused burners inside the boiler to malfunction.

²¹⁴ A 46 relay (negative sequence relay) is used to detect unbalanced load on a generator that may cause excessive rotor heating and result in significant damage to the generator.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

alternate fuel, with 15 units managing the switch successfully. The other units encountered various failures in their switching equipment. Derates also resulted from fuel switching.

- ✓ The Decker CT 2 (54 MW) tripped when attempting to burn fuel oil.
- ✓ The GEUS steam plant was derated by 5 MW due to operating on fuel oil.
- **Operator Error:** Several generators experienced minor problems associated with operator error. In some cases, the problems arose when operators switched control systems from automatic to manual mode. In other cases, generators tripped as the result of improper maintenance procedures.
 - ✓ A flameout of the boiler at one unit forced the burner valves to close but left the main gas trip valve open. In attempting to close the trip switch before restarting the unit, an operator selected the trip switch for the second unit, putting the second unit out of service.
 - ✓ An operator noticed that the fuel forwarding system for two units were operating in the incorrect mode. In attempting to rectify this situation, the operator correctly selected the automatic mode for one pump (it was operating in manual), but mistakenly selected “lagging” instead of “leading.” This caused both units to give low pressure alarms and trip offline.
 - ✓ Hydraulic oil heaters at a generating unit had been left unplugged since the summer of 2009 (they had been unplugged at that time to avoid overheating). During the February event, trips resulted from low hydraulic oil temperatures.
- **Emissions:** At approximately 12:00 PM on February 2, ERCOT informed generators that the Texas Commission on Environmental Quality (TCEQ) was temporarily waiving air permit requirements that were preventing some generators from operating at full capacity during the emergency. (Although ERCOT characterized the action as a waiver, the TCEQ actually stated that it was exercising enforcement discretion.) This decision had little effect on the situation within ERCOT, as it was not announced until after half of the shed load had been restored.
 - ✓ Prior to issuance of the notice, Calpine’s Clear Lake facility, which consists of three combustion turbines and two heat recovery steam

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

generators, was forced to manually shut down its GT102 and GT104 turbines in order to avoid exceeding NO_x Limits.

- ✓ On February 3, another Calpine unit, Freestone Unit GT4, was derated so as not to exceed its NO_x permit limits.
- **Miscellaneous:** A variety of other problems was also experienced, such as the following:
 - ✓ **Switchyard Equipment Problems:** Some generators encountered switchyard problems that led to units failing during the event. One entity was unable to start certain units because a standby transformer was not energized.
 - ✓ **Low Frequency Related Issues:** Two facilities reported frequency-related issues as causes for their units tripping. One facility's three generators tripped as a result of a low frequency turbine protection relay operating improperly. At another facility, the decline in frequency during the event caused the turbine control system to initiate an increase in fuel pressure to increase turbine speed, but it overshot its set point.

ERCOT Gas Supply Outages and Derates

Fuel supply problems did not significantly contribute to the amount of unavailable generating capacity in ERCOT during the first week in February. The outages and derates from inadequate fuel supply totaled 1282 MW from February 1 through February 5. (For comparison, the overall net generating capacity reduction in ERCOT peaked at 14,702 MW on the morning of February 2.) The fuel supply problems also did not occur all at the same time. The following table summarizes generation capacity reductions in ERCOT due to fuel curtailment and fuel quality problems.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Generator	Trip Time	Unit	Gen MW	MW Reduction	Pipeline (s)
Bosque Power Company	2/2 9:26 AM	Bosque Power: Unit 1, Unit 2, Unit 3, and Unit 4	597	154	Enterprise Texas Pipeline, Markwest Lateral
Calpine	2/4 7:55 AM	Corpus Christi: GT1, GT2, and ST1	516	174	South Cross CCNG Transmission
City of Austin (Austin Energy)	2/2 7:30 AM	Decker : Unit 2	450	100	Enterprise Texas Pipeline / Atmos Texas Pipeline
Power Resources	2/2 5:14 PM	Cal Energy: Unit 1	212	7	ONEOK WestTex Transmission
Luminant	2/1 10:00 AM	Lake Hubbard: Unit 1	441	174	Atmos-Texas Pipeline
GEUS	2/1 9:00AM	GEUS Steam Plant	112	112	Atmos-Texas Pipeline
Exelon	2/1 7:30 PM	Mountain Creek: Unit 6, Unit 7, and Unit 8	808	476	Atmos-Texas Pipeline and Energy Transfer Fuel
	2/2 11:00 AM			396	
	2/2 3:00 PM			476	
	2/2 6:00 PM			396	
Frontera Generation	2/2 8:16 AM	Frontera: Unit 1, Unit 2, and Unit 3	485	85	Kinder Morgan Tejas

- Bosque Power Company:** MarkWest PNG Utility operates an intrastate, 30-mile, 18 inch diameter lateral in Hill, Johnson, and Bosque Counties, Texas. The lateral has an operating pressure of approximately 700 psi, and has no compressor stations. Gas is transported from Enterprise Texas Pipeline, a second intrastate pipeline, to the Bosque County Power Plant, the only electric generation facility served by the pipeline.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Bosque Power Company's QSE, EDF Trading North America (EDF), manages all transportation and gas supply purchases, nominations, and scheduling, including capacity on the Enterprise Texas Pipeline. EDF has only interruptible capacity on the Enterprise Texas Pipeline. The majority of its receipt points are in Waha and West Texas.

The power plant's units are programmed to automatically shut down if pipeline pressure drops below a certain point. On February 2, gas pressure steadily dropped to near the automatic shut down point. To mitigate the effects of lower gas pressures, the plant began reducing energy output on all four of its units.

MarkWest informed the task force that there are no compressors on their pipeline, and therefore the declining pressure was likely a gas supply issue. The pipeline had no capacity constraints.

- **Calpine:** The Calpine Corpus Christi facility is supported by one pipeline system, the Southcross CCNG Transmission pipeline (Southcross). Calpine Energy Services (CES), a subsidiary of Calpine Corporation, is an energy marketer that arranges for natural gas supplies for generation facilities owned by Calpine, including the Corpus Christi facility.

On February 3 and 4, CES delivered gas into Southcross at four separate locations. However, at approximately 7:55 AM on February 4, the Calpine units tripped off line due to declining pipeline pressure on the Southcross system. The pressure on Southcross fell below the minimum delivery pressure obligation of 560 psig that is stated in both of CES's firm and interruptible agreements. Southcross reported that the low pressures on its system were due to supply freeze-offs that reduced expected deliveries into its system.

Calpine was able to restart one of its units in less than one hour and run the facility at a derated level. Later in the day on February 4, once Southcross restored its line pack pressures, Calpine successfully brought all units back online.

- **City of Austin (Austin Energy):** The city of Austin has firm capacity on the Enterprise Texas Pipeline and is connected to the Atmos Pipeline-Texas (Atmos), both intrastate pipelines. Under the terms of the city's agreement with Atmos, its capacity rights are reduced when freezing weather is forecasted, pursuant to a specific formula in the contract. Most of the gas supply for the transportation is from Waha.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The plant did not experience curtailments. However, given the limitations on Atmos, usage was limited on February 2. Austin Energy exceeded its contractual hourly take on Enterprise Texas Pipeline and was requested by Enterprise to reduce flows to the hourly take (this is referred to as “back on rate”). This reduction caused a 100 MW derate of the Decker unit.

- **Power Resources:** Power Resources’ Cal Energy Plant ramped down one hour early due to low gas pressure on its supplying pipeline, ONEOK WesTex, an intrastate pipeline located primarily in west Texas and the Texas panhandle.

ONEOK WesTex states that it did not interrupt service but did experience operational difficulties and supply reductions. Beginning on February 1, increased gas usage by towns and power plants reduced the pipeline pressure, and several interconnecting gas processing plants also experienced supply difficulties. Normal operating pressures were restored by the afternoon of February 2.

- **Luminant and GEUS:** These plants are connected to the Atmos system, which traverses the Fort Worth, Permian, and East Texas Basins, all of which experienced supply losses due to freeze-offs.

Transportation for power generation feeding off Atmos is only offered as an interruptible service, and is subject to electric generation restrictions, called “Tier 3 restrictions.” Atmos instituted Tier 3 restrictions beginning at 9:00 AM on February 1, restricting gas flow to zero for the GEUS steam units and for Luminant’s Lake Hubbard generating station. On February 2, increased demand resulted in continued loss of line pack and declining pressures at citygate points in Dallas-Fort Worth. Additionally, suppliers experienced well freeze-offs and equipment problems.

On the morning of February 2, ERCOT initiated rolling blackouts to maintain the grid. The TRC contacted Atmos at approximately 10:00 AM to ask if additional volumes could be delivered to the Lake Ray Hubbard Electric Generating Station to assist with electric grid issues. Atmos explained to the TRC that such action would result in the loss of service to firm residential and commercial customers served by LDCs located to the north of the electric generation station on the pipeline system, and that therefore such deliveries could not be made to an interruptible customer.

- **Exelon:** Exelon has a firm gas transportation contract with Energy Transfer Fuel (ET Fuel) for the Handley Generating Station and an

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

interruptible gas transportation contract with Atmos for Handley Generating Station and Mountain Creek Station. Atmos implemented a Tier 3 restriction during the extreme weather event, which limited hourly flow to both the Handley and Mountain Creek stations.

The fuel curtailments at Handley did not affect operations until Unit 3 was called on the evening of February 2. Gas supply during the day was enough to allow Units 4 and 5 to run at full load. When Unit 3 was brought on line, it fuel switched Unit 4 to run partially on oil to allow Units 3 and 5 to increase output. Mountain Creek Units 6 and 7 ran at minimum load due to fuel restrictions. Mountain Creek Unit 8 ran at full load (but did have other non-gas related derates that affected output).

- **Frontera Generation:** The Frontera Generation plant is on the Kinder Morgan network of pipelines (collectively, KM Texas Pipes). The KM Texas Pipes receive natural gas from producing fields in south Texas, east Texas, the Gulf Coast, the Gulf of Mexico, and the Permian Basin. They also own or control gas storage capacity.

Frontera has firm transportation service with deferred account service. “Deferred account service” is a balancing service that enables a shipper to acquire supply during low demand and deliver it to the KM Texas Pipes for future redelivery during peak demand, subject to contractual limits on hourly, daily, and total quantities.

During the morning of February 2, the KM Texas Pipes contacted those customers that were taking more than their firm contractual rights, including both of the Frontera plants, requesting they stay within their contractual rights because pipeline pressures were falling and putting all firm services at risk. Later that day, ERCOT, along with the TRC, advised the KM Texas Pipes that ERCOT had declared an emergency condition. ERCOT then advised the KM Texas Pipes that the power grid in the Rio Grande Valley was in a critical state. ERCOT and the TRC requested the KM Texas Pipes to allow the Frontera electric generating plant to pull supplies in excess of their firm contractual rights. The KM Texas Pipes complied with this request.

Generation Outages in Salt River Project

The SRP balancing authority suffered several generator outages during the cold weather event, which severely affected its ability to serve load. On February 1 and 2, SRP lost a total of seven units. The failures of three of them were related to weather. On February 1, SRP lost Unit 1 at its Navajo Generating Station due

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

to a frozen transmitter sensing line, reducing generation capacity by 330 MW. On February 2, SRP lost additional generation due to weather-related problems: it lost 75 MW, its 10 percent share, from Unit 4 at Four Corners Generating Station (operated by Arizona Public Service Company), which failed due to a frozen sensing line that served the throttle pressure transmitter; and it lost Unit 2 at Navajo Generation Station, which tripped due to frozen waterwall pressure transmitter sensing lines.

SRP also suffered generation losses from the trips of four units on February 2, due to non-weather related issues: Coronado Generating Station Unit 2, which experienced a mechanical problem with a coal pulverizer, losing peak load of 389 MW; the combustion turbine and the steam turbine units at Santan Generation Station Unit 6, which suffered an internal mechanical failure on the heat recovery steam generator and an accompanying runback of the combustion turbine; Springerville Unit 3 (operated by Tucson Electric Power), which developed high furnace pressure, causing a loss to SRP of its 75 MW share of the plant's 400 MW.

Generation Outages in El Paso Electric

The EPE balancing authority shed approximately 623 MW of firm load over the course of the February event, due to the loss of 646 MW of local generation. Unlike SRP, almost all of EPE's outages were due to the cold weather.

On February 1, EPE lost its Newman Unit 3 because of frozen condensation on the fresh air inlet, and lost Rio Grande Unit 6 because of a frozen gas transmitter. The loss of these units resulted in a 152 MW reduction of capacity.²¹⁵

On February 2, EPE lost 495 MW of capacity from its Newman and Rio Grande plants. Newman Gas Turbines 1 and 2 at Newman Unit 4, each with a capacity of 73 MW, tripped due to faulty drum level readings resulting from the cold weather. Gas Turbines 3 and 4 at Newman Unit 5, each with a 70 MW capacity, also tripped due to frozen drum level instrumentation sensing lines. Newman Unit 4 Steam Turbine, a 64 MW unit, tripped on February 2 due to frozen instrumentation associated with the condenser vacuum. Finally, EPE lost Rio Grande Unit 8, a 145 MW unit, due to frozen transmitter sensing lines that caused a low gas pressure signal.

²¹⁵ The Newman plant is not enclosed; the Rio Grande plant is enclosed.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

El Paso attempted to bring its units back online on February 3 and February 4, with limited success. Newman Unit 4's GTs were restarted, only to trip on subsequent occasions for similar weather-related issues. (Luna and Afton, PNM remote generating facilities from which EPE was receiving energy, also experienced outages on February 3 and February 4.)

During the event, two EPE units, Newman Unit 1 and Rio Grande Unit 7, were offline and EPE tried to bring them online to assist with the shortages. Both units, however, failed to start due to frozen components and, in the case of Newman Unit 1, frozen drum drain lines and transmitter.

B. Natural Gas

Most of the natural gas supply problems experienced in the Southwest during the cold weather event were caused by freeze-offs, principally at the wellhead or, to a lesser degree, at nearby processing plants. Other equipment failures also played a role, as did the rolling blackouts and customer curtailments in the ERCOT region.

In order to analyze the causes of the supply shortfalls, the task force reviewed daily shortfalls at receipt points on pipelines. Most of these receipt points were at processing plants. The following table summarizes the information received from 13 processing companies, which overwhelmingly pointed to upstream supply outages as the major cause of the reduced volumes. (The second column is the maximum estimated production shortfall by basin; the third column is the percentage of shortfall of the processing plants that provided information; the final column lists the causes of the shortfalls.)

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Processing Plant Outages Relative to Daily Production Shortfalls

BASIN	MAXIMUM DAILY PRODUCTION OUTAGE	PROCESSING RESPONSES AS A % OF THE DAILY OUTAGE	CAUSES
Permian	1.31 Bcf on Feb 4	0.44 Bcf (34%)	85% Upstream Supply Freeze-offs, 15% Mechanical/Electricity Outages
San Juan	.43 Bcf on Feb 2 and Feb 3	0.21 Bcf (52%)	Upstream Supply Freeze-offs, Minimal Amount due to Mechanical
Fort Worth	1.63 Bcf on Feb 6	0.17 (11%)	Upstream Supply Freeze-offs, Minimal Amount due to Mechanical
East Texas	.72 Bcf on Feb 3 and Feb 5	NA	NA
Gulf Coast	.65 Bcf on Feb 4	NA	NA

The task force further explored these upstream production outages by surveying 15 of the larger producers in the San Juan, Permian, Fort Worth, East Texas, and Gulf Coast Basins. These producers accounted for almost 40 percent of the total production for the five basins, with the highest percentages from the Fort Worth, San Juan, and Permian Basins.

For February 1 to February 5, an estimated 14.8 Bcf of production was lost from these five basins due to weather-related reasons. Of that amount, the surveyed producers lost 7.1 Bcf, equal to 48 percent of the total.

These production losses occurred for a variety of reasons. Some of the most common occurrences reported to the task force included:

- Freeze-offs (in some circumstances winterization was only designed for temperatures in the 20s),
- Icy roads that hampered logistics such as hauling away water produced by treatment equipment, and
- Rolling blackouts and customer curtailments.

Rolling blackouts were a problem particularly in the Fort Worth Basin, where they caused outages of compressors on gathering lines. In the Permian Basin, deployment of Load Resources by ERCOT during the event caused disruption to electric pumping units. According to information received from the

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

surveyed producers, 27 percent of the outages in the Fort Worth Basin were due to the rolling blackouts, and 29 percent of the outages in the Permian Basin were due to rolling blackouts or the curtailment of interruptible load.

The following table itemizes the reasons stated by these 15 producers for the supply shortfalls (the check marks indicate how many separate producers submitted information for each category):

	Permian	San Juan	Fort Worth	East Texas	Texas Gulf
Rolling Black Outs/ Curtailed Load	✓✓✓✓		✓✓		
Icy Roads	✓✓✓✓	✓	✓✓✓✓✓✓	✓✓	
Freezing of Compressors		✓✓	✓✓✓	✓✓	✓✓
Freezing Meters		✓			✓
Wellhead Freeze-offs	✓✓✓✓✓	✓✓	✓✓✓	✓✓✓✓✓	✓✓✓✓
Processing Facility Shut-in	✓	✓	✓	✓	
Ice Plugs in Gathering Lines	✓				
Frozen Salt Water Disposal Facilities	✓				

A basin-by-basin description of the gas production declines, and the resulting reduction in flows, follows.²¹⁶

Permian Basin

The Permian Basin suffered production losses from February 1 through February 5 of 3.98 Bcf, with a maximum daily decline of 1.31 Bcf on February 4. The reasons provided for these declines are based on information received from

²¹⁶ The information is drawn from materials provided to the task force by producers and processing plants.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

processors representing 34 percent of the maximum daily outage and producers representing 28 percent of the cumulative losses.

Reduced Flows at Processing Plant Pipeline Receipt Points

The task force reviewed receipt points on El Paso, Transwestern, Northern Natural Gas Company, and Enterprise Texas pipelines that had reductions exceeding 20,000 MMBtus per day, and thirteen processing plant points that had reductions of approximately 0.6 Bcf per day.

The receipt points on the El Paso pipeline with flow declines exceeding 20,000 MMBtus per day from February 1 to February 3 are all processing plant/gathering locations. They include Enterprise Waha (reduction of 120,681 MMBtus per day); Southern Union Jal#3 (reduction of 35,966 MMBtus per day); DCP Midstream GPS Eunice, reduction of 32,055 MMBtus per day; DCP Midstream Goldsmith Plant (reduction of 29,562 MMBtus per day); Southern Union Keystone (reduction of 28,515 MMBtus per day); Versado Gas Processors Texaco Eunice (reduction of 26,407 MMBtus per day); DCP Midstream Pegasus (reduction of 23,475 MMBtus per day); and Versado Gas Processors, Warren Monument (reduction of 21,460 MMBtus per day).

Transwestern's supply shortfalls in the Permian Basin were modest, relative to El Paso's, and were most significant at the Frontier Maljamar Gas Plant (reduction of 33,000 MMBtus per day) and at the Agave producer gathering connection (reduction of 44,000 MMBtu per day). Northern Natural processing plant receipt points with large reductions were the Atlas Midkiff Plant (reduction of 63,997 MMBtus per day) and the DCP Linam Ranch Plant (reductions of 106,406 MMBtus per day). Finally, on Enterprise Texas Pipeline, the Crockett Gas Plant had a production shortfall of 34,376 MMBtus per day.²¹⁷

Explanations varied for the reductions from the processing plants located in the Permian Basin.²¹⁸ The largest supply reduction to El Paso was the Enterprise Waha treating plant, which has a capacity of 280 MMcf per day. Enterprise reported that volumes delivered to the Waha Treating Plant decreased from 120 MMcf per day to approximately 40 MMcf per day, due to gas supply freeze-offs on February 2 and February 3. The plant's GE turbine then went down on

²¹⁷ Staff's analysis based on supporting data, display reports and data warehouse on file with Bentek (unpublished); *See also Market Alert: Deep Freeze Disrupts U.S. Gas, Power, Processing*, Bentek Energy LLC, Feb. 8, 2011, at 2-6.

²¹⁸ The task force received materials from a number of processing plants located in the basin. The material cited represents a sampling of data from those materials.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

February 3, due to high discharge pressure when El Paso closed its valve at the plant tailgate (because of a high dew point in the gas stream).

On February 2, DCP's Linam Ranch plant in east New Mexico experienced freezing air ducts, resulting in a modest reduction to El Paso of 4,865 MMBtu per day from February 1 to February 3 (the reduction is 24,092 when measured from January 31). The plant then experienced a delay returning to service because of gas supply shortages from well freeze-offs, resulting in a lack of gas to restart the plant. The plant returned to normal operations on February 6 and supply returned to normal levels on February 7. Reductions in volume at three other DCP plants, Goldsmith, Pegasus, and Eunice, were the result of supply shortages from wellhead freeze-offs. Goldsmith and Pegasus experienced rolling blackouts that resulted in only brief outages, with gas being at the time either processed at the plants or delivered directly into pipelines.

Four DCP Texas processing plants were impacted by the rolling blackouts on February 2, but only one of them had resulting operational problems. The power outage caused the cooling water used for compression at the Roberts Ranch Plant in west Texas to freeze, leading to a plant shut down. (The plant was back in service on February 5.) The remaining plants did not experience any operational issues from the power outages. When the brief power outages occurred, the upstream gas bypassed the plants and was delivered without being processed.

Southern Union operates the Keystone and Jal #3 plants that together flowed reduced volumes of 64,481 MMBtu per day to El Paso. Southern Union reported that it experienced major property damage and significant financial losses due to freezing and failure of wells, pipes, and other facilities. The weather event ultimately resulted in the cessation of operations at many plants and field facilities, with corresponding reductions in deliveries to downstream pipelines. Some of Southern Union's issues were a direct result of rolling power outages at the Keystone facility at 7:25 AM and 9:05 AM on February 2, lasting 34 and 30 minutes, respectively.

Producer Declines in the Permian Basin

Producers representing a customary production level of approximately 0.75 Bcf per day²¹⁹ (approximately 30 percent of total basin production), reported production losses for the period February 1 through February 5 of 1.1 Bcf,

²¹⁹ This number represents the producers' usual production level, absent reductions experienced during the event.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

estimated to be approximately 28 percent of the total basin production losses for the five days. The losses were attributed to the following:

- Power disruptions to electric motors on pumping units (29 percent of the total losses, or 0.32 Bcf),
- Icy roads,
- Ice plugs in gathering lines,
- Freeze-offs, and
- Downtime at processing plant.

Occidental Energy Marketing reports that on February 2, because of its status as a Load Resource on ERCOT's system, electric service to its production facilities were interrupted when ERCOT deployed it as a Load Resource. This interruption resulted in significant production losses. Power began to be restored approximately 1.5 hours after the disruption occurred.

ConocoPhillips Company reports that a significant percentage of its production losses in the Permian Basin were attributable to rolling blackouts that knocked out processing plants and pumps and lifts. The majority of its Permian Basin production comes from oil wells that rely on electric pumps and lifts to maintain oil flow. When the pumps failed, the natural reservoir pressures were unable to sustain flow, the oil congealed, and the wells and flow lines froze.

San Juan Basin

The San Juan Basin suffered production losses from February 1 through February 5 of 1.3 Bcf, with a maximum daily decline of 0.43 Bcf on February 3 and February 4. The reasons provided for these declines are based on information received from processors representing 52 percent of the maximum daily outage and producers representing 71 percent of the cumulative losses.

Reduced Flows at Processing Plant Pipeline Receipt Points

The task force reviewed receipt points on El Paso and Transwestern that had reductions exceeding 20,000 MMBtus per day, and eight processing plant receipt points with a reduction of approximately 0.35 Bcf per day (when netted against increased flows elsewhere).

Receipt points off of El Paso that had flow reductions exceeding 20,000 MMBtus per day are the BP Florida River Plant, with a reduction of 155,691 MMBtus per day, and two Williams Field Services processing plant/gathering locations; Milagro, with a reduction of 66,764 MMBtus per day, and #37, with a reduction of 24,047 MMBtus per day. Transwestern's most significant supply

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

shortfalls in the San Juan Basin for February 1 through February 3 were the William FS Kutz Plant, with reductions of 36,000 MMBtus per day, the Red Cedar Arkansas Loop gathering facility, with a reduction of 33,000 MMBtus per day, the Valverde Gas Plant, with a reduction of 48,000 MMBtus per day, and the Enterprise Chaco Plant, with a reduction of 87,000 MMBtus per day. These reductions were partially offset by increased flow of 100,000 MMBtus per day from the Williams FS Ignacio Plant.

Williams Fields Services reported that they had no operational problems, and the reduced volumes at Milagro and Kutz were due to upstream production shut-ins. With regard to the Chaco Plant, Enterprise reported it was operating at less than full capacity during the first week of February primarily because: (i) gas supplies were limited, (ii) ConocoPhillips moved approximately 100 MMcf²²⁰ from Chaco to their own San Juan processing plant on February 1, and (iii) winter production shut-ins occurred. In addition, the plant tripped on February 2 due to a hazardous gas supply alarm, and Enterprise's attempts to restart it were impeded by the combination of the lower volumes being nominated by producers and the cold weather experienced at the time.

Producer Declines in the San Juan Basin

Producers representing a customary production level of 2.0 Bcf per day (approximately 67 percent of total basin production), reported production losses for February 1 through February 5 of 0.9 Bcf, estimated to be approximately 71 percent of the total basin production losses for the five days.

None of the producers cited power outages as a cause of production losses. The losses were attributed to the following:

- Problems with compressor units,
- Freezing of wellhead meters,
- Cold weather, Freeze-offs,
- Icy roads, and
- Downtime at a processing plant.

Fort Worth Basin

The Fort Worth Basin suffered production losses from February 1 through February 5 of 4.7 Bcf and a maximum daily decline of 1.63 Bcf on February 6. The reasons provided for these declines are based on information received from

²²⁰ MMcf is a million cubic feet per day.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

processors representing 11 percent of the maximum daily outage and producers representing 80 percent of the cumulative losses.

Reduced Flows at Processing Plant Pipeline Receipt Points

The Fort Worth Basin experienced supply reductions of almost 1.3 Bcf per day. Energy Transfer Fuel (ET Fuel) and Crosstex North Texas Pipeline (Crosstex) both receive gas from the Fort Worth Basin, and experienced reduced receipts.

ET Fuel had reduced receipts of 0.35 Bcf per day from January 31 through February 4. The largest reductions on the system occurred at the following receipt points: Chesapeake Energy production, with a reduction of 71,314 MMBtus per day; EOG Resources production, 127,418 MMBtus per day; Quicksilver Gathering, reduction of 69,675 MMBtus per day; and an ET Fuel processing plant, reduction of 61,668 MMBtu per day.²²¹

Crosstex had a flow reduction estimated at 0.14 Bcf per day. The reduced volumes were due largely to the weather-related shut-down of the Silver Creek processing plant. Primarily due to freeze-offs, production at the plant declined by approximately 110,000 MMBtus per day from a normal flow rate of 185,000 MMBtus per day, to a five day average of 75,000 MMBtus per day on the outlet.

Atmos reported that intermittent supply reductions from nominated volumes were 0.13-0.17 Bcf per day.

The Energy Transfer Corporation Texas (ETC Texas) Godley area plant in north Texas experienced weather related difficulties on February 1 when one of its amine systems froze. ETC Texas was able to flow amine again on February 5. From February 1 through February 5, the inlet volume of the Godley Processing Plant decreased by 100 MMcf, due to the loss of third party production from freeze-offs.

Producer Declines in the Fort Worth Basin

Producers representing a customary production level of 3.3 Bcf per day (approximately 69 percent of total basin production), reported production losses from February 1 through February 5 of 3.8 Bcf, estimated to be approximately 80

²²¹ Staff's analysis based on supporting data, display reports and data warehouse on file with Bentek (unpublished); pipeline scheduled volumes.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

percent of the total basin production losses for the five days. The losses were attributed to the following:

- Rolling blackouts primarily affecting compressors on gathering lines (27 percent, or at least 1.0 Bcf),
- Icy roads, and
- Freeze-offs.

One large producer in the basin reported production losses for the period February 1 through February 5 as a result of electrical compression being shut down on a gathering system in the Dallas/Ft. Worth area. After power was restored, production was slow to return to standard rates. It therefore appears likely that a significant percentage of the lost production even after February 2 was due to the loss of power during the rolling blackouts.

East Texas

Producers representing a customary production level of 1.2 Bcf per day (approximately 24 percent of total basin production), reported production losses from February 1 through February 5 of 0.9 Bcf, estimated to be approximately 33 percent of the total basin production losses for the five days. The losses were attributed to the following:

- Equipment freeze-offs,
- Icy roads,
- Downtime at processing plants,
- Freezing of equipment, and
- Wellhead freeze-offs.

Gulf Coast

Producers representing customary production level of 0.7 Bcf per day from February 1 through February 5 (approximately 14 percent of total basin production), reported production losses from February 1 through February 5 of 0.36 Bcf, estimated to be approximately 18 percent of the total basin production losses for the five days. The losses were attributed to the following:

- Compressors freezing,
- Frozen meters, and
- Freeze-offs.

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VII. Prior Cold Weather Events

The arctic cold front that descended on the Southwest during the first week of February 2011 was indisputably severe. Many cities in Texas and New Mexico experienced a 50 degree drop in temperature over an eighteen-hour period. Temperatures dropped to the low teens in Texas and below zero in New Mexico. Much of north Texas experienced record setting sleet and snow, totaling up to seven inches. Exacerbating the effects of the cold temperatures were accompanying sustained winds of 30-40 mph, with gusts as high as 51 mph.

The 2011 winter weather event has been determined by at least one weather service to be a one in 10 year occurrence for some regions of Texas, in terms of low temperatures and duration.²²² Adding the sustained winds to these low temperatures, the resultant convective heat loss (wind speed plus ambient temperature) for some generators was estimated to approach a one in 25 year severity. Specifically in El Paso, only four prior recorded cold weather events approached 2011 in severity, making the storm the worst weather event in the El Paso area in 49 years.²²³

This cold weather event was thus unusual in terms of temperature, wind, and duration. It was not, however, entirely without precedent. The Southwest experienced other cold weather events in 1983, 1989, 2003, 2006, 2008, and 2010. In fact, two of those years, 1983 and 1989, had lower temperatures than 2011.²²⁴ But only in 1989 were the severity, geographical expanse, and duration of cold temperatures and high winds comparable to the February 2011 event.

In most of those prior years, utilities avoided any significant outages or curtailments. In other years, however, that was not the case. This section examines pertinent prior winter weather events to determine if there were lessons that could have been learned that might have prevented or ameliorated the service disruptions experienced in 2011.

²²² Key Document, Severe Weather Readiness Workshop Formerly Generation Weatherization Workshop, Winter Weather Readiness for Texas Generators, (June 8, 2011), <http://www.ercot.com/calendar/2011/06/20110608-OTHER> (citing Weatherbank, Inc).

²²³ Forensic Weather Consultants, LLC, Forensic Weather Investigation of the Weather Conditions and Air Temperatures for the Period 1911-2011 (100 Years) in El Paso, Texas, May 12, 2011, at 1.

²²⁴ Based on data from the National Weather Service.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

A. Electric

The two prior cold weather events of most significance for the ERCOT region occurred in 2003 and 1989; generators experienced weather-related outages in both of those years, and rolling blackouts were implemented in 1989. The winter of 1989 in particular resembles that of 2011, both in the severity of the weather and in loss of load.

These two events are described below, beginning with the most recent.

2003 Event

On Friday, February 21, 2003, weather forecasts predicted a cold front over a large part of Texas. The front moved in earlier and was more severe than projected. Statewide, temperatures ranged from 15 to 27 degrees below normal. On Monday, February 24, with freezing temperatures as far south as San Antonio, the demand for electricity reached 42,029 MW, exceeding ERCOT's forecast by 4218 MW, or 11 percent. Owners of gas-fired generating units were short on gas and tried to acquire more gas on the intraday market. At the same time, the demand for gas increased as a result of heating needs.

System Events

By 6:00 PM on February 24, ERCOT issued a Market Alert to increase available energy and capacity, and ordered all Reliability Must Run (RMR) units raised to maximum output levels. Temperatures remained below freezing in Austin and Dallas into Tuesday. By 7:30 AM on Tuesday, ERCOT issued a Market Advisory requesting more bids. At the same time, gas companies informed customers that they were activating tariff provisions to curtail gas for purposes other than "human need." At the request of three QSEs, the ERCOT Chief Operating Officer signed affidavits stating that gas needed for electric generation met the qualification of human need.

At 9:08 AM on February 25, gas curtailment to a power plant caused three units to trip, resulting in the loss of 745 MW of generation. System frequency dropped to 59.81 Hz and could not be restored. The ERCOT system control error (SCE) was -1,500 MW and increasing. At 12:01 PM, ERCOT declared Emergency Electric Curtailment Plan (EECP) Step 1 (EECP was the predecessor to today's Emergency Energy Alerts). Step 1, invoked when reserves fall below 2300 MW, entailed instructing all available generation to come on line, and securing emergency power from neighboring electrical grids through the DC ties.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The EECF Step 1 succeeded in rebalancing the system within 30 minutes. Step 1 remained in effect for about seven hours and 30 minutes.²²⁵

Gas Supply Problems

Generator owners reported to the PUCT that they had problems acquiring natural gas to run their gas-fired units. Natural gas was suddenly in short supply, but equally significant was the fact that the structure of the natural gas market limited the way generators were able to respond to fuel shortages in real time. Specifically this involved the following:

- **Depleted reserves:** The amount of gas in storage declined rapidly starting in November 2002, faster than the usual drawdown over the winter period, dropping from a five year high to a five year low in just four months.
- **Timeline for gas nominations:** Natural gas trading closed for the weekend, meaning that fuel for Monday must be procured on Friday, thereby not allowing leeway for late changes in the forecast.
- **Fuel shortages and curtailments:** Delivery constraints reduced the fuel supply to some plants, forcing their electric generating capacities to be derated.
- **Lack of on-site storage:** Natural gas pipeline companies have the bulk of their storage underground, but most of the former vertically integrated electric utilities had their own gas storage facilities. Independent power producers generally do not have their own gas storage; in a deregulated environment, most believe it is uneconomical to maintain it.

In 2003, almost three-quarters of the installed electric generating capacity was fueled by natural gas. Of those units, 16 percent had dual fuel capability, the other fuel being oil. Many units switched from gas to oil on February 24 and February 25, but most had to be derated in the process, and some experienced operating problems. Of the total of 5500 MW of capacity that was lost due to gas curtailments, ERCOT estimated that only 3200 MW was regained on back-up fuel oil, yielding a net loss of 2300 MW.

²²⁵ Prices spiked to \$990 per MWh on February 24 and February 25, 2003, as the result of hockey stick bidding. For a discussion of this phenomenon, see the earlier section of this report entitled “The Event: Load Shed and Curtailments.”

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

PUCT Recommendations

The Market Oversight Division of the PUCT investigated the 2003 cold weather event and issued a number of recommendations.²²⁶ Notable among these are the following:

- Stricter enforcement of Resource Plan accuracy.
- Improved weather and electric demand forecasting.
- Consider providing financial incentives for fuel oil inventories to be maintained for use by dual fueled units.
- Curtailment prioritization – development of a joint curtailment methodology for natural gas and electricity production.
- ERCOT should communicate with both QSEs and Transmission / Distribution Service Providers in the future when the power system is under stress.

Consequences

Following the 2003 generating unit outages, ERCOT revised its Protocols to establish Resource Plan performance metrics. These were put in place in 2004. The February 2003 event ultimately became an impetus for the establishing of Emergency Interruptible Load Service in ERCOT.

1989 Event

Beginning on Thursday, December 21, 1989, an arctic air mass descended on Texas for three days, delivering some of the coldest temperatures ever recorded in the state over a one hundred year period. Temperatures bottomed out at 7 degrees in Houston, -1 in Dallas, and -7 in Abilene. As a result of the cold weather, the demand on the ERCOT power system peaked at 38,300 MW, an 11 percent increase over the previous winter's peak and 18 percent above the projected peak for the winter of 1989-1990. This load level was equivalent to 93 percent of the summer peak demand.²²⁷

²²⁶ Julie Gauldin, Richard Greffe, David Hurlbut & Danielle Jaussaud, Pub. Util. Comm'n of Tex., Market and Reliability Issues Related to the Extreme Weather Event on February 24-26, 2003, 29 (May 19, 2003), *available at* http://puc.state.tx.us/industry/electric/reports/ERCOT_annual_reports/special/weather_event.pdf (PUCT 2003 Report).

²²⁷ Elec. Reliability Council of Texas, *ERCOT Emergency Operation: December 21-23, 1989* (Undated), at 5 (ERCOT Emergency Operation).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The high demand, combined with weather-related forced outages of generating units and the curtailment of natural gas fuel supplies, resulted in the need for ERCOT to shed firm load system-wide for the first time in its history or the history of its predecessor.²²⁸ Although there were two subsequent years in which ERCOT shed load during hot weather spells,²²⁹ the 1989 event remained the only cold weather-related load shed event until February 2011.²³⁰

The 1989 event predated deregulation of the electric utility business in Texas, which began in 2002. Utility companies were therefore still vertically integrated and owned and operated generation, transmission, and distribution in their franchise service territories.

System Events

On Wednesday, December 20, 1989, a severe cold weather alert was declared for north Texas, effective the following morning; by 6:00 PM on Thursday, all of ERCOT's territory had been placed under severe alert. The temperature was 21 degrees in Dallas and 41 in Houston at that time. Gas curtailments were experienced starting on December 21, and continued for several days thereafter. These resulted in a considerable number of generators switching to or increasing their mix of fuel oil.

On Friday, December 22, ERCOT was unable to maintain minimum required operating reserve levels, due to record-high loads and a large number of generating units being forced offline. The frequency dropped below 59.95 Hz at 8:30 AM, and ERCOT ordered the start up of all available units. Those local control centers experiencing generation deficiencies also shed interruptible loads and minimized their own internal loads such as mining operations and station

²²⁸ ERCOT's predecessor was Texas Interconnected Systems, formed in 1941. *Id.* at 1.

²²⁹ In May 2003, the loss of two nuclear-powered generating units tripped automatic UFLS relays, resulting in the shedding of 1549 MW of firm load; service was restored within three hours and 30 minutes. In April 2006, an early season heat wave and the loss of four generating units caused ERCOT to shed 1000 MW of firm load via rolling blackouts; service was restored within one hour and 45 minutes.

²³⁰ For the Houston area, which was the hardest hit in Texas, it was the first shedding of firm load in the history of the Houston Lighting and Power Company, dating back to the energizing of its first lighting load in 1882. *See* Bill Beck, *At Your Service: An Illustrated History of Houston Lighting & Power Company* (Houston Lighting & Power Company, 1st ed.1990) at 409; *see also* A Brief history of CenterPoint Energy, 1880-1889, CenterPoint Energy, <http://www.centerpointenergy.com/about/companyoverview/companyhistory/timeline/23b55aef7af66210VgnVCM10000026a10d0aRCRD/> (last visited Aug. 3, 2011).

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

lighting. Utilities made public appeals for customers to voluntarily reduce consumption.

At 10:00 AM on December 22, ERCOT's load peaked at 38,300 MW. At this point, the online generating capacity was 39,800 MW, or 1500 MW greater than the load. Within two hours, decreasing load and the restoration of some generating units that had been forced offline earlier succeeded in bringing reserves back up to acceptable levels. Thus, the record-setting peak load period was met without the need to shed firm load.

However, temperatures continued to drop overnight Friday into Saturday, December 23, when they reached minimums of -7, -1, and 7 degrees in Abilene, Dallas, and Houston, respectively, with wind chill factors down to -35 degrees.

Up until midnight Friday night, approximately 3000 MW of generation was offline due to weather-related problems. The system also suffered 1500 MW of capacity reduction on account of units switching from natural gas to fuel oil. Between midnight and 7:00 AM on the following morning, an additional 4700 MW of generation was forced offline due to weather-related problems. It was also difficult getting power from outside ERCOT. West Texas Utilities offered 220 MW of emergency power to Houston Lighting and Power Company (HL&P), to be delivered over the North Tie, but then had to withdraw the offer due to unspecified technical problems.

By 5:36 AM on Saturday, December 23, the frequency had again dropped below 59.95 Hz, and over the course of the next hour and a half it hovered between 59.79 and 59.92 Hz, indicating the system was in difficulty. Interruptible loads were shed during the early morning hours. At 7:49 AM, ERCOT directed the utilities that were generation deficient to shed firm load.

HL&P had already begun shedding firm load, and increased its load shed to 1000 MW. Lower Colorado River Authority and the City Public Service of San Antonio shed 60 and 150 MW of firm load, respectively.

This firm load shedding, combined with some internal and external power transfers, succeeded in restoring the frequency to 60 Hz, re-stabilizing the system. Around 10:20 AM, however, seven generating units producing a combined 1275 MW were all forced offline nearly simultaneously, causing the frequency to plummet to 59.65 Hz. ERCOT was then forced to invoke system-wide load shedding, beginning with 500 MW, allocated among the utilities. Within ten minutes, the frequency had recovered and the system was stable once again.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

As the midday Saturday load declined (typical for a weekend midday), much of the firm load that had been shed was able to be restored within only 30 minutes. The load shed directive was terminated slightly more than two hours later, when reserves increased to acceptable levels.

Accounts vary regarding the amount of total firm load that was shed. The PUCT reported a total load shed of 1710 MW.²³¹

Generation Outages, Derates and Failures to Start

The following table presents a summary of the causes of the outages, derates, and failures to start experienced in ERCOT during the 1989 cold weather event.

Number of Units	Capacity	Cause
34	11,623 MW	Frozen Instrumentation
6	1385 MW	Paralyzed or Dead Fish Clogging Water Intakes
9	1051 MW	Other, Cold Weather-related
7	1246 MW	Non-weather-related
56	15,305 MW	Subtotal
Not Available	1500 MW	Gas curtailment impact (oil burning derate)
56+	16,805 MW	Total

²³¹ See Pub. Util. Comm'n of Tex., Electric Utility Response to the Winter Freeze of December 21 to December 23, 1989 (Nov. 1990), at 14 (PUCT 1989 Report); ERCOT Emergency Operation at 6.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Virtually all types of generating units encountered problems, whether viewed from the perspective of fuel type or unit type, suggesting that the problems could not be attributed to a particular fuel or unit design. The breakdown is as follows:

- Sorted by **Fuel Type:**

- Coal: 8 units; 4669 MW
- Natural Gas: 29 units; 3881 MW
- Distillate Oil: 1 unit; 257 MW
- Dual Fuel – Gas & Oil: 15 units; 4418 MW
- Dual Fuel – Coal & Gas: 1 unit; 670 MW
- Nuclear: 1 unit; 1250 MW *
- Petroleum Coke: 1 unit; 160 MW

*This unit was forced off line the previous weekend due to the failure of an expansion joint in a steam condenser. An attempt was made to start it up during the December 21-23 cold spell, but that failed due to equipment freeze-ups.

- Sorted by **Unit Type:**

- Conventional Steam Turbine Generators: 32 units; 13,298 MW
- Simple Cycle Gas Turbines: 7 units; 235 MW
- Combined Cycle Units: 17 units; 1772 MW

PUCT Recommendations

The PUCT staff investigated the cold weather event of 1989 and issued a report the following year that evaluated the causes of the generator outages and made recommendations. Because the circumstances of the event, and the causes of the outages, are so similar to those of the 2011 event, it is worth reproducing those recommendations verbatim:²³²

- All utilities should ensure that they incorporate the lessons learned during December of 1989 into the design of new facilities in order to ensure their reliability in extreme weather conditions.
- All utilities should implement procedures requiring a timely annual (each Fall) review of unit equipment and procedures to ensure readiness for cold weather operations.

²³² PUCT 1989 Report at 7.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- All utilities should ensure that procedures are implemented to correct defective freeze protection equipment prior to the onset of cold weather.
- All utilities should maintain insulation integrity and heat tracing systems in proper working order. Generating unit control systems and equipment essential to cold weather operations should be included in a correctly managed preventive maintenance program.
- Additional training programs for plant personnel on the emergency cold weather procedures, including periodic drills, should be implemented by each responsible utility.
- PUC Engineering Staff should modify procedures for power plant CCN [Certificates of Convenience and Necessity] reviews to include a specific review for plant reliability under adverse weather conditions. Of special interest would be the selection of proper design temperature ranges for the power plant site.

The PUCT identified inoperative or inadequate heat tracing systems and inadequate insulation on instrumentation sensing lines as the most common technical equipment problems encountered during the freeze. (These problems also featured prominently in the failure of many generators during the February 2011 event.) Many of the PUCT's recommendations involve weatherization improvements it advised the generators to make, including ensuring the working operation of freeze protection equipment, insulation, and heat tracing systems; instituting preventative maintenance for cold weather equipment; and implementing adequate training for extreme conditions.

The report concluded that "the near complete loss of the ERCOT grid brings an awareness that, even in Texas, plant operators must prepare for cold weather emergencies...this awareness of and attention to cold weather problems must be continued."²³³

Comparison of 1989 and 2011 Events

A summary of the statistics for the 1989 event and the 2011 event show how similar they were. Weather conditions and system events for each year are set forth below.

²³³ *Id.*

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Comparison Table: Basic Information

	December 21-23, 1989	February 1-2, 2011
Min. Temps & Wind Chills in Dallas Area	Temperature: -1 degrees F Wind Chill: -12 degrees F	Temperature: 13 degrees F Wind Chill: -6 degrees F
Peak System Load	38,300 MW	56,334 MW
Net Generating Capacity Reduction	11,809 MW 31% of peak load	14,702 MW 26% of peak load
Gross Generating Capacity Reduction	56+ units 16,805 MW	193 units 29,729 MW
Firm Load Shed	1710 MW 4.5% of peak load	4900 MW 8.7% of peak load
Overall Duration of Firm Load Shedding	5 hours, 47 minutes	7 hours, 24 minutes

The following table compares the causes of the outages, derates, and failures to start for each year.

Comparison Table: Generator Problems

	December 21-23, 1989	February 1-2, 2011
Frozen Instrumentation	34 units 11,623 MW	61 units 13,924 MW
Fish Clogging Water Intakes	6 units 1385 MW	None reported
Other Cold Weather-related	9 units 1051 MW	54 units 6365 MW
Non-weather-related	7 units 1246 MW	63 units 7905 MW
Gas Curtailment Impact	No. of units not specified 1500 MW	15 units 1534 MW
Weather-related % of Gross Capacity Reduction in MW	84 % *	68 % *
Frozen Instr. % of Gross Capacity Reduction in MW	69 %	47 %

* Does not count gas curtailments as weather-related.

Despite the recommendations issued by the PUCT in its report on the 1989 event, the majority of the problems generators experienced in 2011 resulted from failures of the very same type of equipment that failed in the earlier event. And in many cases, these failures were experienced by the same generators. Of the over 56 units and 16,805 MW of generating capacity that became unavailable during the December 1989 event, 43 units (representing 13,606 MW of capacity) are still in service in 2011. And 26 of those units, representing 5654 MW of capacity, experienced problems again during the February 2011 cold weather event.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The failures of these repeating units alone eroded a large share of ERCOT's reserve margin going into the morning of February 2, 2011, putting the entire system in jeopardy. Weighing the shedding of 4000 MW of firm load in February 2011 against the 5654 MW of generation capacity that experienced problems in both the December 1989 and February 2011 events, it can be argued that had three-quarters of that capacity not failed again in 2011, the February 2011 blackouts would not have happened.²³⁴

In its 1989 report, the PUCT commented that "whether the corrective actions being implemented [by the generators in the wake of the event] are sufficient to prevent future freeze-off related power plant failures, only direct experience with another deep freeze will ascertain."²³⁵ Texas has now had that second event, and the answer is clearly that the corrective actions were not adequate, or were not maintained. Generators were not required to institute cold weather preparedness, and efforts in that regard lapsed with the passage of time. It is also possible that new ownership or new plant personnel lacked the historical perspective to make these efforts a priority, at least in the absence of externally imposed requirements.

The task force considered whether cost alone could have been the driving factor in the failure to maintain adequate winterization, and believes it to be unlikely. Based on current industry data, the task force estimates that for conventional gas-fired units and combined cycle units, the capital cost of upgrading basic equipment such as insulation and heat tracing could range from \$50,000 to \$500,000, depending on the age and condition of the materials, the original design temperature of the unit, and any change in the design temperature.²³⁶ (However, if significant plant components needed to be upgraded

²³⁴ The number of units that tripped, had derates, or failed to start was much larger in 2011 than in 1989. This is primarily a matter of scale. The number of generating units in ERCOT increased from 323 in 1989 to 550 in 2011. However, the increase in the number of units does not correlate exactly with the increase in generating capacity from 54,000 MW to 84,400 MW (using full wind power nameplate capacity, i.e., not adjusted) because of the large increase in combined cycle natural-gas fired plants since 1989 and the introduction of wind power. Combined cycle plants have multiple, and smaller, generating units than conventional steam-turbine plants. Wind power installations vary widely in size from tens of megawatts to hundreds of megawatts, adding greatly to the unit count, but less so to the actual capacity. With so many more, and smaller, units on line in 2011, it is not surprising that the number of trips, derates, and failures to start were greater than in 1989.

²³⁵ PUCT 1989 Report at 6.

²³⁶ See Black and Veatch Corp., *Cold Weather Protection Assessment for El Paso Electric Company (Rev. 1)*, at 6-4 and 6-7. In the event an independent engineering analysis is commissioned, and based on current industry estimates, the costs for such an analysis for a gas-fired unit could range from \$25,000 to \$150,000, depending on the type of unit.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

or replaced, the cost could be significantly higher. For instance, if cooling towers had freezing problems, the addition of a cooling tower bypass or variable speed tower fan motor might be needed; such costs could range from \$150,000 to \$500,000.²³⁷)

Texas has recently enacted legislation to deal with the problem of inadequate winterization by generators. A bill was introduced in the Texas legislature following the February 2011 blackouts, with provisions directing the PUCT to prepare a weather emergency preparedness report, to review the emergency operations plans on file, and to recommend improvements to the plans to ensure electric service reliability. In introducing the bill, State Senator Glenn Hegar stated: “What I don’t want, is another storm and another report someone puts on the shelf for 21 years and nobody looks at.”²³⁸

After a Senate Committee hearing, the bill was amended and unanimously adopted by the Texas Senate.²³⁹ The House unanimously passed the bill on May 23, and the bill was signed into law by Governor Richard Perry on June 17, 2011.

B. Natural Gas

Gas production suffered declines in each of the six prior years identified by the task force as having had severe cold weather, and in 1989 and 2003, the declines led to gas curtailments that caused outages or derates to a number of gas-fired electric generators. While some winterization has been put in place by producers and processing plants, production declines occur with each successive severe cold weather event, including the event of February 2011. It may well be that producers have limited market incentives to pay for more elaborate winterization, as they will likely lose less money from short periods of non-production than they would expend on preventing freeze-offs at each of the many wells a producer typically owns.

²³⁷ *Id.*

²³⁸ Eric Dexheimer, *February Power Blackouts Across Texas echoed 1989 Failures, State Report Shows*, Austin American-Statesman, Apr. 10, 2011, <http://www.statesman.com/news/local/february-power-blackouts-across-texas-echoed-1989-failures-1390558.html?viewAsSinglePage=true>.

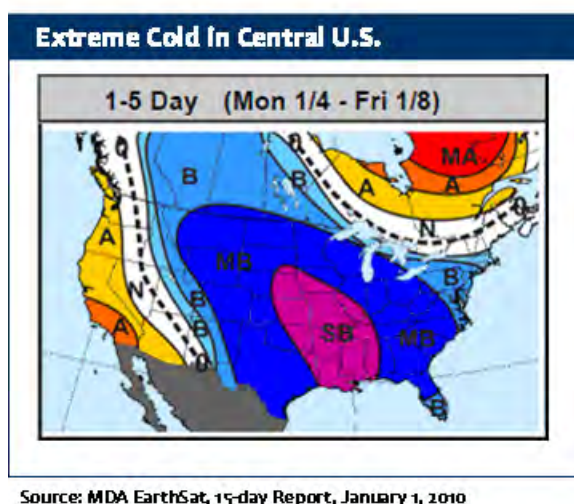
²³⁹ SB 1133, 82 Leg., Reg. Sess. (TX 2011) available at http://www.capitol.state.tx.us/tlodocs/82R/billtext/pdf/SB01133E.pdf#navpanes=0_ The bill would also allow the PUCT to require entities to update their emergency operations plans and to adopt rules relating to implementation of the bill.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Gas production declines in these prior extreme cold weather years are presented below, beginning with the most recent.

January 2010

In 2010, an ongoing cold spell led to wellhead and gathering line freeze-offs in the Rockies, San Juan and other southwestern producing basins. About 0.5 Bcfd²⁴⁰ was lost in the Rockies and another 1.0 Bcfd was lost from the Southwest and shale basins. From January 21 through January 28, Northern Natural Gas and Southwest Gas issued low line pack alerts. High temperatures in every city in the area were above freezing during the month, and low temperatures fell only to the low 20s in a few cities on a few days.



[Color legend: N is normal, B is below normal, MB is much below normal, and SB is strong below normal.]

February 2008

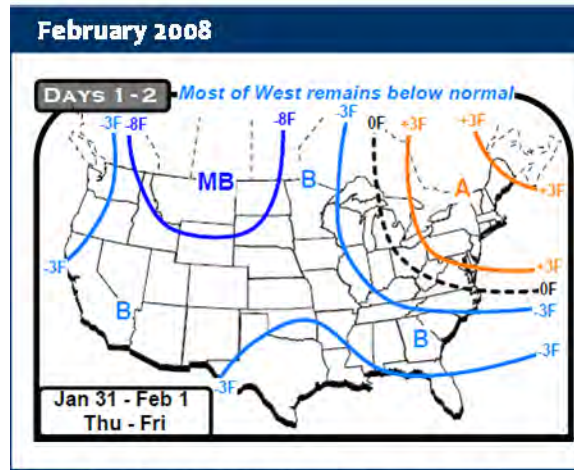
There was widespread cold weather during late January and early February 2008 in the Rockies, Midwest, and Northeast. El Paso, Southwest Gas, Mississippi River Transmission (MRT), Natural Gas Pipeline Company of America (NGPL), ANR, Northern Natural Gas, and Kern River issued low line pack warnings, and receipts at the Opal²⁴¹ processing plant in Wyoming fell due to

²⁴⁰ Production data in this section is drawn from Bentek, Supply and Demand Daily report.

²⁴¹ The Opal processing plant is a major source of output for Rockies production. Major interstate pipelines transport output from that plant to regional markets and markets in the East, the Pacific Northwest, California and the desert Southwest.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

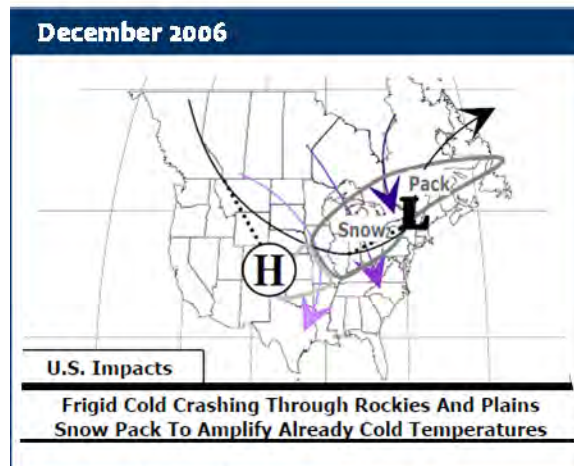
wellhead and gathering line freeze-offs in the region. Rockies production was off between 0.5 and 1.0 Bcfd over a 10-day period. Southwest regional production also fell by about 0.5 Bcfd during that time.



Source: MDA EarthSat, 1-5 Day Outlook, January 31, 2008

December 2006

During the first few days of December 2006, unseasonably cold air accompanied by a good deal of snow covered much of the Rockies, the Great Plains and the Midwest. The Midwest and Chicago took the brunt of the frigid temperatures. Lows were in the single digits with a wind chill of -12 degrees. For two days, wellhead freeze-offs caused midcontinent production to fall almost 1 Bcfd, while Rockies and Texas/Louisiana production each were off about 0.5 Bcfd. Temperatures in Midland and El Paso dipped into the low teens for a short time. The short cold snap set off a flurry of operational warnings and alerts; El Paso issued a system operating condition flow order, and Southwest Gas, MRT, NGPL, Kern River, and Transwestern issued low line pack warnings.

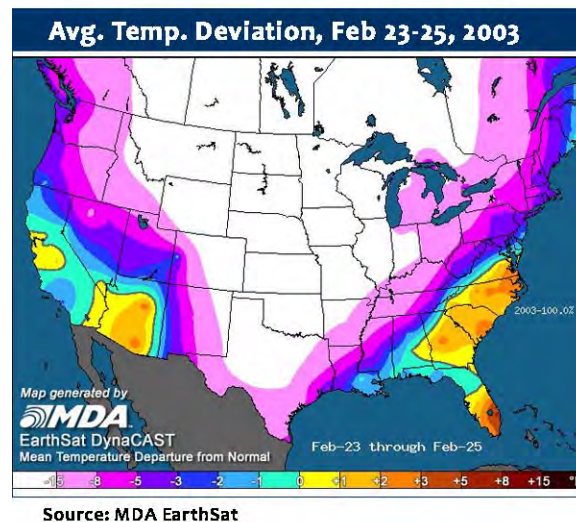


Source: MDA EarthSat, Friday December 1, 2006.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

February 2003

Overall, the winter of 2002/2003 was the third coldest of the most recent 11 winter periods. The winter began with record inventories (at that time) of gas in underground storage. But by April, over 2.5 Tcf (trillion cubic feet) was withdrawn, also a record at the time. Regional and national natural gas storage inventories were at record lows when compared to many metrics. During the period from February 23 through February 25, a shot of very cold air swept out of the Rockies and through the Midwest. It brought wind chills of -50° to portions of Wyoming and Colorado and lows below zero in Chicago. Gathering system and wellhead freeze-offs were reported in the Permian Basin and the midcontinent and Rockies regions, and NGPL issued an operational flow order. Midland and Dallas temperatures fell below freezing, although only for a short time. El Paso and Transwestern did issue low line pack alerts that were quickly lifted. As noted earlier, in ERCOT there were gas curtailments to electric generators, estimated by ERCOT to have resulted in a loss of 5500 MW of capacity.



In a May 19, 2003 report on the 2003 cold weather event, the PUCT observed that the gas supply shortages experienced by electric generators in Texas were due in part to an unusually steep decline in storage volumes in the months preceding the event. Those depleted storage reserves during a time of increased demand made it difficult for generators to obtain adequate gas supply, although only one supplier, the TXU Lone Star Pipeline (now Atmos Pipeline-Texas), actually curtailed industrial customers. The PUCT also noted that newly independent power producers, unlike the old vertically integrated utilities, tended not to have their own storage facilities, a factor that contributed to the supply shortage.²⁴²

²⁴² PUCT 2003 Report at 12-16.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The 2003 PUCT report recommended that the PUCT and the TRC collaborate on developing a joint curtailment methodology for natural gas and electricity.²⁴³ According to industry observers at the time, the recommendation was aimed at coordinating electrical generation needs with gas supply, to ensure that supply was being used where it was most needed during shortages. However, the agencies reportedly were unable to develop a policy and the project died.²⁴⁴

December 1989

December 1989 was described at the time by the National Weather Service as the coldest December ever recorded for the combined northeast, central, and southeast regions of the United States. The freeze of December 21 through December 25 caused severe problems for Texas electric utilities, as described earlier in the discussion on electric prior cold weather events. Record and near record low temperatures occurred across the state. For Dallas, it was the coldest and second coldest days in the last 38 years; for Midland, the third and fifth coldest days; for San Antonio, the first and fourth. Houston and Brownsville each had two days among the top five coldest. Wind chill factors in Houston fell to -5 degrees, and in Dallas and Midland, to -12 degrees and -14 degrees, respectively.

While the gas supply situation was more precarious in the Northeast, the Gulf Coast supply regions, Texas and the Southwest were not without their problems. United States productive capacity had not been tested by a prolonged cold snap for more than a decade. Major processing plants²⁴⁵, refineries and petrochemical plants in the Gulf Coast region shut down. Supply problems occurred in the Gulf of Mexico, Kansas, Texas, Oklahoma, Arkansas, and Louisiana. High winds prevented crews from reaching offshore production platforms that froze off. A major gathering operation in Oklahoma saw 40 percent of its supply frozen off. Producer respondents to a 1991 AGA study said that 10 percent of their production was affected by the cold temperatures.²⁴⁶

Most major interstate pipelines accessing Gulf supply experienced some kind of problem. Texas Eastern Transmission Corporation (TETCO) suspended all interruptible transportation deliveries and reduced firm deliveries by 0.5

²⁴³ *Id.* at 16.

²⁴⁴ Drawn from materials submitted to the task force by a pipeline company.

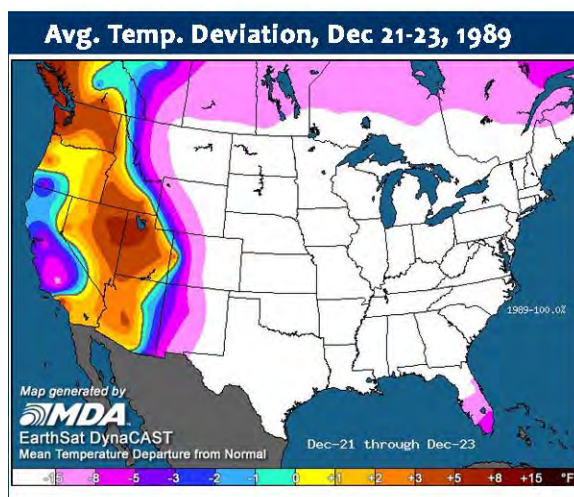
²⁴⁵ Conoco Inc. lost its 1 Bcfd Grand Chenier processing plant in coastal Louisiana due to gas supply and plant operational problems.

²⁴⁶ Foster Natural Gas Report No. 1845 (Oct. 3, 1991) at 20.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Bcfd.²⁴⁷ Trunkline and NGPL also suspended interruptible transportation services. Transco curtailed firm service between 22 percent and 50 percent.²⁴⁸

In ERCOT there were gas curtailments to electric generators, tabulated earlier in the section on prior electric cold weather events.



Source: MDA EarthSat

December 1983

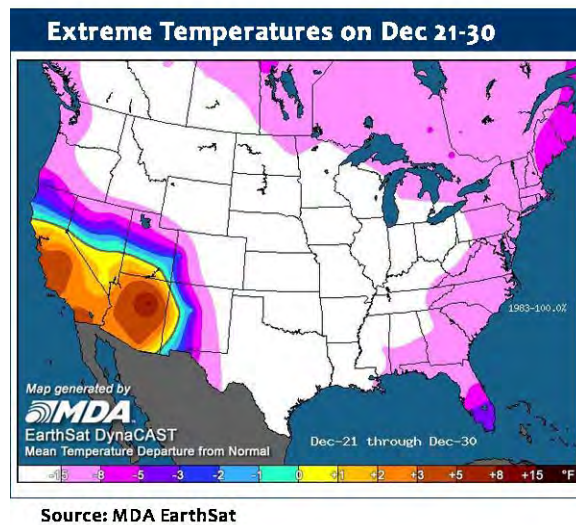
At the end of December 1983, a nine-day stretch of cold weather in Texas resulted in a 3 Bcfd shortfall in supply. Demand was met by massive withdrawals from storage and fuel switching by generators. Refinery operable capacity fell over 72 percent during the week, due to gas supply curtailments. The TRC said that if schools and factories had not been closed for the Christmas holiday, deliveries to high priority customers would have been curtailed. Producers behind Valero Energy reported well freeze-offs, accounting for a 43 percent drop in supply.²⁴⁹

²⁴⁷ TETCO reported a field supply shortfall of 1 Bcfd from its normal of 1.9 Bcfd.

²⁴⁸ See Rick Hagar, Winter Hits U.S. Industry, Strains Gas Supply, OIL & GAS J., Jan. 1, 1990, at 28; see also Rick Hagar, U.S. Gas Industry Ponders Lessons Learned from Severe Winter, OIL & GAS J., Mar. 5, 1990, at 17.

²⁴⁹ See Rick Hagar, TRC Chairman Downgrades Size of Gas Surplus in U.S., OIL & GAS J., Feb. 27, 1984, at 47.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event



An examination of these prior years reveals that production declines are common during cold weather events. However, only in limited circumstances did they lead to curtailment of natural gas customers, including curtailment of gas-fired electric generators.

The production declines raise the question as to why producers did not improve their winterization preparations to withstand these not uncommon cold snaps. The reason most likely comes to one of cost (as well as to the lack of regulation requiring it). A study performed for the task force by the Gas Technology Institute²⁵⁰ has estimated that capital costs for winterization could vary from as little as \$2,800 to more than \$30,000 per well, depending on the degree of cold weather protection required and other variable factors such as gas flow rates, pressures, existing winterization, and the like. In addition to these capital costs, the cost of maintenance and operational supplies such as methanol (antifreeze) could add up to several thousand dollars per year for each well. (These costs include costs associated with protecting field processing, such as separating water from the gas, as well as the flow lines to the separating facilities.)²⁵¹ Since it is not uncommon for the larger producers to have hundreds of wells in a given basin, these costs would quickly mount up. Such costs need to be accounted for in some fashion if mandatory weatherization were to be considered by regulatory or legislative bodies (as would the costs that would be incurred by electric generators to meet comparable requirements.)

²⁵⁰ This report is included as an appendix, entitled “GTI: Impact of Cold Weather on Gas Production.”

²⁵¹ Kent F. Perry, Gas Technology Institute, *Impact of Cold Weather on Gas Production in the Texas and New Mexico Gas Production Regions of the United States During Early February, 2011* (June 2011) at 33.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Producers suggest that even improved winterization of the wells would not prevent a significant portion of production declines, since other problems, such as icy roads that prohibit hauling off water (which, if not done, shuts down the well), are also commonly encountered.

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VIII. Electric and Natural Gas Interdependencies

The February 2011 cold weather event highlights the interdependency of electricity and natural gas, an interdependency that has grown in recent years. Natural gas has become an increasingly popular fuel choice for electric generators. Concurrently, compressors used in the production and transportation of natural gas have come to rely increasingly on electricity for their power source, rather than natural gas.

The reason for the increased popularity of gas-fired electric generation is one of economics. Natural gas prices have fallen due to increased gas production, beginning in 2008 when producers developed the technology to drill the Barnett Shale. Just prior to 2008, average daily marketed production was about 55.5 Bcf per day. Spot prices at the Henry Hub during 2007 averaged almost \$7.00 per MMBtu. Shale production accounted for perhaps five percent of total United States production, and offshore production comprised approximately 15 percent.

But by the end of 2008, average daily production had grown to over 59.3 Bcf per day. In the ensuing years, producers applied the lessons learned in the Barnett Shale to other basins, most notably the Fayetteville, Haynesville and Marcellus Shales, with notable results. Thus far in 2011, gas production is averaging almost 62.8 Bcf per day (and recently topped 64 Bcf per day), while average daily spot prices at the Henry Hub have fallen to \$4.27 per MMBtu. Offshore production in 2010 accounted for only 10 percent of total United States production, and analysts estimate that shale production alone now accounts for 25 percent of total production.

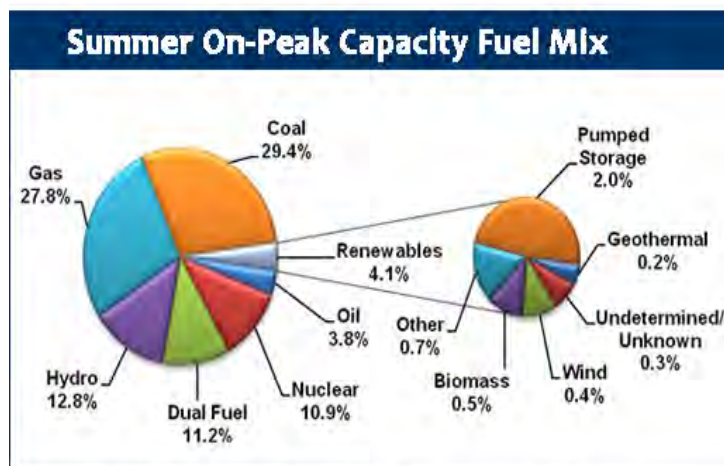
At the same time, gathering companies, as well as pipelines and LDCs located in urban areas, have increasingly turned to electric-powered compressors. Gathering companies prefer electric-powered compressors because they can fit in smaller spaces than gas-fired compressors, and the companies do not need as much compressive power as the large pipelines. For pipelines and LDCs in urban areas, environmental restrictions relating to noise and air quality, as well as the ready availability of electricity, tip the scales in favor of electricity over natural gas. The large pipelines favor gas-fired compressors, because the gas is readily available to them and they have large horsepower demands.

The following chart depicts the mix of generation available for United States electricity needs in the summer of 2010, by fuel type.²⁵² It shows that 27.8

²⁵² NERC 2010 Summer Reliability Assessment (May 2010) at 10, <http://www.nerc.com/files/2010%20Summer%20Reliability%20Assessment.pdf>.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

percent of all generation uses gas as the fuel source, and an additional 11.2 percent is dual-fueled (mostly gas and diesel oil).



Source: NERC's Summer Reliability Assessment, May 2010

The Southwest relies heavily on gas-fired generation to meet its peak capacity needs. In ERCOT, approximately 57 percent of the available on-peak summer and winter capability is from gas-fired generation (with 40 percent solely gas-fired and 17 percent having dual-fuel capability with gas as the primary fuel).²⁵³ In the SPP region, 50 percent of the summer and winter on-peak capability is from gas-fired generation, and in WECC, 41 percent.

In New Mexico, gas-fired generating units consume approximately 70,102 MMcf annually, representing approximately one percent of total national consumption of gas used in the utility sector.²⁵⁴ In Texas, gas-fired generating units consume approximately 1,387,421 MMcf of natural gas annually, representing approximately 20.2 percent of total national consumption of gas used in the utility sector.²⁵⁵ And in Arizona, gas-fired generating units consume approximately 261,904 MMcf of natural gas annually, representing approximately 3.8 percent of total national consumption of gas used in the utility sector.²⁵⁶

²⁵³ Based on data provided by ERCOT.

²⁵⁴ EIA, Natural Gas Annual 2009, at 128-129 (Table 58), http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/natural_gas_annual/nga.html.

²⁵⁵ *Id.* at 152-153 (Table 70).

²⁵⁶ *Id.* at 70-71 (Table 29).

Interdependency Effects During the February Event

The task force examined data from numerous electric and gas entities to gauge the severity that shortfalls in one commodity had on the other during the February event. Materials received from natural gas producers indicate that the rolling blackouts (or customer curtailments) in ERCOT were a significant cause, from 29 to 27 percent respectively, of production shortfalls in the Permian and Fort Worth Basins. For pipelines and LDCs, however, the effects of the rolling blackouts were negligible.²⁵⁷

Gas shortfalls caused problems for some generators in Texas, although not nearly to the extent as did direct weather-related causes such as equipment failure from below-freezing temperatures. In ERCOT, as detailed in the section of this report entitled “Causes of the Outages and Supply Disruptions,” the outages and derates from inadequate gas supply during the cold weather event totaled 1282 MW, compared to a peak net capacity reduction of 14,702 MW. While gas supply to SRP and EPE was compromised due to problems at the Chevron Keystone Storage Facility, EPE’s generating units failed for other reasons, and SRP was able to obtain gas from other sources. However, during the 2003 cold weather event, there were significant gas curtailments to electric generators in Texas, which affected generating capacity. Gas curtailments also caused a loss of generating capacity in 1989, although to a lesser extent.

The task force was cognizant of the possibility that gas shortages may have been a less significant factor only because so many generators were forced offline for other reasons, and thus unable to take the gas (as was the case with EPE). The task force attempted to answer the question of whether there would have been adequate gas supplies to ERCOT had its failed gas-fired generators been able to take the gas. To do so, the task force tallied and compared the MWs forced offline, the amount of gas demand the generators would have imposed on suppliers had they been capable of running, and the capacity of the gas supply system at the time.

The task force determined that 5256 MW of generation in ERCOT could have imposed demands on the gas supply system had the generating units not experienced trips, derates, or failures to start. This number represents the total 5556 MW of the 55 gas-fired generating units in ERCOT, reduced by 300 MW for those generating units connected to a single pipeline that had pressure or gas

²⁵⁷ An exception for LDCs supplying gas is the surge effect experienced when electricity is restored after an outage, which places instant and simultaneous demand on gas equipment and systems. This effect is described in the section of this report entitled “The Event: Outages and Curtailments.”

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

quality problems (making it unlikely the generating units could have received gas even if they had had no operational difficulties). Each unit was assumed to have a 9,000 Btu/kWh heat rate. In the aggregate, these units would have added a maximum additional gas demand of approximately 1.1 Bcf per day.

Adding this additional hypothetical demand to the actual peak demand of 12.5 Bcf per day²⁵⁸ would have imposed total demand on the system of 13.6 Bcf. Supply in January was running at 17.7 Bcf per day; these volumes declined during the first week of February. On February 2, the worst day from the standpoint of ERCOT, supply declined to 16.35 Bcf per day. On February 4, when production volumes hit their lowest point for the week, supply declined to 14.08 Bcf per day.

A comparison of these supply and demand numbers shows that total demand (actual demand plus hypothetical demand) would still have been below the available supply during the February cold weather event, particularly so on February 2, the day rolling blackouts were implemented. The task force's analysis therefore indicates there would have been adequate gas to supply the generators in ERCOT that failed for other reasons.²⁵⁹ This conclusion was confirmed by knowledgeable industry observers, who were of the opinion that the Texas supply of gas would have been adequate had the generators not experienced weatherization problems.

Fuel Switching

A not insignificant amount of gas-fired generation in the Southwest has fuel switching capability. In ERCOT, 16 percent of total generation can fuel switch; in SPP, it is seven percent. Within WECC, of those generating units that are directly connected to El Paso, Northern Natural Gas, or ONEOK WesTex, 38 have fuel switching capability.

Fuel switching enables a simple or combined cycle generating turbine to alternate between fuel sources, typically natural gas and some type of fuel oil.

²⁵⁸ The actual demand listed is a worst case scenario, because the calculation was derived by adding together the peak demand of each of the three major pipelines in Texas serving gas-fired generating units. A more realistic number would probably be demand of approximately 12 Bcf per day or less.

²⁵⁹ The excess gas was sold out of state, but had the generators in ERCOT been able to use it, they could have gotten it. Since gas prices rose modestly in the region during the event, the shippers would very likely have redirected the gas to Texas to take advantage of the higher prices, had the generators been able to accept it. This would be true whether or not the contracts were interruptible, since a shipper could adjust its purchases and sales to take advantage of the pricing differential.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Fuel switching can be as simple as a control room operator pushing a button which automatically switches to oil, or as complicated as having to remove gas injectors and install oil injectors in every position around the boiler, a process that can take days rather than minutes.

It is common for units that switch to an alternate fuel type to experience a capacity derate, since normally each unit is designed to most efficiently burn a particular fuel.

The choice to perform fuel switching is primarily based on three factors: 1) cost, 2) environmental restrictions, and 3) the availability of natural gas. Running the generating unit on alternate fuels, such as fuel oil, may cost up to twice as much on a MW basis.²⁶⁰ And environmental and air quality control restrictions, which vary by state, may limit the number of hours per year a generator is allowed to run on fuel oil.

Fuel switching capability was a more desirable option in the past, when the relative prices of gas and oil fluctuated, making one or the other more economical at any given time. Given the decline in natural gas prices, this option has become less valuable.

During the February event, 20 generating units in ERCOT attempted to switch fuels, with 15 managing it successfully.²⁶¹ (This echoed ERCOT's experience during the 2003 cold weather event, when a number of units that attempted to switch fuels were unable to do so, and those that did switch experienced derates of capacity.²⁶²) SRP has nine units capable of switching, and EPE has three units capable of switching. None was asked to switch during the event, as the units either failed for other reasons or were able to obtain adequate gas supply. In SPP, of the three representative entities the task force examined, eight generating units have fuel switching capabilities; four attempted to switch during the event and ultimately succeeded, although half had initial difficulties.

²⁶⁰ Based on information supplied to the task force by an LDC.

²⁶¹ A majority of the units that attempted to switch fuels but were unable to do so experienced a mechanical failure of some sort in the switching equipment, which could have been due to the cold temperatures, inadequate maintenance, lack of regular testing, or the infrequent use of the alternate fuel in normal operations.

²⁶² PUCT 2003 Report at 17. The PUCT recommended that providing financial incentives for fuel oil inventories, to be maintained for use by dual-fueled generating units, should be considered.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Fuel switching raises a number of questions, such as: whether generators that have the capability to switch fuels should be required to maintain their alternate fuel equipment and stockpile an adequate supply of the alternate fuel, whether subsidies or incentives should be instituted to compensate for such requirements or to add fuel switching capabilities to those units that do not currently have it, and whether units that can switch fuels should be paid to do so in order to preserve gas supplies for residential consumers. These are issues that can be most fruitfully addressed in forums involving representatives of both the electric and natural gas industries operating in the region, as well as the regulatory bodies overseeing them.

Communications

In 2004, NERC released a report entitled “Gas/Electricity Interdependencies and Recommendations,” which summarized the findings of its Gas/Electricity Interdependency Task Force (GEITF). The GEITF held a series of meetings with representatives of both the electric and gas industries and prepared a list of recommendations for NERC’s consideration. The GEITF reported that a recurring theme expressed by gas industry participants was concern about communications between pipeline operators and entities other than the pipeline’s contractual customers. While the pipelines communicate with the LDCs serving a generator or with the generator itself, they do not communicate with a regional reliability coordinator, apparently due to confidentiality restrictions. The GEITF recommended that NERC, in concert with other energy industry organizations, formalize communications between the electric industry and the gas transportation industry for the purposes of education, planning, and emergency response.

Communication failures between gas and electric entities did not seem to play a role during the February 2011 event (although there were complaints of communication issues between shippers and pipelines). Nonetheless, the electric and gas industries might consider revisiting the GEITF recommendations to see if procedures should be developed for communications between pipelines and reliability coordinators.²⁶³

²⁶³ NERC plans to conduct an electric/gas interdependency study in 2011 to reevaluate the GEITF recommendations. The study will analyze whether procedures should be developed for communications between the electric and gas industries.

IX. Key Findings and Recommendations

The facts that came to light in the course of the joint inquiry conducted by the staffs of FERC and NERC, as well as the conclusions drawn from them, have been presented throughout the body of this report. Because the matters examined are complex and detailed, this section presents in summary form the task force's key findings. It also presents recommendations that the task force believes, if implemented, could significantly contribute to preventing a recurrence of the rolling blackouts and natural gas curtailments experienced in the Southwest during the February 2011 cold weather event.

A. The Electric Industry

Key Findings -- Electric

- During the February event, temperatures were considerably lower (15 degrees plus) than average winter temperatures, and represented the longest sustained cold spell in 25 years. Steady winds also accelerated equipment heat loss. However, such a cold spell was not unprecedented. The Southwest also experienced temperatures considerably below average, accompanied by generation outages, in December 1989. Less extreme cold weather events occurred in 2003 and 2010. Many generators failed to adequately apply and institutionalize knowledge and recommendations from previous severe winter weather events, especially as to winterization of generation and plant auxiliary equipment.
- While load forecasts fell short of actual load, the forecasts were not a factor in the loss of load. ERCOT manually increased its February 1 and February 2 forecasts by 4000 MW to factor in wind chill, and had established sufficient reserves to accommodate both forecasted load and the actual load that transpired. The reason blackouts had to be initiated was that over 29,000 MW of generation that was committed in the day-ahead market or held in reserve either tripped, was derated, or failed to start. This was the largest loss of generation in ERCOT's history, including during the prior cold weather load shed event in December 1989 and the two hot weather load shed events in 2003 and 2006. While units of all types (except nuclear generating units) tripped, derated, or failed to start in 2011, in ERCOT, gas combined cycle units had the highest percentage of failures, compared to their percentage of the total fuel mix.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- ERCOT and the generators within ERCOT could better coordinate generator scheduled outages, both in terms of the total amount of scheduled outages at a given time and their location. A substantial amount of generation (11,566 MW) was on scheduled outage going into the cold weather event. ERCOT's current Protocols provide that requests for scheduled outages submitted earlier than eight days before the outage is to begin are automatically approved, unless they would violate a Reliability Standard.
- ERCOT's fast action in initiating rolling blackouts prevented more widespread and less controlled ERCOT-wide blackouts. Had ERCOT not initiated manual load shedding, its under-frequency load shedding relays would have instantaneously dropped approximately 2600 MW (five percent of system load), a loss that could have created further system disturbances and resulting generation outages. Load shedding by the transmission and distribution operators in ERCOT's footprint was generally carried out in a timely and effective manner.
- Transmission operators and distribution providers generally did not identify natural gas facilities such as gathering facilities, processing plants or compressor stations as critical and essential loads.
- Balancing authorities, reliability coordinators and generators often lacked adequate knowledge of plant temperature design limits, and thus did not realize the extent to which generation would be lost when temperatures dropped.
- The lack of any state, regional or Reliability Standards that directly require generators to perform winterization left winter-readiness dependent on plant or corporate choices. While Reliability Standard EOP-001 R.4 and R.5 refer to winterization as a consideration in emergency plans, these requirements apply only to balancing authorities, transmission owners, and transmission operators.
- Generators were generally reactive as opposed to being proactive in their approach to winterization and preparedness. The single largest problem during the cold weather event was the freezing of instrumentation and equipment. Many generators failed to adequately prepare for winter, including the following: failed or inadequate heat traces, missing or inadequate wind breaks, inadequate insulation and lagging (metal covering for insulation), failure to have or to maintain heating elements and heat lamps in instrument cabinets, failure to train

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

operators and maintenance personnel on winter preparations, lack of fuel switching training and drills, and failure to ensure adequate fuel.

- Gas curtailment and gas pressure issues did not contribute significantly to the amount of unavailable generating capacity in ERCOT during the event. The outages, derates, and failures to start from inadequate fuel supply totaled 1282 MW from February 1 through February 5, as compared to an overall peak net generating capacity reduction of 14,702 MW.

Recommendations -- Electric

PLANNING AND RESERVES

1. Balancing Authorities, Reliability Coordinators, Transmission Operators and Generation Owner/Operators in ERCOT and in the southwest regions of WECC should consider preparation for the winter season as critical as preparation for the summer peak season.

The large number of generating units that failed to start, tripped offline or had to be derated during the February event demonstrates that the generators did not adequately anticipate the full impact of the extended cold weather and high winds. While plant personnel and system operators, in the main, performed admirably during the event, more thorough preparation for cold weather could have prevented many of the weather-related outages.

Capacity margins going into the winter of 2010/2011, for both ERCOT and the southwest regions of WECC, were adequate on paper. (ERCOT reported a 57 percent margin above forecasted winter peak demand, and the southwest regions of WECC projected a 105.7 percent margin.) But those margins did not take into account whether many of the units counted would be capable of running during the severe cold weather that materialized in February.

While the probability of a winter event in the predominantly summer peaking Southwest appears to be low, shedding load in the winter places lives and property at risk. The task force recommends that all entities responsible for the reliability of the bulk power system in the Southwest prepare for the winter season with the same sense of urgency and priority as they prepare for the summer peak season.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

2. Planning authorities should augment their winter assessments with sensitivity studies incorporating the 2011 event to ensure there are sufficient generation and reserves in the operational time horizon.

Both ERCOT and the Southwest regions of WECC undertake planning studies to ensure that sufficient reserves are available to meet seasonal peak loads. However, the forecasted peak demand in the winter assessments for 2010/2011 was not as high as that actually experienced in early February.

Planners should undertake a sensitivity study, using the 2011 actual conditions as a possible extreme scenario, that reflects expected limits on available generation. These limits would include those due to planned outages, limited operations during periods of extreme cold weather, ambient temperature operating limitations, and any likely loss of fuel sources.

This sensitivity study should be used by operational planners to identify various system stress points, and by Reliability Coordinators, Balancing Authorities, and Transmission Operators to improve and refine strategies to preserve the reliability of the bulk power system during an extended cold weather event. These strategies should include procedures relating to utilization of generators with fuel switching capabilities and implementing early start-ups for generators with long start-up times.

3. Balancing Authorities and Reserve Sharing Groups should review the distribution of reserves to ensure that they are useable and deliverable during contingencies.

This recommendation is designed to ensure that Balancing Authorities take into account transmission constraints, other demands on reserve sharing resources, the possibility that more than one reserve sharing group member might experience simultaneous emergencies, and other factors that might affect the availability or deliverability of reserves. ERCOT is currently considering a similar recommendation, which was presented to its Board of Directors in March, 2011.

4. ERCOT should reconsider its protocol that requires it to approve outages if requested more than eight days before the outage, consider giving itself the authority to cancel outages previously scheduled, and expand its outage evaluation criteria.

ERCOT's Protocols provide that it may not forbid an outage request submitted more than eight days prior to the scheduled outage, unless the outage would keep ERCOT from meeting applicable Reliability Standards or Protocol requirements. The Protocols further limit review of outage requests made earlier

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

than eight days before the outage to the following three things: load forecast, other known outages of both generation and transmission, and the results of a contingency analysis to indicate whether the outages would cause overloads or voltage problems.

The task force recommends that ERCOT consider lengthening the period for which ERCOT may deny an outage request, assuming the conditions for doing so are met. (ERCOT is presently considering a Protocol revision to give itself the authority to deny an outage request that is not scheduled more than 90 days prior to the outage date, a revision which the task force supports.) In addition, ERCOT should consider giving itself the authority to cancel previously approved outages in cases of approaching extreme weather conditions, even up to the time of the event itself. In making this evaluation, ERCOT should take into account the costs that would be imposed on the generator as well as the practical difficulties of returning it to service if plant components are disassembled, as well as the generator's need to perform maintenance at some point while also avoiding the high demand summer season.

In addition to the criteria for outage evaluation currently provided in the Protocols, the task force recommends that ERCOT take into consideration the potential loss of units based on weather conditions beyond their design limits, and the effects likely to result from the totality of scheduled and proposed outages.

In furtherance of these criteria, ERCOT should:

- Have available to it the design temperatures of all generation resources.
- Take into consideration as an extreme weather event approaches which plants will not be available based on their design temperature limits.
- Consider increasing reserve levels during extreme weather events.
- Commit, for purposes of serving load and being counted as reserves, only those plants whose temperature design limits fall within the forecasted temperature range.
- Determine, prior to approving an outage, if the combination of previously approved scheduled outages with the proposed scheduled outages might cause reliability problems.

5. ERCOT should consider modifying its procedures to (i) allow it to significantly raise the 2300 MW responsive reserve requirement in extreme low temperatures, (ii) allow it to direct generating units to utilize pre-operational warming prior to anticipated severe cold weather, and (iii) allow

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

it to verify with each generating unit its preparedness for severe cold weather, including operating limits, potential fuel needs and fuel switching abilities.

ERCOT data on forced outages during the 50 coldest days between 2005-2011 show a correlation between low temperatures and forced outages. This was demonstrated not only by the February 2011 event but also by the 1989 event; in both cases, extremely low temperatures led to the loss of large amounts of generation and the implementation of rolling blackouts.

Increasing the amount of responsive reserves going into a cold weather event would compensate for the probability that a number of generating units might fail, and would provide better response to system instability in the event of such losses.

Additionally, pre-operational warming would help prevent freezing and identify other operational problems. Running a unit prior to the start of extreme cold weather would utilize the unit's own radiant heat to help prevent freezing. And starting it up would permit correction of any problems that otherwise would not be noticed until the unit was called upon for performance.

While pre-operational warming has considerable value, issues of whether or how generators are to be compensated for taking such actions at ERCOT's direction would need to be addressed.

COORDINATION WITH GENERATOR OWNERS/OPERATORS

6. Transmission Operators, Balancing Authorities, and Generation Owner/Operators should consider developing mechanisms to verify that units that have fuel switching capabilities can periodically demonstrate those capabilities.

Sixteen percent of ERCOT's generation capacity is listed as having fuel switching capabilities. During the February cold weather event, a quarter of the 20 units that attempted to switch fuel were unsuccessful. If a unit represents itself as having fuel switching capability, verification of the adequacy of its capability would provide useful information to the Balancing Authority or Transmission Operator as to the availability of that unit in the event of natural gas curtailments.

Fuel switching verification might consist of the following:

- Documented time required to switch equipment,
- Documented unit capacity while on alternate fuel,
- Operator training and experience,

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- Fuel switching equipment problems, and
- Boiler and combustion control adjustments needed to operate on alternate fuel.

7. Balancing Authorities, Transmission Operators and Generator Owners/Operators should take the steps necessary to ensure that black start units can be utilized during adverse weather and emergency conditions.

The task force determined that a combination of scheduled and forced outages of ERCOT's black start units would have put ERCOT's ability to restore the system in jeopardy, had an uncontrolled blackout not been averted by the implementation of load shedding. Balancing Authorities and Transmission Operators should take steps to ensure the availability and reliability of their black start units during adverse weather and emergency conditions, particularly to prevent a gap in this function before 2013, when the provisions of Reliability Standard EOP-005-2 on System Restoration from Blackstart Resources becomes mandatory. These steps should ideally include auditing Generator Owner/Operators, random testing of black start units during temperature extremes (both hot and cold), determining the ambient operating temperature limitations of the black start units, evaluating the effects of extreme temperatures on implementation of the entity's black start plan; and ensuring that operators are trained to start the black start units during extreme weather conditions. ERCOT is presently considering Protocol revisions that would provide for unannounced testing of black start units and "claw back" payments for black start units that fail testing or fail to perform.

8. Balancing Authorities, Reliability Coordinators and Transmission Operators should require Generator Owner/Operators to provide accurate ambient temperature design specifications. Balancing Authorities, Reliability Coordinators and Transmission Operators should verify that temperature design limit information is kept current and should use this information to determine whether individual generating units will be available during extreme weather events.

In order to ascertain actual capabilities during extreme weather conditions, Balancing Authorities and Reliability Coordinators should require Generator Owner/Operators to provide accurate ambient temperature design operating limits for each generating unit that is included in its portfolio (including the accelerated cooling effect of wind), and update them as necessary. These limits should take into account all temperature-affected generator, turbine, and boiler equipment, and associated ancillary equipment and controls.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The Balancing Authorities should take steps to verify that Generator Owner/Operators comply with this requirement, and should prepare for the winter season by developing a catalog of individual generating unit temperature limitations. These should be used to determine if forecasted temperatures place a particular generating unit in a high risk category.

Lastly, Balancing Authorities and Reliability Coordinators should consider the feasibility of counting on a generating unit whose rating falls below forecasted weather conditions, and should consider whether to take into account weather-related design specifications in ranking units in the supply stack during critical weather events.

9. Transmission Operators and Balancing Authorities should obtain from Generator Owner/Operators their forecasts of real output capability in advance of an anticipated severe weather event; the forecasts should take into account both the temperature beyond which the availability of the generating unit cannot be assumed, and the potential for natural gas curtailments.

Balancing Authorities are permitted to request a forecast of real output capability under Reliability Standard TOP-002-02 R15. Doing so would allow operators to make proactive decisions prior to the onset of cold weather, including but not limited to:

- Requesting cancellation of planned outages,
- Directing advanced fuel switching,
- Directing startup of units with startup times greater than one day,
- Requesting startup of seasonally mothballed units, and
- Making advance requests for conservation.

In the case of ERCOT, which does not own the generators in its footprint, consideration needs to be given to ensuring that there is an adequate cost recovery mechanism in place for reliability measures taken by the generators at ERCOT's direction.

10. Balancing Authorities should plan ahead so that emergency enforcement discretion regarding emission limitations can be quickly implemented in the event of severe capacity shortages.

Some generators experienced derates during the event due to emission limitations. The Texas Commission on Environmental Quality (TCEQ) exercised enforcement discretion with respect to its emission restrictions during the event; however, this action, which was taken after the TCEQ received requests during the event itself, did not come in time to prevent all the emissions-related derates that

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

occurred on February 2. It is recommended that ERCOT work out procedures in advance with the TCEQ for the exercise of its enforcement discretion in the case of severe weather events, and have an internal procedure in place that delegates specific ERCOT personnel as responsible for contacting the TCEQ and other environmental regulatory bodies during the early stages of an event, in order to inform them of the significance of the situation.

WINTERIZATION

11. States in the Southwest should examine whether Generator/Operators ought to be required to submit winterization plans, and should consider enacting legislation where necessary and appropriate.

The task force determined during its inquiry that certain generators were better prepared than others to respond to the February cold weather event. In many cases the entities that performed well had emergency operations or winterization plans in place to provide direction to employees on how to keep their units operating. Although the implementation of a winterization plan cannot guarantee that a unit will not succumb to cold weather conditions, it can reduce the likelihood of unit trips, derates and failed starts.

The state of Texas has provided a starting point for such legislation with SB 1133, which was signed into law on June 17, 2011. This statute incorporates two important components: (1) mandatory reporting of emergency operations procedures, and (2) independent review by the PUCT.

In addition to the matters covered in the Texas statute, the task force recommends that planning take into account not only forecasts but also historical weather patterns, so that the required procedures accommodate unusually severe events. Statutes should ideally direct utility commissions to develop best winterization practices for its state, and make winterization plans mandatory. Lastly, it is recommended that legislatures consider granting utility commissions the authority to impose penalties for non-compliance, as well as to require senior management to acknowledge that they have reviewed the winterization plans for their generating unit, that the plans are an accurate representation of the winterization work completed, and that they are appropriate for the unit in light of seasonal weather conditions.

NERC staff has concluded there would be a reliability benefit from amending the EOP Reliability Standards to require Generator Owner/Operators to develop, maintain, and implement plans to winterize plants and units prior to extreme cold weather, in order to maximize generator output and availability. Accordingly, NERC intends to submit a Standard Authorization Request, the first

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

step in the Reliability Standards development process, proposing modifications to the Reliability Standards for Emergency Preparedness and Operations.

Plant Design

12. Consideration should be given to designing all new generating plants and designing modifications to existing plants (unless committed solely for summer peaking purposes) to be able to perform at the lowest recorded ambient temperature for the nearest city for which historical weather data is available, factoring in accelerated heat loss due to wind speed.

The ideal time to prepare a generating unit to withstand cold temperatures is in the design stage. For that reason, the low temperatures and wind chills that can occur during the occasional severe storm should be incorporated in the design process.

13. The temperature design parameters of existing generating units should be assessed.

The task force found that for existing generating units, it is often not known with any specificity at what temperature the unit will be able to operate, or to what temperature heat tracing and insulation can prevent the water or moisture in its critical components from freezing. For that reason, Generator Owner/Operators should conduct engineering analyses to ascertain each unit's operating parameters, and then take appropriate steps to ensure that each unit will be able to achieve the optimum level of performance of which it is capable.

The task force recommends the following:

- Each Generator Owner/Operator should obtain or perform a comprehensive engineering analysis to identify potential freezing problems or other cold weather operational issues. The analysis should identify components/systems that have the potential to: initiate an automatic unit trip, prevent successful unit start-up, initiate automatic unit runback schemes and/or cause partial outages, adversely affect environmental controls that could cause full or partial outages, adversely affect the delivery of fuel to the units, or cause other operational problems such as slowed valve/damper operation.
- If a Generator Owner/Operator does not have accurate information about the ambient temperature to which an existing unit was designed, or if extensive modifications have been made since the unit was designed (including changes to plant site), it should obtain an engineering analysis

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

regarding the lowest ambient temperatures at which the unit can reliably operate (including wind chill considerations).

- Each Generator Owner/Operator should ensure that its heat tracing, insulation, lagging and wind breaks are designed to maintain water temperature (in those lines with standing water) at or above 40 degrees when ambient temperature, taking into account the accelerated heat loss due to wind, falls below freezing.
- Each Generator Owner/Operator should determine the duration that it can maintain water, air, or fluid systems above freezing when offline, and have contingency plans for periods of freezing temperatures exceeding this duration.

Maintenance/inspections generally

14. Generator Owner/Operators should ensure that adequate maintenance and inspection of its freeze protection elements be conducted on a timely and repetitive basis.

The task force found a number of inadequacies in generating units' preparations for winter performance. These included a lack of accountability and senior management review, lack of an adequate inspection and maintenance program, and failure to perform engineering analyses to determine the correct capability needed for their protection equipment.

The task force recommends the following:

- Each Generator Owner/Operator's senior management should establish policies that make winter preparation a priority each fall, establish personnel accountability and audit procedures, and reinforce the policies annually.
- Each Generator Owner/Operator should develop a winter preventative maintenance program for its freeze protection elements, which should specify inspection and testing intervals both before and during the winter. At the end of winter, an additional round of inspections and testing should be performed and an evaluation made of freeze protection performance, in order to identify potential improvements, required maintenance, and freeze protection component replacement for the following winter season.
- Each Generator Owner/Operator should prioritize repairs identified by the inspection and testing program, so that repairs necessary for

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

the proper functioning of freeze protection systems will be completed before the following winter.

- Each Generator Owner/Operator should use the recommended comprehensive engineering analysis, combined with previous lessons learned, to prepare and update a winter preparation checklist. Generator Owner/Operators should update checklists annually, using the previous winter's lessons learned and industry best practices.

Specific Freeze Protection Maintenance Items

The task force found that many generating units tripped, were derated, or failed to start as a result of problems associated with a failure to install and maintain adequate freeze protection systems and equipment. Based on these findings, on an examination of freeze protection systems of many of the affected generating units, and in some cases on standards issued by the Institute of Electrical and Electronics Engineers, the task force has prepared a number of recommendations designed to prevent a repeat of the spotty generator performance experienced during the February cold weather event. Of course, specific actions should conform to best industry practices at the time improvements are made, as well as to the requirements of any mandatory winterization standards imposed by regulatory or legislative bodies.

Heat tracing

15. Each Generator Owner/Operator should inspect and maintain its generating units' heat tracing equipment.

Specifically, the task force recommends:

- Each Generator Owner/Operator should, before each winter begins and before forecasted freezing weather, inspect the power supply to all heat trace circuits, including all breakers and fuses.
- Each Generator Owner/Operator should, before each winter begins and before forecasted freezing weather, inspect the continuity of all heat trace circuits, check the integrity of all connections in the heat trace circuits, and ensure that all insulation on heat traces is intact. This inspection should include checking for loose connections, broken wires, corrosion, and other damage to the integrity of electrical insulation which could cause grounds.
- Each Generator Owner/Operator should, before each winter begins, inspect, test, and maintain all heat trace controls or monitoring devices for proper

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

operation, including but not limited to thermostats, local and remote alarms, lights, and monitoring cabinet heaters.

- Each Generator Owner/Operator should, before each winter begins, test the amperage and voltage for its heat tracing circuits and calculate whether the circuits are producing the output specified in the design criteria, and maintain or repair the circuits as needed.
- Each Generator Owner/Operator should be aware of the intended useful life of its heat tracing equipment and should plan for its replacement in accordance with the manufacturer's recommendations.

Thermal Insulation

16. Each Generator Owner/Operator should inspect and maintain its units' thermal insulation.

Specifically, the task force recommends:

- Each Generator Owner/Operator should, before each winter begins, inspect all accessible thermal insulation and verify that there are no cuts, tears, or holes in the insulation, or evidence of degradation.
- Each Generator Owner/Operator should require visual inspection of thermal insulation for damage after repairs or maintenance have been conducted in the vicinity of the insulation.
- Each Generator Owner/Operator should ensure that valves and connections are insulated to the same temperature specifications as the piping connected to it.
- Each Generator Owner/Operator should be aware of the intended useful life of the insulation of water lines and should plan for its replacement in accordance with the manufacturer's recommendations.

Use of Wind breaks/enclosures

17. Each Generator Owner/Operator should plan on the erection of adequate wind breaks and enclosures, where needed.

Specifically, the task force recommends:

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- A separate engineering assessment should be performed for each generating unit to determine the proper placement of temporary and/or permanent wind breaks or enclosures to protect and prevent freezing of critical and vulnerable elements during extreme weather.
- Temporary wind breaks should be designed to withstand high winds, and should be fabricated and installed before extreme weather begins.
- Generator Owner/Operators should take into account the fact that sustained winds and/or low temperatures can result in heat loss and freezing even in enclosed or semi-enclosed areas.

Training

18. Each Generator Owner/Operator should develop and annually conduct winter-specific and plant-specific operator awareness and maintenance training.

Operator training should include awareness of the capabilities and limitations of the freeze protection monitoring system, proper methods to check insulation integrity and the reliability and output of heat tracing, and prioritization of repair orders when problems are discovered.

Other Generator Owner/Operator Actions

19. Each Generator Owner/Operator should take steps to ensure that winterization supplies and equipment are in place before the winter season, that adequate staffing is in place for cold weather events, and that preventative action in anticipation of such events is taken in a timely manner.

Specifically, the task force recommends:

- Each Generator Owner/Operator should maintain a sufficient inventory of supplies at each generating unit necessary for extreme weather preparations and operations.
- Each Generator Owner/Operator should place thermometers in rooms containing equipment sensitive to cold and in freeze protection enclosures to ensure that temperature is being maintained above freezing and to determine the need for additional heaters or other freeze protection devices.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- During extreme cold weather events, each Generator Owner/Operator should schedule additional personnel for around-the-clock coverage.
- Each Generator Owner/Operator should evaluate whether it has sufficient electrical circuits and capacity to operate portable heaters, and perform preventive maintenance on all portable heaters prior to cold weather.
- Each Generator Owner/Operator should drain any non-critical service water lines in anticipation of severe cold weather.

Transmission Facilities

20. Transmission Operators should ensure that transmission facilities are capable of performing during cold weather conditions.

Transmission Operators reported several incidents of unplanned outages during the February 2011 event as a result of circuit breaker trips, transformer trips, and other transmission line issues. Although these outages did not generally contribute materially to any transmission limitations, some transmission breaker outages did lead to the loss of generating units. Many breaker trips were the result of low air in the breaker, low sulfur hexa-fluoride (SF₆) gas pressure, failed or inadequate heaters, bad contacts, and gas leaks.

Specifically, the task force recommends:

- Transmission Owner/Operators should ensure that the SF₆ gas in breakers and metering and other electrical equipment is at the correct pressure and temperature to operate safely during extreme cold, and also perform annual maintenance that tests SF₆ breaker heaters and supporting circuitry to assure that they are functional.
- Transmission Owner/Operators should maintain the operation of power transformers in cold temperatures by checking heaters in the control cabinets, verifying that main tank oil levels are appropriate for the actual oil temperature, checking bushing oil levels, and checking the nitrogen pressure if necessary.
- Transmission Owner/Operators should determine the ambient temperature to which their equipment, including fire protection systems, is protected (taking into account the accelerated cooling effect of wind), and ensure that temperature requirements are met during operations.

COMMUNICATIONS

21. Balancing Authorities should improve communications during extreme cold weather events with Transmission Owner/Operators, Distribution Providers, and other market participants.

During the February event, ERCOT communicated with Transmission Owners and Transmission Service Providers (an ERCOT-specific term) concerning the initiation of load shedding and the subsequent restoration of service. These communications appear to have been made in accordance with applicable ERCOT Operating Guidelines and Reliability Standards. However, ERCOT and several of its Transmission Service Providers that were responsible for curtailing firm load suggested areas for improvement in communications.

Transmission Service Providers are dependent on ERCOT for much of their information on ERCOT-wide system conditions, as they do not have information regarding generator trips beyond those on their own systems, and can only track ERCOT-wide system status by monitoring ERCOT's posted Physical Response Capability levels or monitoring frequency levels. Some of these Transmission Service Providers suggested that ERCOT should have communicated concerns about deteriorating conditions much earlier than it did.

A task force appointed by ERCOT's Board of Directors to look into the February 2 rolling blackouts concluded that there was a need for earlier dissemination of operational information to Transmission Service Providers and Distribution Service Providers (an ERCOT-specific term) during the period leading up to a possible emergency, a conclusion with which this task force agrees.

22. ERCOT should review and modify its Protocols as needed to give Transmission Service Providers and Distribution Service Providers in Texas access to information about loads on their systems that could be curtailed by ERCOT as Load Resources or as Emergency Interruptible Load Service.

Some ERCOT Transmission Service Providers expressed concern that they have virtually no information regarding loads on their own systems that may be deployed by ERCOT as Load Resources or Emergency Interruptible Load Service resources. These loads contract directly with ERCOT, and the Transmission Service Provider does not receive information about their status. When these loads are shed by ERCOT without prior notification to the Transmission Service Providers and Distribution Service Providers, they have the potential to cause localized imbalances in line flows, voltages, and other system parameters that may be problematic.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

The task force suggests that ERCOT share information about the status of these loads with Transmission Service Providers on a daily basis, and study the effects of the loss of large blocks of these loads on the transmission grid.

23. WECC should review its Reliability Coordinator procedures for providing notice to Transmission Operators and Balancing Authorities when another Transmission Operator or Balancing Authority within WECC is experiencing a system emergency (or likely will experience a system emergency), and consider whether modification of those procedures is needed to expedite the notice process.

The Task Force observed a lag in communicating a declared system emergency in WECC. In one instance, a Reliability Coordinator did not issue an EEA 3 declaration until seven minutes after the decision had been made to do so; the delayed declaration appeared to have been the first official notice by the Reliability Coordinator to other WECC entities of the seriousness of the generation failures on the system of the Balancing Authority in question.

24. All Transmission Operators and Balancing Authorities should examine their emergency communications protocols or procedures to ensure that not too much responsibility is placed on a single system operator or on other key personnel during an emergency, and should consider developing single points of contact (persons who are not otherwise responsible for emergency operations) for communications during an emergency or likely emergency.

The task force's review of incidents during the event, as well as of operating procedures and protocols in place at the time, indicated that critical employees such as operators had numerous responsibilities that, while manageable in non-emergency situations, could prove impossible to meet during the often-compressed time frame of an emergency situation. In at least one instance, overloading a single on-call operations representative appears to have led to a delay in making emergency power purchases.

LOAD SHEDDING

25. Transmission Operators and Distribution Providers should conduct critical load review for gas production and transmission facilities, and determine the level of protection such facilities should be accorded in the event of system stress or load shedding.

Keeping gas production facilities in service is critical to maintaining an adequate supply of natural gas, particularly in the Southwest where there is a relatively small amount of underground gas storage. And keeping electric-

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

powered compressors running can be important in maintaining adequate pressure in gas transmission lines.

The task force suggests that a review of curtailment priorities be made, to consider whether gas production facilities should be treated as protected loads in the event of load shedding.

26. Transmission Operators should train operators in proper load shedding procedures and conduct periodic drills to maintain their load shedding skills.

The task force found that at least one Transmission Operator in WECC experienced a minor delay in initiating its load shedding sequence, due to problems notifying the concerned Distribution Provider. Another Transmission Operator experienced delay in executing its load shedding because the individual operators had never shed load before and had not had recent drills. These incidents underscore the necessity of adequate training in load shedding procedures.

B. The Natural Gas Industry

Key Findings -- Natural Gas

- Extreme low temperatures and winter storm conditions resulted in widespread wellhead, gathering system, and processing plant freeze-offs and hampered repair and restoration efforts, reducing the flow of gas in production basins in Texas and New Mexico by between 4 Bcf and 5 Bcf per day, or approximately 20 percent, a much greater extent than has occurred in the past.
- The prolonged cold caused production shortfalls in the San Juan and Permian Basins, the main supply areas for the LDCs that eventually curtailed service to customers in New Mexico, Arizona, and Texas.
- Wellhead freeze-offs normally occur several times a winter in the San Juan Basin but are not common in the Permian Basin, which is the supply source that LDCs in the Southwest region typically rely upon when cold weather threatens production in the San Juan Basin.
- Electrical outages contributed to the cold weather problems faced by gas producers, processors, and storage facilities in the Permian and Fort Worth Basins, with producers being more significantly affected by the blackouts; however, based on information obtained from a sampling of producers and

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

processing plants in the region, the task force concluded that the effect of electric blackouts on supply shortages was less important than the effect of freezing temperatures.

- Although producers in the New Mexico and Texas production areas implemented some winterization measures such as methanol injection, production was nevertheless severely affected by the unusually cold weather and icy road conditions, which prevented crews from responding to wells and equipment that were shut in.
- The extreme cold weather also created an unprecedented demand for gas, which further strained the ability of the LDCs and pipelines to maintain sufficient operating pressure.
- The combination of dramatically reduced supply and unprecedented high demand was the cause of most of the gas outages and shortages that occurred in the region.
- Low delivery pressures from the El Paso Natural Gas interstate pipeline, caused by supply shortages, contributed to gas outages in Arizona and southern New Mexico.
- Some local distribution systems were unable to deliver the unprecedented volume of gas demanded by residential customers.
- No evidence was found that interstate or intrastate pipeline design constraints, system limitations, or equipment failures contributed significantly to the gas outages.
- The pipeline network, both interstate and intrastate, showed good flexibility in adjusting flows to meet demand and compensate for supply shortfalls.
- Additional gas storage capacity in Arizona and New Mexico could have prevented many of the outages that occurred by making additional supply available during the periods of peak demand. Natural gas storage is a key component of the natural gas grid that helps maintain reliability of gas supplies during periods of high demand. Storage can help LDCs maintain adequate supply during periods of heavy demand by supplementing pipeline capacity, and can serve as backup supply in case of interruptions in wellhead production. Additional gas storage capacity in the downstream market areas closer to demand centers in Arizona and New Mexico could

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

have prevented most of the outages that occurred by making additional supply available in a more timely manner during peak demand periods.

Recommendations – Natural Gas

1. Lawmakers in Texas and New Mexico, working with their state regulators and all sectors of the natural gas industry, should determine whether production shortages during extreme cold weather events can be effectively and economically mitigated through the adoption of minimum, uniform standards for the winterization of natural gas production and processing facilities.

The Texas and New Mexico production basins experienced unusually sharp declines due to the prolonged freezing weather of early February 2011. Although these areas typically experience occasional freeze-offs during periods of sub-freezing weather, and although natural gas producers and processors in those regions employ some winterization techniques, to a significant degree those measures were inadequate to meet consumer demand during this event. Production difficulties were compounded by icy road conditions, which disrupted routine maintenance and delayed repairs.

Some industry representatives stated that producers and processors already have strong economic incentives to keep gas flowing at all times, and that increased winterization would not have prevented many of the shortfalls that occurred in the Southwest production basins in early February 2011. Others stated that the levels of winterization typically employed in these areas are designed to deal with less severe, more typical winter weather conditions, and that additional winterization could protect the system from the effects of unusually harsh weather. Many expressed the view that along with increased reliance upon natural gas for energy, steps should be taken to improve the reliability of gas supply during extreme cold weather events.

Whether the adoption of uniform winterization standards for natural gas facilities is the right way to meet the goal of increased reliability is a complex question. Among the issues that need to be resolved are the following:

- Determining the costs of increased winterization and balancing those costs against the need for increased reliability,
- Determining who should ultimately bear the costs of additional winterization, and whether ratemakers would be willing to pass the costs of increased reliability along to consumers,
- Determining whether it is practical to design for very low temperatures, which may not recur for years or even decades,

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

- Ensuring that standards are uniformly applied, and determining whether state commissions would have adequate resources or authority to promulgate and enforce those standards, and
- Identifying possible incentives for industry that could improve the reliability of winter supply without government regulation.

Because the Commission does not have jurisdictional authority over this sector of the natural gas industry for these purposes, we recommend that state lawmakers and regulators in Texas and New Mexico investigate whether minimum standards for the winterization of gas production and processing facilities should be adopted, by way of legislation, regulation, or the adoption of voluntary industry practices, and whether such standards would be likely to effectively and reliably improve supply during extreme weather events.

2. The gas and electric sectors should work with state regulatory authorities to determine whether critical natural gas facilities can be exempted from rolling blackouts.

The natural gas industry depends in many instances on electric utilities for the power that helps move gas from the production fields to end users. Electric-powered instrumentation, compression, pumps, and processing equipment are essential links in that process, and in some instances, even the brief, temporary loss of electric power can put a gas production, processing, compression, or storage facility out of service for long periods of time, especially where weather conditions delay access to those facilities. The resulting gas outages can contribute to electricity shortages by cutting off or reducing fuel supply to gas-fired generating plants.

Gas producers, processors, pipelines, storage providers, and LDCs should identify portions of their systems that are essential to the ongoing delivery of significant volumes of gas, and which are dependent upon purchased power to function reliably under emergency conditions. State regulatory authorities should work with the gas industry and electric transmission operators, balancing authorities and reliability coordinators to determine whether such facilities can be shielded from the effects of future rolling blackouts.

3. State utility commissions should work with LDCs to ensure that voluntary curtailment plans can reduce demand on the system as quickly and efficiently as possible when gas supplies are disrupted.

One tool available to LDCs faced with supply disruptions during periods of high consumer demand is the implementation of voluntary curtailment plans, which seek reductions or curtailment from large commercial users. State

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

regulators, who review and approve the voluntary curtailment plans of LDCs, should assess whether they are designed and implemented in a way that maximizes their potential effect in emergency situations.

Voluntary curtailment plans should include multiple points of contact for large customers and up to date, 24-hour contact information. Where appropriate, the plans should provide for pre-event planning, training, and customer education. Large customers should be contacted prior to emergencies and efforts should be made to explain the circumstances under which reductions or curtailments would be sought and to obtain advance commitments for possible reductions, giving LDCs a clearer idea of the amount of demand that can be reduced in an emergency. While voluntary curtailment does nothing to increase supply, in light of the importance of reducing demand when distribution systems are near collapse, regulators and the LDCs should ensure that planning for voluntary curtailments is as thorough and well-thought out as possible.

4. State utility commissions should work with balancing authorities, electrical generators, and LDCs to determine whether and under what circumstances residential gas customers should receive priority over electrical generating plants during a gas supply emergency.

Gas-fired generation provides much needed electrical power during a weather emergency, but also consumes large amounts of natural gas. Although restoring residential electricity service after a rolling blackout is a fairly simple process, restoring gas service after an outage is both labor-intensive and time-consuming.

State utility commissions should work with LDCs to identify situations where consumption by gas-fired generators could contribute to residential gas customer outages, and should consult with those generators and the relevant Balancing Authority to determine whether alternative power suppliers or fuel supplies could be used in emergency situations. The state commissions should also evaluate the relative importance, for human needs customers, of gas-fired generation and residential use, and should assess the relative impacts of curtailing generating plants versus gas supply to residences.

5. State utility commissions and LDCs should review the events of early February 2011 and determine whether distribution systems can be improved to increase flows during periods of high demand.

In some instances during the winter storm event, LDC distribution systems were unable to flow scheduled volumes, suggesting that downstream parties may not have had sufficient capacity or facilities to handle historically high demand.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

Accordingly, state commissions and distribution companies should determine whether system enhancements can be made to improve volume handling capacity, such as additional distribution valving, looping, more compression, or reconfigured compression. Although such system improvements would probably not compensate for the level of supply shortfalls that occurred in early February 2011, they might allow LDCs to take higher volumes for longer periods of time.

6. State utility commissions should work with LDCs to determine whether the LDC distribution systems can be improved so that curtailments can be implemented, when necessary, in a way that improves the speed and efficiency of the restoration process.

The events of early February 2011 demonstrated that once operational pressures and line pack begin to fall beyond normal tolerances, little time may be available to evaluate, locate, and shut off portions of the pipeline systems of the LDCs to avoid system collapse. Regulators should work with LDCs, as part of the annual system review process, to determine whether the systems under their regulatory authority should be further sectionalized to provide more options when involuntary curtailments are necessary.

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ATTACHMENTS

Acronyms

Glossary

Appendices

Task Force Members

Legislative and Regulatory Responses by the States

Categories of NERC Registered Entities

Electricity: How it is Generated and Distributed

Power Plant Design for Ambient Weather Conditions

Impact of Wind Chill

Winterization for Generators

Natural Gas: Production and Distribution

Natural Gas Storage

Natural Gas Transportation Contracting Practices

GTI: Impact of Cold Weather on Gas Production

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

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Acronyms

AC	Alternating Current	Hz	Hertz
ACE	Area Control Error	IMM	Independent Market Monitor
ANR	ANR Pipeline Company	ISO	Independent System Operator
Bcf	Billion Cubic Feet	LDC	Local Distribution Company
Btu	British Thermal Unit	LNG	Liquefied Natural Gas
CFE	Comisión Federal de Electricidad	LRGV	Lower Rio Grande Valley
CNG	Compressed Natural Gas	Mcf	Thousand Cubic Feet
COP	Current Operating Plan	MMcf	Million Cubic Feet
DC	Direct Current	MW	Megawatt
DC Tie	Direct Current Tie	MWh	Megawatt Hour
EEA	Energy Emergency Alert	NGL	Natural Gas Liquids
EILS	Emergency Interruptible Load Service	NMGC	New Mexico Gas Company
EPE	El Paso Electric Company	NERC	North American Electric Reliability Corporation
ERCOT	Electric Reliability Council of Texas	OCN	Operating Condition Notice
ERO	Electric Reliability Organization	OFO	Operational Flow Order
FERC	Federal Energy Regulatory Commission	PNM	Public Service Company of New Mexico

Acronyms

PRC	Physical Response Capability	RUC	Reliability Unit Commitment
PUCT	Public Utilities Commission of Texas	SCADA	Supervisory Control and Data Acquisition
QSE	Qualified Scheduling Entity	SPP	Southwest Power Pool
RMR	Reliability Must Run	SRSG	Southwest Reserve Sharing Group
SRP	Salt River Project Agricultural Improvement and Power District	TRE	Texas Reliability Entity, Inc.
		TRC	Texas Railroad Commission
SRSG	Southwest Reserve Sharing Group	UFLS	Under-Frequency Load Shedding
RTO	Regional Transmission Organization	WECC	Western Electricity Coordinating Council

Glossary

Active Power - Also known as real power, this is the rate at which work is performed or at which energy is transferred, usually expressed in kilowatts (kW) or megawatts (MW) when referring to electricity. In the field of electric power, the terms “active power” or “real power” are often used in place of the term “power” alone to differentiate it from reactive power. (See Reactive Power)

Allocation of Capacity - A process by which capacity available in a pipeline is distributed to parties in the event requests for volume (*i.e.*, nominations) are in excess of the available space. Typically the allocation is based on service type, contract type and a company's tariff provisions.

Alternating Current (AC) - Electric current that changes periodically in magnitude and direction with time. In power systems, the changes follow the pattern of a sine wave having a frequency of 60 cycles per second in North America. AC is also used to refer to voltage which follows a similar sine wave pattern.

Ambient Conditions - Common, prevailing, and uncontrolled atmospheric conditions at a particular location, either indoors or out. The term is often used to describe the temperature, humidity, and airflow or wind that equipment or systems are exposed to.

Ancillary Services - The services necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system. These include, but are not limited to, voltage support, regulation, reserves, and black start capability.

Aquifer Storage - The storage of gas underground in porous and permeable rock stratum, the pore space of which was originally filled with water and in which the stored gas is confined by suitable structure, permeability barriers, and hydrostatic water pressure.

Area Control Error (ACE) - The instantaneous difference between a Balancing Authority's net actual and scheduled interchange, plus the instantaneous difference between the interconnection's actual frequency and scheduled frequency and a correction for meter error.

Asynchronous - In AC power systems, two systems are asynchronous if they are not operating at exactly the same frequency. Two systems may also be considered asynchronous if, at potential interconnection points, there is a significant difference in phase angle between their respective voltage waveforms.

Glossary

Auto-Transformer - A power transformer with a single coil for each electrical phase, as opposed to a conventional transformer, which has two coils per phase. In an auto-transformer, the entire coil acts as the primary winding while a portion of the same coil acts as the secondary winding.

Automatic Generation Control (AGC) - A feature of a power system's centralized control system that automatically adjusts generation in a Balancing Authority Area to maintain the Balancing Authority's interchange schedule plus its Frequency Bias.

Balancing (Natural Gas) - Equalizing a shipper's receipts and deliveries of gas on a transportation pipeline. Balancing may be accomplished daily, monthly or seasonally, with penalties generally assessed for excessive imbalances.

Balancing Authority (BA) - The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority area, and supports interconnection frequency in real time.

Base Load (Natural Gas) - A given volume of gas used by a LDC or other large user, remaining fairly constant over a period of time. Base load does not vary with heating degree-days.

Baseload Generating Units - Electric generating units which produce energy at a constant rate, usually at a low cost relative to other generating units available to the system. Baseload units are used to meet some or all of a given region's continuous energy demand on a seasonal or daily basis, including at minimum load levels, and tend to operate non-stop except for maintenance or forced outages.

Base Load Storage (Natural Gas) - Storage facilities capable of holding enough natural gas to satisfy long term seasonal demand requirements.

Blade - The component of a steam turbine that is acted upon by the flow of steam. Blades in steam turbines are also referred to as "buckets." Similarly, in gas, or combustion turbines, the blades are the components acted upon by the flow of the high pressure, high temperature gases produced in the combustor. In both steam turbines and combustion turbines, the blades are arranged in multiple stages of varying diameter, with many blades per stage. Modern wind turbines, in contrast, typically utilize only three long blades. The purpose of the blades is to extract energy from the motion of the propelling fluid (steam, combustion gases, or air) and convert it into rotational form by direct coupling to a common spinning shaft which is in turn used to drive a generator.

Glossary

Boiler - The component of a steam power plant in which water is heated and converted into steam.

British Thermal Unit (BTU) - the measurement of heat released by burning any material. The amount of energy necessary to raise the temperature of one pound of water by one degree Fahrenheit from 58.5 to 59.5 degrees Fahrenheit under standard pressure of 30 inches of mercury at or near its point of maximum density.

Bulk Electric System - The electrical generation resources, transmission lines, interconnections with neighboring systems, and associated equipment, generally operated at voltages of 100 kV or higher. Radial transmission facilities serving only load with one transmission source are generally not considered to be part of the bulk electric system.

Capacitor Bank - A capacitor is a device that stores an electric charge. Although there is energy associated with the stored charge, it is negligible in terms of its capability to serve load. A capacitor bank is made of up of many individual capacitors. Its purpose is to provide reactive power to the system to help support system voltage by compensating for reactive power losses incurred in the delivery of power.

Capacity Market - A market where Load Serving Entities purchase generating capacity (including adequate reserves) to cover their peak loads.

Capacity Release (Natural Gas) - A mechanism by which holders of firm interstate transportation capacity can relinquish their rights to utilize the firm capacity to other parties that are interested in obtaining the right to use that capacity for a specific price, for a given period of time and under a specifically identified set of conditions. The firm transportation rights may include transmission capacity and/or storage capacity.

Capacity-Short Charge - In ERCOT, a monetary charge to Qualified Scheduling Entities (QSEs) who cannot meet their resource commitments when a Reliability Unit Commitment (RUC) study (conducted periodically) determines there is insufficient generation to meet projected demand, and the costs associated with bringing the needed additional generation on-line cannot be fully recovered using energy revenue. The capacity-short charge is the mechanism for covering those costs. This is done on the basis of settlement intervals.

Centrifugal Compressor Unit(s) -Compressors that produce pressure by centrifugal force from rotation of a compressor wheel that translates kinetic energy

Glossary

into pressure energy of the gas. Centrifugal compressors are commonly used in gas transmission systems due to their flexibility.

Charge - In physics, charge, also known as electric charge, electrical charge, or electrostatic charge is a characteristic of an object that expresses the extent to which it has more or fewer electrons than protons. A single electron carries an elementary charge of negative polarity, whereas a single proton carries the same, except of positive polarity. The unit of electrical charge is the coulomb (symbolized C) where 1 C is equal to 6.24×10^{18} elementary charges. It is not unusual for real-world objects to hold charges of many coulombs. When two objects having electric charges are brought into proximity with each other, an electrostatic force is manifested between them – attractive if the charges are of opposite polarity and repulsive if the charges are of the same polarity.

Circuit Breaker - In electrical power systems, circuit breakers are used to disconnect and reconnect transmission lines, transformers, generators, and other facilities from the power system or from each other. Circuit breakers trip to interrupt the flow of current when faults develop, de-energizing the faulted facility and isolating it from the system. They are also used to switch facilities in or out of service.

Citygate - The point at which a Local Distribution Company receives natural gas from an interstate or intrastate pipeline.

Cold Load Pickup - Phenomenon that takes place when a distribution circuit is re-energized following an extended outage of that circuit. Cold load pickup is a composite of two conditions: 1) inrush current which reestablishes the magnetic fields in motors and transformers and the necessary temperatures in heating coils and incandescent lamp filaments and 2) loss of load diversity due to cyclic loads which normally cycle randomly with respect to one another, such as refrigerator compressors, all restarting at the same time. The inrush current may last up to several seconds while the loss of load diversity may persist for many minutes.

Combined Cycle Unit - This type of electric generating unit consists of one or more gas turbines, also referred to as combustion turbines, equipped with heat recovery steam generators to capture heat from their exhaust. Steam produced in the heat recovery steam generators then drives a steam turbine generator to produce additional electric power. A typical arrangement consists of two natural gas-fired combustion turbines combined with a single steam turbine, each driving its own electrical generator, for a total of three generators. The heat recovery aspect of combined cycle units increases the overall efficiency of electric power production.

Glossary

Comisión Federal de Electricidad (CFE) - A Mexican governmental entity that generates, transmits, distributes and sells electricity to more than 34.2 million customers, representing more than 100 million people annually. CFE interconnects to ERCOT via two high voltage DC (HVDC) ties and to WECC via AC transmission lines at the California border just south of San Diego.

Compressor or Compressor Units - Mechanical equipment that adds pressure to the natural gas stream to enable the flow of natural gas through a pipeline system.

Compressor Station - A permanent facility that houses compression equipment that supplies pressure to move natural gas through pipelines.

Condensate and Water Return Lines - Plumbing in a generating station that captures condensate and used water for recycling or re-use.

Condenser - In a steam turbine generating station, the condenser is a type of heat exchanger that cools the steam exiting the turbine to the point where it condenses into water, thereby recovering the high quality feed water for reuse. The cooling is accomplished using separate cooling water. Surface condensers use a shell and tube assembly wherein the cooling water is circulated in the tubes, and the steam and condensate are contained in the tank-like housing, or shell, that surrounds and encloses the tubes.

Conductor - In physical terms, any material, usually metallic, exhibiting a low resistance to the flow of electric current. A conductor is the opposite of an insulator. In electric power systems, the term conductor generally refers to the actual wires in overhead transmission and distribution lines, underground cables, and the metallic tubing used for busses in substations. Aluminum and copper are the predominant metals used for conductors in power systems.

Contingency - The unexpected and sudden failure or outage of a power system component, such as a generator, transmission line, transformer, or other electrical element.

Contingency Reserve Level - Contingency reserve is the provision of capacity deployed by a Balancing Authority to meet the Disturbance Control Standard (DCS) and other NERC and Regional Reliability Organization contingency requirements. The Contingency Reserve Level is that level of reserves required for the reliable operation of an interconnected power system. Adequate generating capacity must be available at all times to maintain scheduled frequency, and avoid loss of firm load following transmission or generation contingencies. This

Glossary

capacity is necessary to replace capacity and energy lost due to forced outages of generation or transmission equipment.

Contract Pressure (Natural Gas) - The maximum or minimum required operating pressure at a natural gas receipt or delivery point, as specified in the agreement between a pipeline and its customer.

Control Area - An electric power system or combination of electric power systems to which a common automatic control scheme is applied in order to: 1) match, at all times, the power output of the generators within the electric power system(s) with the load in the electric power system(s); 2) maintain scheduled interchange with other Control Areas; 3) maintain the frequency of the electric power system(s); and 4) provide sufficient generating capacity to maintain operating reserves, all within reasonable limits in accordance with Good Utility Practice.

Controllable Load Resources (CLR) - In ERCOT, CLRs are a type of load resource capable of controllably reducing or increasing consumption under dispatch control (similar to automatic generation control or AGC) and able to immediately respond proportionally to frequency changes (similar to generator governor action) to provide the following ancillary services: Up and Down Regulation (URS & DRS), Responsive Reserve (RRS), and Non-Spinning Reserve (NSRS).

Cooling Tower - A structure and associated equipment intended to facilitate the evaporative cooling of water by contact with air. In steam turbine generating stations, cooling water is routed through the cooling tower for cooling after having absorbed heat in the condenser.

Cooling Water - In steam turbine generating stations, water that is used in the condenser to extract heat from steam exiting the turbine for the purpose of condensing that steam back to feed water. The feed water is then cycled back through the boiler to make steam again. The cooling water is generally taken from a nearby lake (often man-made for this purpose) or river and is distinctly separate from the feed water that is used to make steam and which must be specially treated to prevent corrosion. Electric generating stations use wholly separate cooling water systems to extract heat from the large copper conductors comprising the generator stator windings.

Cooling Water Intakes - The point at which industrial plants, including power plants, bring cooling water into their system from lakes, rivers, or other sources.

Glossary

Broadly, the total physical structure and any associated constructed waterways used to withdraw cooling water.

Current (Electric) - The rate of flow of electrons in an electrical conductor. The symbol for current is “I” and the unit is the ampere, or amp, where one amp is defined as one coulomb of charge per second.

Current Operating Plan (COP) - In ERCOT, a plan by a Qualified Scheduling Entity (QSE) reflecting anticipated operating conditions for each of the resources that it represents for each hour in the next seven operating days, including resource operational data, resource status, and ancillary service schedule.

Curtailement (Electric) - A reduction in the scheduled capacity or energy delivery of an Interchange Transaction.

Curtailement (Natural Gas) - A method to balance a utility's natural gas requirements with its natural gas supply. Customers are typically ranked by priority in the utility's curtailement plan. A customer may be required to partially cut back or totally eliminate its take of gas depending on the severity of the shortfall between gas supply and demand and the customer's priority.

Day-Ahead Market - A daily, co-optimized market in the 24 hour period before the start of the next operating day for ancillary service capacity, certain congestion revenue rights, and forward financial energy transactions.

Day-Ahead RUC (DRUC) - In ERCOT, a Reliability Unit Commitment (RUC) process performed for the next operating day.

Decommitment Payment - In ERCOT, a payment made to a resource committed by the Reliability Unit Commitment (RUC) process if the directive to use that resource is cancelled prior to its scheduled start time.

Demand (Electric) - The rate at which electric energy is delivered to or by a system or part of a system, generally expressed in kilowatts (kW) or megawatts (MW), at a given instant or averaged over any designated interval of time. The term “demand” is often used interchangeably with the term “load” with respect to electric power systems.

Depleted Oil and/or Gas Fields - Naturally occurring reservoirs that once held deposits of oil and gas, consisting of porous and permeable underground formations confined by impermeable rock or water barriers. The working gas requirement for this type of storage reservoir is generally about 50% of the total

Glossary

reservoir capacity. Gas is typically withdrawn in the winter season and injected in the summer.

Derate (Electric Generator) - A reduction in a generating unit's net dependable capacity.

Direct Current (DC) - Electric current that is steady and does not change in either magnitude or direction with time. DC is also used to refer to voltage and, more generally, to smaller or special purpose power supply systems utilizing direct current either converted from AC, from a DC generator, from batteries, or from other sources such as solar cells.

Direct Current (DC) Tie - In electric power systems, the term "DC Tie" or, more correctly, "HVDC Tie" referring to high voltage DC, is used to describe a transmission-level facility that interconnects between two portions of a power system, two different power systems, or two different electric power interconnections. The DC Tie consists of: (1) a converter station to convert three phase AC power to DC; (2) a DC connection to a second converter station; and (3) a second converter station that reconverts the DC power back to three-phase AC. The DC connection between the two converter stations (step 2 above) may be either a long HVDC transmission line or, in the case of "back-to-back" converters at the same location, a simple set of bus bars. The power flow in DC ties is not free-flowing as it is in AC lines, but rather is controlled precisely by control systems on the converters. Unlike AC lines, DC ties can interconnect between asynchronous interconnections such as ERCOT, the Eastern Interconnection, and the Western Interconnection because concerns about frequency, phase angle, and voltage differences are rendered immaterial by the AC-to-DC-to-AC conversion process.

Distribution (Electric) - The function of distributing electric energy to retail customers, and all associated physical means of serving that function, including substations, low voltage distribution lines, transformers, etc.

Distribution Provider - As defined by NERC, a Registered Entity that provides and operates the "wires", *i.e.*, distribution lines, transformers, and associated facilities, between the transmission system and the end-use customer. For those end-use customers who are served at transmission voltages, the Transmission Owner also serves as the Distribution Provider.

Distribution Service Provider - As defined by ERCOT, an entity that owns or operates a Distribution System for the delivery of energy from the ERCOT Transmission Grid to Customers.

Glossary

Electrical Energy - Electric power generated, transmitted, distributed, and consumed over a period of time, expressed in kilowatt hours (kWh), megawatt hours (MWh), or gigawatt hours (GWh).

Electric Reliability Council of Texas, Inc. (ERCOT) - ERCOT is an Independent System Operator (ISO) that manages the flow of electric power to 23 million customers in Texas representing 85 percent of the state's electric load and 75 percent of its land area. ERCOT is registered with NERC to serve the following roles: Balancing Authority, Interchange Authority, Planning Authority, Reliability Coordinator, Resource Planner, and Transmission Service Provider. It is also jointly registered with other entities as a Transmission Operator.

Electric Reliability Organization (ERO) - The Energy Policy Act of 2005 required the creation of an independent Electric Reliability Organization (ERO) to be certified by FERC and tasked with developing and enforcing mandatory reliability standards applying to the bulk power system. (*See* Energy Policy Act of 2005, Pub. L. No. 109-58, section 102.)

Electromagnetic Induction - The creation of a voltage in a conductor due to a relative movement between the conductor and a magnetic field. Electromagnetic induction is the basic principle of operation of generators.

Emergency Interruptible Load Service (EILS) - In ERCOT, EILS is an emergency load reduction service designed to decrease the likelihood of the need for firm load shedding. It is provided by qualified loads that make themselves available for interruption in an electric grid emergency. Customers meeting EILS criteria may bid to provide the service through their Qualified Scheduling Entities (QSEs). EILS is called upon during an Energy Emergency Alert (EEA) Level 2B to assist in maintaining or restoring system frequency. EILS is not an Ancillary Service.

Energy - See Electrical Energy.

Energy Emergency Alert (EEA) - NERC Reliability Standard EOP-002-2.1 prescribes the use of an energy emergency alert (EEA) procedure when a load serving entity is unable to meet its customers' expected energy requirements. These energy emergencies are declared by the load serving entity's Reliability Coordinator, and are categorized by level of severity, *i.e.*, EEA1, 2, or 3, with level 3 being the most severe. ERCOT defines EEA as an orderly, predetermined procedure for maximizing use of available resources and, only if necessary, curtailing load during an emergency condition while providing for the maximum possible continuity of service and maintaining the integrity of the ERCOT system.

Glossary

Energy Imbalance Service (EIS) - EIS is provided when a difference occurs between the scheduled and the actual delivery of energy to/from the transmission system over a single hour. The market participant must purchase this service from the transmission provider or make comparable alternate arrangements with another market participant who will purchase this service from the transmission provider.

Energy-only Market (Electric) - A market for electric energy that pays resources only for delivered energy and ancillary services, and does not pay for installed capacity (ICAP).

Energy-only Resource Adequacy Mechanism - A mechanism that allows real-time energy prices to rise in times of scarcity in order to provide incentives for investment in peaking as well as base-load generation.

E-Tag - Electronic Tagging, or e-Tag, is used to schedule an interchange transaction in a wholesale electricity markets. NERC and/or Regional Entities (such as WECC) collect all e-Tag data in near real-time to assist Reliability Coordinators in identifying transactions to be curtailed to relieve overload when transmission constraints occur. NERC defines an interchange transaction as “an agreement to transfer energy from a seller to a buyer that crosses one or more Balancing Authority area boundaries.”

Export - In electric power systems, exports refer to energy that is generated in one power system, or portion of a power system, and transmitted to, and consumed in, another.

Firm Service (Natural Gas) - Transportation service on a firm basis means that the service is not subject to a prior claim by another customer or another class of service and receives the same priority as any other class of firm service.

Flow Line - Flow lines carry the fluids or natural gas from the wellhead to and in-between individual vessels in separation, treating, heating, dehydrating, compression, pumping or other processing equipment generally located at or near the well site.

Force Majeure - A superior force, “act of God” or unexpected and disruptive event, which may serve to relieve a party from a contract or obligation.

Forced Outage - The removal from service availability of a generating unit, transmission line, or other facility for emergency reasons. This can be done automatically, as in the case of tripping, manually, as in the case of forced

Glossary

shutdowns, or by withholding a generating unit, transmission line, or other equipment from returning to service due to unresolved problems.

Frequency - The rate, in terms of time, at which a periodic pattern repeats itself. In electric power systems, frequency is measured in cycles per second, or Hertz (Hz). The symbol is “F”. The nominal, or base, frequency for power systems in North America is 60 Hz.

Frequency Bias - A weighting factor applied to the difference between the Interconnection’s actual frequency and scheduled frequency during the calculation of a Balancing Authority’s Area Control Error (ACE). The weighting factor determines how strongly a Balancing Authority will respond to deviations from the scheduled frequency. Larger Balancing Authorities will usually have a larger Frequency Bias.

Frequency Deviation - Broadly, a change in the frequency of an electrical interconnection. More typically, sudden changes that result in the frequency of the interconnection going outside the normal bounds of 59.95 Hz to 60.05 Hz due to the unexpected loss of a significant amount of generation or load.

Generation - The process of producing electrical energy from other sources of energy such as coal, natural gas, uranium, hydro power, wind, etc. More generally, generation can also refer to the amount of electric power produced, usually expressed in kilowatts (kW) or megawatts (MW) and/or the amount of electric energy produced, expressed in kilowatt hours (kWh) or megawatt hours (MWh).

Generator - Generally, a rotating electromagnetic machine used to convert mechanical power to electrical power. The large synchronous generators common in electric power systems also serve the function of voltage support and voltage regulation by supplying or withdrawing reactive power from the transmission system, as needed.

Generator Operator - An entity that operates a generating unit or a fleet of generating units and performs the functions of supplying energy and interconnected operations services to a power system.

Generator Owner - An entity that owns and maintains a generating unit or a fleet of generating units.

Generator Runback - The intentional rapid reduction of the output level of an electric generating unit or an entire generating station, either manually or

Glossary

automatically via plant controls, due to any of a variety of problems in the plant that limit the plant's capacity to generate power, or problems on the transmission system external to the plant which limit the capability of the system to accept the plant's power output.

Good Utility Practice - Any of the practices, methods and acts engaged in or approved by a significant portion of the electric power industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be limited to the optimum practice, method, or act to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in the region.

Grid - An electrical transmission and/or distribution network. Broadly, an entire interconnection.

Heat Tracing - The application of a heat source to pipes, lines, and other equipment which, in order to function properly, must be kept from freezing. Heat tracing typically takes the form of a heating element running parallel with and in direct contact with piping.

Hertz - The unit of frequency equal to one cycle per second.

Hockey Stick Bidding - A pricing strategy during a supply shortage whereby a trader offers to sell a small quantity of energy at a price well above marginal cost, in order to manipulate prices upward.

Hourly RUC (HRUC) - In ERCOT, any Reliability Unit Commitment (RUC) executed after the Day-Ahead RUC (DRUC).

Human Needs Customers - Customers such as residential users, hospitals, and nursing homes, who use natural gas for essential human needs.

Hydrate Crystals - Crystals of hydrates formed under certain pressure and temperature conditions by hydrates and water present in natural gas. Hydrate crystals can form when the temperature is above the melting temperature of ice and can block natural gas wells, gathering systems, and pipelines.

Import Limit - The maximum level of electric power that can flow into a power system or portion of a power system over a transmission path or paths without

Glossary

violating facility thermal ratings, voltage ratings, transient stability limits, or voltage stability limits either in real-time or post contingency, *i.e.*, after the loss of a generator, transmission line, or other facility.

Independent System Operator (ISO) - An organization responsible for the reliable operation of the power grid in a particular region and for providing open access transmission access to all market participants on a nondiscriminatory basis. ISOs in the U.S. include the California ISO, ISO New England, the New York ISO, PJM, the Midwest ISO, and ERCOT. These ISOs dispatch generation in their respective geographic territories.

Induction Machine - A rotating electromagnetic machine using alternating current that may be a generator or a motor. When a generator, the induction machine's rotor is driven at a speed greater than synchronous speed. When a motor, the induction machine's rotor is driven at a speed less than synchronous speed. Induction generators are rarely used for large scale power generation. Induction motors, on the other hand, are the most common type of AC motor. Induction machines absorb reactive power and cannot be used to produce reactive power (as a synchronous machine can).

Insulator - A material with a high resistance to the flow of electric current. More broadly, mechanical supports and spacers constructed of insulating materials. Electrically speaking, an insulator is the opposite of a conductor.

Interchange - Electrical energy transfers that cross Balancing Authority boundaries.

Interconnection - In North America, any one of the four major electric system networks – Eastern, Western, Quebec, and ERCOT. These operate asynchronously with respect to one another.

Interruptible Service - Service on an interruptible basis means that the capacity used to provide the service is subject to a prior claim by another customer or another class of service and receives a lower priority than such other classes of service.

Interruptible Responsive Reserve - In ERCOT, Interruptible Responsive Reserve is provided by load resources that are automatically interrupted when system frequency decreases to 59.7 Hz. The total amount of Interruptible Responsive Reserve procured for a given hour is limited to one half of the Responsive Reserve Service required for that hour.

Glossary

Inverter - A converter designed and operated to convert DC power to AC power. In power systems, inverter generally refers to high voltage DC (HVDC) converters.

Island (Electrical) - An electrically isolated portion of an interconnection.. The frequency in an electrical island must be maintained by balancing generation and load in order to sustain operation. Islands are frequently formed after major disturbances wherein multiple transmission lines trip, or during restoration following a major disturbance.

Joule-Thomson Effect - The cooling that occurs when a compressed gas is allowed to expand in such a way that no external work is done. The effect is approximately 7 degrees Fahrenheit per 100 psi for natural gas.

Lateral Line - A pipe in a gas distribution or transmission system that branches away from the central and primary part of the system.

Line Pack - Natural gas occupying all pressurized sections of the pipeline network. Introduction of new gas at a receipt point “packs” or adds pressure to the line. Removal of gas at a delivery point lowers the pressure (unpacks the line).

Line Trip - This refers to the automatic disconnection of a transmission line by its circuit breakers. Line trips are initiated by protective relays and are designed to protect the power system when a short circuit, or fault, occurs on a line by isolating the faulted line from the system.

Liquefied Natural Gas (LNG) - Natural gas (primarily methane) that has been liquefied by reducing its temperature to -260 degrees Fahrenheit at atmospheric pressure.

Long Haul Pipeline - A transportation pipeline that transports natural gas a significant distance (hundreds of mile or more) from the production area.

Load - See Demand (Electric).

Load Acting as Resource (LaaR) - This term, discontinued by ERCOT when they transitioned from a Zonal Market to a Nodal Market on December 1, 2010, was replaced by the term Load Resource (see below).

Load Resource - In ERCOT, Load Resources provide ancillary services for either Responsive Reserve Service (RRS) or Non-Spinning Reserve Service (NSRS). There are two types of Load Resources – Controllable Load Resources (CLRs)

Glossary

and Non-Controllable Load Resources (NCLRs). “Controllable” refers to the capability to control the load remotely from the ERCOT control center rather than solely at the end-use customer location (or by its Qualified Scheduling Entity (QSE)).

Load Service Entity - An entity that secures energy and transmission service (and related interconnected operations services) to serve the electrical demand and energy requirements of its end-use customers.

Load Shedding - The reduction of electrical system load or demand by interrupting the load flow to major customers and/or distribution circuits, normally in response to system or area capacity shortages or voltage control considerations. In cases of capacity shortages, load shedding is often performed on a rotating basis, systematically and in a predetermined sequence. (See Rolling Blackouts.)

Local Distribution Companies (LDC) - Any firm, other than a natural gas pipeline, engaged in the transportation or local distribution of natural gas and its sale to customers that consume the gas.

Magnetic Field - The invisible lines of force between the north and south poles of a magnet. A magnetic field is created when electric current flows through a conductor.

Make-Whole Charge - In ERCOT, a charge made to a Qualified Shedding Entity (QSE) for a resource to recapture all or part of the revenues received by a QSE that exceed the Make-Whole Payment for a resource (see below).

Make-Whole Payment - In ERCOT, a payment made to a Qualified Scheduling Entity (QSE) for a resource to reimburse it for allowable startup and minimum energy costs of a resource not recovered in energy revenue when a resource is committed by the Day-Ahead Market (DAM) or by a Reliability Unit Commitment (RUC).

Maximum Allowable Operating Pressure - The maximum operating pressure at which a pipeline system may be operated safely.

Mercaptans - A group of strong-smelling chemical compounds added to natural or LP gases as a safety measure, to warn of leaks.

Metering (Electric) - A meter is a device for measuring and displaying an electrical quantity. For example, meters are used to measure power flows, voltage, current, frequency, etc. The term “metering” generally refers to a group of meters

Glossary

associated with a given facility, and the information from those meters transmitted to and displayed in a control room or control center.

Methanol - A light volatile flammable poisonous liquid alcohol used especially as a solvent, antifreeze, or denaturant for ethyl alcohol, and in the synthesis of other chemicals.

Nomination - A request for a physical quantity of natural gas under a specific purchase, sales or transportation agreement, or for all contracts at a specific point. A nomination will continue for specified number of days or until superseded by another service request for the same contract.

North American Energy Standards Board - A non-profit, private standards development organization established in January 2002 to develop voluntary standards and model business practices designed to promote more competitive and efficient natural gas and electric service.

Nodal Market (Electric) - Prices are assessed at points (*i.e.*, nodes) where electricity enters or leaves the grid. Transmission lines throughout the grid may be subject to congestion rents, which means generators may receive different prices based on how they contribute to or relieve congestion on the grid. ERCOT transitioned from a zonal to a nodal market on December 1, 2010. Their nodal market calculates transmission costs from the point of generation from roughly 4,000 delivery points. Nodal pricing is intended to provide a more detailed and accurate picture of transmission and generation than zonal pricing. ERCOT's nodal system reduces the time interval for which the market-clearing price is calculated to five minutes (from fifteen minutes in their former zonal market).

Non-Controllable Load Resources (NCLRs) - In ERCOT, these represent loads that provide selected Ancillary Services, but that do not have the capability of being switched or controlled directly from the ERCOT control center. (Compare Controllable Load Resources)

Non-Spinning Reserve Service - In ERCOT, this refers to generation resources capable of being ramped to a specified output level within thirty minutes or load resources that are capable of being interrupted within thirty minutes. The generation resources must be capable of running at a specified output level for at least one hour, and the load resources must similarly be capable of remaining out of service for at least one hour.

Glossary

Operating Condition Notice (OCN) - In ERCOT, this is the first of four possible levels of communication issued (by ERCOT) in anticipation of a possible emergency condition.

Operating Reserve - That capability above firm system demand required to provide for regulation, load forecasting error, forced and scheduled equipment outages, and local area protection. It consists of spinning and non-spinning reserve.

Operational Balancing Agreement - A contract that specifies the procedures that will be used between two interconnected natural gas pipelines in order to manage variances or imbalances at major interconnect points.

Operational Flow Order (OFO) - A notice to natural gas pipeline users designed to protect the operational integrity of the pipeline. OFOs require shippers to take action to balance their supply with their customers' usage on a daily basis within a specified tolerance band. Shippers may deliver additional supply or limit supply delivered to match usage.

Outage - The period during which a generating unit, transmission line, or other facility is out of service. Outages are typically categorized as forced, due to unanticipated problems that render a facility unable to perform its function and/or pose a risk to personnel or to the system, or scheduled / planned for the sake of maintenance, repairs, or upgrades.

Peak Load - As defined by NERC, the highest hourly integrated Net Energy For Load (generation plus imports minus exports) within a Balancing Authority area occurring within a given period (*e.g.*, day, month, season, or year), or the highest instantaneous demand within the Balancing Authority area.

Peak Load Storage (Natural Gas) - Storage that provides high-deliverability of gas supplies to the market over short periods of time.

Peaking Unit or Peaking Power Plant - Peaking plants operate primarily during times when load or demand increases rapidly to a maximum level and remains there for only a short time, *e.g.*, on hot summer afternoons when air conditioning causes electricity usage to reach its highest level in the daily cycle. Peaking plants are often powered by natural gas, but they can also be powered by water at hydroelectric dams or by fuel oil. These plants can be brought online and taken offline quickly, in response to changing demand.

Glossary

Phase (Electrical) - In AC power systems, power is generated, transmitted, and distributed using three virtually identical sets of (1) coil windings in generators and transformers, (2) conductors in overhead and underground transmission and distribution lines and busses, (3) electrical poles and contacts in circuit breakers and switches and (4) other power equipment such as capacitor banks, reactors, etc., known as phases, and often identified by the letters A, B, and C. The three individual phase windings of a typical generator stator are arranged so that they're evenly spread out around the circular / cylindrical design/construction, each oriented one third of a turn apart (120 degrees) from the other two. As the rotor spins, its magnetic field sweeps through each of these windings sequentially as it completes a single rotation. The voltage, current, and power associated with each phase are therefore separated in time from the other two phases by virtue of this sequence. This method is much more efficient than a single phase approach not only for generating power, but also for its transmission and distribution.

Physical Responsive Capability (PRC) - In ERCOT, this is defined as the total amount of system wide On-Line capability that has a high probability of being able to quickly respond to system disturbances. It can be made up of generation and load resources.

Pigging - The practice of using pipeline inspection gauges or 'pigs' to perform various operations on a pipeline without stopping the flow of natural gas in the pipeline.

Planning Reserve Margin - Planning reserve margin is designed to measure the amount of generation capacity available to meet expected demand through the planning horizon, which can range from the upcoming season to a ten-year period. It is calculated as the difference between resources and peak demand, divided by peak demand to arrive at a percentage figure.

Poles - The opposite ends of a magnet where the field is most concentrated, designated as the north and south poles. In a synchronous generator, the magnetic poles are established by DC current passing through the field winding on the rotor which is essentially the coil of an electromagnet. Separately, in AC electrical equipment, particularly in switches and circuit breakers, poles refer to the contact assemblies associated with a particular phase. For example, it is common to refer to pole A, B, or C of a three phase disconnect switch. (See Phase)

Potomac Economics, Ltd. - The Independent Market Monitor (IMM) for ERCOT.

Glossary

Power - In physics, power is defined as the rate at which energy is expended to do work. In the electric power industry, power is measured in watts (W), kilowatts (1 kW = 1,000 watts), megawatts (1 MW = 1 million watts), or gigawatts (1 GW = 1 billion watts). For reference, 1 kW = 1.342 horsepower (hp).

Power System - The collective name given to the elements of the electrical system. The power system includes the generation, transmission, distribution, substations, etc. The term power system may refer to one section of a large interconnected system or to the entire interconnected system.

Processing Plant - A surface installation designed to separate and recover natural gas liquids such as propane, butane, ethane, or natural gasoline from a stream of produced natural gas through the processes of condensation, absorption, adsorption, refrigeration, or other methods, and to control the quality of natural gas marketed or returned to oil or gas reservoirs for pressure maintenance, re-pressuring, or cycling.

Production Separator - An item of production equipment used to separate liquid components of the well stream from gaseous elements.

Qualified Scheduling Entity (QSE) - In ERCOT, a Market Participant that is qualified for communication with ERCOT for Resource Entities and Load Serving Entities (LSEs) and for settling payments and charges with ERCOT. QSEs submit schedules on behalf of Resource Entities or LSEs such as retail electric providers (REPs). QSEs must submit daily schedules for their bilateral transactions with total generation and demand and bid curves for zonal balancing up and balancing down energy. The schedules for generation and demand are required to be balanced so that supply equals demand. QSEs also bid for ancillary services.

Ramp or Ramp Rate (for Interchange Schedules) - The rate, expressed in megawatts per minute, at which the interchange schedule is attained during the ramp period.

Ramp or Ramp Rate (for Generator Output) - The rate, expressed in megawatts per minute, that a generator changes its output, or is expected to change its output.

Rating - The operational limits of a transmission system element under a set of specified conditions. In power systems, equipment and facility power-handling ratings are usually expressed either in megawatts (MW) or in mega-volt-amperes (MVA). The term is also sometimes used to describe the output capability of generators.

Glossary

Reactive Power - The portion of electricity that establishes and sustains the electric and magnetic fields of AC equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers. It is also needed to make up for the reactive losses incurred when power flows through transmission facilities. Reactive power is supplied primarily by generators, capacitor banks, and the natural capacitance of overhead transmission lines and underground cables (with cables contributing much more per mile than lines). It can also be supplied by static VAR converters (SVCs) and other similar equipment utilizing power electronics, as well as by synchronous condensers. Reactive power directly influences system voltage such that supplying additional reactive power increases the voltage. It is usually expressed in kilovars (kvar) or megavars (Mvar), and is also known as “imaginary power.”

Reciprocating Compressor Unit(s) - Also known as “positive displacement” compressors, reciprocating compressors operate by trapping a certain volume of natural gas within the compressor and reducing the volume. The high-pressure gas is then released through the discharge valve into the pipeline. Piston-operated reciprocating compressors fall within the category of positive displacement compressors. These compressors have a fixed volume and are able to produce high compression ratios.

Rectifier - A converter designed and operated to convert AC power to DC power. Electrically speaking, rectifiers are the opposite of inverters. High voltage DC (HVDC) converter stations contain large numbers of high power rectifiers.

Regional Entity - An independent, regional entity having delegated authority from NERC to propose and enforce Reliability Standards and to otherwise promote the effective and efficient administration of bulk power system reliability.

Regional Transmission Organization (RTO) - A voluntary organization of electric transmission owners, transmission users and other entities approved by FERC to efficiently coordinate electric transmission planning (and expansion), operation, and use on a regional (and interregional) basis. Operation of transmission facilities by the RTO must be performed on a non-discriminatory basis.

Regulation - The ability to maintain a quantity within acceptable limits. For example, frequency regulation is the control or regulation of the system frequency to within a tight bandwidth around 60 Hz. Voltage regulation is the control of a voltage level within a set bandwidth. In power systems operations, regulation often refers broadly to changing the output level of selected generators to match changes in system load.

Glossary

Regulator, Pressure - A device that maintains the pressure in a fluid flow line, less than its inlet pressure within a constant band of pressures, regardless of the rate of flow in the line or the change in upstream pressure.

Relay Misoperation - Any unintentional operation of a protective relay when no fault or other abnormal condition has occurred.

Reliability Must Run (RMR) Unit - A unit that must run for operational or reliability reasons, regardless of economic considerations. ERCOT specifies that an RMR unit would not otherwise be operated unless it is necessary to provide voltage support, stability or management of localized transmission constraints under first contingency criteria where market solutions do not exist.

Reliability Unit Commitment (RUC) - In ERCOT, a process to ensure that adequate resource capacity and ancillary service capacity are committed in the proper locations to serve the forecasted load. ERCOT conducts at least one Day-Ahead RUC (DRUC) and at least one Hourly RUC (HRUC) before each hour of the operating day, but additional RUCs are conducted when needed to evaluate and resolve reliability issues.

Reserve Sharing Group - A group whose members consist of two or more balancing authorities that collectively maintain, allocate, and supply operating reserves required for each balancing authority's use in recovering from contingencies within the group.

Resource Entity (RE) - In ERCOT, Resource Entities either own or control a generation resource or behave as a load resource that can comply with ERCOT instructions to reduce electricity usage or provide an ancillary service. Each RE must also be represented by a Qualified Scheduling Entity (QSE), which establishes a control interface with ERCOT.

Responsive Reserve Services (RRS) - As defined by ERCOT, an ancillary service that provides operating reserves that is intended to: (1) arrest frequency decay within the first few seconds of a significant frequency deviation on the ERCOT transmission grid using primary frequency response and interruptible load, (2) help restore frequency to its scheduled value to return the system to normal, (3) provide energy or continued load interruption during the implementation of an Energy Emergency Alert (EEA), and (4) provide backup regulation. RRS can be provided by generation or by load resources having Interruptible Responsive Reserve capability.

Glossary

Restoration - The process of returning generators and transmission system elements and restoring load following an outage on the electric system.

Reticulated Pipelines - Natural gas pipelines with highly networked, web-like transmission lines, with many possible transportation paths for natural gas supplies to reach the desired marketplace.

Rolling Blackouts - Also known as rotating outages, these are controlled, temporary interruptions of service to customers, most commonly initiated by switching off selected distribution circuits intended to reduce load during times of capacity shortfalls due to significant forced outages of generation and/or transmission facilities. The service interruptions are transferred from one group (or block) of customers to another over time so that no one group bears the entire burden of the necessary reduction in load.

Rotor - The rotating component of a generator attached to the spinning shaft of the generator. In the large synchronous generators that are predominant in electric power systems, the rotor winding acts as an electromagnet that produces the magnetic field used to induce voltage in the stator windings.

RUC Clawback Charge - In ERCOT, money returned by a Qualified Scheduling Entity (QSE) to ERCOT for a resource that was committed by the RUC process when the resource's start-up and minimum energy costs are lower than those allowed by the prevailing RUC guaranteed payment.

RUC Make-Whole Payment - In ERCOT, a payment made to a Qualified Scheduling Entity (QSE) for a resource that was committed by the RUC process when the resource's start-up and minimum energy costs are less than revenues received.

Salt Cavern - An underground natural gas storage cavern which has been developed in a salt dome by the solution mining process.

Scarcity Pricing Mechanism - A pricing mechanism based on the idea that under scarcity conditions, generating units will receive higher compensation for producing electricity. The additional revenue is intended to provide an incentive for investment in new generation facilities, and to promote overall system reliability. Under this mechanism, when available supply falls below a predetermined threshold, the price of additional power rises significantly.

Scheduled Frequency - For power systems in North America, the scheduled frequency is normally 60.00 Hz. During periods of time error correction, which

Glossary

may last several hours, the scheduled frequency in a given interconnection is set to 59.98 Hz to slow down clocks that use synchronous motors when they are running fast, and to 60.02 Hz to speed them up when they are running slow. The fact that the clocks are running fast or slow is an indication that system frequency averaged slightly higher or lower than 60.00 Hz over a long duration, signaling the need for a correction.

Sine Wave - The graphical representation of a mathematical function that describes the smooth, symmetrical, and periodic variation of a quantity that oscillates in magnitude or amplitude. In AC electric power systems, the voltage and current are characterized by sine waves having a frequency of 60 Hz. These waveforms, starting from a zero baseline, traverse a path that increases to a crest (positive maximum), then falls back to zero, continues downward to a trough (equal but opposite to the crest, *i.e.*, in the negative direction), and back to zero in one-sixtieth of a second.

Sluicing/Service Water Systems - A system used to remove bottom ash from many coal-fired boilers.

Southwest Power Pool (SPP) - A Regional Transmission Organization serving members in Arkansas, Kansas, Louisiana, Mississippi, Missouri, Nebraska, New Mexico, Oklahoma, and Texas (non-ERCOT). SPP is connected to and is part of the Eastern Interconnection.

Southwest Reserve Sharing Group (SRSG) - A pool of electric load-serving entities in Arizona, New Mexico, Nevada, southern California, and El Paso, Texas that have entered into an agreement to share contingency reserves. SRSG is a NERC Registered Entity that administers certain requirements on behalf of its members related to disturbance control and emergency operations. SRSG is connected to and is part of the Western Interconnection.

Spinning Reserve - Unloaded generation capacity that is synchronized and available to serve additional demand.

Stability - The ability of an electric power system to maintain a state of equilibrium during normal and abnormal system conditions or disturbances. Instances of instability are serious because they have the potential to cause widespread outages in the power system, and possibly even in the entire interconnection.

Static VAR Converter / Compensator (SVC) - A combination of shunt reactors and shunt capacitors whose switching is precisely controlled by power electronics

Glossary

to automatically manage reactive power injections and withdrawals from the power system to help maintain proper transmission voltage.

Stator - The stationary component of a motor or generator surrounding but not making physical contact with the spinning rotor in the typical cylindrical design/construction.

Substation - A site that houses circuit breakers, disconnect switches, transformers, reactors, capacitors, and other equipment serving as an electrical hub in the power system, especially at interfaces between different voltage levels. The prefix “sub” distinguishes substations from generating stations. A central control house is often provided to house control and protective equipment.

Supervisory Control and Data Acquisition Systems (SCADA) - A system of remote control and telemetry used to monitor and control a power system or a natural gas transportation or distribution system.

Synchronize - The process of bringing two electrical systems together by closing a circuit breaker at an interface point when the voltages and frequencies are properly aligned. Also, when generators are brought on-line, they are said to be synchronized to the system.

Synchronous - To be in-step with a reference. The rotor of a synchronous machine, be it a motor or a generator, spins in unison with the power system in terms of frequency (see Synchronous Speed, below).

Synchronous Speed - The speed at which the rotor of a synchronous generator must rotate in order to stay in synchronism with the rotating magnetic field of the system. The synchronous speed is determined by the frequency of the power system and the number of magnetic poles in the rotor. For example, the synchronous speed of a two pole steam-turbine generator in a 60 Hz system is 3600 revolutions per minute (rpm), while the synchronous speed of a 24 pole hydro generator is only one-twelfth of that, or 300 rpm.

System (Electric Power) - A combination of generation, transmission, and distribution facilities, equipment, and components.

System Operator - An individual at a control center (Balancing Authority, Transmission Operator, Generator Operator, Reliability Coordinator) whose responsibility it is to monitor and control that electric system in real time.

Glossary

System Operating Limit (SOL) - The value of any of a number of electrical quantities such as real power flow (in MW), total power flow (real plus reactive) (in MVA), voltage (in kV), current (in amperes) or frequency (in Hz) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure that established reliability criteria are satisfied.

Telemetry - Equipment for measuring a quantity (amperes, volts, MW, etc.) and transmitting the result via a telecommunication system to a remote location for indication and/or recording.

Texas Reliability Entity (TRE) - Texas Reliability Entity, Inc. is authorized by NERC to develop, monitor, assess, and enforce compliance with NERC Reliability Standards within the geographic boundaries of the ERCOT region. In addition, TRE has been authorized by the Public Utility Commission of Texas (PUCT) and is permitted by NERC to investigate compliance with the ERCOT Protocols and Operating Guides. TRE is independent of all users, owners, and operators of the bulk power system.

Thermal Insulation - Any material which slows down or retards the flow or transfer of heat.

Transformer - A type of electrical equipment in the power system that operates on electromagnetic principles to increase (step up) or decrease (step down) voltage.

Transient Flow or Unsteady State Flow - The process which involves changes within the control volume with time.

Transmission - An interconnected group of lines and associated equipment operated at high voltage levels in the range of 100 kV to 765 kV in North America for the movement or transfer of electric energy between points of supply and points at which it is transformed for delivery to customers or is delivered to other electric systems.

Transmission Operator - The entity responsible for the reliability of its “local” transmission system, and that operates or directs the operations of the transmission facilities.

Transmission Owner - The entity that owns and maintains transmission facilities, including, but not limited to, overhead and underground transmission lines, substations, transformers, circuit breakers, capacitor banks and busses.

Glossary

Transmission Service Provider (TSP) - As defined by NERC, an entity that administers the transmission tariff and provides transmission service to transmission customers under applicable service agreements. ERCOT specifies that TSPs own or operate transmission facilities.

Treatment Plant - A plant designed primarily to remove undesirable impurities from natural gas to render the gas marketable. Examples of these impurities are water, water vapor, sulfur compounds, carbon dioxide, nitrogen and helium.

Turbine - A rotating mechanical device driven by the force of a working fluid. The working fluid is typically steam, water, combustion gases or, in the case of wind turbines, air.

Under Frequency Load Shedding (UFLS) - The automatic disconnection or tripping of customer load based on a decline in system frequency. The set points are predetermined. For example, a utility may trip 5% of their connected load if frequency falls below 59.3 Hz, an additional 10% if it falls below 58.9 Hz, and a final 10% if it falls below 58.5 Hz. The purpose of UFLS is to arrest the frequency decline accompanying major system disturbances generally involving the sudden loss of large amounts of generation or multiple transmission line tripping that results in the formation of an electrical island in which the remaining generation is inadequate to supply the load, thereby forestalling a complete system collapse.

Under Voltage Load Shedding (UVLS) - The tripping of customer load based on a decline in system voltage. For example, a utility may trip 5% of their connected load if voltage falls below 92% of nominal and an additional 10% of their load if voltage falls below 90% of nominal. The purpose of UVLS is typically to avoid a voltage collapse, but it can also be used to avoid overloading transmission facilities during contingency conditions when other transmission facilities trip or are forced out of service.

Unit Commitment - The process of selecting which generating units will be placed on line to serve the load and reserve requirements.

Verbal Dispatch Instruction - In ERCOT, a dispatch instruction issued by operators in the control center to a generating unit or units, load resource, or their Qualified Scheduling Entities (QSEs) orally over the telephone, as opposed to one issued in writing or issued automatically by a control system and delivered electronically via telecommunications.

Glossary

Vertically Integrated Utility - An electric utility company or a federal, state, or municipal agency that owns and operates all aspects of the power system in its franchise service territory, *i.e.*, generation, transmission, and distribution. The ownership of certain facilities may be shared or held wholly by others, but the vertically integrated utility still controls the power system in the territory.

Voltage - The force characteristic of a separation of charge that causes electric current to flow. The symbol is “V” and units are volts or kilovolts (kV).

Well Freeze-offs - Natural gas flow blockages resulting from water vapor freezing or the formation of crystal hydrates in the gas stream.

Wellhead - The assembly of fittings, valves, and controls located at the surface and connected to the flow lines, tubing, and casing of the well so as to control the flow from the reservoir.

Wellhead Choke - Points at the wellhead where flow and pressure are primarily controlled.

Western Electricity Coordinating Council - The Regional Entity responsible for coordinating and promoting bulk electric system reliability in the Western Interconnection.

Wheeling (Natural Gas) - The transportation of customer-owned gas by a transmission company for the customer at a pre-determined cost to the customer.

Windbreaks - Temporary or permanent structures intended to obstruct, or serve as a barrier against, the wind for the comfort and safety of people and/or the protection of property or equipment.

Wind Chill Factor - The term “Wind Chill Factor,” is often used to explain the additional heat loss people experience through convection cooling when exposed to the wind. Whenever there is a temperature difference at a surface, *e.g.*, the difference between normal body temperature and ambient air at a lower temperature on the surface of human skin, heat is conducted across the surface from the warmer body to the cooler air. In the process, the layer of air on the surface is warmed and forms a thermal boundary which tends to slow the rate of heat loss. Wind accelerates the heat loss by literally sweeping away that boundary layer and replacing it, continuously, with air at the ambient temperature. This acceleration of heat loss caused by the wind makes people to feel that the air temperature is colder than it actually is. This feeling is quantified by assigning a

Glossary

stationary air temperature, known as the Wind Chill Temperature, which yields an equivalent perception of cold.

Zonal Market - A market for electric energy divided into regional pricing zones. Generators within a zone receive the same price for the power they provide, and transmission lines crossing zonal boundaries are assessed additional costs due to market congestion when the power flowing through them reaches operational constraints.

Appendix: Task Force Members

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FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

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Appendix: Legislative and Regulatory Responses by the States

The natural gas and electricity shortages that occurred in the Southwest in early February 2011 seriously affected three states: Arizona, New Mexico and Texas.¹ Each state took different regulatory and legislative actions in response to the events. As part of its inquiry, the task force contacted state regulators and followed subsequent legislative and regulatory developments. The following section describes the actions taken by each state.

Arizona

In Arizona, approximately 19,000 customers in the Tucson and Sierra Vista areas lost gas service on February 3, 2011. Most of those customers had their service restored within four days.² The Arizona Corporation Commission (ACC), which among other things, regulates public utilities in the state, took the lead in reviewing the circumstances surrounding the gas outages.³ One commissioner met with Southwest Gas Corporation representatives on February 3,⁴ and another sent data requests to four impacted pipelines on February 16, 2011.⁵

On March 2, 2011 the ACC held an open meeting on the Southern Arizona gas outages, with witnesses from Southwest Gas Corporation and El Paso Natural Gas Company testifying. At the hearing, representatives from both companies stated that cold weather was the primary reason for the outage, as demand far outweighed supply during the record-low cold temperatures.

¹ The task force contacted regulatory staff with the Public Service Commission of Nevada and the California Public Utilities Commission, who informed us that they did not experience a substantial, direct impact from the February 2011 gas supply shortages, and that no related inquiries or proceedings were underway in their states.

² See Alex Dalenberg, *ACC Meeting will Delve into SW Gas Outage*, *Arizona Daily Star* (Feb. 13, 2011).

³ The Arizona legislature did not hold hearings or take any legislative actions in response to the outages.

⁴ See Letter from Commissioner Barbara Burns to the Chairman and Commissioners of the Arizona Corporation Commission, Docket No. G-00000C-11-0081 (Feb. 11, 2011), *available at* <http://images.edocket.azcc.gov/docketpdf/0000123284.pdf> (last visited Aug. 5, 2011).

⁵ See Letter from ACC Commissioner Sandra Kennedy to Southwest Gas Corporation; El Paso Natural Gas Company; UNS Gas, Inc.; and Transwestern Pipeline Company, LLC, Docket No. G-00000C-11-0081 (Feb. 7, 2011), *available at* <http://images.edocket.azcc.gov/docketpdf/0000123172.pdf> (last visited Aug. 5, 2011).

Appendix: Legislative and Regulatory Responses by the States

The ACC held two follow up meetings, on April 6, 2011 and April 7, 2011, to gather information from customers affected by the outages.⁶ No further action has taken place in the ACC proceeding.

New Mexico

More than 30,000 customers lost gas service in New Mexico on February 2 and 3, 2011, some for as long as a week. Shortly thereafter, a New Mexico State Senator asked the state's Attorney General to look into the causes of the outages,⁷ and the legislature announced that it would hold hearings. On February 11, 2011, a hearing was held before the full New Mexico Senate, which heard testimony from some of the individuals who lost gas service and from representatives of New Mexico Gas Company (NMGC), El Paso Natural Gas Company, and the New Mexico Public Regulation Commission (PRC).

On February 14, 2011, the New Mexico Senate directed the PRC to convene a task force to investigate how and why New Mexico consumers lost natural gas service and to make recommendations on how to prevent such loss of service in the future.⁸

On March 16, 2011, Governor Susana Martinez signed a bill⁹ into law that created a state task force to investigate the causes of the outages and to make recommendations on how to prevent similar outages in the future.¹⁰ As of the date of this report, the report from the Natural Gas Emergency Investigation Legislative Task Force is pending.

⁶ See *Tucson Residents Tell Commissioners About Freezing Nights and No Natural Gas Service*, Associated Press, (Apr. 8, 2011).

⁷ See *State Senator Carlos Cisneros, Senator Calls on AG to Immediately Investigate Gas Outage* (Feb. 8, 2011), available at http://www.democracyfornewmexico.com/democracy_for_new_mexico/2011/02/sen-carlos-cisneros-requests-immediate-investigation-into-gas-outage-by-ag.html (last visited Aug. 5, 2011).

⁸ SM 30 (Engrossed), 2011 Regular Session (NM, 2011), available at <http://www.nmlegis.gov/Sessions/11%20Regular/final/SM030.pdf> (last visited Aug. 5, 2011).

⁹ HB 452 (Engrossed), 2011 Regular Session (NM, 2011), available at <http://www.nmlegis.gov/Sessions/11%20Regular/final/HB0452.pdf> (last visited Aug. 5, 2011).

¹⁰ See House Executive Message No. 2 (Mar. 16, 2011) available at <http://www.governor.state.nm.us/uploads/FileLinks/7bbb779a53dd4071933247333d38f22c/House%20Executive%20Message%202.pdf> (last visited Aug. 5, 2011).

Appendix: Legislative and Regulatory Responses by the States

The United States Senate Committee on Energy and Natural Resources held a field hearing in New Mexico on February 21, 2011 to receive testimony regarding the natural gas service disruptions in New Mexico and the reliability of regional energy infrastructure.¹¹ The Committee heard testimony from three different panels, and sent follow up questions to the Federal Energy Regulatory Commission.

The PRC opened its investigation into the outages on February 11, 2011.¹² In its order opening the inquiry, the PRC directed NMGC, Public Service Company of New Mexico, El Paso Electric Company, and Southwestern Public Service Company to provide testimony responding to specific questions within 30 days of the order.¹³

At the same time, the PRC also initiated a non-docketed proceeding entitled the NMPRC Informal Task Force Investigation into Severe Weather Cascading Events. The Informal Task Force, which included representatives of several New Mexico utilities,¹⁴ PRC staff, the state Attorney General's Office, several municipalities, and the general public, was charged with developing a summary of the weather event, identifying the causes, determining how to mitigate the impact of future events, and reviewing the policies and rules of the PRC and other New Mexico agencies.¹⁵

On May 3, 4, and 5, 2011, the PRC held hearings on the outages, hearing testimony from gas company representatives and other parties, including

¹¹ See Recent Natural Gas Service Disruptions in New Mexico and Reliability of Regional Energy Infrastructure before the Senate Energy and Natural Resources Committee, 112th Congress (Feb. 21, 2011) *available at* http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=169bb12f-e360-3d3f-378c-4a762ddf0b56 (last visited Aug. 5, 2011).

¹² See Press Release, Public Regulation Commission, NMPRC initiates investigation into Natural Gas Delivery Failure (Feb. 10, 2011), *available at* <http://www.nmprc.state.nm.us/news/pdf/2011-02-10-gasinvestigation.pdf> (last visited Aug. 5, 2011).

¹³ In the Matter of an Investigation into New Mexico Gas Company's Curtailments of Gas Deliveries to New Mexico Consumers, Order Initiating Investigation and Setting Hearing, New Mexico Public Regulation Commission, Case No. 11-00039-UT (Feb. 15, 2011), *available at* <http://164.64.85.108/infodocs/2011/2/PRS20156381DOC.PDF> (last visited Aug. 5, 2011).

¹⁴ The utilities are Public Service Company of New Mexico, Southwestern Public Service Company, El Paso Electric Company, NMGC, Zia Natural Gas Company, and Raton Natural Gas Company.

¹⁵ February 2011 Severe Cold Weather Investigations & Status, Presentation before the Natural Gas Emergency Investigation Legislative Task Force (July 25, 2011) at pp. 1-2.

Appendix: Legislative and Regulatory Responses by the States

representatives of the affected municipalities. Since then, the parties have submitted additional written testimony and briefs to the PRC. As of the date of this report, the PRC's investigation is still pending.

Texas

With several million consumers affected by electrical blackouts, the State of Texas was severely impacted by the extreme weather events of early February. Two regulatory agencies in Texas have jurisdiction over the industries in question – the Public Utilities Commission of Texas (PUCT) (which has primary jurisdiction over the electrical power industry) and the Texas Railroad Commission (TRC), whose jurisdiction includes the natural gas industry.

The PUCT reacted at once to the electric outages, asking the state's independent energy market monitor on February 4, 2011 to investigate whether power generators, pipeline companies or others broke market rules.¹⁶

The PUCT also directed the Texas Reliability Entity, Inc. (TRE) to investigate the Electric Reliability Council of Texas (ERCOT) Energy Emergency Alert Level 3 that occurred on February 2, 2011. At the same time, the PUCT asked El Paso Electric Company to investigate and report back on the weather-related issues surrounding this event.

On February 8, 2011, the TRC held the first state hearing on the outages. One of the witnesses, the TRE, addressed the impact of the rolling blackouts on natural gas service.¹⁷

On February 15, 2011, the Texas Senate's Committee on Natural Resources and Committee on Business and Commerce jointly convened a hearing to discuss the causes of the rolling blackouts.¹⁸ The hearing included testimony from the PUCT, the TRC, the Texas Commission on Environmental Quality, ERCOT, and the Office of Public Utility Counsel. The House Committee on State Affairs also held a hearing on the causes of the rolling blackouts on February 17, 2011.

¹⁶ See Rebecca Smith, *Texas to Probe Rolling Blackouts*, *Wall Street Journal* (Feb. 7, 2011).

¹⁷ See Press Release: Railroad Commission Emergency posted item to be discussed at 1:30 P.M. today, Texas Railroad Commission (Feb. 8, 2011), *available at* <http://www.rrc.state.tx.us/pressreleases/2011/020811.php> (last visited Aug. 5, 2011).

¹⁸ See Chris Tomlinson, *Texas Senate Investigates Power Outages*, *The Associated Press* (Feb. 16, 2011).

Appendix: Legislative and Regulatory Responses by the States

Prompted by the hearings, the legislature enacted a bill to address the perceived causes of the rolling blackout.¹⁹ On June 17, 2011, that bill was signed into law.²⁰

The law directs the PUCT to prepare a “weather emergency preparedness report on power generation weatherization preparedness.”²¹ Under the law, the PUCT must review the emergency operations plans it currently has on file,²² determine the Texas electricity grid’s ability to operate continuously during extreme weather events in the upcoming year, consider the upcoming year’s forecasted weather patterns, and recommend improvements to emergency operations plans to ensure electric service reliability.²³ In addition, the law permits the PUCT to require entities to update their emergency operations plan when it does not contain information sufficient to determine whether that entity can perform during adverse weather. The law also permits the PUCT to adopt rules implementing the legislation.²⁴

On April 21, 2011, the Independent Market Monitor reported that “there was no evidence of market manipulation or market power abuse” within the ERCOT region.²⁵ The Independent Market Monitor similarly determined “that the ERCOT real-time and day-ahead wholesale markets operated efficiently and the outcomes are consistent with the ERCOT energy-only wholesale market design.”²⁶

¹⁹ SB 1133, 82 Leg., Reg. Sess. (TX, 2011), *available at* <http://www.capitol.state.tx.us/tlodocs/82R/billtext/pdf/SB01133I.pdf#navpanes=0> (last visited Aug. 5, 2011).

²⁰ Another bill was introduced which would have required the PUCT to develop a process for obtaining emergency reserve power generation capacity, but it was not considered during the legislative session. HB 1986, 82 Leg., Reg. Sess. (TX, 2011), *available at* <http://www.capitol.state.tx.us/tlodocs/82R/billtext/pdf/HB01986I.pdf#navpanes=0> (last visited Aug. 5, 2011).

²¹ SB 1133, 82 Leg., Reg. Sess. (TX, 2011), *available at* <http://www.capitol.state.tx.us/tlodocs/82R/billtext/pdf/SB01133I.pdf#navpanes=0> (last visited Aug. 5, 2011).

²² P.U.C. Subst. R. 25.53(c)(2) (TX, 2011).

²³ S.B. 1133, 82 Leg., Reg. Sess. (TX, 2011), *available at* <http://www.capitol.state.tx.us/tlodocs/82R/billtext/pdf/SB01133I.pdf#navpanes=0> (last visited Aug. 5, 2011).

²⁴ *Id.*

²⁵ Investigation of the ERCOT Energy Emergency Alert Level 3 on February 2, 2011, Potomac Economics LTD. (April 21, 2011), *available at* http://www.puc.state.tx.us/files/IMM_Report_Events_020211.pdf at 2 (last visited Aug. 5, 2011).

²⁶ *Id.*

Appendix: Legislative and Regulatory Responses by the States

On May 13, 2011, the TRE issued a report on whether ERCOT Protocols and Operating Guides were followed during the period leading up to the Energy Emergency Alert event.²⁷ The TRE concluded that event “was caused by either insufficient or ineffective preparation of generating facilities for prolonged freezing weather.”²⁸ The report went on to find that “ERCOT Market Participants committed potential violations of the ERCOT Protocols and Operating Guides in connection with the event.”²⁹ The TRE will conduct additional investigations as necessary and forward information to the PUCT for further action, as appropriate.³⁰

Also, on May 13, 2011, PUCT staff issued a report on El Paso Electric Company’s activities during the weather event.³¹ PUCT staff did not identify any violations of the Public Utility Regulatory Act or the PUCT’s Substantive Rules.³² The report, however, did conclude that “designed cold weather tolerances of El Paso Electric Company’s current generation equipment and/or weatherization preparation were inadequate to prevent failures in the conditions during the event timeframe.”³³

²⁷ Protocol and Operating Guide Compliance Report of the ERCOT Emergency Alert (EEA) Level 3 on February 2, 2011, Texas Reliability Entity, Inc. (May 13, 2011), *available at* http://www.puc.state.tx.us/files/TX_RE_EEA_Protocol_Comp_Report.pdf (last visited Aug. 5, 2011).

²⁸ *Id.* at 1.

²⁹ *Id.*

³⁰ *Id.*

³¹ Report on El Paso Electric Company Weather-Related Issues in February 2011, Staff of the Public Utilities Commission of Texas (May 2011), *available at* http://www.puc.state.tx.us/files/EPE_Report_05-13-11.pdf (last visited Aug. 5, 2011).

³² *Id.* at 4.

³³ *Id.* at 1.

Appendix: Categories of NERC Registered Entities

All entities that fall within one or more of the following categories must register with NERC. Many entities carry out multiple roles and therefore have multiple registrations.

Function Type	Acronym	Definition/Discussion
Balancing Authority	BA	The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within BA area, and supports interconnection frequency in real-time.
Distribution Provider	DP	Provides and operates the “wires” between the transmission system and the end-use customer. For those end-use customers who are served at transmission voltages, the Transmission Owner also serves as the DP. Thus, the DP is not defined by a specific voltage, but rather as performing the distribution function at any voltage.
Generator Operator	GOP	The entity that operates generating unit(s) and performs the functions of supplying energy and interconnected operations services.
Generator Owner	GO	Entity that owns and maintains generating units.
Interchange Authority	IA	The responsible entity that authorizes implementation of valid and balanced Interchange Schedules between Balancing Authority Areas, and ensures communication of Interchange information for reliability assessment purposes.
Load-Serving Entity	LSE	Secures energy and transmission service (and related interconnected operations services) to serve the electrical demand and energy requirements of its end-use customers.
Planning Authority	PA	The responsible entity that coordinates and integrates transmission facility and service plans, resource plans, and protection systems.

Appendix: Categories of NERC Registered Entities

Purchasing-Selling Entity	PSE	The entity that purchases or sells and takes title to energy, capacity, and interconnected operations services. PSE may be affiliated or unaffiliated merchants and may or may not own generating facilities.
Reliability Coordinator	RC	The entity that is the highest level of authority who is responsible for the reliable operation of the bulk power system, has the wide area view of the bulk power system, and has the operating tools, processes and procedures, including the authority to prevent or mitigate emergency operating situations in both next-day analysis and real-time operations. The RC has the purview that is broad enough to enable the calculation of interconnection reliability operating limits, which may be based on the operating parameters of transmission systems beyond any Transmission Operator's vision.
Reserve Sharing Group	RSG	A group whose members consist of two or more Balancing Authorities that collectively maintain, allocate, and supply operating reserves required for each BA's use in recovering from contingencies within the group. Scheduling energy from an adjacent BA to aid recovery need not constitute reserve sharing provided the transaction is ramped in over a period the supplying party could reasonably be expected to load generation in (e.g., ten minutes). If the transaction is ramped in quicker, (e.g., between zero and ten minutes) then, for the purposes of disturbance control performance, the areas become a RSG.
Resource Planner	RP	The entity that develops a long-term (generally one year and beyond) plan for the resource adequacy of specific loads (customer demand and energy requirements) within a PA area.

Appendix: Categories of NERC Registered Entities

Transmission Owner	TO	The entity that owns and maintains transmission facilities.
Transmission Operator	TOP	The entity responsible for the reliability of its local transmission system and operates or directs the operations of the transmission facilities.
Transmission Planner	TP	The entity that develops a long-term (generally one year and beyond) plan for the reliability (adequacy) of the interconnected bulk electric transmission systems within its portion of the PA area.
Transmission Service Provider	TSP	The entity that administers the transmission tariff and provides transmission service to transmission customers under applicable transmission service agreements.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

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Appendix: Electricity - How It Is Generated and Distributed

Electricity is one of the most widely used forms of energy in the industrialized world. According to the U.S Energy Information Administration, in 2009 the U.S. electric utility net generation was 2,372,776 gigawatt hours. Table 1 shows the share of net electricity generation by energy source in the United States.

Energy Source	Net Generation (%)
Coal	44.5
Nuclear	20.2
Natural Gas	23.3
Hydro	6.8
Oil (Petroleum) and other	1.6
Renewables	3.6

Table 1: Share of net electricity generation in 2009 in the U.S.
(Source: U.S. Energy Information Administration)

Electric power is produced at generating stations and transmitted via transformers, transmission lines, switching devices and protection and control equipment for delivery to end users. The electric power system as shown in figure 1 is an integrated system made up of generation, transmission and distribution subsystems.

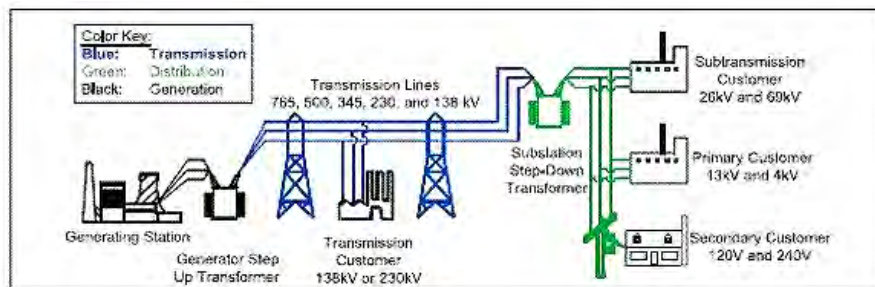


Figure 1 – Basic structure of the electric system (NERC)

Generation

Generating plants produce electricity by burning fuels such as oil, coal, natural gas, or lignite to create steam that drives a turbine, which in turn drives a turbine generator shaft. In a coal-fired plant (figure 2), coal is ground by pulverizers into fine powder, mixed with pre-heated air and injected into a combustor, where it is ignited. The hot combustion gas rises through the boiler and heats water that enters the steam generator. The partially vaporized water enters the steam drum, where steam is separated from the water. The remaining

Appendix: Electricity - How It Is Generated and Distributed

water cycles through the boiler again, and through tubes lining the furnace walls. The steam is passed through another section of the boiler known as the superheater, where the temperatures are increased to well above boiling.

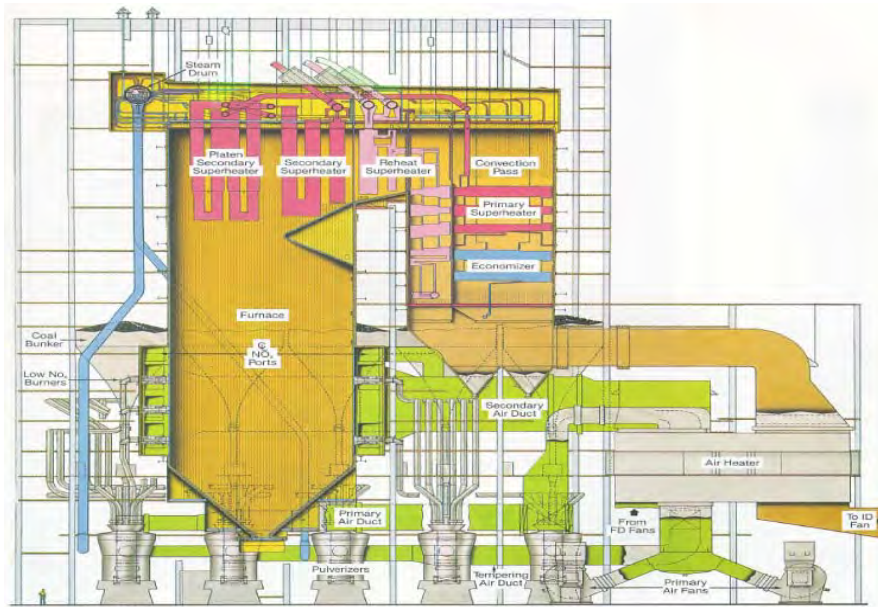


Figure 2 – Typical drum-type coal/lignite boiler plant
(PJM Generation Basics)

The superheated steam, now at very high pressure, passes through a high pressure turbine (shown in figure 3), causing the turbine to spin and turning the shaft of an electrical generator. After passing through the high pressure turbine, the steam is piped back to the boiler to be reheated, then enters an intermediate pressure turbine and low pressure turbine before it passes through a condenser, where the steam is converted back to water, which is usually cycled back to the steam generator for reuse. The mechanical energy generated by the spinning generator shaft is converted to electrical energy for delivery to the electric power system.

Appendix: Electricity - How It Is Generated and Distributed

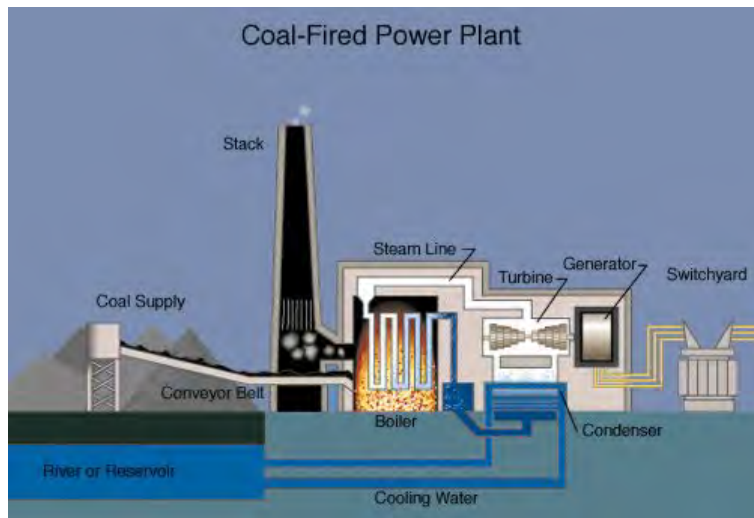


Figure 3: Typical coal burning generating plant with cooling tower (Department of Energy)

In nuclear generating stations, steam is also used to drive a turbine. However, the energy required to produce the steam is derived from nuclear fission, typically fueled by uranium.

Wind turbines use blades to collect the energy of the wind. As wind blows, it flows over the blades, causing them to turn. The blades are connected to a gear box with a drive shaft that turns an electric generator to produce electricity.

Appendix: Electricity - How It Is Generated and Distributed

In hydroelectric plants, the gravitational force of water flowing downhill drives the turbine generator shaft (as shown in figure 4). The mechanical energy of the spinning shaft is then converted to electrical energy.

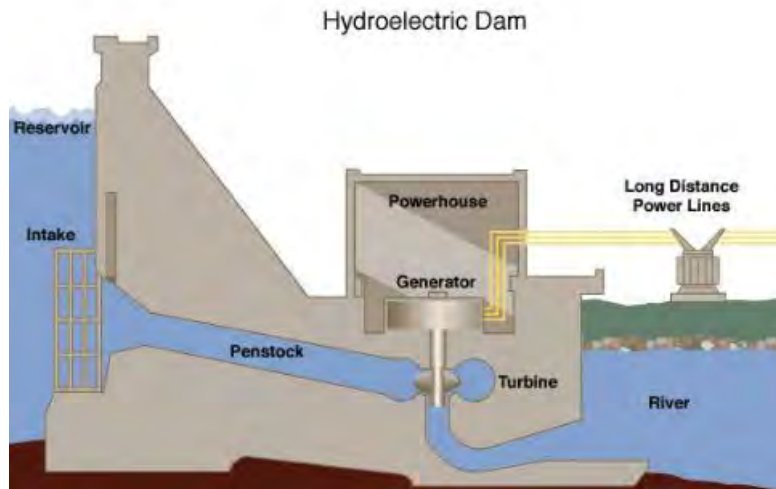


Figure 4: Typical hydroelectric generator
(Energy Information Administration)

Electric energy can also be produced by simple cycle or combined cycle combustion turbines or internal combustion engines, which usually burn natural gas or fuel oil. The combustion turbine drives an electric generator to produce electricity. One advantage of combustion turbines is that they can be started quickly, making them suitable for emergencies and during peak periods, when demand for electricity is at its highest.

A combined cycle combustion turbine is shown in figure 5. Note: a simple cycle combustion turbine plant does not include a heat recovery steam generator (HRSG), steam turbine, and a second generator as depicted in figure 5.

Appendix: Electricity - How It Is Generated and Distributed

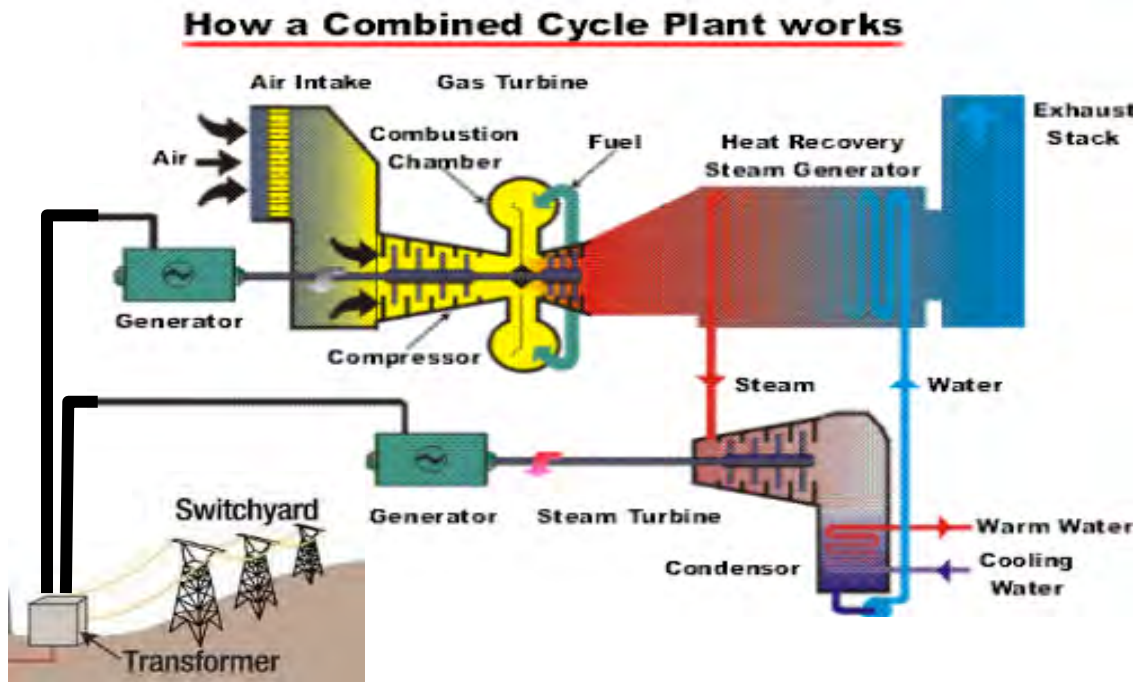


Figure 5: Combined cycle turbine generator with steam generator and HRSG
(Washington State University)

Conversion of Mechanical Energy to Electrical Energy

A generator works on the principle of electromagnetic induction, discovered by scientist Michael Faraday between 1831 and 1832. Faraday discovered that the flow of electric charges could be induced in a coil of wire by passing a magnet through the coil. This movement creates a voltage difference between the two ends of the wire or electrical conductor, which in turn causes the electric charges to flow, thus generating electric current.

Every modern generator consists of two main components: the rotor (the moving part) and the stator (the stationary part). In an AC generator, the rotor spins inside the stator. A mechanical device is used to spin or turn the rotor. With every rotation, the changing magnetic field creates a current in the stator windings. A generator does not actually make electrical energy. Instead, it uses mechanical energy supplied to it to cause the movement of electric charges present in the wire of the stator windings, thereby generating an electric current that is supplied to the grid. A generator is akin to a water pump, which causes the flow of water but does not actually create the water flowing through it.

Most large power generators are three-phase generators and have three windings (A, B and C phases), one winding for each phase. In a three-phase

Appendix: Electricity - How It Is Generated and Distributed

generator, a rotor rotates at the center of the three windings creating the changing magnetic field. Each one of the winding sets produces a voltage. Each phase voltage has a 120° phase angle separation from the other two phase voltages as shown in figure 6. The waveform of the induced voltages is a sine wave (also shown in figure 6) in which each phase voltage periodically reverses direction. The current produced from this generator is known as alternating current (AC).

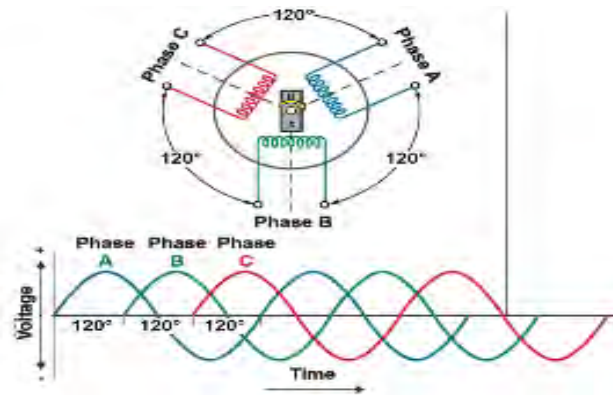


Figure 6: Three-phase generator diagram & waveform
(Electric Power Research Institute)



Figure 7: Three-phase power generator
(Electric Power Research Institute)

There are two general types of AC generator: synchronous and asynchronous. The terms synchronous and asynchronous refer to the relationship between the generator rotor's speed of rotation and the power system speed. Power system speed (or synchronous speed) is the speed of rotation of the AC electrical system to which the generator is connected. When a generator is connected to the power system, the rotating magnetic field of the generator is synchronized with the rotating magnetic field that already exists in the three-phase system. An AC generator can be designed to rotate in-step, or in synchronism,

Appendix: Electricity - How It Is Generated and Distributed

with the power system's rotating field. This type of AC generator is called a synchronous machine. Most utility power generators and most large motors are synchronous machines.

An AC generator's rotor can also be designed to rotate slower or faster than synchronous speed. This type of machine is called an asynchronous machine. Most small AC motors are asynchronous machines. Induction machines – alternating current machines in which power is supplied to the rotor by means of electromagnetic induction – are the most common type of asynchronous machines. Most wind turbines use induction generators.

Synchronous machines are the most common type of generator used for large-scale power production, and can be used to produce both active¹ and reactive power². This is in contrast to conventional induction machines, which cannot produce reactive power, only active power. The latest design for wind turbine generators, however, includes sophisticated power electronic interfaces and controls that allow these units to inject or absorb reactive power from the grid, as well as providing frequency response, inertial response, etc.

Transmission

Electricity from generators is stepped up to higher voltages by means of a generator step-up transformer for transportation in bulk over transmission lines. Operating the transmission lines at high voltage (100,000 to 765,000 volts) reduces electricity losses from conductor heating and allows power to be transported economically over long distances. The higher the voltage, the lower the current flow needed to transmit the same amount of power. Since losses are related to high current flow, lowering the current lowers the losses. Transmission lines are interconnected at switching stations and substations to form a network of lines and stations called a power grid. Electricity flows through the interconnected network of transmission lines from the generators to the loads in accordance with the laws of physics, along paths of least resistance. When power arrives near a load center, it is stepped down to lower voltages by means of step-down transformers, usually located at substations throughout the system. These substations contain other equipment such as communication, control, protection

¹ Active Power is the useful or working energy supplied by a power source. It is used to perform work such as lighting a room or heating a building or turning a motor shaft.

² Reactive Power is used to support the magnetic and electric fields necessary to operate power system equipment. Reactive power is never consumed by the power system and is stored in the electrical and magnetic fields that exist in the system.

Appendix: Electricity - How It Is Generated and Distributed

and metering equipment. The Bulk Power System (BPS) is predominantly an AC system, as opposed to a direct current (DC) system, because of the ease and low cost with which voltages in AC systems can be converted from one level to another.

Three-phase AC power is normally transmitted by overhead AC circuits, which consist of aluminum conductors with a reinforcing steel core suspended from metal towers by porcelain insulators, as shown in figure 8. Underground transmission circuits can also be used, but are used less frequently than overhead circuits due to the costs involved, as well as the associated reduction in current carrying capacity. Transmission cables installed underground must be insulated, increasing cost and limiting the current carrying capability of the system.

High Voltage Direct Current (HVDC) systems are usually employed for special purposes, including the transmission of large blocks of power from remote sources to load centers or interconnection to systems that operate at different frequencies. A DC transmission system consists of a two conductor line connecting two AC systems. A rectifier at one end of the line converts the AC voltage to a constant DC value and an inverter at the other end reconverts the DC into AC.

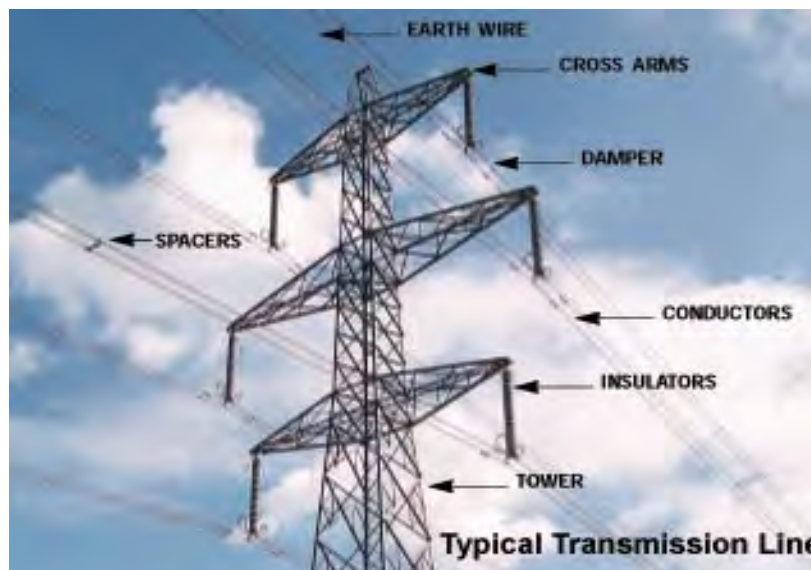


Figure 8: Transmission tower (National Grid)

While the power system is commonly referred to as “the grid,” there are actually three distinct power grids or interconnections in the United States. Figure 9 shows the various interconnections. The Eastern Interconnection includes the eastern two-thirds of the continental United States and Canada from Saskatchewan east to the Maritime Provinces. The Western Interconnection includes the western

Appendix: Electricity - How It Is Generated and Distributed

third of the continental United States (excluding Alaska), the Canadian provinces of Alberta and British Columbia, and a small part of Mexico near the California border. The third interconnection comprises most of the state of Texas. The three interconnections are electrically independent from each other except for a few small DC ties. Within each interconnection, electricity is produced the instant it is used, and flows over virtually all transmission lines from generators to loads. The frequency at which the various interconnects were designed to operate is 60 Hz.

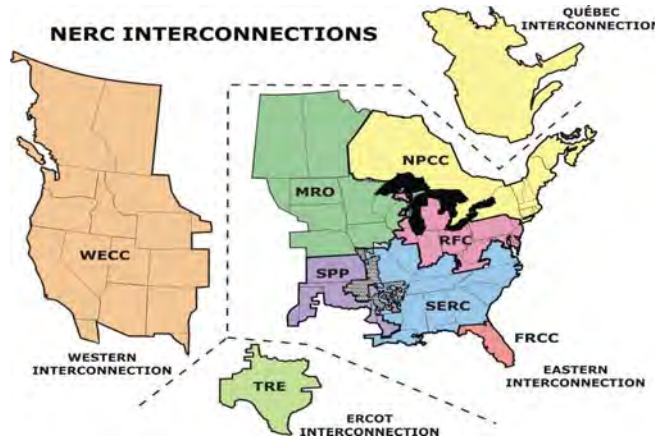


Figure 9: North American interconnections (NERC)

System Frequency

If the total demand from customers is not in balance with the available generation, the electrical frequency of an entire interconnection will deviate from 60 Hz. The target frequency is referred to as the scheduled frequency. When the actual frequency deviates from the scheduled frequency, a frequency deviation has occurred. For example, if the scheduled frequency is 60 Hz but the actual frequency is 59.95 Hz then a -0.05 Hz frequency deviation has occurred. When the supply of generation to the transmission system is inadequate, the frequency falls below 60 Hz. When too much generation is supplied to the transmission system, the frequency rises above 60 Hz. Individual power systems within an interconnection work together to maintain the frequency within a narrow band around the 60 Hz nominal frequency.

Under normal conditions, the power system frequency in a large interconnection (such as the Eastern Interconnection) varies approximately ± 0.03 Hz from the scheduled value. If the scheduled frequency is 60 Hz, the normal range is 59.97 to 60.03. These variations are normal and constantly occur due to the varying nature of the interconnection's load. However, large downward, or negative, frequency deviations can trigger automatic load shedding schemes in most areas, designed to reestablish the necessary balance between generation and

Appendix: Electricity - How It Is Generated and Distributed

load. Depending on the region, automatic under-frequency load shedding usually begins when the frequency declines to levels of 59.3 to 59.7 Hz. Distribution loads are typically shed in various size blocks before generating units start to trip.

System Voltage

The maintenance of voltage within a narrow range is critical to utility customers. Transmission voltage fluctuations of more than ten percent can affect the overall stability of the transmission system. Entities that experience sustained voltage fluctuations equal to or greater than ten percent must file a report with NERC.³ Capacitor banks, Static VAR Compensators, load tap changing transformers, phase shifters, and voltage regulators are used to control system voltage. Low voltage conditions are usually caused by the loss of critical transmission or generation facilities and may result in the overload of adjacent circuits, which could require bringing power in over tie lines.

Load Balancing

An electric power system must have enough generating capacity to supply expected peak load demand plus a reserve margin to accommodate forced outages of generating units. Operating reserves also are necessary to regulate and respond to unanticipated events such as load forecast errors.

Large frequency deviations from the scheduled value occur when there is a significant mismatch between total load demand and total generation. The frequency rise or decay will in most cases be halted by the action of the speed governors on generators which respond to frequency changes and automatically adjust generation to meet demand. Governor action is supplemented by the Automatic Generation Control (AGC) system which over a period of several minutes brings the frequency and interchange (energy transfers that cross Balancing Authority boundaries) back to schedule.

AGC can be a very effective tool during system restoration. The primary function of AGC is to make continuous and automatic adjustments to the output of selected generators in a way that meets load demand and the established interchange schedule at the desired operating frequency. AGC software is normally designed to control a defined portion (within the Balancing Authority boundaries) of the interconnected system. To accomplish the AGC control function, control parameters are continuously monitored. The control parameters

³ Reliability Standard EOP-004-1 (Disturbance Reporting).

Appendix: Electricity - How It Is Generated and Distributed

consist of an actual frequency reading and all tie-line MW flows to neighboring Balancing Authority areas. These control parameters are selected and normally fixed for the portion of the system being controlled. A key assumption to the typical AGC control strategy is that the power system is operating in an interconnected mode.

Distribution

Some larger industrial and commercial customers take service at intermediate voltage levels (4,000 to 115,000 volts), but most residential customers take their electrical service at 120 and 240 volts. Residential customers receive power via overhead or pad mounted transformers supplied by distribution feeders from substations. The transformers step down the voltage from a typical voltage of 13,000 volts to 120/240 volts. The lines carrying the power to a business or residence usually terminate at an electric meter owned and maintained by the distribution company. The meter records the energy consumed by the end user and is read periodically by the distribution company to monitor energy usage and for billing purposes.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

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Appendix: Power Plant Design for Ambient Weather Conditions

Geographic location and the corresponding ambient weather conditions, including expected temperatures and wind speed, have a direct impact on the preferred design for generating facilities. In the northern regions of the United States, most generating plants (especially steam-cycle plants) are designed and constructed with the boilers, turbines/generators, and certain ancillary equipment housed in one or more enclosed buildings. In the colder months, heat radiated from boilers, other generation equipment, and supplemental heaters can generally maintain temperatures at a high enough level to prevent freezing. Enclosed areas are generally designed and constructed with fresh air inlets and roof-mounted exhaust ventilators for cooling purposes during the hot weather months.



Enclosed coal fired power plant in the northeastern United States (Allegheny Energy)¹

In the southern and other warm weather regions of the U.S., generating plants are designed and constructed without enclosed building structures, with the boilers, turbine/generators, and other ancillary systems exposed to the weather, in order to avoid excessive heat build up. For the colder months, when temperatures may fall below freezing, generation owners and operators undertake specific freeze protection efforts, which typically involve a combination of heat tracing, insulation, temporary heating, and temporary wind breaks (to prevent heat loss from normal operations and from supplemental heating sources).

¹ Available at <http://www.industcards.com/st-coal-usa-wv.htm> (last visited Aug. 10, 2011).

Appendix: Power Plant Design for Ambient Weather Conditions



Non-enclosed coal fired power plant in the southern United States (Luminant)²

Common Freezing Problems

Some power plant components and systems are susceptible to freezing. Any power station system that uses water, air (which can contain moisture), or rotating machinery (which uses lubricating oil) can develop operational problems or trip off-line as a result of sub-freezing temperatures, unless adequate cold weather protection is in place.

- **Instrumentation** - Instrumentation provides operational data necessary for process monitoring and control systems. Freezing often may occur not in the instrumentation itself, but in the sensing lines that run from piping, pressure vessels, and tanks that contain water or steam. The sensing lines are filled with a static water column that, if frozen, will send incorrect data, possibly resulting in unit trips, load rejection, unit runback schemes, or incorrect operator actions. Critical instrumentation sensing lines that are susceptible to freezing include lines used to monitor boiler steam drum water level, deaerator pressure, feedwater heater water levels, and various critical cooling water flows (generator, turbine oil cooling, etc.).
- **Feedwater systems** - The condensate and boiler feedwater systems for steam-cycle generation units utilize water from the condenser and add heat (through a series of feedwater heaters) and pressure (through condensate and boiler feedwater pumps) to increase cycle efficiency before the water enters the boilers. Piping, pressure vessels, and valves contained in these systems are all susceptible to freezing. This is especially true of generation units that are not in operation at the onset of freezing temperatures, due to static water in the feedwater systems. In addition, the reverse osmosis

² Available at http://www.powermag.com/environmental/Luminants-Oak-Grove-Power-Plant-Earns-POWER-s-Highest-Honor_2877_p2.html (last visited Aug. 10, 2011).

Appendix: Power Plant Design for Ambient Weather Conditions

equipment, demineralizers, filters, and storage tanks often found in condensate make-up water systems are susceptible to freezing.

Cooling Water Systems

- **Cooling Water Intakes** - Steam cycle power plants require large quantities of cooling water, often supplied by rivers or lakes. Water drawn from a river or lake is filtered through trash racks and circulating water screens to remove tree branches, debris, and fish. When temperatures drop below freezing, ice can clog racks and screens, limiting the flow of cooling water. Water intakes can also become clogged by fish kills during extreme cold weather, as happened in Texas in 1989.
- **Cooling Towers** - Cooling towers lower the temperature of water used in the cooling process so that it can be reused (reducing the amount of water taken from lakes and rivers) or discharged at lower temperatures. Cooling towers use mechanically induced draft or natural draft designs. Mechanical cooling towers (box) have fans mounted on the top to draw air through the water as it falls over trays to remove the heat gained in the steam condenser. Natural draft cooling towers are of the familiar, hyperbolic design that can be seen at many large coal and nuclear power plants. During extended periods of freezing temperatures, ice can accumulate on the trays in the towers and affect operations or damage the unit.
- **Equipment Cooling Water** - Various equipment and systems in power plants require cooling water to stay operational. These include turbine lubricating oil coolers, generator/hydrogen coolers, pump and fan bearings, and air compressors. Freezing of the piping, valves, and instrumentation sensing lines in these systems can cause derates or outages.
- **Sluicing/Service Water Systems** - Sluicing water is used to remove bottom ash from coal-fired boilers. Icing problems in the bottom ash removal system can interfere with ash removal and may lead to derates or outages. Service water is used for various wash down systems and fire protection systems. Loss of service water due to freezing should not affect unit capacity, but could affect equipment protection systems.
- **Wastewater Systems** - Various power plant systems that use water can create waste streams that must be treated for contaminants before re-use or discharge. Those systems include boiler blowdown, cooling tower blowdown, various cooling systems, bottom ash sluicing water, and service water systems.

Appendix: Power Plant Design for Ambient Weather Conditions

Freezing of valves and piping on these systems can result in the accumulation of wastewater, which could affect other systems.

Emission Reduction Systems

- **Sulfur Dioxide Removal Systems** - Among the methods available to reduce and remove sulfur dioxide from emission flue gas on coal plants, the predominant technology has been use of wet lime or limestone scrubbers. Lime or limestone contains calcium oxide, which when mixed (slaked) with water forms calcium hydroxide. Calcium hydroxide is sprayed through the flue gas to produce a chemical reaction to form calcium sulfite or sulfate (gypsum). As the waste product is processed, it contains less and less water, which is then reused in the scrubber. The scrubbing and waste processes require many runs of piping and instrument/control locations, many of which are susceptible to freezing. Freezing problems on piping runs or sensing lines could cause scrubber chemistry problems, tank overflows, etc., which could lead to derates or unit shutdowns if the plant is unable to stay within permitted emission limits.
- **Nitrogen Oxides Reduction Systems** - As with sulfur dioxide systems, numerous technologies are available to reduce nitrogen oxides in fossil fuel plants. Many of these technologies use water in the emissions reduction process. These systems are susceptible to freezing that can lead to failure in the emissions reduction process, resulting in derates or unit shutdowns.

Control Air Systems, Control Drives, Valve Actuators, Valves

- **Freezing in Control Air Systems** - Air is compressed and used to operate pneumatic control valves, boiler damper control drives, and various other pneumatic controls in the plant. Moisture in the air can condense and accumulate in lines, air receivers, and component control mechanisms. If moisture is not removed (through use of air dryers and air receiver blow-downs), these pneumatic controls can freeze and cause equipment controls to malfunction or fail, which can in turn cause a unit shutdown or limit the unit's output.
- **Sluggish Valve Operation** - When exposed to severe cold weather, the operation of valves and control valves can become sluggish. This can lead to instability in boiler or turbine controls and ultimately lead to a unit trip.

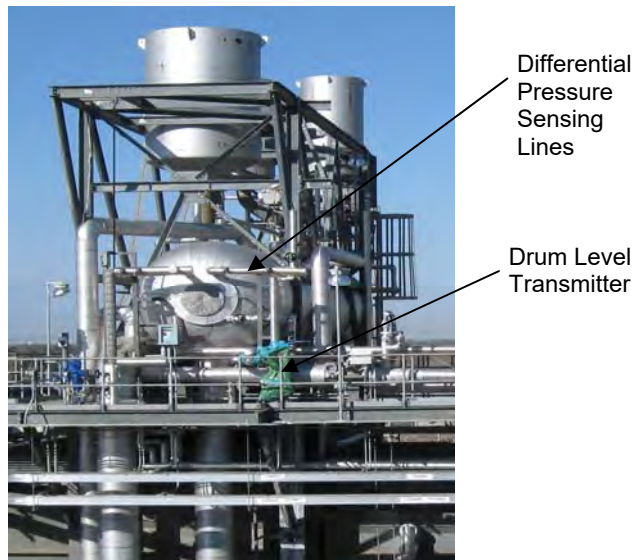
Appendix: Power Plant Design for Ambient Weather Conditions

- **Lubricating Oil** - Various types and grades of lubricating oil and grease are used in power plants on rotating machinery and other moving parts. As the temperature decreases, the lubricating properties and viscosity of these oils change, possibly affecting operation of the equipment.

Fuel

- **Coal** - Severe cold weather can limit or prevent the transfer of coal into a plant. Coal in Texas (lignite) typically contains between 30 and 40% moisture. When temperatures are low enough to freeze moisture in the coal, the coal may slide on conveyor belts or block belt transfer points, chutes, and crushers, limiting supply.
- **Natural Gas Supply** - Freezing weather can cause gas valves to malfunction, adversely affecting gas supply to the units.
- **Fuel Oil** - During cold and freezing weather, fuel oil supplies in storage can gel without the appropriate additives. Gelled fuel oil can affect pump and burner performance, which in turn affects the unit's output. Some types of fuel oil must be heated before they can be used in cold weather.

Steam Drum Level Measurements



One of the most critical measurements made on a drum type steam boiler is the water level in the main drum. Too high a water level can result in water being

Appendix: Power Plant Design for Ambient Weather Conditions

injected into the boiler tubes or steam turbine, damaging the boiler tube or turbine blade. Too low a water level or no water can result in overheating the drum or boiler tubes, leading to drum or boiler tube damage.

The steam drum in a southern plant can be located outside, near or at the top of the boiler. During the February 2011 cold weather event many of the plants had problems with freezing in the drum level water level regulating system.

A typical drum level measurement system works by maintaining the differential pressure between the steam side and water side of the drum to a constant value. The drum level transmitter monitors and regulates this differential pressure by controlling the amount of water being added or removed from the drum. On a normal drum, the water level is controlled to approximately plus or minus 2 inches of the desired level.

Appendix: Impact of Wind Chill

Wind Chill Factor

The term “Wind Chill Factor,” is often used to explain the additional heat loss people experience through convection cooling when exposed to the wind. Whenever there is a temperature difference at a surface, *e.g.*, the difference between normal body temperature and ambient air at a lower temperature on the surface of human skin, heat is conducted across the surface from the warmer body to the cooler air. In the process, the layer of air on the surface is warmed and forms a thermal boundary which tends to slow the rate of heat loss. Wind accelerates the heat loss by literally sweeping away that boundary layer and replacing it, continuously, with air at the ambient temperature. This acceleration of heat loss caused by the wind makes people feel that the air temperature is colder than it actually is. This feeling is quantified by assigning a stationary air temperature, known as the Wind Chill Temperature, which yields an equivalent perception of cold.

The polar explorer and geographer Paul Siple first used the term “wind chill” in 1939. During the second expedition of Admiral Richard Byrd, Siple and his partner Charles Passel conducted experiments at Little America, Antarctica, to determine the time required to freeze water in plastic vials exposed outside in the wind. They developed a formula for relating heat loss to wind speed and air temperature, expressed in units of atmospheric cooling-watts per square meter. Later, the formula was modified to allow computation of a wind chill equivalent temperature.

Wind Chill Temperature is only defined for ambient temperatures at or below 50 degrees Fahrenheit and wind speeds above 3 mph. Bright sunshine may increase the wind chill temperature by 10 to 18 degrees.

Wind Chill Effect on Inanimate Objects

The Wind Chill Factor, *per se*, applies only to human beings and animals. The only effect wind chill has on inanimate objects, such as car radiators and water pipes, is to more quickly cool objects to the current air temperature. Objects will not cool below the actual air temperature. For example, when the temperature outside is -5 degrees and the Wind Chill Temperature is -31 degrees, a car’s radiator will not get any colder than -5 degrees. Similarly, if the ambient temperature is above freezing, stationary water in piping exposed to the wind will not freeze, no matter how strongly the wind may blow.

Appendix: Impact of Wind Chill

Wind Chill Effect on Industrial Plants

Industrial plants, including electric generating stations, can nevertheless be affected by the accelerated rate of heat loss, or cooling, caused by air movement. During the hot summer months, this cooling effect can help prevent temperatures from exceeding equipment operating limits. For this reason, many plants in warmer climates are of an open-air design, without walls or enclosures. In the winter, however, the enhanced cooling from the unimpeded flow of air can cause freezing problems.

On cold days when the outside temperature drops below freezing, sustained high winds can quickly and continuously remove the heat radiating from boiler walls, steam drums, steam lines, and other equipment in an electric generating station, causing ambient temperatures to drop below freezing in spite of the heat being produced by the facility. If stationary water lines, such as those used for differential pressure measurement, are exposed to the wind under those conditions, they can freeze if they lack adequate freeze protection such as heat tracing and insulation. Wind screens and enclosures can slow the rate of heat loss caused by high winds, while at the same time acting to contain heat supplied by supplemental space heaters at critical locations.

Wind Chill Effect on Electric Demand or Load

The accelerated cooling effect of the wind affects buildings and homes throughout the community, and can significantly increase demand for electric power. In particular, buildings that are not well insulated, with frequently opened doors or drafty windows, can experience higher rates of heat loss on windy days, increasing the demand for heating energy.

During the February 2011 weather event, ERCOT engineers and operators concluded, based on archived historical data, that the forecasted wind speeds would significantly increase the load on the system. They therefore increased the conventional load forecast by 4000 MW to account for the added load created by high winds combined, with low temperatures.

Appendix: Winterization for Generators

Extreme cold weather can cause generators to fail for many reasons, including the failure or absence of heat tracing on key components, missing or inadequate wind breaks, inadequate insulation, lack of supplemental heating devices, human error, or inadequate training, maintenance, or preparation. As discussed below, effective winterization programs incorporate both physical components and operational processes to protect generating plants from freezing weather.

Physical Components of Winterization

Physical freeze protection is accomplished by three primary components:

- Heat tracing – the application of a heat source to pipes, lines, and other equipment that must be kept above freezing;
- Thermal insulation – the application of insulation material to inhibit the dissipation of heat from a surface; and
- Windbreaks – temporary or permanent structures erected to protect components from wind.

Generators use other temporary measures to prevent freezing in plants, including installing space heaters, draining non-essential water lines, and placing small heat lamps in cabinets.

Heat Tracing

Types of Heat Tracing Cable

Electric heat tracing involves the application of heat to the outside of pipes or other lines to maintain proper operating temperature. A heat tracing system is typically made up of the following: (i) heat tracing cable wound around the pipe; (ii) a thermostat that measures ambient air temperature; (iii) thermal insulation; and (iv) a power source. The failure of any of these components can result in frozen instrumentation.

There are five main types of heat trace cable. “Self-regulating” cable automatically increases power to produce additional heat as the temperature falls. It can be used on metal or plastic components for freeze protection, temperature maintenance, and foundation heating, and is typically found on sensing lines and other ancillary components. However, it cannot be used on surfaces that have high surface temperatures.

Appendix: Winterization for Generators

“Power-limiting” heat tracing is similar to self-regulating heat tracing in that it increases power and heat as temperatures drop, and decreases power as temperatures rise. It is specifically designed to produce high temperatures and to be used on high surface temperature fixtures.

“Parallel constant watt” heat tracing cable consists of a continuous series of short, independent heating circuits that maintain a consistent output of heat for up to several hundred feet. One benefit of this type of cable is that if one of the independent circuits fails, the rest of the cable will continue to operate. However, the length of the cable is limited, based upon the distance between the circuits, making it impractical for certain situations.

A “series constant watt” heat tracing cable is designed specifically for components that need longer circuit length. These cables are made of high-resistance wire that is powered at a particular voltage to generate heat. However, a break anywhere along the cable will result in failure of the entire heat tracing installation.

Another common type is “mineral insulated” heat tracing cable, which is typically used to maintain high temperatures, or in locations where it will be exposed to high temperatures. Mineral insulated cable is also used to provide heat over long distances, and is often used to protect high temperature steam lines.

Power Supply

Each heat tracing cable must be connected to a power source. In a typical installation, several cables covering one component of a generating unit will be connected to a freeze protection electric panel that contains circuit breakers or fuses for the various circuits. Depending on the size and layout of the generating unit, it may have dozens of freeze protection panels. These panels are often equipped with visual displays that indicate when the system is energized and when the heat tracing is activated. Images 1 and 2 are examples of the inside and outside of a new freeze protection panel.

Appendix: Winterization for Generators



Figure 1: Freeze Protection Panel Interior



Figure 2: Freeze Protection Panel Exterior

As can be seen in the example above, lights on the front of the panel indicate the status of the freeze protection system. Such indicator lights must be regularly monitored and tested by plant employees, since control room personnel are not always able to monitor panels remotely.

The failure of a freeze protection panel during cold weather can cause heat trace cables connected to that panel to fail. Failure to properly maintain or inspect the panel can cause corroded connections to go unnoticed and go unrepaired, possibly resulting in a short circuit that shuts off power to other panels.

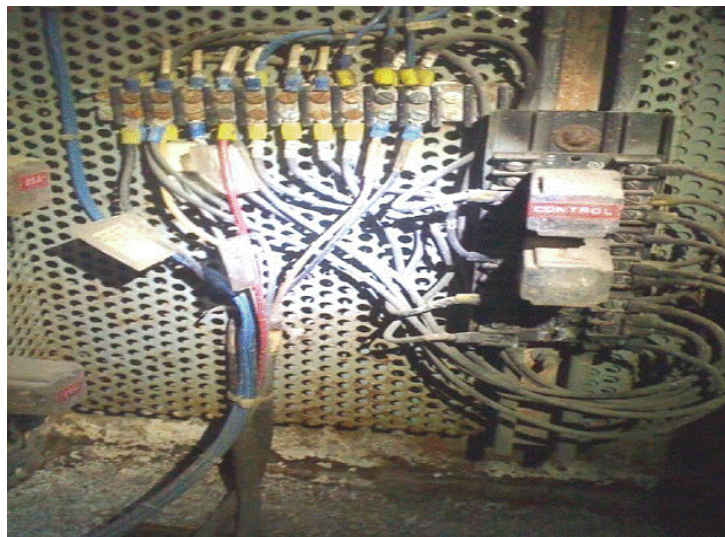


Figure 3: Corroded Freeze Protection Panel

Appendix: Winterization for Generators

Thermostats

Although the panel is always energized, heat tracing cables are turned on only when low temperatures call for freeze protection. Power to the cable is supplied either by a contactor (wherein two metal plates, usually separated, are pressed together to power the cables), or by a solid state controller. In most cases the system is turned on by a thermostat located at the panel. In some cases plants initiate freeze protection procedures at certain specific temperatures, and in some instances, the heat tracing must be turned on manually by plant personnel.

Thermal Insulation

A layer of thermal insulation is placed on top of the heat tracing that is installed on a pipe. This insulation is similar to home insulation, but is composed of different materials. A weatherproof skin is typically applied as an external layer to protect the insulation and heat trace from damage.



Figure 4: Insulated Piping with Heat Tracing

Thermal insulation plays a significant role in freeze protection, particularly in windy conditions, by preventing rapid heat loss. However, even small gaps in insulation have been known to result in frozen lines.

Appendix: Winterization for Generators

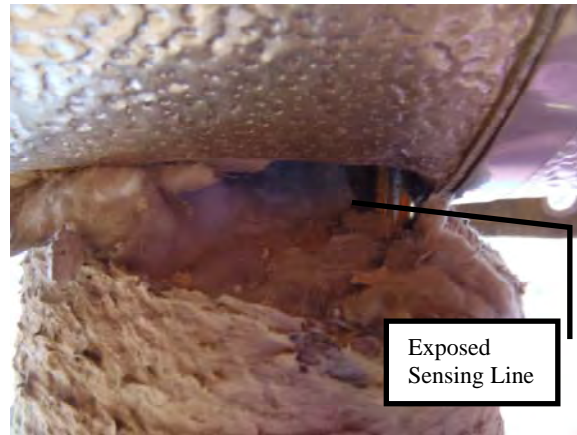


Figure 5: Gap in Insulation

In addition to the pipe itself, valves, flanges, traps and fittings should be insulated to the extent possible. Non-insulated valves, like those pictured below, can cause pipe to freeze if enough surface area is exposed to freezing wind conditions.



Figure 6: Exposed valves emerge from thermal insulation and are not heat traced

Windbreaks

The third major component to winterization is windbreaks. Windbreaks are temporary or permanent structures used to prevent wind from blowing directly over exposed components and dissipating heat at an increased rate.

Appendix: Winterization for Generators



Figure 7: Temporary windbreak created with scaffolding and tarpaulin

Other Winterization Efforts

In addition to the three major winterization techniques, generating stations sometimes use other freeze protection measures. These include keeping water flowing to reduce freezing, draining liquids from valves, purging drained lines of water with compressed air, and installing space heaters in enclosed areas to raise ambient air temperatures.

Winterization Processes

Although designing freeze protection systems for exposed areas is critical to cold weather operation, preparation for freezing conditions is equally important. In order to achieve good freeze protection, a generator must know what areas are likely to freeze, and must take steps to ensure that appropriate procedures are put in place. The following paragraphs describe some of the steps that can be taken to prepare for winter, and discuss how the proper use of checklists can help plant managers implement effective winterization measures.

Winter Preparation

Preparation for winter weather should begin well before its arrival, and many generator operators in Texas and the Southwest start their winterization programs in the fall of each year. These procedures include verifying that installed heat tracing is working, components are properly insulated, space heaters are operational, fuel switching can be initiated, and instrument systems are free of moisture. Many generators also verify that their inventory of freeze protection equipment – such as heat lamps, heat guns, propane torches, tarps, de-icing

Appendix: Winterization for Generators

material, fuel, insulation, sand, and extension cords – is adequate for the upcoming season. Timeliness is an important aspect of pre-winter preparation – it should begin early in the season so that there is time to make necessary repairs before cold weather hits.

In addition to pre-season preparation, generating stations typically have a set of procedures that are initiated whenever a winter storm is expected. Much of the work that is done before a storm arrives is similar to pre-season preparation. However, the pre-storm procedures may include calling in additional operators and maintenance personnel, moving motor vehicles into garages, draining non-essential water lines, and moving portable heaters into position.

As winter weather sets in, generating stations may adjust their operations to protect against freezing conditions. Such changes may include switching instrument air to nitrogen backup, warming up standby boilers every two hours, opening bypass valves on steam traps, and rotating pumps every two hours.

A critical component of winterization plans is the opportunity for post-winter critiques and reports on lessons learned. Applying lessons learned is sometimes done informally but some generators go further, requiring plant managers to conduct post-winter meetings to identify necessary improvements and to file written reports on the plant's performance during the winter season.

Checklists

In order to ensure that all of the plant-specific tasks are properly completed, many generator operators create checklists for plant personnel to follow. Although the form of such checklists may vary depending on the size of the plant and the types and locations of the generating units, effective checklists tend to have certain characteristics.

Good checklists are sufficiently detailed to allow plant operators and maintenance personnel to adequately prepare for and deal with cold weather events. For example, a checklist may specify who is responsible for assigning personnel to freeze protection duty, or may identify specific tasks triggered by different freeze alert levels.

A checklist can be broken down not only by task, but also by area and by individual components or areas to be checked. For example, the checklist can specify which particular lines should be drained and which vents should be closed.

Appendix: Winterization for Generators

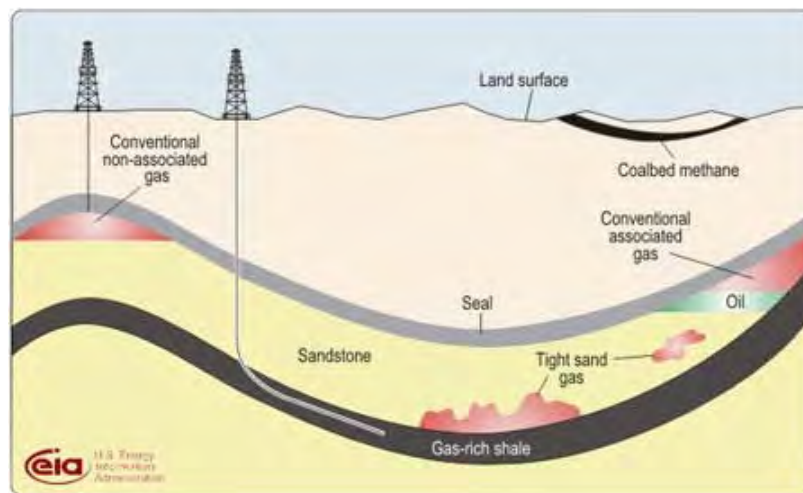
A list that is lacking in detail and that only includes general tasks such as turning off vent fans or checking boiler and duct air heater enclosures will not be effective. Plant employees might understand which components should be included in such general references, but non-specific descriptions are inadequate to ensure that all systems are identified and checked.

Checklists can also offer generating stations the ability to audit their performance in implementing winterization. A common feature of effective checklists is a requirement that employees initial and date the checklist for each task completed. Not only does this provide confirmation that the tasks were completed, but it also holds operators and maintenance staff accountable for their performance.

Appendix: Natural Gas – Production and Distribution

What Is Natural Gas?

Natural gas is a highly compressible, naturally occurring mixture of hydrocarbons, principally containing methane, that migrate upward through geological formations until the migration is halted by a physical barrier that allows the natural gas to accumulate in the small pore spaces within a geological formation, or reservoir. The physical barrier is a non-permeable formation that is known as a reservoir seal or caprock. The type of formation where the natural gas can accumulate, which can include sandstone, coal as well as shale, depends upon the location of deposition of the original organic material and the geologic formations that lie above. To access the natural gas that has accumulated within the reservoir, drilling companies will drill down to the formation using drilling rigs that punch into the formation using drill bits and long string pipes to bring the natural gas to the surface at the well site.



(Energy Information Administration)

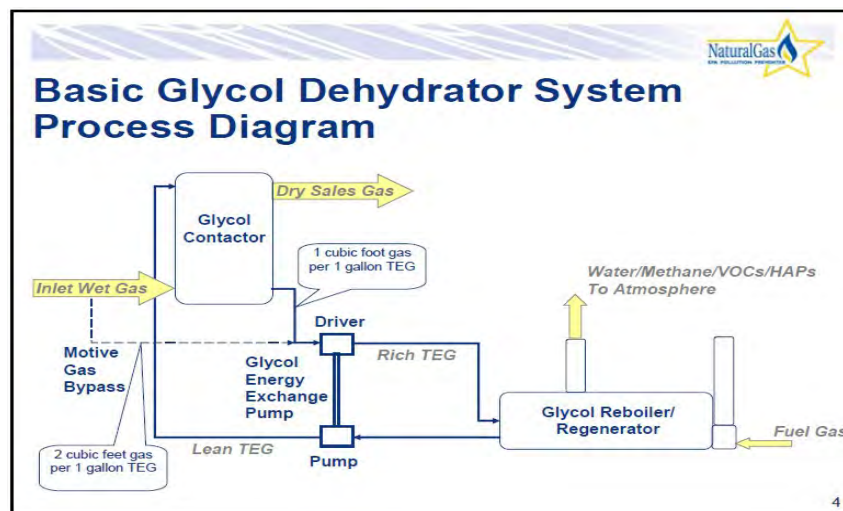
While in the ground, the natural gas is under high pressure. When these formations are produced, the natural differential in pressure, between the high pressure in the formation and lower pressure at ground level, can provide the driving force to move the gas to the surface. The company in charge of producing the natural gas, by allowing the natural gas to flow from the subsurface formation up to the surface, will drill several wells to maximize its ability to produce the natural gas while maintaining the integrity of the reservoir within the geological formation to ensure a long and active production life.

As part of the natural gas stream that reaches the surface and is produced from the wellhead, there are many other gas constituents other than methane. Heavier hydrocarbons, such as ethane, propane, butane, and pentane plus, are also produced along with the methane-rich gas stream. After production, these heavy hydrocarbons or natural gas liquids (NGLs) can be removed through processing and sold separately from the natural gas. Other gases, such as hydrogen, carbon dioxide, nitrogen, oxygen, sulfur, and hydrogen sulfide, are also produced, and most of the gases will be removed from the

Appendix: Natural Gas – Production and Distribution

natural gas stream through the use of treating plants. Unlike NGLs, some of these gases are undesired impurities with little or no commercial value.

Another common byproduct of natural gas production is water. Just as natural gas can migrate through geologic formations and into reservoirs, water and crude oil can follow the same process. Water that accompanies natural gas is removed through the use of dehydration facilities located at or near the wellhead.¹ The water is then commonly injected back into the outer limits of the reservoir's geological formation to help produce additional natural gas from the reservoir by displacing the natural gas from the pore spaces within the geologic formation and push the natural gas toward the producing wells. Unless water is removed from the gas stream, it can freeze in the pipeline and stop the flow of gas from the wellhead.



(Environmental Protection Agency)

Over time, multiple wells are drilled into the formation in order to maximize production of natural gas in the reservoir. After each well is tested and examined by the production company, the wells are connected through a series of pipelines increasing in diameter as more gas is gathered and transported through the gathering pipeline.

¹ The dehydration of natural gas usually involves one of two processes – absorption or adsorption. Absorption occurs when the water vapor is taken out by a dehydrating agent. Adsorption occurs when the water vapor is condensed and collected on the surface. The absorption process requires a chemical with an affinity for water, such as glycol, which is the most commonly used dehydration agent. After absorbing the water, the glycol falls out of solution to the bottom of the tank where the water-rich glycol is removed. The adsorption process is a physical-chemical process in which the gas is concentrated on a surface of a solid or liquid to remove the impurities. Natural Gas Supply Association, Processing Natural Gas, available at http://www.naturalgas.org/naturalgas/processing_ng.asp (last visited Aug. 5, 2011); Saeid Mokhatab, William A. Poe & James G. Speight, Handbook of Natural Gas Transmission and Processing 262 (Elsevier 2006).

Appendix: Natural Gas – Production and Distribution

Depending upon the impurities in the natural gas stream, the pipeline will funnel the natural gas stream to processing and treatment plants. The treatment plants are used to remove impurities and other objectionable material usually before the natural gas stream is transported to the processing facilities.

The natural gas stream often contains other contaminants that must be removed before the natural gas stream is delivered to downstream pipelines. Some of these contaminants are hydrogen sulfide, carbon dioxide and other sulfur-based impurities, which are sometime referred to as “acid gas.”² When hydrogen sulfide combines with water in the natural gas stream, sulfuric acid forms. Similarly, carbon dioxide that combines with oxygen forms carbonic acid. These acid gases can cause damage which, if left unchecked, could lead to pipeline failure.³

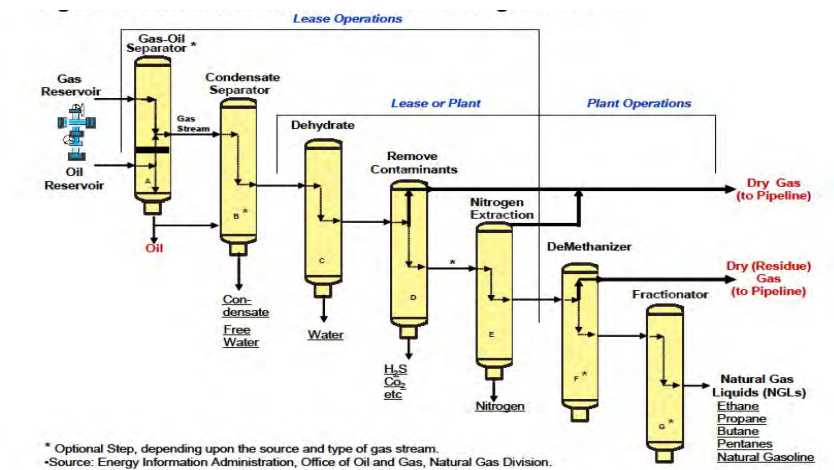
The processing plants typically remove NGLs through a refrigeration process that involves a form of rapid cooling of the natural gas stream. Two types of this cooling process are mechanical refrigeration, as used in lean oil absorption, and turbo-expander or cryogenic process. The technology used will depend upon the age of the processing facilities as well as the desired result. Mechanical refrigeration is a process whereby the natural gas stream is chilled by a vapor compression refrigeration process, similar to the process used by a refrigerator or an air conditioner, but producing much colder temperatures. This is coupled with the use of glycol as an absorption fluid that combines with the NGLs and falls out of the gas stream. In the cryogenic process, the high pressure natural gas stream is rapidly expanded by decreasing the pressure. This process causes the gas stream to cool rapidly (Joule-Thomson Effect)⁴ to temperatures that will cause the NGLs to move from a gaseous phase to a liquid phase. The NGLs fall out of the gas stream and are collected for sale and additional processing. The residual gas, from which the NGLs have been removed, is transferred to a downstream pipeline for transmission to end users. Both of the above processes are effective means for recovering NGLs and for reducing the possibility that NGLs will condense and fall out of the gas stream as liquids that could cause damage to downstream equipment.

² Natural gas containing hydrogen sulfide is considered “sour” gas while natural gas without hydrogen sulfide is considered “sweet” gas. *Id.* at 261.

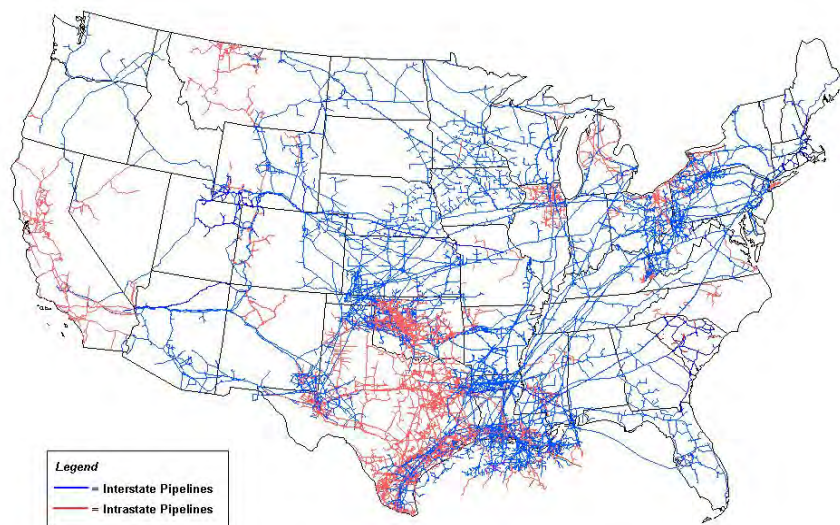
³ Frøydis Eldevik, *Safe Pipeline Transmission of CO₂*, Pipeline & Gas J., April 2011, Vol. 238 No.4, p. 3, available at <http://www.pipelineandgasjournal.com/safe-pipeline-transmission-co2?page=3> (last visited Aug. 5, 2011).

⁴ Joule-Thomson Effect is the change in temperature or cooling effect resulting from the rapid expansion of pressurized natural gas through a valve.

Appendix: Natural Gas – Production and Distribution



After treating and processing, the natural gas can be transported to market centers by the intrastate and interstate pipeline system. This network is made up of more than 210 pipeline systems with over 305,000 miles of varying diameter pipeline, 1,400 compressor stations, and 400 underground storage facilities, all connecting the various natural gas production areas, both onshore and offshore, to multiple markets throughout the United States.⁵



Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

Types of pipeline systems

The interstate pipelines can be divided into two types of systems – long-haul and reticulated. Long-haul pipelines receive natural gas supplies from producers and

⁵ U.S. Energy Information Administration, *About U.S. Natural Gas Pipelines – Transporting Natural Gas*, available at http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/index.html (last visited July 20, 2011).

Appendix: Natural Gas – Production and Distribution

processors and transport it across hundreds of miles to market areas outside the production areas. Reticulated pipelines resemble a spider web that overlays both the supply areas and the market areas, and typically have multiple lines that can change direction of gas flow through the system, depending upon market needs.

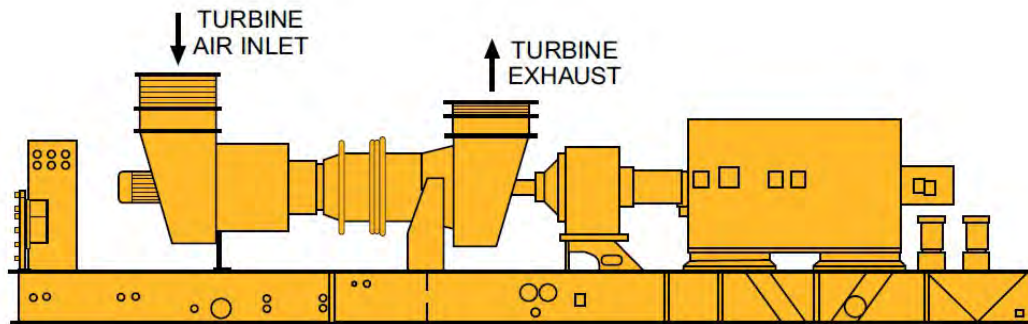
Pipeline Design

A natural gas pipeline system can be as simple as a single diameter pipe receiving gas from one source and transporting it to a single delivery point, or as complex as a network of multiple diameter pipes covering hundreds of miles with compressor stations, storage facilities, and numerous receipt and delivery points. In order to move natural gas supplies from the supply areas to the market areas, a pipeline must be designed to transport the required volume of gas supplies, while maintaining system pressures along the length of the pipeline necessary to serve its shippers.

The design of all pipeline systems starts with the same basic idea, the need to transport a specific volume of natural gas from at least one supply source to a specific destination while maintaining contractual delivery pressure obligations. Due to frictional loss resulting from the gas flow, the pressure of the gas stream will decrease. Compressor stations are designed to re-pressurize the gas stream in order to overcome the pressure losses associated with movement of gas in a pipeline. Compressor stations are above-ground facilities where the pipeline connects with large individual compressor units through various smaller pipelines or “yard piping” as well as meter and regulation equipment. Compressors are mechanical devices that increase the pressure of the gas stream. After the gas stream has been re-pressurized, the gas re-enters the pipeline for further transmission to downstream markets. Compression facilities are needed along the length of the pipeline, and are typically placed at 40 to 60 mile intervals.

Compressors are split into two basic parts, the compressor and the driver, or motor. The motor, which can be fueled by electricity or gas-fired, powers the compressor unit that compresses the gas. The two types of compressors that are most commonly used by the interstate natural gas companies are centrifugal and physical displacement or reciprocating compressors. Centrifugal units are turbines that spin at high rates of speed to compress and accelerate the gas stream. These compressors are used to accommodate high flow rates at high pressures. Most interstate pipeline systems use centrifugal compressor units on their mainlines. The following is an illustration of a centrifugal compressor and gas-fired motor.

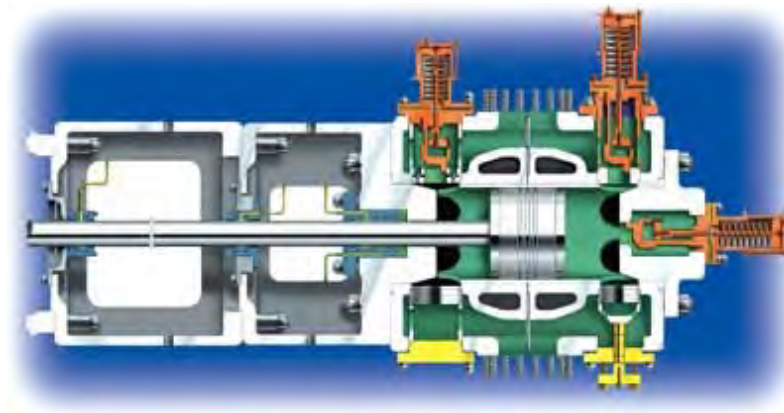
Appendix: Natural Gas – Production and Distribution



(Solar Turbines Incorporated (a Caterpillar Company))

The gas stream enters the inlet or suction side of the compressor unit, where it is forced through the rotating turbines at high speed and exits the compressor at the discharge side, moving back into the transmission pipeline. With gas-fired compressor motors, a small amount of natural gas is funneled from the gas stream at the suction side to provide fuel for the motor.

Reciprocating units increase the pressure of the gas stream by compressing or reducing the volume of the gas through the use of pistons within a cylinder similar to the pistons in a car engine. These compressors can be found on interstate pipelines' mainline systems, which need to compress gas volumes with greater pressure differentials. Storage facilities also utilize reciprocating compressors to inject gas supplies received from pipeline systems at pressures ranging from 500-1,000 psig, into storage caverns at pressures that can exceed 2,000 psig. Just like the motors used by gas-fired centrifugal compressors, a small amount of natural gas is taken from the gas stream to provide fuel.



Reciprocating Compressor Cylinder Assembly (machinerylubrication.com)⁶

⁶ "Reciprocating Compressor Basics," available at <http://www.machinerylubrication.com/Read/775/reciprocating-compressor> (last visited Aug. 5, 2011).

Appendix: Natural Gas – Production and Distribution

Line pack

Line pack is the volume of gas in the pipeline at a given point in time. Pipeline operators use line pack to maintain system operating pressures while accommodating the system's highly variable load requirements.

Most gas supplies enter a pipeline system at a relatively even hourly rate, or about $1/24^{\text{th}}$ of the total amount of gas per hour (4.17 percent per hour) for the entire day, also known as “steady-state” conditions.⁷ On the demand side, deliveries rarely leave the system at an even hourly rate. Deliveries are not constant primarily due to variations in demand caused by inlet and outlet flow changes, non-performance of receipt or delivery points, scheduled or unscheduled maintenance, and compressor startups and shutdowns.⁸ Flow conditions that vary over time are known as transient flow conditions. Depending upon the flexibility provided by the interstate pipeline within its tariff or contract with the customer, the hour rates for gas delivery could be 5 percent and even up to 8 percent per hour. These hour rates are equivalent to a 20 hour to a 12.5 hour day, or simply stated, the customer can take the entire scheduled and confirmed quantity of gas for the entire 24-hour gas day in as little as 20 to 12.5 hours. Managing these transient loads could not be done without actively managing system line pack.

In order to prepare for the upcoming gas day, the pipeline operator will increase system pressures by increasing the use of available compression horsepower at compressor stations strategically located along the pipeline system. The increase in pressure will allow the pipeline operator to “pack” the pipes with additional gas from other portions of the pipeline system located closer to the supply points. Further, depending upon demand forecasts for the upcoming gas day, customers will often increase their receipts in order to ensure that they will be able to meet their load requirements. Unlike electricity, which is added to the transmission lines instantaneously, natural gas must be physically moved through the pipeline from the supply areas to the market areas for delivery. Depending upon the length of the pipeline system, this physical transportation of gas from the supplier to the end user can take days. Most interstate pipeline systems move gas at speeds between 20 and 30 mph. If the pipeline has its origin in the Gulf of Mexico and the destination is the New York City market area, 1,500 miles away, the gas will need roughly two days to travel that distance

⁷ Steady-state flow conditions exist when the gas volumes both received into and delivered out of the pipeline system are equal at every moment in time while the pipeline is operating at a constant pressure and temperature. For example, a pipeline is said to operate under steady-state conditions when $1/24^{\text{th}}$ of the gas volumes are entering the system every hour while simultaneously $1/24^{\text{th}}$ of the gas volumes are leaving the pipeline system every hour. Gas volumes going into the system must equal the gas volumes leaving the system to be considered steady-state conditions.

⁸ Saeid Mokhtab, William A. Poe & James G. Speight, Handbook of Natural Gas Transmission and Processing 414 (Elsevier 2006).

Appendix: Natural Gas – Production and Distribution

at 30 mph. This is why it is critical for pipeline systems to receive gas supplies nominated, scheduled and confirmed in order to replace the system line pack in a timely manner.

Maximum Allowable Operating Pressure

The Maximum Allowable Operating Pressure (MAOP) is one of the many design assumptions that will limit either a pipeline's design capacity or peak day capacity. The MAOP, which represents the maximum pressure at which a pipeline may operate its system,⁹ is an operational or safety-based constraint that protects the integrity of the pipeline system while defining an upper capacity limit. As such, the MAOP will act as a physical constraint¹⁰ that the pipeline companies' system design engineers must address with each pipeline expansion project before the Commission.

When a pipeline company files an application to add a new service or to expand its existing facilities, it will look to the Commission's regulations (18 C.F.R. § 157.14(a)(7)-(9)(vi)) for guidance. Under these regulations, the pipeline company is required to provide to the Commission flow diagrams reflecting "Daily Design Capacity" and "Maximum Capabilities" for both its existing and proposed facilities. Currently, most of the interstate pipeline companies justify the need for facility augmentation through the use of a steady-state model of their respective systems while operating under design peak day flow conditions. These models are designed to meet the pipeline's firm contractual obligations while maintaining: (1) the volumetric requirements of its existing firm shippers; (2) the minimum contractual delivery pressure obligations; (3) controlling pressures located at critical points on their system; and (4) the full utilization of the existing available capacity through the use of all available compression horsepower along the path of the new service.

Implicit in the pipeline companies' design process is the need to maintain actual operating pressures at or below the MAOP in order to maximize throughput levels on their respective systems. From the design perspective, this is a relatively simple task. In most cases the pipeline's design capacity is based upon maximum utilization of compression facilities while transporting gas volumes between primary contractual

⁹ In its November 14, 2002 comments in Docket No. PL02-9-000, the Office of Pipeline Safety (OPS) stated that the purpose of setting regulatory standards for determining pipeline MAOP is to "prevent pipeline failure that could result from excess operating pressure, startup and shutdown." OPS defines MAOP as the maximum pressure at which a pipeline or pipeline segment may operate. The Office of Pipeline Safety, Comments in Response to Open Forum at the Natural Gas Markets Conference Oct. 25, 2002, Docket No. PL02-9-000 at 4 (filed 11/14/2002); *see also* 49 C.F.R. § 192.3.

¹⁰ Physical constraint, or pipeline bottleneck, is a point on a system where the existing facilities are inadequate to accommodate 100 percent of the flowing capacity of the upstream pipeline facilities.

Appendix: Natural Gas – Production and Distribution

receipt and delivery points. Under these specific design assumptions, maintaining operating pressures at or approaching the MAOP will ensure that existing shippers will receive their gas requirements.¹¹ However, as previously discussed, the changing load requirements and the capacity release market could potentially reduce the pipeline's ability to maintain optimum operating pressures to meet new demands on its system if the new loads are not proximate to the traditional markets. The potential impact of new markets could reduce the operational flexibility of the pipeline by reducing the operating pressure. If the pipeline cannot maintain historical operating pressures that are necessary to meet the requirements of its shippers, the throughput capacity of the pipeline will be reduced.

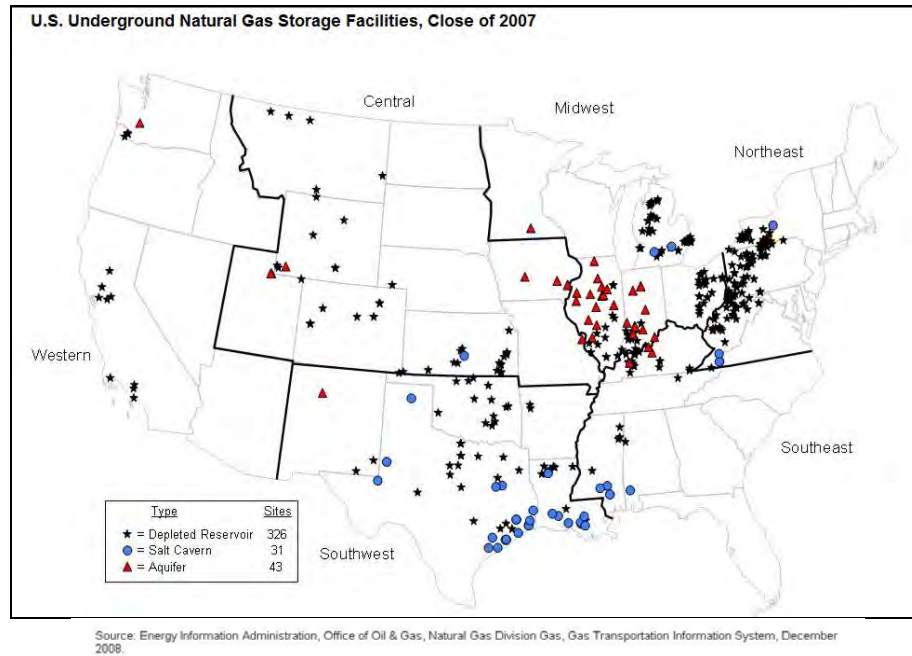
¹¹ Scheduled and unscheduled maintenance is not incorporated into the pipeline's design capacity. As a result, required maintenance will reduce the pipeline's ability maximize throughput capacity and could prevent the pipeline from meeting its firm contractual requirements.

FERC/NERC Staff Report on the 2011 Southwest Cold Weather Event

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Appendix: Natural Gas Storage

Natural gas, like many other sources of energy, can be stored during periods of low use and called upon during periods of greatest demand. There are over 400 underground storage facilities, eight LNG import facilities and over 100 LNG peaking facilities located throughout the U.S.¹



Base load vs. Peak load Storage Facilities

Storage facilities are designed to meet either base load or peak load requirements. Base load storage is designed to meet seasonal demand that exceeds the average deliverability of the pipeline system. Base load storage facilities have sufficient capacity to meet the long-term seasonal demand requirements for the pipeline's market areas. Historically, these storage facilities were used by the pipeline's customers to inject natural gas supplies into the storage facility during periods of low system use, such as the non-heating season (when gas prices are low), which typically runs from April 1 through October 31. These gas volumes were then withdrawn to meet base load requirements during the heating season, which usually runs from November 1 through March 31.²

¹ United States Energy Information Administration, *About U.S. Natural Gas Pipelines – Transporting Natural Gas*, available at http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/index.html (last visited July 20, 2011).

² This trend has changed in the last decade as newer and more efficient natural gas-fired electric generation facilities have replaced higher emission oil-burning facilities. As a result, more natural gas is needed during the spring and summer months to meet increased electrical demand for the summer cooling season. Now, instead of having one peak season, market areas served by some pipelines may have two peak periods, during both the summer and winter months.

Appendix: Natural Gas Storage

Base load storage facilities are usually large depleted oil or gas reservoirs that have relatively low withdrawal rates. They can provide a steady flow of natural gas and typically have turnover rates of once a year due in part to the length of time necessary to replenish the gas supplies. Depleted gas reservoirs are the most common type of base load storage facilities.

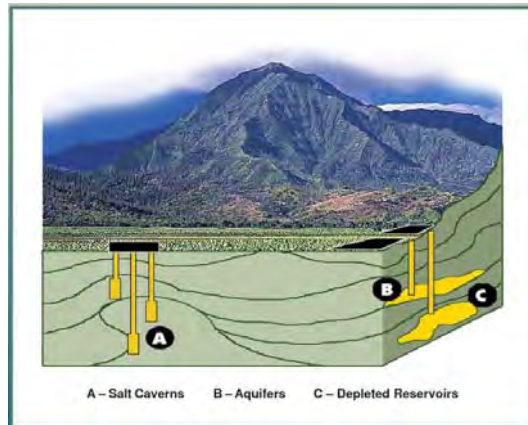
Peak load storage facilities, on the other hand, are designed to operate at high rates of withdrawal. These facilities are used to meet peak load requirements that can call for large amounts of gas over short periods of time. Peak load facilities are much smaller than base load facilities but can be quickly replenished – in some cases within days or weeks.

Different Types of Underground Storage Facilities

Three types of reservoirs or geological formations are used as underground storage facilities – aquifers, depleted reservoirs, and salt caverns. All of these formations must be developed or reworked in order to create the space necessary to provide the storage service. Natural gas is injected slowly into the formation through the use of compression facilities in order to build up the reservoir pressure necessary to allow the natural gas to flow freely from the storage facility directly into the downstream pipeline systems. Toward the end of the withdrawal season, when the prevailing reservoir pressures fall below the operating pressures of downstream pipeline systems, compression equipment that was used to inject gas volumes into storage is used to re-pressurize the gas stream so that gas from storage can be moved downstream into the pipeline systems.

Not all of the natural gas in storage facilities can be withdrawn. In order to maintain the integrity of the formation and to prevent migration of water into the reservoir, some natural gas must be left in the reservoir. This is typically called “base gas” or “cushion gas.” Similar to line pack in a natural gas pipeline, base gas is the volume of gas left in the reservoir to provide the pressure needed to extract the remaining gas. The gas that is withdrawn from the storage field is referred to as “working gas.” The amount of working gas within the reservoir represents the storage capacity of the facility.

Appendix: Natural Gas Storage



Types of Underground Natural Gas Storage Facilities (FERC)

Depleted Reservoirs

Depleted gas reservoirs are the most commonly used formations for storage reservoirs. These formations are formerly producing gas reservoirs that have had all of the economically recoverable natural gas extracted, and which can be readily converted from production to storage. However, to maximize the usefulness of the facility, the reservoir should be located near a market area (for base load or peaking facilities) or a supply area, (to supplement supply when production is interrupted). The reservoir also must be located near a mainline pipeline facility. Most depleted gas reservoirs are located in production areas, leaving aquifers and salt caverns as the only option for storage development in other areas.

Aquifers

Aquifers are underground porous, permeable rock formations that act as natural water reservoirs. A porous rock formation has small spaces between the grains of rock where natural gas, oil and water can be found. A permeable formation is one where liquid can flow through small channels that connect the small pore spaces within the formation. Aquifers are the least desirable and most expensive types of natural gas storage facilities for the following reasons:

- The geological formations are not as well known as depleted reservoirs, which are explored during the development and production process. Accordingly, there is a significant cost associated with developing and studying the geological characteristics of an aquifer in order to determine its suitability as a storage reservoir.
- Aquifers do not have in place the facilities and equipment associated with a producing gas reservoir, such as extraction equipment, pipelines, dehydration facilities, and compressors. Aquifers may also produce large

Appendix: Natural Gas Storage

volumes of water as natural gas is withdrawn from storage, increasing costs.

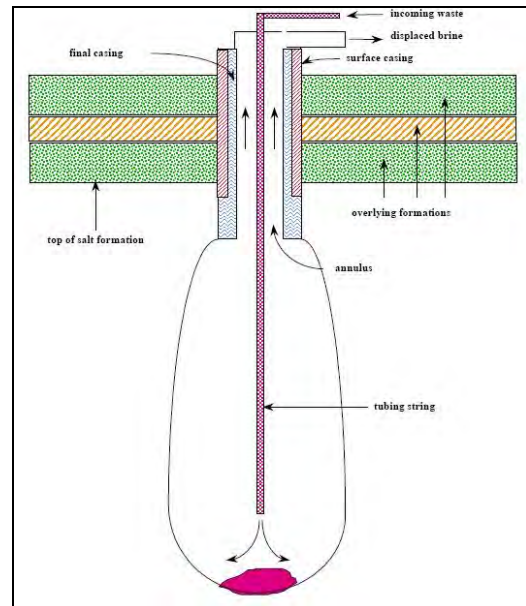
- Development of an aquifer as a gas storage facility can take twice as long as development of a depleted reservoir facility.

Salt Caverns

A salt formation is a naturally occurring deposit of salt that may exist in two forms: salt domes and salt beds. Salt domes are formations that have migrated through sedimentary geological formations to form large domes of salt. These domes can be a mile wide and 30,000 feet thick. Salt domes most often used as salt caverns are generally found about 6,000 feet beneath the surface. Salt beds are not as thick or as deep – these formations are usually less than 1,000 feet thick and are less stable than salt domes, but both formations are well suited to natural gas storage.



Salt Cavern Underground NG
Storage Reservoir
(Energy Information Administration)



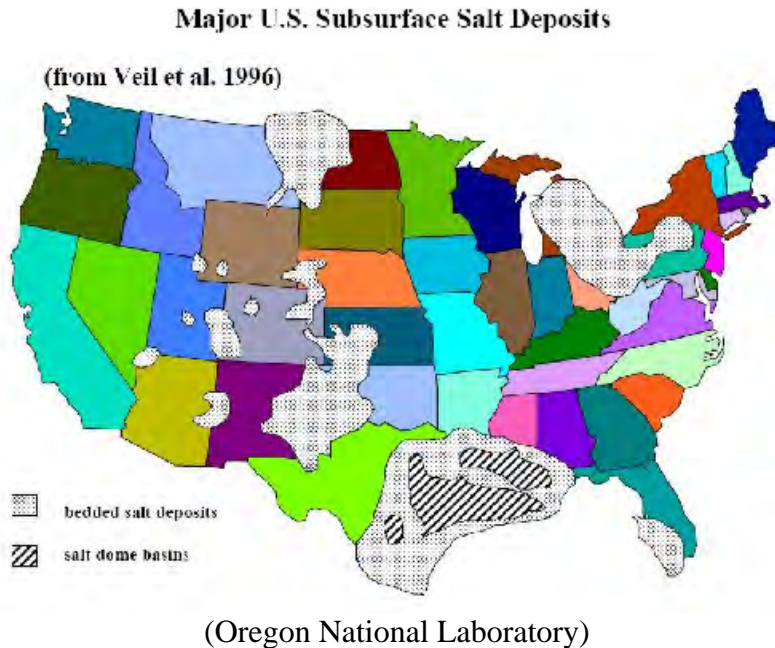
Salt Cavern Leaching
(Oregon National Laboratory)

Salt caverns are developed by drilling into the salt formation and circulating large amounts of water under high pressure to dissolve and extract the salt, leaving a large void. This process is known as “salt cavern leaching.”³ Once created, the salt cavern offers an underground vessel-like structure that can provide very high rates of delivery.

³ Salt Cavern Storage, *What is Salt Cavern Storage?* available at <http://www.saltcavernstorage.com/what-is-salt-cavern-storage.html> (last visited July 20, 2011).

Appendix: Natural Gas Storage

Salt caverns provide another operational benefit, in that they can operate with less base gas than depleted reservoirs and aquifers.



Because salt cavern storage reservoirs are typically much smaller than depleted gas reservoirs, they cannot hold the volumes necessary to meet base load storage requirements. However, because the deliverability of the salt caverns is typically much higher, gas stored in these facilities can be more quickly withdrawn and replenished than gas stored in any other type of facility.

LNG and LNG Peak Shaving Facilities

Liquefied natural gas (LNG) is natural gas that is stored and transported in liquid form at -260 degrees Fahrenheit. In liquefied form, the gas volume is reduced by a factor of 610. This reduction in volume makes the transportation and storage of liquefied natural gas more practical.

In order to introduce LNG into the pipeline system, the LNG must be warmed and re-gasified. This is done at specially built re-gasifier terminals attached directly to the interstate pipeline grid or to LDC distribution systems.

LNG can also be produced on a much smaller scale at liquefaction facilities, which receive natural gas directly from the pipeline system, convert it to liquid form, and store it in above ground facilities until needed to meet peak load requirements. These facilities are referred to as “peak shaving” plants.

Appendix: Natural Gas Storage



LNG Peak shaving plant (Energy Information Administration)

Appendix: Natural Gas Transportation Contracting Practices

Interstate natural gas pipeline rates for transportation of natural gas may be based on distance transmitted (zone matrix) or on a “postage-stamp” basis, where all consumers pay the same rate regardless of distance transmitted. Natural gas pipelines’ tariffs may contain rates based on a function of the volume reserved for a particular buyer (a set capacity charge) and a variable based on the pipeline volume actually consumed by the buyer (a commodity charge). Gas is sold by unit of energy, not by volume. Prices are usually stated in price per unit of energy, such as dollars per million British thermal units (Btu), rather than price per unit volume, such as dollars per thousand cubic feet (Mcf). Interstate natural gas transportation tariffs are often priced per thermal unit or energy unit, not on a volumetric basis.

The wholesale market is composed of both the natural gas commodity market and the transportation market. Since 1984, when FERC Order No. 436 was issued, large numbers of industrial customers, electric generators, and end use customers have been buying gas from parties other than the pipelines or LDCs. After the issuance of FERC Order No. 636 in 1992, the industry witnessed a dramatic growth in the use of marketers to provide gas, arrange transportation, or provide both services to LDCs, industrials, retail users, and electric generators.

Gas customers use marketers in a variety of ways. LDCs, which hold firm transportation rights on a single pipeline, can use the marketer to obtain and deliver gas to an interconnect point on that pipeline, and the LDC can use its firm transportation service to deliver that gas to its citygate delivery point. Other customers, such as industrials, may employ a marketer to acquire gas and interstate transportation service to deliver the gas to the industrial’s citygate delivery point. Increasingly, marketers are offering additional services to customers such as asset management services, where the marketer manages capacity for LDCs, as well as providing price hedging, financing, and risk management services.

The transportation market also has developed to provide shippers with alternative means of acquiring capacity. Shippers can choose either short or long-term services from the pipeline or can acquire capacity from other shippers through the capacity release mechanism.

The use of released capacity has made possible the development of virtual pipelines. A virtual pipeline can be created when a marketer or other shipper acquires capacity on interconnecting pipelines and schedules gas supplies across the interconnect, creating in effect a new pipeline between receipt and delivery points not on a single pipeline company’s system.

Appendix: Natural Gas Transportation Contracting Practices

Nominations, Confirmations, and Scheduling

The North American Energy Standards Board (NAESB) is an independent, industry-supported entity whose primary purpose is to set business standards across the industry. The Commission's standards relating to nominating, confirming, and scheduling gas across the interstate pipeline system were developed by industry representatives in conjunction with NAESB. The nomination, confirmation, and scheduling processes control the movement of gas across the interstate pipeline system.

Nominations

A nomination is a request for service under any transportation agreement by a gas purchaser (referred to as the shipper) to transport gas from a specified receipt point to a specified delivery point over a specific time period. In short, a nomination is the request for space in a pipeline to ship gas. Pipelines use the nomination process to coordinate and reconcile gas from different shippers on their pipelines.

A shipper purchases capacity on a pipeline by entering into a service agreement with that pipeline. For example, a shipper may have a firm transportation agreement with Pipeline A for 100,000 dekatherms (DTH) per day of service. Since the agreement is firm in nature, as opposed to interruptible, the shipper pays for that full capacity whether it uses it or not, and has priority for that capacity on the pipeline.

On a given day, the shipper may not need the full 100,000 DTH of capacity, but might need, for instance, 75,000 DTH to meet its needs. The shipper will thus nominate 75,000 DTH for that day, and the pipeline can then schedule the unused 25,000 DTH of available pipeline capacity to another shipper as interruptible transportation.

The industry-standard gas day begins each day at 9:00 AM central time, and runs for 24 hours. In order to standardize nominations across the interstate pipeline system, FERC has implemented four time cycles where shippers may nominate gas (or change their nominations) over the course of each gas day. These nomination cycles follow the NAESB standards. While this is the minimum number of nomination cycles that a pipeline must have in its tariff, some pipelines offer more nomination options.

The first of the four standard nomination times is the "timely nomination cycle." Under the timely nomination cycle, shippers must make their nominations

Appendix: Natural Gas Transportation Contracting Practices

by 11:30 AM the day before the gas is to flow. The pipeline will acknowledge receipt of the nomination by 11:45 AM and will issue its final confirmations by 3:30 PM and post scheduled quantities by 4:30 PM. Gas under the timely nomination cycle will flow at 9:00 AM the following morning, which is the beginning of the gas day.

The second nomination cycle – which also occurs prior to gas flow – is the “evening nomination cycle.” Shippers must make their nominations for this cycle by 6:00 PM the day before gas flows, and the pipeline will acknowledge receipt of the nomination by 6:15 PM, issuing its final confirmations by 9:00 PM and posting scheduled quantities by 10:00 PM. Gas under the evening nomination cycle will flow at 9:00 AM the following morning. During the evening nomination cycle, the firm shipper can adjust his nomination to his full contractual capacity for the next day, taking precedence over, or “bumping,” an interruptible shipper’s nomination.

The two remaining cycles are known as intra-day nomination cycles, since they occur while gas is flowing during the same gas day. Under the intraday 1 nomination cycle, shippers must make their nominations by 10:00 AM on the gas day. The pipeline will acknowledge receipt by 10:15 AM, issue its final confirmations by 1:00 PM, and post scheduled quantities by 2:00 PM. Gas under the intraday 1 nomination cycle will flow at 5:00 PM on that gas day. The same bumping procedures apply to the intraday 1 nomination cycle. The intraday 1 nomination cycle is the first opportunity for shippers to adjust their gas flows during the gas day.

For the intraday 2 nomination cycle, shippers must make their nominations by 5:00 PM, and the pipeline will acknowledge receipt of the nomination by 5:15 PM, issue its final confirmations by 8:00 PM, and post scheduled quantities by 9:00 PM. Gas nominated under the intraday 2 nomination cycle flows at 9:00 PM on the same gas day.

Bumping rights do not apply to the intraday 2 nomination cycle. FERC implemented this no-bumping rule for the intraday 2 nomination cycle because shippers bumped this late in the gas day would be unlikely to be able to arrange alternative transportation.

Confirmations

Once a nomination is received by the pipeline or the party providing the requested service, the nomination must be confirmed. The confirmation process verifies that (a) the shipper agrees to supply the nominated quantity to the pipeline

Appendix: Natural Gas Transportation Contracting Practices

for transportation, and (b) the pipeline agrees to transport the nominated quantity, based on the availability of capacity. The confirmation process provides a degree of assurance to the parties that gas will be delivered, and is also important for record keeping purposes.

Scheduling

For each nomination cycle, once the shippers nominate gas on a particular pipeline, it is the pipeline's responsibility to schedule the gas. Scheduling refers to the process by which nominations are consolidated by receipt point and by contract, and verified by upstream and downstream parties. If there is enough capacity to accommodate all nominations, then all nominated quantities will be scheduled. If the nominated capacity exceeds the available capacity on a pipeline, quantities will be allocated according to what is referred to as scheduling priorities. Shippers with a higher priority service will receive their capacity before shippers with a lower priority service.

Scheduling priorities for each pipeline are set forth in that pipeline's tariff. Although scheduling priority specifics may differ from pipeline to pipeline, all follow a general priority model. In general, primary firm shippers are given highest priority. Firm shippers are shippers that have entered into firm transportation agreements with pipelines. Firm shippers reserve a volume of capacity on a pipeline and pay for that capacity whether they use it or not. Each transportation agreement specifies a primary receipt and delivery point for service under the agreement. In some cases, the agreements may set forth multiple primary receipt and delivery points that can be used. When the shippers take service under the primary receipt and delivery points set forth in the agreement, they are considered primary firm shippers, and receive the highest priority of service.

In general, secondary firm shippers are given the second highest service priority. Under FERC policy, shippers may use receipt and/or delivery points for service other than the primary points set forth in their agreements, but only if capacity is available at those points. These alternate points are referred to as secondary points. In general, when a firm shipper takes service under secondary receipt and/or delivery points, that shipper no longer has the highest priority of service, but rather the second highest service priority. These secondary firm shippers get their gas scheduled after the primary firm shippers.

Interruptible shippers are generally given the third highest priority service. Interruptible service is service that is not guaranteed. Whereas firm shippers pay for the capacity whether they use it or not (and are given highest priority on that

Appendix: Natural Gas Transportation Contracting Practices

capacity), interruptible shippers only pay for transportation capacity when it is used.

Pipelines implement various methods for allocating interruptible capacity. One method is to schedule interruptible nominations *pro rata*, whereby all shippers with interruptible capacity have a proportional share of their capacity scheduled. Another method is based on economic ranking, where shippers who pay more for their interruptible capacity receive priority over shippers who pay less. A particular pipeline's practices for scheduling interruptible capacity will be set forth in the priority provisions of its tariff.

Nominations and Scheduling on Intrastate Natural Gas Pipelines

The NAESB standards do not apply to intrastate pipelines, which follow their own scheduling practices. Only thirteen percent of the member companies of the Texas Pipeline Association that responded to an informal poll reported that they accept electronic nominations, and none indicated that they follow the NAESB standards.

In Texas, intrastate pipelines schedule gas transportation five days a week, with no weekend scheduling. Some intrastate pipelines do not schedule volumes at particular delivery points on their systems, but instead accept nominations from customers, typically LDCs, that can have hundreds of delivery points. These customers do not schedule volumes at a particular point, but submit a nomination that covers all of their points, with the right to obtain delivery at any of them.

The Commission requires major non-interstate pipelines to post scheduled volumes no later than 10:00 PM central time the day before gas is to flow. This deadline occurs after interstate natural gas pipelines are required to post their evening cycle schedule confirmations by receipt and delivery point.

Imbalances

A point imbalance is the difference between the volume of gas that is scheduled to flow at a receipt or delivery point, and the volume of gas that actually flows through the point (typically determined by meters). A transportation imbalance is the difference between net receipts under a specific agreement (total receipts minus any fuel receipts), and total deliveries made under a specific agreement. When an imbalance occurs on a pipeline system, the pipeline must resolve that imbalance to keep all parties whole. There is no single method pipelines use to handle system imbalances. Instead, each pipeline resolves

Appendix: Natural Gas Transportation Contracting Practices

imbalances in accordance with the imbalance provisions set forth in its FERC NGA Gas Tariff.

Operational Balancing Agreements

An operational balancing agreement (OBA) is a contract between two physically interconnected parties specifying the procedures to be used in processing imbalances or differences in hourly flows between the parties. An OBA ensures that a shipper, once it has properly nominated and had its gas confirmed, will not be subjected to imbalance penalties resulting from the transfer of gas between the pipelines. In Order No. 587-G, the Commission adopted a requirement that each interstate pipeline enter into an Operational Balancing Agreement at all points of interconnection between its system and the system of another interstate or intrastate pipeline. That requirement is codified in section 284.12(b)(2)(i) of the Commission's regulations.



***Impact of Cold Weather on Gas Production in the Texas
and New Mexico Gas Production Regions of the United
States During early February, 2011***

Winterization Document

Prepared for Federal Energy Regulatory Commission

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July, 2011

Table of Contents	Page
Introduction	5
The Phenomena of Wellhead Freezing and Cold Weather Impact on Gas Production Operations	5
Potential for Freezing - Within the Reservoir, Wellbore and Wellhead	6
Potential for Freezing - Gas Well Production Facilities Located at or Near the Wellhead	9
Potential for Freezing - Gas Gathering System Including Compressor Stations and Gas Processing Plants	11
Prevention of Wellbore, Wellhead and Production Facilities from Freezing – General Discussion and Description	16
Alternatives to Cold Weather Control Techniques	25
Discussion of Gas Hydrates Formation	26
Gas Quality Considerations and Gas Processing	28
Discussion of Cost Implications to Winterize Gas Wells – Per Well Cost and Per Field Cost Cold Weather Production Equipment	30
References	37

Figures	Page
Figure 1 - Schematic of Gas Reservoir (Barnett Shale as example), Wellbore and Wellhead Flow Paths to Production Facilities	7
Figure2 - Gas Well Producing Location with Typical Equipment for Gas Production Operations– Does Not Include Gas Processing or Compressor Station	10
Figure3 - Gas Flow Diagram – Dry Gas from Dehydration Facilities through Gas Compression and Gas Processing Plant	12
Figure 4 - Natural Gas Compressors within the U.S. Natural Gas System	13
Figure 5 - Fully Enclosed, Insulated and Heated Compressor; For Cold Weather Environments	14
Figure 6 - Flowchart for A Gas Processing Facility – Illustrates the Complexity Of the Process and the Many Steps That Can Be Required	16
Figure 7 - Methanol Injection Pump Utilized to Inject Methanol into a Wellhead and/or Flow Line to Prevent Freezing and Hydrate Buildup	18
Figure 8 - Fiberglass Housing Surrounding Production Equipment at Gas Storage Field in Midwest United States	19
Figure 9 - Gas Wellhead with Insulation on Flow line to Protect Freezing	20
Figure 10 - Gas Production Wellhead and Production Equipment In Northern Region of United States Winterized for Cold Weather Operations	21
Figure 11- Pipeline Pig Inside of Cut out Section of Pipeline	22
Figure 12 - Pipeline Pig Launch and Receiving Station	23
Figure 13 - Typical Wellhead in Warm Climate	25
Figure 14 - Hydrate Photos – Inset is the Water-Methane Hydrate Structure	27
Figure 15 - Methane Hydrate Phase Diagram	28
Figure 16 - Barnett Shale Gas Development Area near Dallas, TX	31

Tables	Page
Table 1 – Points of Freezing Potential in the Reservoir, Wellbore and Wellhead	16
Table 2– Potential for Freezing – Gas Well Production Facilities Located at or Near the Wellhead	10
Table 3 – Barnett Shale Gas Compositions	29
Table 4 - Winterization Equipment Cost for a Gas Well Located in a Cold Climate	33
Table 5 – Cumulative Cost for Winterizing Gas Wells – Variable Well Counts and Individual Well Equipment Cost.	35
Table 6 – Itemization of Capital and Operating Expenses for a Typical Gas Well	36

Introduction

Colder-than-normal weather during the first week in February led to the biggest non-hurricane natural gas supply disruption in the United States since at least 2005.

Due to a combination of well freeze-offs (gas flow blockages resulting from water vapor freezing in the gas stream) and other temperature-related well failures, processing plant shutdowns, electric power outages, and pipeline operational issues, estimated daily natural gas production fell from about 62 billion cubic feet per day (Bcfd) to less than 57 Bcfd, a decrease of 8%. (Ref. 1)

The cold weather likely impacted thousands of natural gas wells in Texas and Louisiana, home to one-third of U.S. gas production. Because it rarely freezes in these southern U.S. latitudes gas wells aren't built to withstand the phenomenon called "well head freeze off." That's when the small amount of water produced alongside the natural gas crystallizes inside pipelines, completely blocking off the flow and shutting down the well.

In particular, along with the cold weather came severe icing conditions. Icy roads inhibited the movement of water hauling trucks in particular and the ability to access wellheads. The result was that fail safe switches on water and condensate storage tanks at wellheads and at compressor stations were activated. The fail safe switches are designed to shut down operations to prevent spills. (Ref. 2)

This report focuses on gas well winterization technology that is deployed in colder climates and discusses to what degree they might be applied to the impacted production areas (Texas and New Mexico) addressed with this study.

The Phenomena of Wellhead Freezing and Cold Weather Impact on Gas Production Operations

Freezing is a potential and serious problem starting at the production wellhead through the last point in the customer delivery system. The occurrence of freezing is continuously reduced each step of the way, but care must be taken at each and every step to assure smooth operational conditions and satisfied consumers at the end of the line. Freezing not only affects the wellhead and gas pipeline but is also a significant contributor to measurement errors, instrumentation upsets or failures and other regulation equipment that can be found at compressor stations, gas processing plants, regulator stations and other critical points of operation. (Ref. 3)

Many criteria can have an impact on the freezing issue including:

- Gas quality and composition
- Wellhead and wellbore design and configuration
- Piping designs, regulation or restriction points

- Instrument take-off points
- Other

Three areas will be reviewed as to the potential for freezing due to cold weather conditions:

1. The reservoir, wellbore and wellhead environment.
2. The gas well production facilities located at or near the wellhead.
3. The gas gathering system including compressor stations and gas processing plants.

Potential for Freezing - Within the Reservoir, Wellbore and Wellhead

Natural gas resides in geologic formations for time periods of millions of years (geologic time). Over this extended time period the gas becomes saturated with water. The volume of water that natural gas can carry as water vapor is a function of pressure, temperature and gas composition. Figure 1 is a schematic of a gas reservoir (Barnett shale in this example), its gas quality, reservoir conditions and gas flow pathway from the reservoir to the surface. The gas flows from the reservoir through perforations in the pipe (casing) and then up through the production tubing, through the wellhead and then to production facilities.

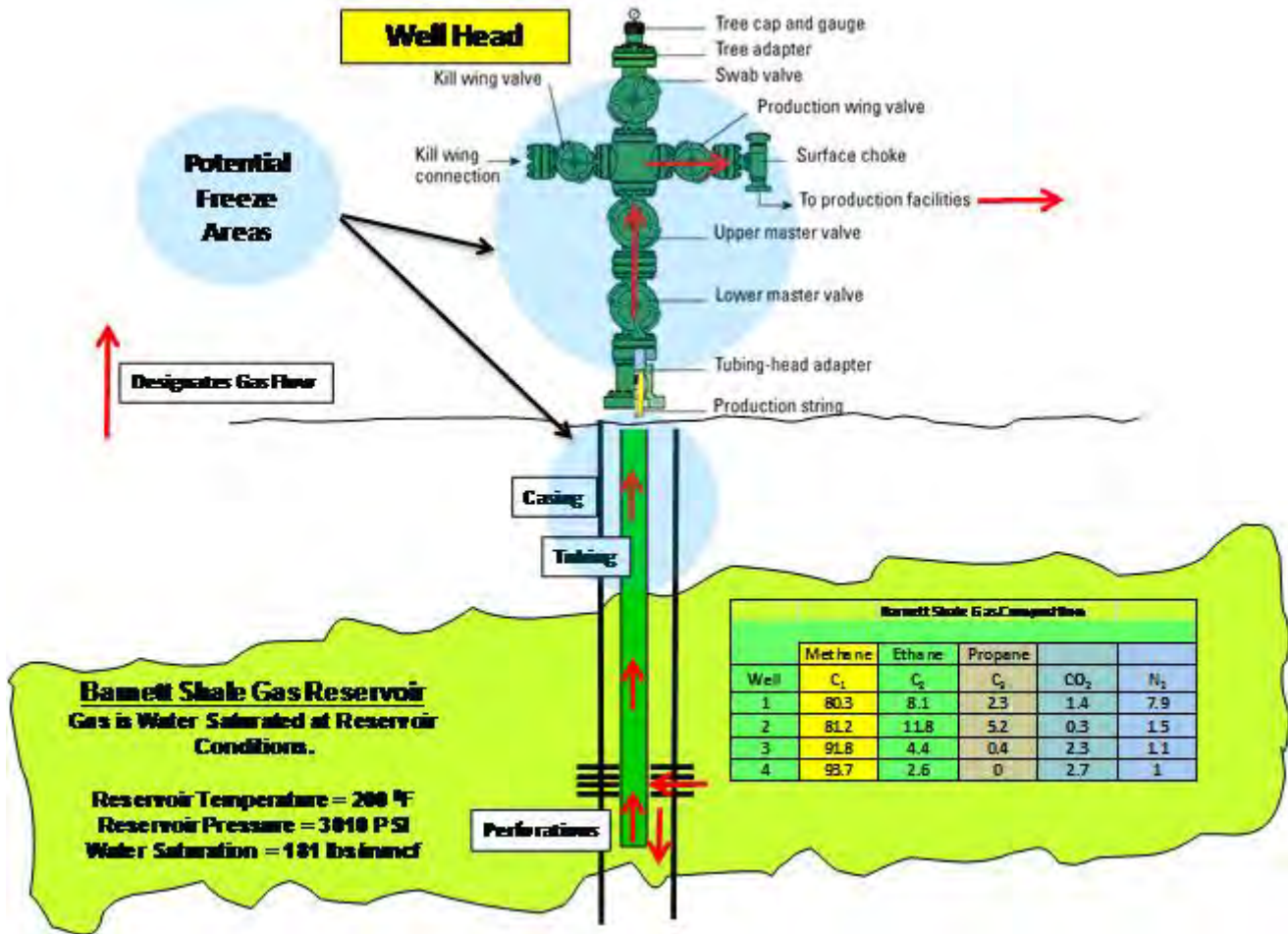


Figure 1 – Schematic of Gas Reservoir (Barnett Shale as example), wellbore and wellhead flow paths to Production Facilities, (Ref. 4&5) (Figure from GTI)

Under the Barnett example reservoir conditions the gas can hold as much as 181 lbs of water per mmcf of natural gas. For production operations, 7 lbs of gas per mmcf is considered to be dry gas, or at least dry enough for safe and efficient transportation of the gas without undo problems due to water fallout or freezing. Many natural gas compositions include not just methane CH₄ but also heavier hydrocarbons such as ethane and propane. In the Barnett example, the composition of well #2 contains over 11% ethane and 5% propane. The existence of these heavier hydrocarbons can facilitate the formation of hydrates (a combination of hydrocarbons and water that form ice under conditions well above freezing). Hydrates are discussed in more detail later but for this discussion can be thought of as ice capable of reduction or complete blockage of gas flow. (Ref. 4 &5)

As the gas flows up the production tubing and nears the surface it experiences a drop in pressure and can also be cooled by gas expansion (Joule Thompson effect) and exposure to cold ambient temperatures at the surface. The Joule-Thomson rule of temperature effect as a result of pressure reduction is such that temperature will decrease approximately 7 degrees Fahrenheit for every 100 psi

pressure reduction. As an example, if you can have gas flowing at 60 degrees Fahrenheit and 700 psi and you may have no evidence of freezing. If you pass through a flow choke and cut the pressure to 225 psi, the flowing temperature at the point of regulation will drop 33 degrees to approximately 27 degrees Fahrenheit. If the gas stream is saturated with water vapor and condensate, you will quickly experience freezing. The gas stream is the same, but conditions have changed and icing problems can impact your operations. (Ref. 3 &4)

The presence of ice or hydrates can not only shut off the pipeline, but can also alter measurement. If ice forms on the rim of the orifice plate, the flow measurement will be in error as a result of the reduced orifice diameter. If ice forms in the instrumentation supply lines, controllers will cease to function causing a loss of control of the system. Ice can block off sensing ports and other vital instrument readings. Once the ice begins to thaw, problems are still going to be present. On the initial start-up of a new or cold well, probes, intrusive instruments and orifice plates should have been removed from the pipeline. Large balls of ice traveling down the pipeline can do physical damage to the pipeline itself and to any object protruding into the pipeline such as sample probes, temperature probes, meters, orifice plates and similar intrusive devices. After the flowing stream has stabilized and temperature conditions are above the hydrate point, these items can be safely re-installed. (Ref. 3 &4)

The likely areas for icing and/or hydrate buildup and the typical solution for these problems as applied in cold weather climates are described in Table 1. See also Figure 1.

Table 1 – Points of Freezing Potential in the Reservoir, Wellbore and Wellhead (Ref.4)

Point of Freezing Potential	Cause of Freezing	Solution
Near Surface Wellbore	As the natural gas travels from the reservoir to the surface, cooling can occur due to gas expansion and exposure to colder temperatures near the surface.	Methanol is injected into the flow stream at the wellhead. The flow of methanol is down the wellbore annulus and then is carried up the gas flow stream through the wellhead preventing freezing.
Wellhead including Wellhead Valves	At the wellhead a change in flow path size can change causing an increase in velocity and cooling. Well head also exposed to surface weather conditions.	Solution is as above, methanol injection. In some cases the wellhead can be completely enclosed in a small building or “hut”, insulated and heated, but methanol is the most practiced solution.
Wellhead Chokes	Wellhead chokes are points at the wellhead where flow and pressure is primarily controlled. Significant pressure	As above with methanol application. Also, wellhead design should consider choke points and avoid wherever

	drop often occurs and expansion cooling can be severe. This cooling combined with cold ambient temperatures can cause significant freezing issues.	possible.
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Potential for Freezing – Gas Well Production Facilities Located at or Near the Wellhead

The basic flow of natural gas from a wellhead through the processing equipment and to the gas sales distribution system is illustrated in Figure 2. Note that this is described as a typical configuration keeping in mind that variations to equipment placement and metering occur dependent upon the number of wells, their proximity to each other, well ownership and other factors.

Referencing Figure 2, when gas leaves the wellhead it sometimes flows through a line heater which will warm the gas, any gas condensate and water within the flow stream, mitigating freezing and facilitating the separation of these three phases. (Line heaters are not always deployed in warmer production climates unless large flow volumes requiring pre-heating before separation of phases are experienced). The flow stream next enters the production separator (sometimes described as a heater treater) where gravity, heat and flow through mesh material separate the gas condensate from gas and from water. The condensate and water flow to storage tanks through liquid meters in some cases, or alternatively volumes are measured directly within the storage tank. These liquids are marketed by truck or pipeline in the case of condensate and the water sent to disposal facilities by truck or pipeline dependent on volumes and distances.

The gas flow stream exits the top of the production separator and flows to the dehydration unit. It is noted that the gas, while free of liquid phase water and condensate at this stage, is still saturated with liquid vapors notably water. Gas flows into a dehydration unit for removal of water or dehydration of the gas, drying it to normally 7 lbs/mmcft or less allowing for transport without freezing and water fallout issues. The normal dehydration process utilizes glycol which absorbs the water from the gas leaving the hydrocarbons within the flow stream. The glycol when saturated with water is sent to a glycol reboiler that through application of heat boils off the water. The dry gas is now metered and flows to the gas gathering system. (Ref. 4&6)

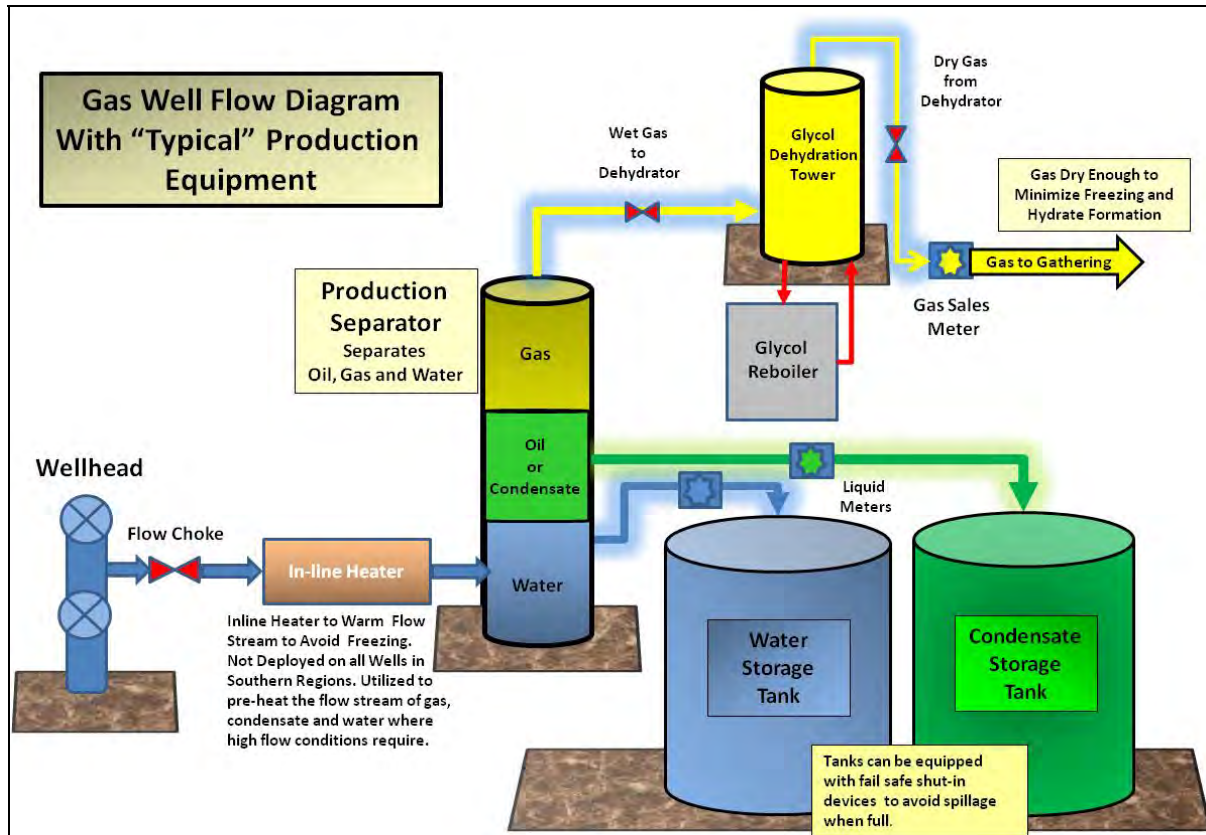


Figure 2 – Gas Well Producing Location with Typical Equipment for Gas Production Operations – Does not Include Gas Processing or Compressor Station. Production Equipment is Equipped with Fail Safe Devices to Shut-in Production to Avoid Spillage and Equipment Damage - (Ref. 4&6). (Figure from GTI)

The likely areas for icing and/or hydrate buildup and the typical solution for these problems as applied in cold weather climates are described in the following Table 2. See also Figure 2.

Table 2– Potential for Freezing – Gas Well Production Facilities Located at or Near the Wellhead. (Ref. 3, 4&6)

	Cause of Freezing	Solution Utilized in Colder Gas Production Regions
Flow lines from wellhead to line heater. If no line heater (common in warmer regions)	Exposure to low surface temperatures, gas has cooled due to expansion, gas contains water and heavier hydrocarbons which are prone to freezing or hydrate development.	Methanol injection, line heating, maintaining level flow lines to avoid liquid build-up, and limit choking points. Additional protection is usually required including insulating

Appendix: GTI Report

then flow line to separator.		flow lines, wrapping with heat tape or glycol tubing under the insulation.
Production Separator	The production separator has equipment and instrumentation that can be impacted by cold weather. Gas, water and condensate flow throughout the unit. It is exposed to surface temperatures.	The unit is sometimes placed in a heated housing unit or hut. Alternatively, a cold weather version needs to be utilized. The cold weather unit is designed such that all piping and potential freeze instruments are internalized to the unit or insulated.
Gas Flow lines to Dehydration Facilities	If exposed these lines, which are still carrying water saturated gas and other hydrocarbons are prone to freezing and hydrate formation. This can take place in a particularly exposed portion of the line or at a bend or reduction in line size.	Sometimes these lines can be buried if it is some distance to the dehydration facility. This alone may not be adequate and insulation and heating may be required. A methanol injection point can be designed into the flow scheme if a particular area becomes a problem.
Flow Line to Sales Meter and Meter	The gas flowing to the sales meter has now been dried and is much less prone to freezing. The gas however can still be comprised of ethane and higher hydrocarbons as well as CO ₂ or N ₂ or other constituents. Depending on conditions of T & P Hydrates can still form despite dry (water content) gas.	Hydrate control can be achieved through application of heat, housing the meter and protecting from weather, methanol injection and other techniques described for managing wet gas freezing.
Condensate and Water Lines and Storage Tanks.	The lines to the storage tanks are at low pressures and the water is usually brine so freezing and hydrates are not as much of an issue. Depending on fluids and climate however some freezing can occur. If this takes place in the flow lines it can disrupt the separator causing production shut-in.	These lines can be insulated or in severe conditions heated with electric tape or glycol tubing. The tanks themselves do not normally present a problem.

Potential for Freezing - Gas Gathering System Including Compressor Stations and Gas Processing Plants.

After natural gas leaves the wellhead and wellhead production site it continues flow downstream through the natural gas system (Figure 3). Along the way, gas compression is required to maintain pressure and gas processing is applied to further dry the gas and remove heavy hydrocarbon components. Each is discussed further in this section.

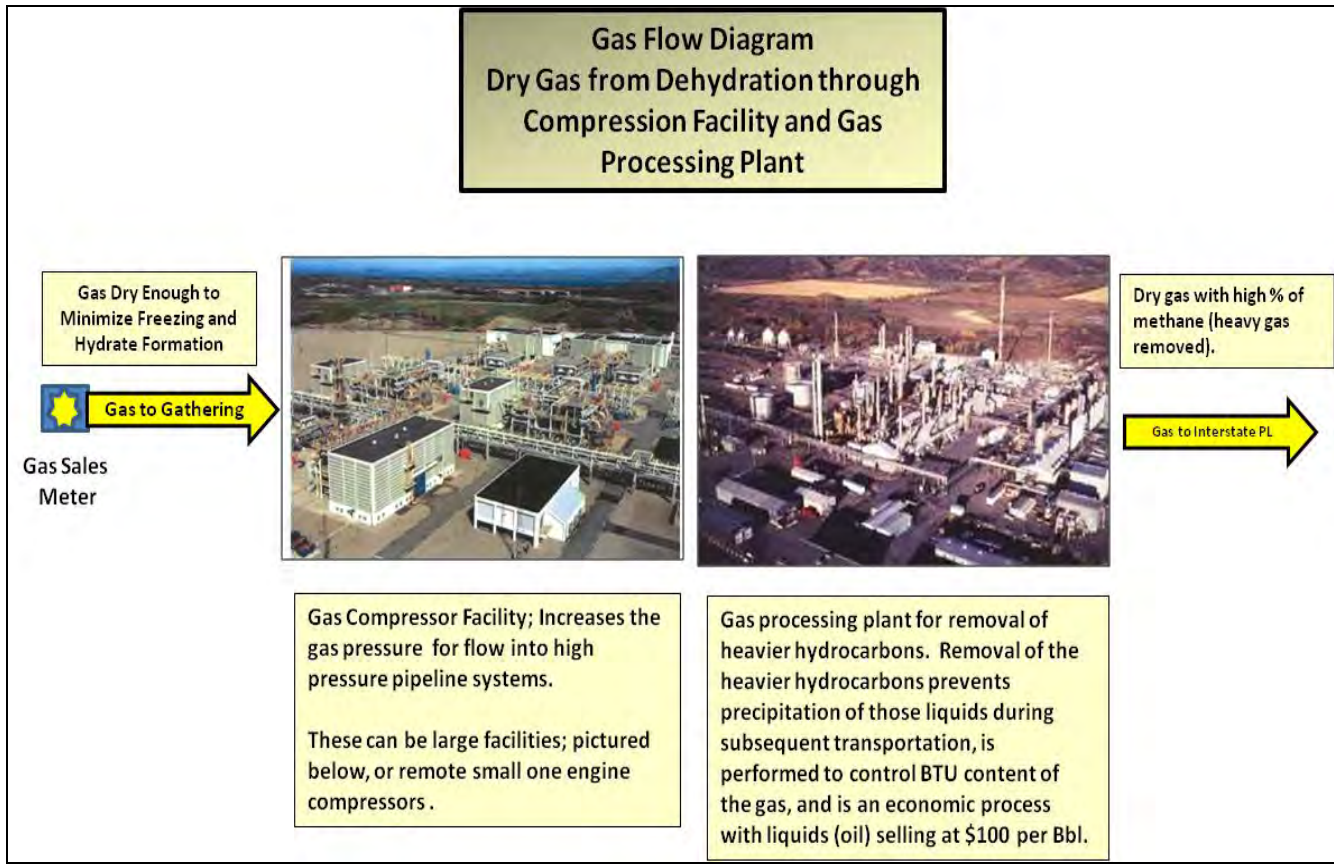


Figure 3 – Gas Flow Diagram – Dry Gas from Dehydration Facilities through Gas Compression and Gas Processing Plant. (Figure from GTI and ABB Oil and Gas and Duke Energy Canada)

Compression - After the natural gas stream leaves the dehydration facility it will at times flow through a compression facility or single compressor. The purpose of this is to boost the pressure of the gas such that it is able to flow into a sales line that is at higher pressure. The natural gas industry utilizes a large number and wide variety of compressors. Overall greater than 45,000 compressors are in place in the United States (Figure 4) (Ref. 7).

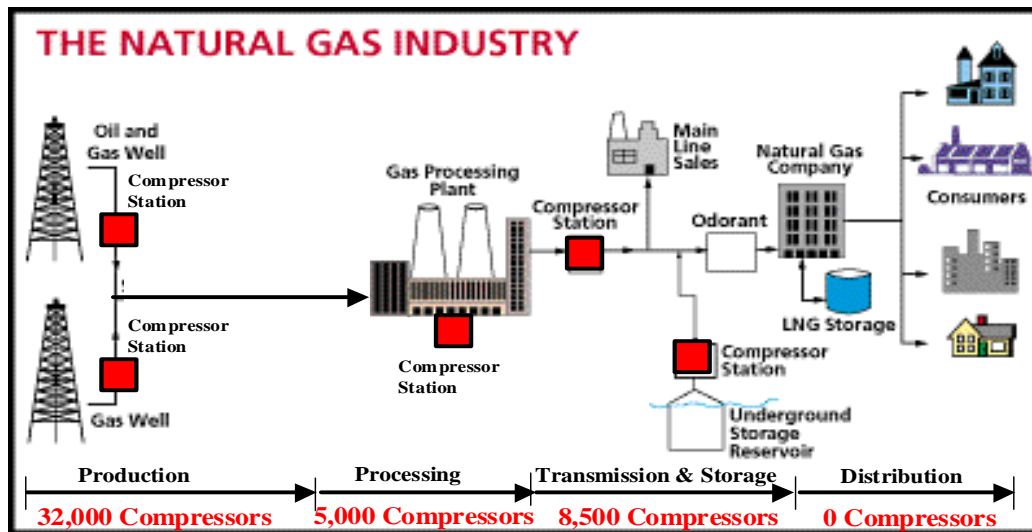


Figure 4 – Natural Gas Compressors in the U.S. Natural Gas System (Ref. 9) (Diagram from Wikimedia Commons)

Compression facilities range from small single compressors to large facilities handling large volumes of gas at aggregation points. The compression facilities within a producing gas field will change with time due to several factors:

- The drilling of new wells over time introduces increased gas volumes in a gas producing region.
- Existing wells will decline in gas production volumes over time reducing gas volumes.
- Gas flowing from the wellhead is initially at high pressure but then declines as gas is produced. This decline can be very rapid for the newer gas shale wells being developed, requiring compression facilities to be installed at appropriate points to keep wells flowing.
- The older well flow rates (at low pressure) will be reduced by the high pressure new wells in the absence of compression facilities. It is under these circumstances that new and sometimes remotely located compressors are installed.

The overall effect of these changing conditions is that compressors may need to be installed, removed or resized based on the many factors impacting their size and number requirements.

The impact of cold weather on compressor stations can vary. Compressor stations all have safe guard instrumentation that senses temperature, pressures and flow rates. If pressure, as an example, gets too high or too low, the compressor will shut itself down to prevent expensive damage. These instrumentation processes can be impacted by cold weather. In colder climates, compressors can be housed to protect against any severe weather conditions (Figure 5). The majority of these compressors are fueled by natural gas as it is readily available due to it being the medium being compressed and transported. (Ref. 4, 7, 8)

Compressor stations take low pressure gas and increase the pressure significantly which is accompanied with temperature increases of the gas flow stream. Changes in pressure and temperature will cause additional liquids to drop out of the gas stream. The temperature and pressure conditions can vary considerably at these facilities. Some of the variables and conditions involved include:

- Pressure changes can occur; pressures can be dropped to manage the inlet pressure conditions to the compressor. High pressure and low pressure wells may be feeding the inlet side of the compressor. These well pressures are brought into balance at the inlet section of the compressor by dropping some well pressures to balance with the low pressure wells.
- The drop in pressure can cause gas cooling (Joule Thompson effect).
- Increasing pressure through the compression facility can cause gas heating.
- Temperatures and pressures are monitored throughout the compressor system and automatic shut down devices will be activated if they deviate from a defined range (too high or too low).
- Many of these changes can cause liquids (water and condensate) to condense from the gas stream and need to be removed and stored in nearby storage tanks.
- The storage tanks must be emptied on a regular schedule or fail safe shut-in devices will activate.

In urban areas (Dallas Ft. Worth as an example) electric compression is sometimes required due to noise limitations or emissions constraints. These facilities in particular are subject to any reduction in electric power due to weather or other conditions. There are some electric compression facilities in the Ft. Worth area but not in large enough numbers to have significant impact on gas production. (Ref. 4, 7, 8, 9)



Figure 5 - Fully enclosed, insulated and heated compressor; for cold weather environments. The unit offers metering, separation, and compression, all on one skid. (Photo Wikimedia Commons)

Larger compressor facilities are located at gas aggregation points where larger volumes of gas are compressed to higher pressures. These can be complex facilities with extensive piping, metering, and instrumentation. Cold weather can impact these facilities similar to smaller, more remote facilities. The incentive to weatherize however is greater at these locations due to the size and gas flow rates they address. There is an economic incentive as well as a reliability of service incentive to maintain flow at these aggregation points. The technology is readily available for winterization of these facilities and is commonly applied in colder regions of the country. As with the wellhead and production sites, the weatherization approach is a combination of heating important components via electric supply or warmed liquid flow (glycol), insulation of components, housing critical portions of the facility, injection of anti-freeze type chemicals (methanol), drying of the gas flow components, drying instrumentation gas via desiccants or other drying medium, or a combination of these techniques. (Ref. 4, 6)

Gas processing plants function to remove heavier hydrocarbons from the gas stream. These include ethane, propane, butane and others. There are three factors that drive the gas processing business:

1. The need to control gas heating value (BTU). Gas going into most end use functions (residential, commercial) requires gas within a certain BTU range which is often a narrow window around 1000 BTU/Ft³ of gas.
2. For gas to be transported long distances through interstate pipeline systems it needs to be relatively free of heavier hydrocarbons. The heavier constituents will eventually precipitate during the pressure ups and downs encountered during long distance transportation. They then form liquids inside of the pipeline causing an unwanted pressure drop, freezing (through hydrate formation) or other interference.
3. With high oil prices, liquids are more valuable than natural gas. Therefore an economic incentive exists to remove the heavier hydrocarbons and sell into the liquids market as opposed to keeping them in the gas phase and selling based on BTU value alone.

These plants can be very complex (Figure 6) with extensive piping, processing units, regulators, instrumentation and other components. Many of these components can be impacted by weather conditions and to assure ongoing processing plant operation must be protected against weather. (Ref. 4, 10)

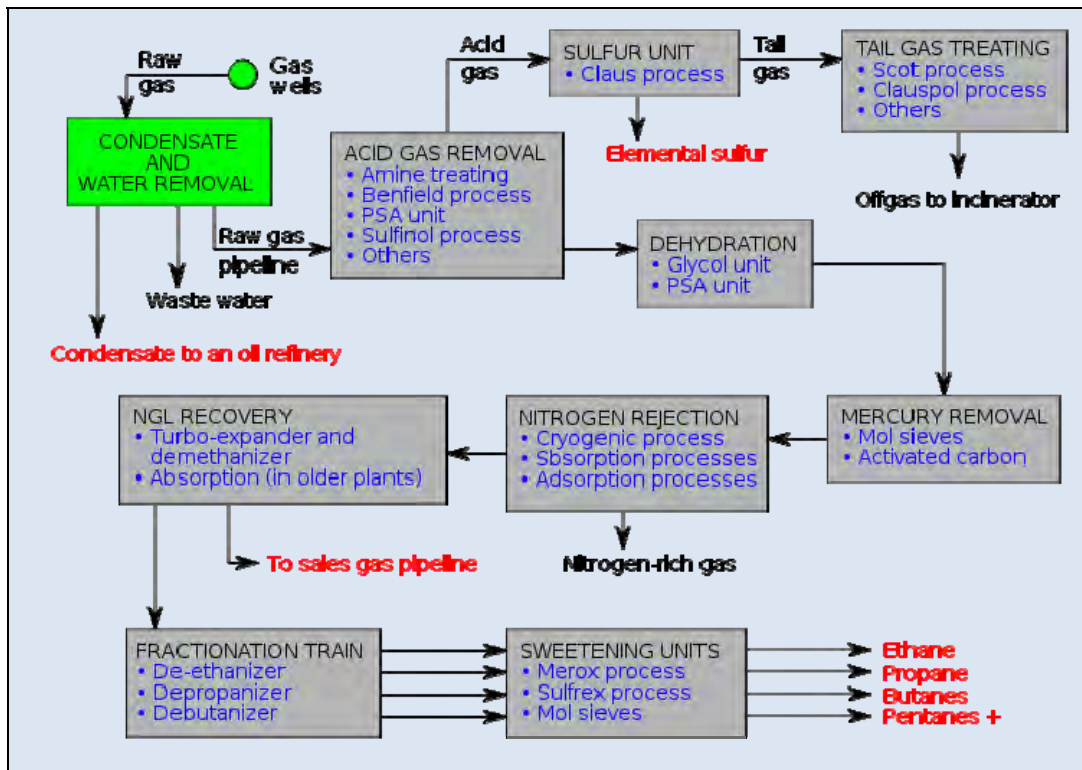


Figure 6 – Flowchart for a Gas Processing Facility – Illustrates the Complexity of the Process and the many Steps that can be Required. Levels of Complexity vary from Plant to Plant based on Need. (From ABB Oil and Gas).

Gas processing plants operate in cold weather climates along with other gas production facilities and as such, winterization equipment and processes are well known. It is a matter of frequency of events (cold weather) and the amount of time the facility is impacted, vs. the cost and time to winterize. Some processing plants have adequate piping and flow schematics to bypass some processes that might be impacted by cold weather. (Ref. 10)

Prevention of Wellbore, Wellhead and Production Facilities from Freezing – General Discussion and Description

There are several options for the prevention of freezing problems. Many of these are practiced on a regular basis in the colder regions of the country, to a lesser extent in the Mid-Continent region of the United State and not at all (in many cases) in Southern regions of the country. In order to correct freezing problems that occur under differing operational conditions, solutions must be designed for the particular needs of the location where the problem exists. Protection against freezing requires deployment of one or more mitigation techniques. Each of these techniques requires and investment in capital and operating expenses. The application of these techniques is usually determined by the

need or frequency of use along with the consequences (loss of production for a certain time period) of not utilizing.

In Southern regions of the United States, cold weather can be infrequent and when it does occur, can be limited in duration. A consequence is that the investment in freeze protection equipment and operations can be limited. The consequence to the producing life of a well can be minimal compared to the investment for cold weather operations in that lost production occurs for several days from a well with 20-30 years of operation life. On the other hand, if the level of impact is similar to the events of early February, 2011 and occurs on a more frequent basis, there can be a detrimental impact to the overall natural gas industry, as lack of reliability and accountability can result in loss of market. (Ref. 4)

Described below in general order of frequency of use are several techniques that can be applied to prevent freezing in gas operations:

1. **Methanol Injection to Prevent Freezing** - Methanol (an anti-freeze type solution) injection is a very common practice for freeze protection of wellbores and pipelines where wet gas flow occurs. Injection down the annulus of a wellbore by chemical injection pumps is utilized in production facilities in cold climates and in many gas storage operations where reliable, high flow rates in cold weather is required. The same technique can be practiced within a pipeline system and production facilities. The methanol is injected into the gas stream by chemical injection pumps or enters the pipeline by methanol drips and effectively lowers the freeze point of the gas. The amounts of methanol required can be calculated by using available tables for specific applications.

A small volume methanol tower can also be fabricated allowing small volumes of gas to pass through the methanol for treatment. Because of the sensitive nature of many pneumatic controllers, this method is occasionally used to prevent freeze-ups in these devices and to prevent liquid migration into small orifices and passages. An additional filter is often used to ensure that the methanol is not carried over into the instrumentation. (Ref. 4, 11)

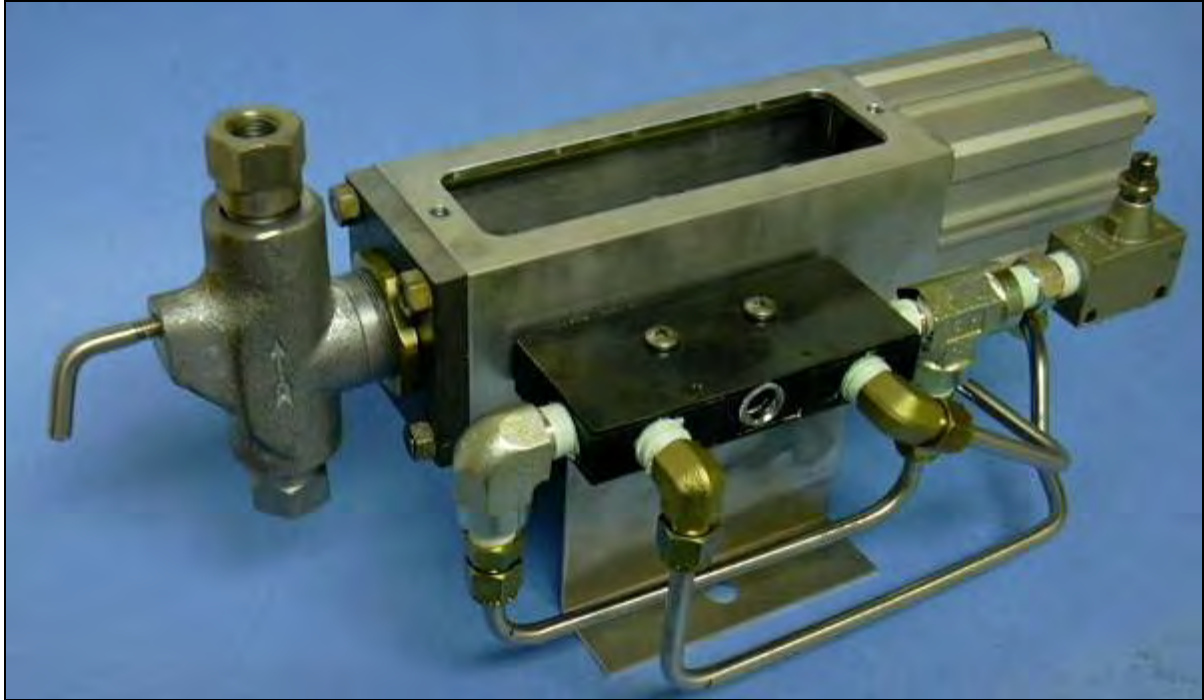


Figure 7 – Methanol Injection Pump Utilized to Inject Methanol into a Wellhead and/or Flow line to Prevent Freezing and Hydrate Buildup. Usually Located in Protected Housing on the Gas Well Location. (Ref. 11) (Photo Source ZKO Oilfield Industries; PTAC.org)

2. **Buildings or “Huts” to Enclose Production Equipment and other Weather Sensitive Equipment**
Buildings are often constructed to house weather sensitive equipment in cold weather. This can be the preferred method for protecting production equipment and is widely applied in colder climates. The housing can be heated by catalytic heaters and can be insulated as needed for the extremes of weather conditions anticipated.

Figure 8 is a typical setup for a Midwest Gas Storage Field (Manlove Gas Storage Field near Champaign, IL). The green fiberglass housing structure protects metering and other production equipment from freezing. Heating devices of various types can be utilized within the structure. Methanol chemical injection pumps are housed within the structure. During gas withdrawal operations (winter conditions) methanol is injected into the wellbore to prevent freezing. The wellhead itself is not enclosed. The wellhead is left open to allow for workover rigs to access the wellbore for any type of downhole maintenance required. Also, the heating of the wellhead may not preclude the formation of gas hydrates down in the wellbore some distance. This requires methanol injection as described in #1 above (Ref. 4, 12)



Figure 8 - Fiberglass Housing Surrounding Production Equipment at Gas Storage Field in Midwest United States (Ref. 12) (Photo credit Wikimedia Commons)

3. **Water Removal from the Gas Stream by Glycol Dehydration.** Gas dehydration is practiced on all natural gas flow systems to enable flow of gas without problems of hydrate formation, freezing, water drop out, corrosion and other issues. One of the most common methods of dehydration for large volumes of gas is glycol absorption. Gas passes through the glycol inside a vessel called a contactor (See Figure 2). The object is to remove the water to a point where the water vapor dew point of the gas will not be attained at the highest pressure and lowest temperature of the pipeline system. The glycol absorbs water and is then treated by circulating the glycol to a regenerator and distilling the water out of the glycol. The reconditioned glycol is returned to the contractor and the procedure is repeated. This process can reduce the water dew point to 60-70 degrees Fahrenheit. Colder climates frequently dictate a dehydration system in a natural gas system, but even warmer climates may require central dehydration due to pressure, temperature and gas composition. A producer can basically look at three dehydration options.
 - a. Partial dehydration at the well head and later additional steps to meet contract specifications.
 - b. Chemical injection at the well head with later dehydration at the central delivery point.
 - c. Full and complete dehydration at each and every well head.

The glycol dehydration system is a low cost system with continuous operation and minimal pressure loss across the unit, thus making it a preferred approach in several areas of operation. The drawbacks can be glycol carry-over during surges, contamination by solid particles and inefficiency during fluctuating flow rates. (Ref. 4, 13)

4. **Heat Application for freeze protection** - Heat is a logical solution to freezing problems. It is also a costly approach to the problem for several reasons. Obviously, if the gas is never allowed to reach freezing temperatures, ice cannot form and will not be present. The water will likely not be removed, which remains an issue for operations and contracts, but the freezing is eliminated. The problems with heat are that it is expensive equipment to install, it requires additional fuel (energy and revenue) to produce the heat, and the heat will not remain effective as it travels down the pipeline and away from the heat source. Heat is also a potential hazard as it can provide an ignition point for the gas. Safety and special emphasis on proper application is a must when using a heat source. The most common application of heat for freeze protection is in a specific and direct situation, as in the case of a regulator valve body. The pressure drop at the regulator is the only problem point and therefore, can be the only specific location where freeze protection is required. There are multiple ways to apply heat from heating blankets, to catalytic heaters, to fuel line heaters, or in some cases, steam systems where they are properly designed, installed and maintained. Heat systems can be very effective for a localized freezing problem. Heat application coupled with insulation is a common technique for protecting flow lines in northern climates. (Figure 11). (Ref. 3)



Figure 9 – Gas Wellhead with Insulation on Flow line to Protect Freezing. (Photo Courtesy of ABB Oil and Gas)

- 5. Combination of Techniques are Often Utilized** – A combination of winterization techniques are often required to fully protect a gas well production facility. Figure 10 illustrates a typical installation for a cold climate.

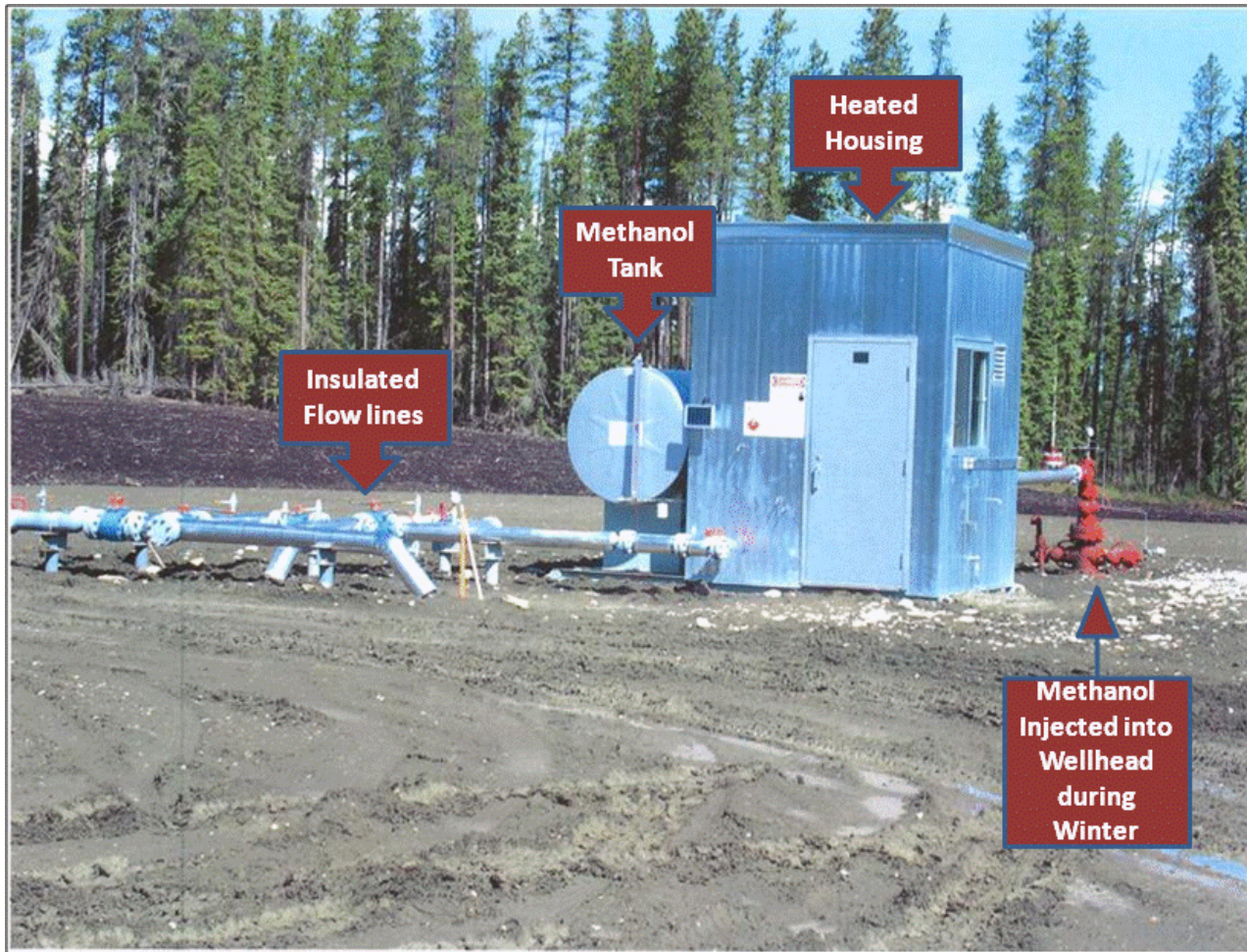


Figure 10 – Gas Production Wellhead and Production Equipment in Northern Region of United States Winterized for Cold Weather Operations. (Photo Source ZKO Oilfield Industries; PTAC.org and modified by GTI)

Referencing Figure 10, the following equipment and steps are practiced for flow assurance in cold weather climates:

- Flow lines are insulated.
- All wellheads are set up to inject Methanol which is done throughout the cold months.
- Assurance that flow lines are level, avoiding low spots where water can accumulate.
- Utilization of gas fired line heaters ahead of the production separators to keep all fluids warm enough to avoid freezing prior to separation of gas, gas condensate and water phases (See Figure 6).

- All flow lines beyond the production separator are insulated and heat traced. This is accomplished by electrical heat tape when electricity is available. Where there is no electric service, glycol tubes for circulating glycol are utilized to maintain flowing temperatures.
 - Minimizing flow chokes is also practiced wherever feasible. Flow chokes are notorious Joule Thompson freeze points.
 - Fiberglass huts over the wellheads are sometimes considered but difficult to accommodate due to impediments to accessing the wellbore for work-over and other considerations. (Ref. 3, 4, 6, 11)
6. **Pipeline Pigging** - Pigging in the maintenance of gas pipelines refers to the practice of using pipeline inspection gauges or 'pigs' to perform various operations on a pipeline without stopping the flow of the gas in the pipeline (Figure 11).

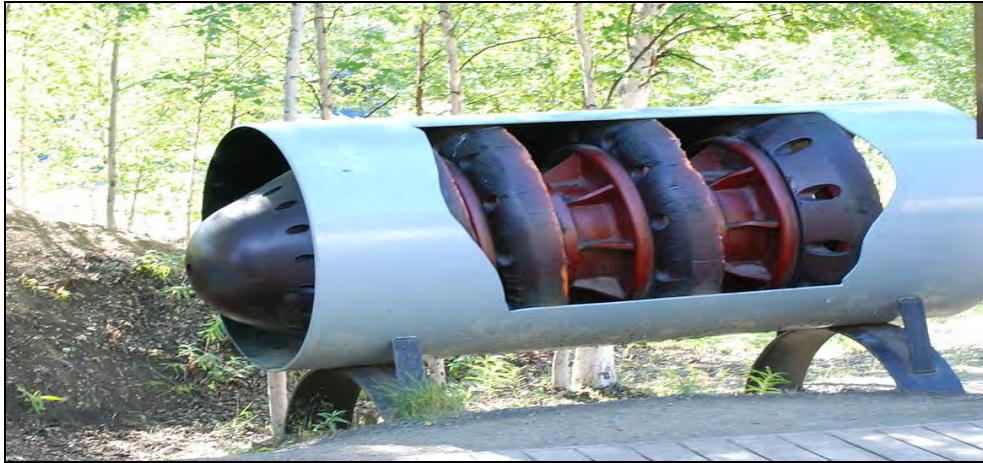


Figure 11 – Pipeline Pig Inside of Cut out Section of Pipeline (Photo Credit Wikimedia Commons).

These operations include but are not limited to cleaning and inspecting of the pipeline. This is accomplished by inserting the pig into a 'pig launcher'. The launcher / launching station is then closed and the pressure of the product in the pipeline is used to push it along down the pipe until it reaches the receiving trap - the 'pig catcher' (Figure 12). (Ref. 14)



Figure 12 – Pipeline Pig Launch and Receiving Station (Photo credit Wikimedia Commons).

If the pipeline contains butterfly valves or other restrictions in line diameter the pipeline cannot be pigged. Pigging has been used for many years to clean larger diameter pipelines in the oil industry. Today, however, the use of smaller diameter pigging systems is now increasing in many areas to maintain pipeline flow integrity.

Pigs are also used in gas pipelines where they are used to clean the pipes, but also there are "smart pigs" used to measure pipe properties such as pipe thickness and corrosion. They usually do not interrupt production, though some natural gas can be lost when the pig is extracted. Most of the pigging operations are deployed in the gas gathering, transmission and distribution portions of the gas system as opposed to the wellhead production areas where pipeline configurations and sizes do not allow for pigging operations.

Pigging operations are conducted on a year around basis as needed to keep pipelines in working flow conditions. During cold weather their deployment can be increased due to additional liquids fallout and due to increased flow rates during cold weather. (Ref. 14)

7. **Practical Piping and Equipment Construction Considerations for Freeze Protection** - During the design phase of the piping and the instrumentation system, certain steps can be taken to reduce the negative effects of freezing problems. Piping configurations that would allow for liquid accumulation should be avoided if at all possible. Drainage should slope towards drain fittings located at low spots. Where possible, use ball valves and large diameter tubing for instrument feed lines and sensing lines. Avoid restrictions where flow will occur. Limit choking points. Tubing runs should slope back toward the pipeline and you should have a leak free

instrument system. Liquids, if they are present, will be drawn towards the leak. If you avoid creating traps and liquid drop out areas, your freezing problems will be minimized. (Ref. 3, 4).

8. Other Water Removal Techniques for Cold Weather Protection, Especially for Instrumentation

- a. **Solid Absorption** - A very efficient method of water removal is the dry bed or molecular sieve method. The gas is passed through large towers of solid particles and the molecular sieve absorbs the water very aggressively. Very dry gas over a wide range of flow rates can be attained by this method. Eventually, the sieve becomes saturated and must be regenerated. The stream must be switched to a second tower and hot gas is introduced to the original unit to evaporate the water and dry the sieve. Cool gas is then used to cool the desiccant and the tower is ready for re-use. This cycle is repeated until the desiccant has degenerated and is no longer effective. While this method produces very dry gas and has several positive operating characteristics, it is more costly than typical glycol systems and more complex to operate. If the gas contains heavier hydrocarbons they can sometimes interfere with the sieves.
- b. **Drip pots, coalescers and automatic liquid dumps can reduce freezing problems on instrumentation** - Occasional slugs of liquid can damage or even “shut in” many instrument supply systems. Where this slug potential exists or in cases where liquid is a severe problem in the gas supply used for instrumentation, drip pots and coalescers can effectively knockout or reduce the water and condensate in a small volume instrument supply system. If the problem is excessive, an automatic liquid dump designed for instrumentation can be extremely helpful. Whereas the drip pot requires routine manual draining, the automatic liquid dump will act as a drip pot collection vessel with a coalescer and as a result of an internal float assembly and pivot valve, will automatically release the collected liquid to a lower pressure point.
- c. **Instrument filters designed for freeze protection to control equipment** - Many instrument controllers and other sensitive measurement equipment powered by instrument gas supply need the highest level of clean and dry instrument supply that is attainable. In some cases a good linear polyethylene filter can provide adequate protection. But the most common solution for instrument supply gas is the filter dryer. These units are designed for high pressure applications with removable media cartridges. While various types of media are available from molecular sieve to special H₂S removal media, most are equipped with a combination desiccant and charcoal filter cartridge. Coupled with providing extremely dry and fresh gas, the ancillary filtration elements in the cartridge provide for 2-4 micron protection as well. (Ref. 3, 4).

Natural gas systems, from mainstream pipeline flow to low pressure instrumentation, are subject to freezing conditions. Figure 10 is contrasted with Figure 13 where a non winterized location is illustrated.

Through careful planning and evaluation of a specific application, proper selection of available options, and a good routine maintenance program, this industry wide concern can be controlled and minimized. The cost of dealing with the aftermath can be more expensive than the preventative action that could have been taken.



Figure 13 - Typical wellhead in Warm Climate. (GTI) No methanol or other injection equipment for freeze mitigation. Flow line is elevated without insulation of other protection from cold weather. Tank battery and other production equipment are not protected from cold weather. (Ref. 4)

Alternatives to Cold Weather Control Techniques

Emissions of natural gas and other greenhouse gases are under increasing scrutiny as the concern about global warming continues to grow. Natural gas can be emitted to the atmosphere in many locations along the gas system. The gas industry has taken steps to mitigate these releases and continues to do so. Gas dehydration facilities are one step in the process where some gas is emitted. The dehydration step is required to remove water vapor from the gas stream to allow for safe and efficient transportation of the gas, and in particular to avoid gas line freeze-up when weather conditions turn cold.

One alternative to gas dehydration is the continuous injection of methanol into the system from the wellhead to a point of aggregation of the gas where it can be dried to pipeline specifications. This practice would eliminate the need for many individual dehydration facilities and thus the gas emissions. This is relevant when discussing flow assurance under cold weather conditions as well. The

injection of methanol could have the additional impact of avoiding freezing conditions within the gas flow system. This mechanism is practiced in the offshore environment where long pipelines transport oil, gas and water to onshore facilities for processing. Application of this technique onshore however, is often hampered by the many different mineral owners involved with each well. Each mineral owner has a royalty interest in the well allowing him a percentage of the revenue generated. This requires that a gas sales meter be installed to measure his appropriate share prior to mixing the flow volume with another well. Accurate gas measurement requires dry, liquid free gas leading to dehydration facilities at most wells. In the offshore environment there is only one royalty owner, the Federal Government. (Ref. 4, 11)

Discussion of Gas Hydrates Formation

Gas hydrate formation, also known as freezing, is a potentially serious problem in natural gas flow lines starting at the production well all the way through to the customer delivery system. The effective inhibition of hydrate formation, especially during cold weather, is essential for producers and transmission companies if they are to maintain a continuous supply of natural gas. Methods to control freezing range from removing water from the gas stream to lowering the water's dew point by injection of chemicals such as methanol.

Natural gas hydrates are ice-like substances that form through entrapment of hydrocarbon molecules inside the lattice of ice crystals. Hydrate crystals are formed under certain pressure and temperature conditions where the temperature may be above the melting temperature of ice. Many types of hydrates can form based on the presence of various gases. These include methane, ethane and propane hydrates, carbon dioxide and nitrogen hydrates and others.

Hydrates are very complex systems and their formation and dissolution remain a topic of ongoing research. They are known to exist in nature and form frequently within natural gas flow systems from the wellbore through the distribution systems for natural gas. They have been known to plug pipelines in the Gulf of Mexico for thousands of feet shutting in flow from multiple production platforms and significantly interrupting gas supply. In the Gulf of Mexico, where flow lines lay on the ocean floor in deep, cold water, and where the flow through the pipelines includes oil, gas and water prior to separation at onshore facilities; hydrate formation is a threat throughout the year. The solution to this problem is simply to inject methanol and other chemicals that inhibit hydrate development. This is performed as an ongoing operation and continues to be practiced. Research continues to better understand and control the formation of hydrates under these conditions, but today the application of methanol is the only effective solution. (Ref 4, 16)



Figure 14 – Hydrate Photos – Inset is the Water- Methane Hydrate Structure (Ref. 16, 17) (Photo Credits National Energy Technology Center (DOE) and Wikimedia Commons)

Figure 14 is comprised of two hydrate photos, one illustrating the melting of hydrates with the associated release of methane which has been ignited. It is through this phenomenon that the term “burning ice” is often used when describing hydrates. The smaller inset figure illustrates the hydrate cage formed by water and methane.

Methane hydrate, much like ice, is a material very much tied to its environment—it requires very specific conditions to form and be stable. Remove it from those conditions, and it will quickly dissociate into water and methane gas. A key area of basic hydrate research is the precise description of these conditions so that the potential for occurrence of hydrates in various localities can be adequately predicted and the response of that hydrate to intentional, unintentional, and/or natural changes in conditions can be assessed.

Figure 15 illustrates the combination of temperatures and pressures (the phase boundary) that describes hydrate formation conditions. When conditions move to the left across the boundary, hydrate formation will occur. Moving to the right across the boundary results in the dissociation (akin to melting) of the hydrate structure and the release of free water and methane.

In general, a combination of low temperature and high pressure is needed to support methane hydrate formation. Note that depending on the ambient pressure, methane hydrate can form at temperatures well above the freezing temperature for water; for example at 2500 psi pressure, the ice-like methane hydrate will form at 65 ° F.

Heavier hydrocarbon gases and other gases such as carbon dioxide can form hydrates at higher temperatures and lower pressures than methane. Hydrates may form in wet natural gas streams containing high percentages ethane, propane, CO₂ and H₂S where no methane hydrate is formed.

Referring to Figure 15, note that the phase line for CO₂ and ethane are to the warm side of the methane phase boundary indicating that under a given pressure CO₂ and ethane hydrates form at higher temperatures. (Ref 4, 16, 17)

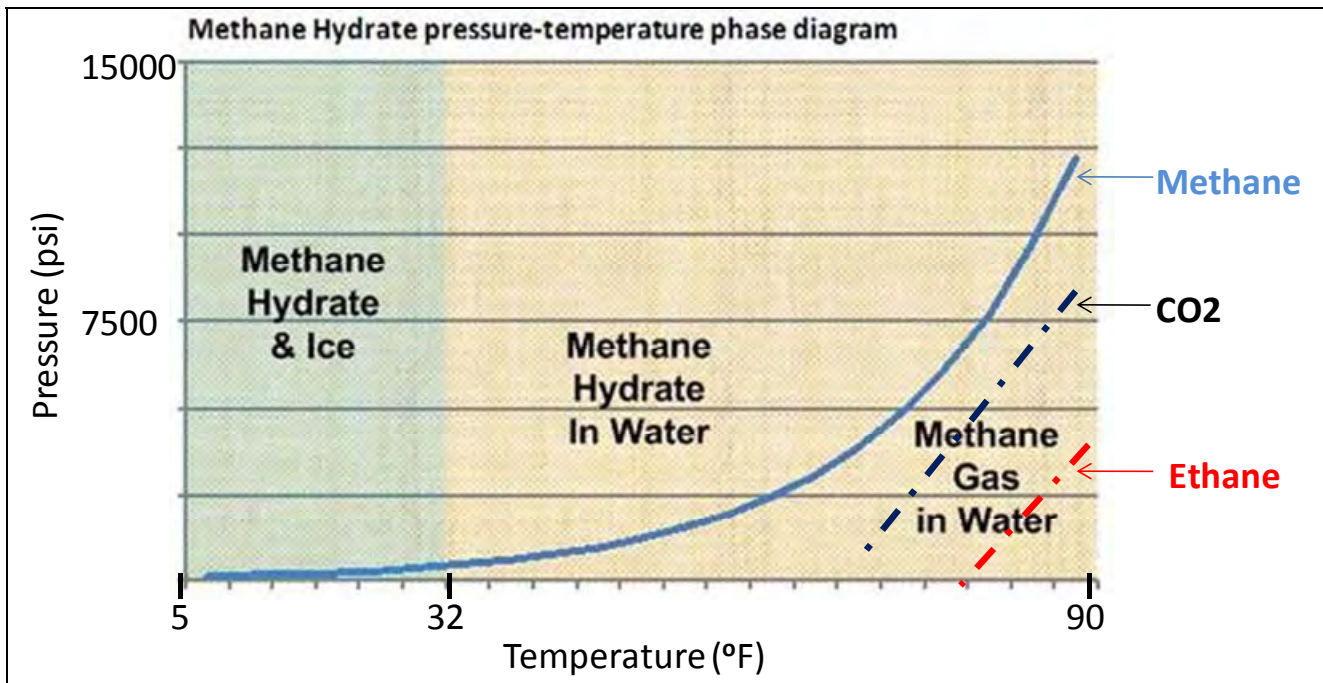


Figure 15 - Methane Hydrate Phase Diagram (Diagram Modified from Physical Chemical Characteristics of Natural Gas Hydrate).

The control of hydrates as previously discussed is accomplished in the same manner as for the control of icing conditions; application of heat, drying of the gas or chemical injection. With hydrates however it must be noted that they can form in somewhat dry gas especially if heavier hydrocarbons are present.

Gas Quality Considerations and Gas Processing

New technology has enabled the development of many new and significant shale gas plays in the United States including the Barnett, Marcellus, Eagle Ford, Fayetteville and others. The quality of the gas from these shale resources is different in each area requiring different approaches to production and gas processing. The volume of ethane, propane, carbon dioxide, nitrogen and other constituents vary considerably from play to play and can vary considerably within a single shale area such as the Barnett.

The gas processing industry has scrambled to keep up with the growth of the Barnett shale. Gas production has increased to 4 Bcf/day from near zero in 1999. Major gas processing plants have been constructed by Devon, Quicksilver, Enbridge and others. Most of the plants include compression, CO₂ treating with amine units, Cryogenic separation and fractionation. The process gas moves east toward Carthage, Texas where it can reach the Midwest markets via various hubs or it moves Southeast via the Transco or Florida gas pipeline. The gas processing plant typically process large volumes of gas. Within the Barnett region, plant capacities can range from 35 mmcf/day increasing to 1.0 bcf/day. Given the size of these plants, the volume of gas processed, the investment and sophisticated processes and equipment they are likely better able to withstand weather changes and disruptions due to rapid declines in temperature. When they do occur the problems can be identified and resolved. Unlike individual well locations the scale of these operations can justify winterization equipment and processes even for infrequent events. (Ref. 4, 5)

Table 3 – Barnett Shale Gas Compositions (Ref. 5) *Oil and Gas Journal*, March 9, 2009, Compositional Variety Complicates Processing Plans for U.S. Gas Shales.

Barnett Shale Gas Composition					
	Methane	Ethane	Propane		
Well	C ₁	C ₂	C ₃	CO ₂	N ₂
1	80.3	8.1	2.3	1.4	7.9
2	81.2	11.8	5.2	0.3	1.5
3	91.8	4.4	0.4	2.3	1.1
4	93.7	2.6	0	2.7	1

Table 3 illustrates the gas composition from 4 wells from the Barnett shale producing area. As can be seen the compositions vary considerably. These changes and levels of gas constituents across the Barnett region have the following impact on gas production with respect to cold weather:

- The presence of the heavier hydrocarbons establishes a higher probability of hydrate formation even after the gas stream has been dried to 7 lbs/mmcf.

- There is the potential for liquids fallout with the heavier gases that may be accelerated during cold weather. This condensation may occur without hydrate formation.
- The heavier liquids provide an economic incentive along with high oil prices to establish gas processing plants to remove liquids.
- The presence of CO₂ and N₂ require that these waste gases be removed or blended with other gases to bring their percentage levels down to pipeline specifications.

In general the variation in gas composition adds complexity as compared to a dry gas producing region. The complexity consists of additional gas handling, processing, transportation, blending, metering and other operations that potentially can be impacted by cold weather. The exposure of this additional equipment to weather can impact the reliability of gas flow under conditions not normal for an area. (Ref. 4)

On the other hand, independent of the heavier hydrocarbons, gas shale production has all of the issues associated with water production and methane hydrate formation. There is the possibility that these conditions alone are enough to cause disruption during cold weather spells and as such the presence of heavier hydrocarbons may have limited additional impact. (Ref. 4)

What needs to be determined is the impact of cold weather on gas processing plants which are established solely for heavy gas removal. They being located at aggregation points can disrupt large volumes of gas flow when problems occur. Alternatively they are large complex facilities, located in a contained area (as compared to wellheads spread across many miles) which combines to provide both the incentive and opportunity for cold weather control technology.

Discussion of Cost Implications to Winterize Gas Wells – Per Well Cost and Per Field Cost

Recent technology development has enabled the recovery of gas from shale formations around the U.S. and now around the world. Unlike offshore platforms or large flow volume conventional gas wells, many wells are required to recover gas from low permeability gas fields. Gas well spacing requirements can reach down to one well per 10 or 20 acres in some cases. In the Barnett area typical spacing is one well per 40 acres and over time greater than 14,000 gas wells have been drilled over a 12 county area (Figure 10). This development took place in stages over a 10 year period as a better understanding of the full potential developed.

Another factor regarding gas fields with a large number of wells is the time required to respond to an event that impacts every wellhead. Within the time frame of the recent cold weather event it would have been impossible to attend to each of 14,000 wellheads, most at a different location to alleviate freezing and/or other cold weather issues. (Ref 4, 18)

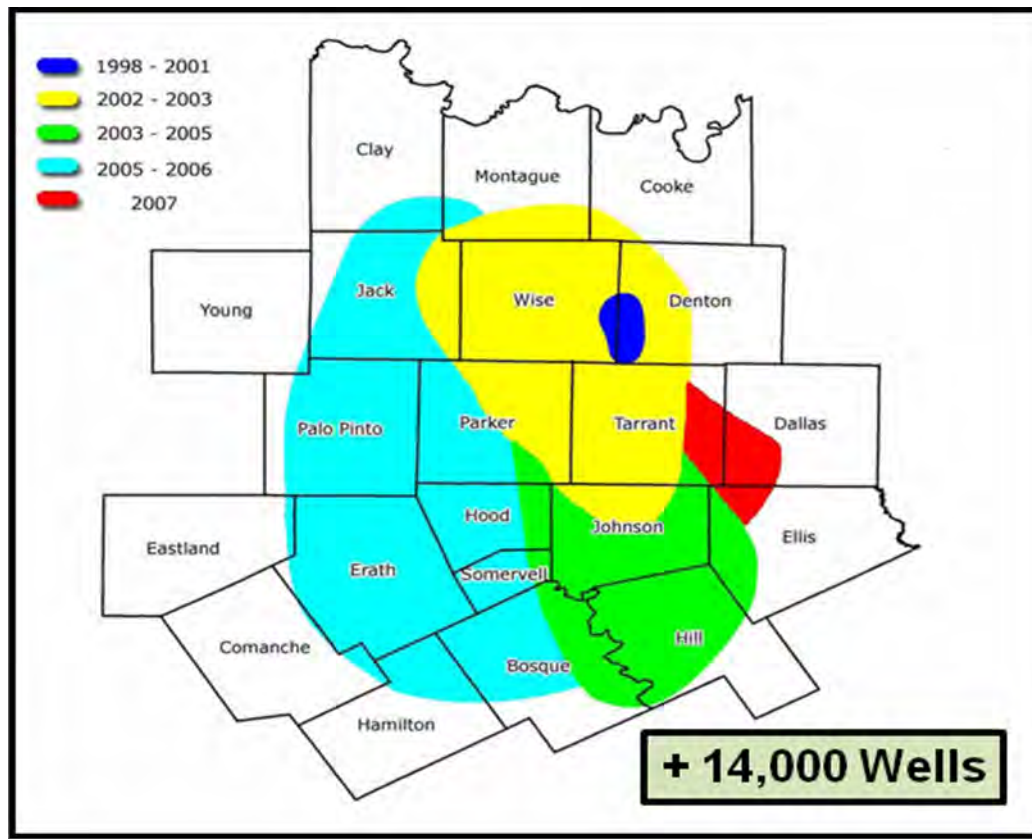


Figure 16 – Barnett Shale Gas Development Area near Dallas, TX, (Ref. 18) (Figure Courtesy Perryman Group – HART Unconventional Gas Conference).

The implications for cold weather flow assurance is that unlike the ability to winterize a large volume of gas flow at a single well location with a single investment, unconventional gas development requires winterization of many locations at practically the same capital expense.

Winterization of a gas well requires both capital expenditures and annual operating expense. Table 6 identifies the cost per well of these items.

In Northern regions of the country this equipment is normally part of the original well design and installed as a matter of necessity along with all other production equipment. On wells that can cost well in excess of \$1 million each, these costs are not as significant as when compared to a retrofit after the well has been placed on production. This investment needs to be weighed against the impact and ramifications of the reduction in gas flow, power reductions and outages during this time period. (Ref 4, 19, 20)

Winterization cost of a wellhead or associated production equipment can vary considerably based on the size of facilities to be winterized, location, weather conditions, gas quality and other criteria.

Some approaches can be relatively simple with other facilities requiring more elaborate winterization equipment. Several scenarios based on conditions are described below with discussion of cost.

- **Case 1 - Cost Analysis for Simple Methanol Injection Pump and Hookup**

In some areas, possibly in many locations in the warmer climate production areas in Texas and New Mexico, a simple installation of a methanol injection system to be utilized during cold weather spells may be effective. Unlike northern climates where severe cold is experienced throughout the extended winter, the warmer production regions may not require significant equipment installation. If problem areas or key producing facilities are identified they may be protected with a simple investment.

A methanol injection and solar powered pump system can be installed for a capital cost of approximately \$2,800 per installation. The systems are designed to reduce maintenance and operation expenses. Methanol costs are \$12.00 per mmcf of gas throughput based on a treating ratio of 3 gallons of methanol per mmcf at a cost of \$4.00 per gallon. Based on a well producing 1 mmcf per day of gas, methanol costs would equal \$12 per day. On an annualized basis assuming methanol injection for 5 months the methanol cost equals \$1800. Labor is estimated at \$1000 per month or \$5000 total. (Ref. 15)

Capital Cost = \$2800 per installation.

Operating Cost for 5 months cold weather = \$6800.

- **Case 2 - Cost Analysis for Building to Enclose Production Equipment**

In some cold weather climates the most efficient approach to winterization is to house the susceptible equipment in a small building or hut. This can sometimes save on more expensive approaches while at the same time protecting all equipment from year around weather conditions. These buildings can be heated with specialized heating equipment or in many cases can be warmed simply from the heat given off by the production equipment itself (assumes a heated production unit is within the building). In cold weather climates the design and construction of the production equipment includes the insulated housing, all of which is skid mounted for portability. When managed in this fashion the additional cost for winterization can be negligible compared to total well cost. Building cost can vary according to size requirements. This may be an option for critical equipment in the Texas, New Mexico producing regions.

Building cost = \$2500 to \$10,000

- **Case -3 - Cost Analysis for Equipment to Winterize Gas Wellhead in Very Cold Climate e.g., Canada (See Figure 10).**

In very cold production areas such as Canada, several winterization techniques need to be applied including methanol injection, line insulation, a small hut to protect chemical injection pumps small heaters, and methanol storage. The total cost of this installation is estimated at \$34,425 per installation (see itemization below). (Ref. Table 10) Operating cost for a 5 month period is estimated at \$6800 the same as Case 1.

Table 4 – Winterization Equipment Cost for a Gas Well Located in a Cold Climate

Equipment	Description	Cost
Winterized Production Unit - Net Cost for Winterization	Production unit winterized by internal piping and insulation.	\$23,000
Timberline solar powered methanol pump w/solar panels		\$2,800
Chemical Pump to Supply Chemical Inhibitors	Chemical Inhibitor Pump for Corrosion Protection	\$1,350
Vent Gas Bottle to Supply Heater	System to Collect Vent Gas from Injection Pumps to Supply Heaters	\$675
Methanol Tank	Stores Methanol	\$1,000
Methanol Injection Tubing - High Pressure - \$5/Ft - 100 Ft	Methanol Transfer	\$500
Flow Line Insulation - \$3/Ft - 100 Ft	Insulate Flow Line	\$300
Flow Line Heat Tape - \$4/Ft - 100 Ft	Provide Heat to Flow Line	\$400
Fiberglass Hut for Enclosing Production Equipment	Weather Protection	\$1,500
Catalytic Heater for Location Housing	Heating for Hut	\$500
Installation Cost - 2 men for 3 days at \$50 per hour.	Labor	\$2,400
Total Capital Cost per Well		\$34,425

- **Case 4 - Cost Analysis for Equipment to Winterize Gas Wellhead Equipment Including Gas Production Unit**

In areas where a gas production unit is required to remove liquids (water or condensate or both) from the production stream a gas separator must be installed. The cost of a separator can vary based on

size which is dependent on the total flow volume to be handled by the separator. In warm weather climates the piping and instrumentation for the separator is installed externally to the unit as freezing is not an issue. For cold weather climates all of the piping needs to be internalized where heat from the production unit itself, in addition to insulation where required will prevent freezing. The additional design requirements, locating of piping and instrumentation in a confined space can add as much as \$23,000 to the cost of a production unit. (Ref. 20) A less expensive option in some cases can be as described in Case 2 where all of the production equipment is housed in a small building or hut. These insulated buildings often require no additional heat beyond what is supplied by the heating unit in the production separator itself. (Ref 21)

- **Case 5 – Installation of Additional Storage Capacity at Critical Facilities**

During the recent cold weather spell in Texas and New Mexico many wells and compressor facilities were shut-in by automatic fail safe shut down devices that were triggered by tanks filling up with liquids. The fail safe shut-in devices protect against tank overflow and spillage. For critical facilities such as central compressor stations, gas processing plants or important well tank batteries, additional storage could be installed to allow for operations during bad weather conditions. Additional tanks are relatively inexpensive when compared to the impact of significant gas flow reductions.

Total Cost Discussion

The cost estimates for winterization can vary considerably based on the type of facility, the number of installations being considered, the degree of cold weather protection that is required, gas flow rates, pressures and other factors.

Simple weatherization such as for Case 1 above can be accomplished for an estimated \$2800 capital cost and \$6800 annual operating cost.

More comprehensive winter protection can increase the capital cost to over \$11,000 per installation.

Winterization of production units, if required can add an additional \$23,000 per installation depending on production unit size.

Overall, the cost of winterization, given the number of wells can be considerable. The simple table below illustrates cumulative capital cost with variable well counts and per well equipment costs.

Table 5 – Cumulative Cost for Winterizing Gas Wells – Variable Well Counts and Individual Well Equipment Cost.

			Well Count		
	10,000	20,000	30,000	40,000	50,000
Cost per Well			Cumulative Cost		
\$2,500	\$25,000,000	\$50,000,000	\$75,000,000	\$100,000,000	\$125,000,000
\$10,000	\$100,000,000	\$200,000,000	\$300,000,000	\$400,000,000	\$500,000,000
\$20,000	\$200,000,000	\$400,000,000	\$600,000,000	\$800,000,000	\$1,000,000,000
\$35,000	\$350,000,000	\$700,000,000	\$1,050,000,000	\$1,400,000,000	\$1,750,000,000

For 50,000 wells the total cost could vary from \$125 million to \$1.75 billion based on per well equipment needs. It may be that key compressor locations and gas processing facilities, if winterized or supplied with additional liquid storage tanks, could mitigate a significant percentage of the cold weather flow problem. The total number of these locations is likely to be much reduced from the number of wells noted in Table 5 above. If 1000 facilities of this type required a \$10,000 investment each the total would equal \$10 million, a much reduced number from those illustrated above.

Table 6 which follows itemizes capital cost and operating expenses for winterization of production facilities. The capital costs do not total within the spreadsheet as there is duplication of equipment in some cases.

Appendix: GTI Report

Table 6 – Itemization of Capital and Operating Expenses for a Typical Gas Well – (Note, the Capital Costs Items Listed in the Table are not Totaled as Locations will require a Subset of these Items).

Gas Well Winterization Expenses					
Cold Weather Protection Equipment	Description		Cost Per Well - Excludes Duplicate Applications	Source	
Capital Cost					
Winterized Production Unit - Net Cost for Winterization	Production unit winterized by internal piping and insulation.		\$23,000	Sivals Engineering, Odessa, Tx., Ref 20	
Methanol Injection Pump	High Pressure Pump to Inject Methanol		\$1,648	ZKO Oilfield Industries, Ref. 11	
Timberline solar powered methanol pump w/solar panels			\$2,800	Timberline Manufacturing, Ref. 22	
Chemical Pump to Supply Chemical Inhibitors	Chemical Inhibitor Pump for Corrosion Protection		\$1,350	ZKO Oilfield Industries Ref. 11	
Vent Gas Bottle to Supply Heater	System to Collect Vent Gas from Injection Pumps to Supply Heaters		\$675	ZKO Oilfield Industries Ref. 11	
Methanol Tank	Stores Methanol		\$1,000	estimate	
Methanol Injection Tubing - High Pressure - \$5/Ft - 100 Ft	Methanol Transfer		\$500	Drillspot .com	
Flow Line Insulation - \$3/Ft - 100 Ft	Insulate Flow Line		\$300	Drillspot .com	
Flow Line Heat Tape - \$4/Ft - 100 Ft	Provide Heat to Flow Line		\$400	Drillspot .com	
Fiberglass Hut for Enclosing Production Equipment	Weather Protection		\$500	JW Williams Co. Casper, Wyoming, Ref. 21	
Catalytic Heater for Location Housing	Heating for Hut		\$500	ZKO Oilfield Industries Ref. 11	
Installation Cost - 2 men for 3 days at \$50 per hour.	Labor		\$2,400	JW Williams Co. Casper, Wyoming, Ref. 21	
Operating Expense for Methanol Injection					
Methanol costs are \$4.00 per gallon. Assume 10 gallons per day for 5 months. Methanol cost = 5 months * 30 days/mo.*10 gal/day * \$4/gallon = \$6000	Methanol Cost		\$6,000	Timberline Manufacturing, Ref. 22	
Maintenance - Per Month - \$200 @ 5 months			\$1,000		
Total - Cost per Year			\$7,000		

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Exhibit F

**Complaint of Michael Mabee Related to
Mandatory Reliability Standards
in the Texas Grid Collapse of 2021**

ELECTRIC DIVISION EVALUATION REPORT

**ELECTRIC UTILITY RESPONSE TO THE WINTER FREEZE
OF DECEMBER 21 to DECEMBER 23, 1989**

**An Evaluation of the Actions Taken by Texas Utilities
to Correct Technical Plant Equipment Problems**



November 1990

**Public Utility Commission of Texas
7800 Shoal Creek Boulevard, Suite 400N
Austin, Texas 78757**

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TABLE OF CONTENTS

	Page Number
Section I Introduction	1
Section II Background	1
Section III Utility Responses	2
Section IV Costs of Corrective Actions	5
Section V Evaluation of Utility Responses	6
Section VI Recommendations	6

ATTACHMENTS

Attachment No. 1 Sequence of Events During the Freeze	
Attachment No. 2 Causes of Plant Shutdowns (Summary)	
Attachment No. 3 Copies of Individual Utility Responses	
Attachment No. 4 Cogeneration Plant Shutdowns (Summary)	
Attachment No. 5 Plant Design Temperatures	

This report and the ideas expressed
in this report do not necessarily
represent a consensus of position of
the Public Utility Commission of
Texas or of its Staff members.

Chester R. Oberg 11/15/90
Chester R. Oberg, Nuclear Projects

Section I

INTRODUCTION

Several major electric power generating utilities, within the State of Texas, were severely affected by the freezing weather conditions in December of 1989. In May of 1990 the utilities were requested to provide the PUC Staff information on the corrective actions taken by them to prevent recurrence of the technical problems experienced by plant equipment. A variety of corrective actions to the problems were reported by the utilities that were affected by the cold weather.

The intent of this Electric Division Evaluation Report is to compile the answers from the utilities and to assess the adequacy of the responses to the equipment problems. This report will not address changes to any PUC emergency notification measures nor will it consider ERCOT and utility emergency power curtailment procedures or steps that should be taken to manage consumer demand for electrical power prior to or during an extreme weather related emergency. These topics will be address elsewhere. This report is principally based on information provided by the utilities.

Section II

BACKGROUND

The winter freeze of December 21 through December 23, 1989, greatly strained the ability of the Texas electric utilities to provide reliable power to their customers. Record and near record low temperatures were felt throughout the state resulting in a significantly increased demand for electrical power. At the same time that demand was increasing, weather related equipment malfunctions were causing generating units to trip off the line. The combination of heavy demand and loss of generating units caused near loss of the entire ERCOT electric grid.

It should be noted that other states also experienced similar power shortages resulting in rolling blackouts. The State of Florida experienced depressed temperatures that ranged from 20 degrees F to 30 degrees F below normal for that time of year. Most Florida utilities resorted to "rolling blackouts" to prevent the State grid from collapsing. The actual Florida peak demand during the rolling blackout period was 15,929 MW. This exceeded the projected demand by 18% and the Florida State 1988-1989 winter peak of 12,897 MW by 23.5%.

Most of the Texas electric generating utilities met the increased electric demands during this emergency with a minimum of service interruptions. Using emergency plan procedures, ERCOT, the Electric Reliability Council of Texas, was able to lessen the load of those utilities hit hardest by transferring power from utilities with a generating surplus to those lacking generation capacity.

Early on December 23rd, the loss of generating units and rising customer demands caused Houston Lighting and Power Company (HL&P), Lower Colorado River Authority (LCRA), and the City Public Service Board of San Antonio (CPSB) to use their remaining spinning reserves. Next these three utilities requested available spinning reserve power from other utilities in ERCOT to maintain the integrity of their control areas.

The ERCOT Emergency Electric Curtailment Plan calls for individual utilities having difficulties meeting their load to do all they can before other utilities are asked to shed load to preserve the entire electric system. As loads continued to increase on December 23rd, and with all available spinning reserves in ERCOT having been already utilized, individual utilities with generating deficits were required to start shedding load. Firm load was shed by HL&P from 6:53 to 10:58 a.m., by CPSB from 7:08 to 10:48 a.m., and by LCRA from 8:33 to 11:02 a.m.

System-wide, pre-allocated on a percentage basis, firm load shedding is the last step in the ERCOT emergency operating procedures and requires all utilities to reduce demand by interrupting customer service. When an additional set of generating units were lost around 10:15 a.m. because of the freeze-up of instrumentation, all ERCOT utilities were ordered to shed additional firm load between 10:21 and 10:31 a.m. on December 23rd to halt and reverse the collapse of the electric grid.

A detailed sequence of events is presented in Attachment No. 1. This attachment also contains graphs illustrating the ERCOT capacity vs. load demand and a partial representation of the resultant changes in the system frequency on December 23, 1989. Changes in demand load and temperature variation are also shown for one utility.

SECTION III**UTILITY RESPONSES**

A questionnaire was sent to those ERCOT utilities affected by the severe December weather. In general, the questionnaire solicited the actions taken by the utilities to prevent recurrence of the equipment problems under similar conditions and the cost of those actions. The following specific questions were asked for each affected unit:

- (1) Unit Name and Unit MW Capacity
- (2) Unit general design temperature limitations (Maximum and minimum), in degrees F.
- (3) List of equipment(s) (or plant systems) that were adversely affected by the cold weather.
- (4) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit.
- (5) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure.
- (6) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion.
- (7) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense.

The extreme weather pointed out several weak areas in power plant operations. Inoperative or inadequate heat tracing systems and inadequate insulation on instrumentation sensing lines seemed to be the most common technical equipment problem encountered during the freeze. Some plant operators battled this type of problem with hand held propane torches to keep pipes from freezing during the emergency. Other problems encountered ranged from fish plugging cooling water intake screens to frozen grease

that prevented fuel valves from freely operating. The causes of unit failures are summarized in Attachment No. 2.

Utility detailed responses have been included in this report in Attachment No. 3. The responses of the utilities varied. One utility instituted a comprehensive engineering review of their power plants. Others merely corrected the specific equipment failures. In some cases there was a lack of maintenance evident, although it would be difficult to state that if the maintenance had been accomplished the unit would not have shut-down.

Cogeneration plants also experienced problems during the freezing weather. The problems of the cogenerators were similar in nature to those experienced by the larger generating power plants. A summary of cogeneration data is included in Attachment No. 4.

Some of the most prevalent post emergency actions taken by the utilities to prevent future power plant shutdowns caused by cold weather included:

1. Improving heat tracing and insulation coverage on power plant instrumentation,
2. Upgrading instrumentation air supplies by removing excessive moisture with desiccant instrument air dryers,
3. Purchasing fish nets to be placed in front of intake water screens if fish begin running,
4. Developing plant procedures calling for inspections of plant equipment prior to the cold weather season, and
5. Installing wind breaks and enclosures around certain equipment exposed to the weather.

One of the critical areas is that of the unit/plant design temperature range. In general, the utilities reported design temperatures were pushed to their lower limits. The following design temperatures apply to those plants that were reported to have failed during the freeze:

<u>Utility</u>	<u>Design Temperature Ranges(Pre-Dec. 1989)</u>
CPL:	10 degrees F with 30 MPH winds

<u>Utility</u>	<u>Design Temperature Ranges (Pre-Dec. 1989)</u>
HL&P	10 to 105 degrees F, in general. STP was determined to be able to operate in a range of 3 to 105 degrees F. Limestone is protected to 5 degrees F with freeze protection equipment.
TUE	-10 degrees F with 35 MPH winds.
LCRA	1 to 110 degrees F (No design temperatures were available for Sim Gideon 2.)
TMPA	15 to 107 degrees F

When power plant equipment is exposed to weather conditions beyond its design limits, subsequent failures can be expected. At that time only the dedication and adaptability of plant operations and maintenance personnel to rapidly changing conditions is able to mitigate plant problems.

The specific design temperature ranges of reported units is contained in Attachment No. 5, Plant Design Temperatures.

SECTION IV

COSTS OF CORRECTIVE ACTIONS

As part of Attachment No. 2, the costs of the corrective actions are listed for each plant with the dates that the corrective action was taken. The expenses listed vary considerably for each plant, from a high of \$ 109,266 for a significant amount of heat tracing and insulation installation on a single unit to nominal, or essentially no cost for many of the other units. The no cost corrective actions usually involved routine maintenance tasks such as the resetting of instrumentation, sealing equipment to prevent water intrusion or the replacement of frozen valves.

The cost to "fix" the freezing weather plant problems is about \$ 2,773,253. The costs have been divided approximately equal between O & M (\$ 1,194,553), maintenance cost allocation, and capital expense (\$ 1,578,700). The majority of the expenses being funded from maintenance cost allocations. Since the rules for determining a capital expense vary from utility to utility, it is difficult to draw any conclusions regarding this type of cost division.

It should be noted that the cost of "fixing" the generating units is not confined only to those units that were shutdown as a result of the cold weather. The utilities are also taking measures to ensure that those generating units that were not affected will be able to continue to operate in any future adverse weather conditions.

The costs of corrective action for cogeneration units was not included in the total costs given above or in Attachment No. 2. Only a portion of the cogenerators reported a cost to correct identified plant problems. Based on the reporting cogeneration units, their estimated corrective action costs are approximately \$ 650,000.

SECTION V

EVALUATION OF UTILITY RESPONSES

Whether the corrective actions being implemented by the utilities are sufficient to prevent future freeze related power plant failures, only direct experience with another deep freeze will ascertain.

The design temperatures for all of the reported power plants have a range from -10 degrees F to +110 degrees F. Because of the size of Texas and its varying climates, it is not feasible for the PUC to entertain implementation of a single required design temperature range. It is clearly the responsibility of each utility to ensure that the proper temperature range is selected by the Design Engineer when a power plant is being designed and that it is constructed in accordance with that design. The selection of the proper temperature range is the essential ingredient that will determine the reliability of a power plant to respond correctly to adverse weather conditions. Where necessary the utilities should supplement instrumentation and control systems with supplemental heat tracing systems and other forms of protective devices.

After a power plant has been constructed, it is necessary to maintain the plant to keep it functioning in accordance with its design. Each unit's active and passive equipment must be maintained. Insulation must retain its integrity in order to be effective. Heat tracing systems must be checked for correct operation on a regular basis. Control air systems should be drained of excess moisture. Cold weather operating procedures need periodic review for changing circumstances, and plant personnel need training in order to maintain their operating

proficiency. The results of improper maintenance and training will be seen in increased O & M expenses for the repair of failed equipment as well as loss of plant reliability.

The near complete loss of the ERCOT grid brings an awareness that, even in Texas, plant operators must prepare for cold weather emergencies. This awareness of and attention to cold weather problems must be continued.

A complete system blackout was prevented by timely implementation of the ERCOT emergency operating procedures and dedicated utility plant personnel working under adverse conditions to keep power plants generating.

SECTION VI

RECOMMENDATIONS

All utilities should ensure that they incorporate the lessons learned during December of 1989 into the design of new facilities in order to ensure their reliability in extreme weather conditions.

All utilities should implement procedures requiring a timely annual (each Fall) review of unit equipment and procedures to ensure readiness for cold weather operations.

All utilities should ensure that procedures are implemented to correct defective freeze protection equipment prior to the onset of cold weather.

All utilities should maintain insulation integrity and heat tracing systems in proper working order. Generating unit control systems and equipment essential to cold weather operations should be included in a correctly managed preventive maintenance program.

Additional training programs for plant personnel on the emergency cold weather procedures, including periodic drills, should be implemented by each responsible utility.

PUC Engineering Staff should modify procedures for power plant CCN reviews to include a specific review for plant reliability under adverse weather conditions. Of special interest would be the selection of proper design temperature ranges for the power plant site.

ATTACHMENT NO. 1

SEQUENCE OF MAJOR EVENTS DURING THE FREEZE

ATTACHMENT No. 1

SEQUENCE OF MAJOR EVENTS DURING THE FREEZE

December 21, 1989

12:00 midnight TMPP, TUE and WTU all curtailed by Lone Star Gas.

4:00 AM ERCOT's North Texas Security Center declares a Severe Cold Weather Alert for North Texas.

12:00 noon ERCOT's South Texas Security Center declares a Severe Cold Weather Alert for South Texas.

December 22, 1989

12:00 midnight Some South Texas utilities curtailed of spot market supplies of gas.

8:30 AM ERCOT's operators observe system frequency drop to 59.95 hertz.

8:40 AM ERCOT requests utilities to implement 1st step of Emergency Electric Curtailment Plan (EECP 2.3.1.1)

9:00 AM ERCOT requests utilities to implement 2nd step of Emergency Electric Curtailment Plan (EECP 2.3.1.2).

12:00 noon EECF canceled in North Texas

12:30 PM EECF canceled in South Texas

December 23, 1989

1:30 AM WTU offers 220 MW of emergency power from Oklahoma DC tie.

3:50 AM HL&P takes 220 MW of emergency power from WTU.

4:20 AM WTU cancels emergency power from Oklahoma due to problems up there.

Attachment No. 1 Sequence of Major Events

5:30 AM ERCOT prepares to declare EECF again. System operators preparing for possibility of shedding firm load.

5:36 AM ERCOT system operators observe system frequency drop to 59.95 again.

6:00 AM CPSB, LCRA and HL&P unable to maintain spinning reserve obligation.

6:04 AM CPSB drops interruptible load.

6:07 AM Frequency drops to 59.85 recovers to 59.92.

6:20 AM TUE drops interruptible load.

6:38 AM Frequency drops to 59.90.

6:40 AM ERCOT declares EECF 2.3.1.2.

6:43 AM Frequency drops to 59.87. ERCOT requests utilities to implement EECF 2.3.1.3.

6:53 AM HL&P drops 300 MW of firm power.

6:56 AM Frequency drops to 59.79.

6:59 AM ERCOT requests utilities to implement EECF 2.4.1. CPL drops 85 MW of interruptible power transfers 11 MW to Mexico.

7:08 AM CPSB drops 150 MW of firm power.

7:49 AM ERCOT requests utilities implement EECF 2.4.2.

8:20 AM HL&P begins rolling blackouts of 1000 MW.

8:33 AM LCRA sheds 60 MW of firm load.

9:45 AM HL&P receive emergency power from TUE(200 MW) and TMPP(50 MW). CPSB receives emergency power from WTU(50 MW).

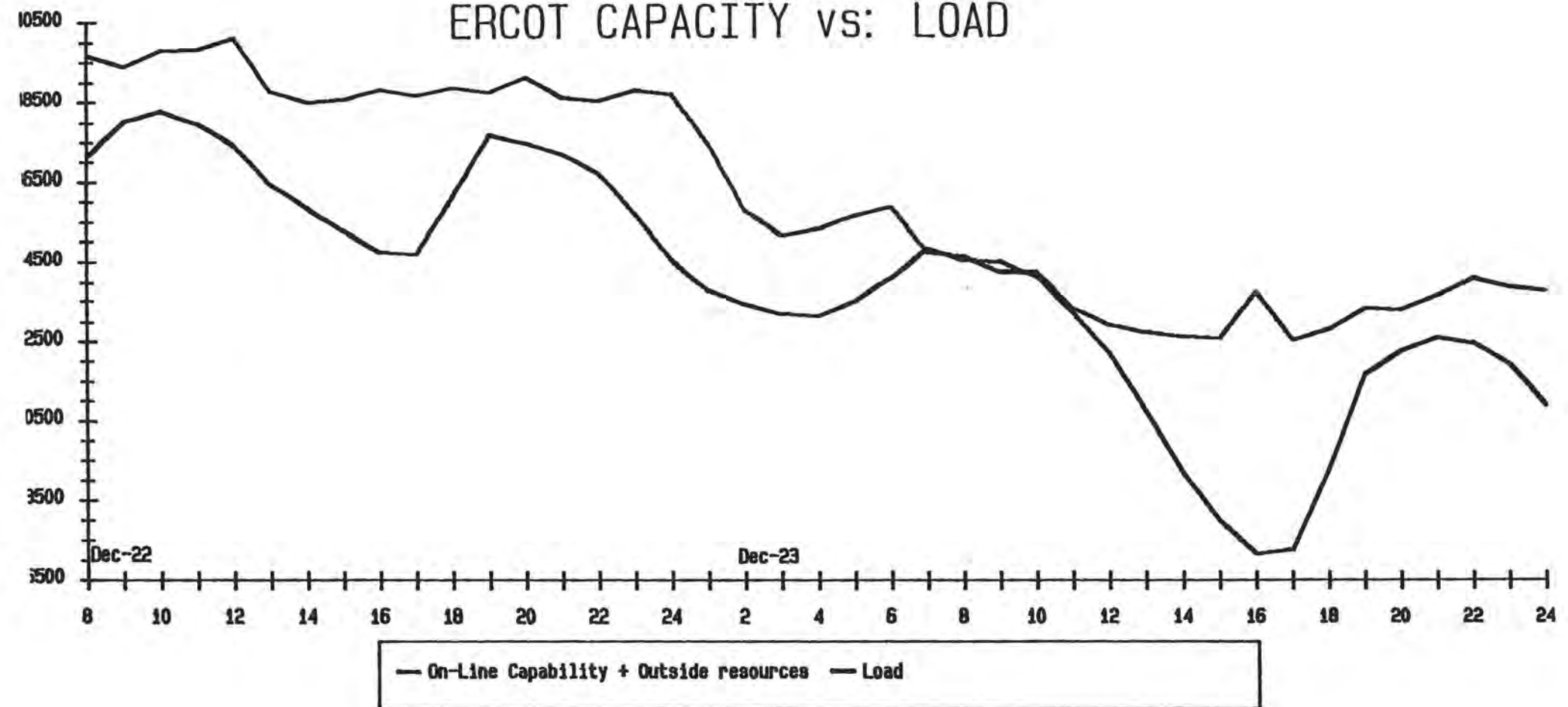
10:20 AM After recovery to 60.03, frequency drops back down to 59.65. ERCOT requests implementation of EECF 2.4.2.2 and 2.4.2.3.

10:21 AM All ERCOT utilities drop firm load.

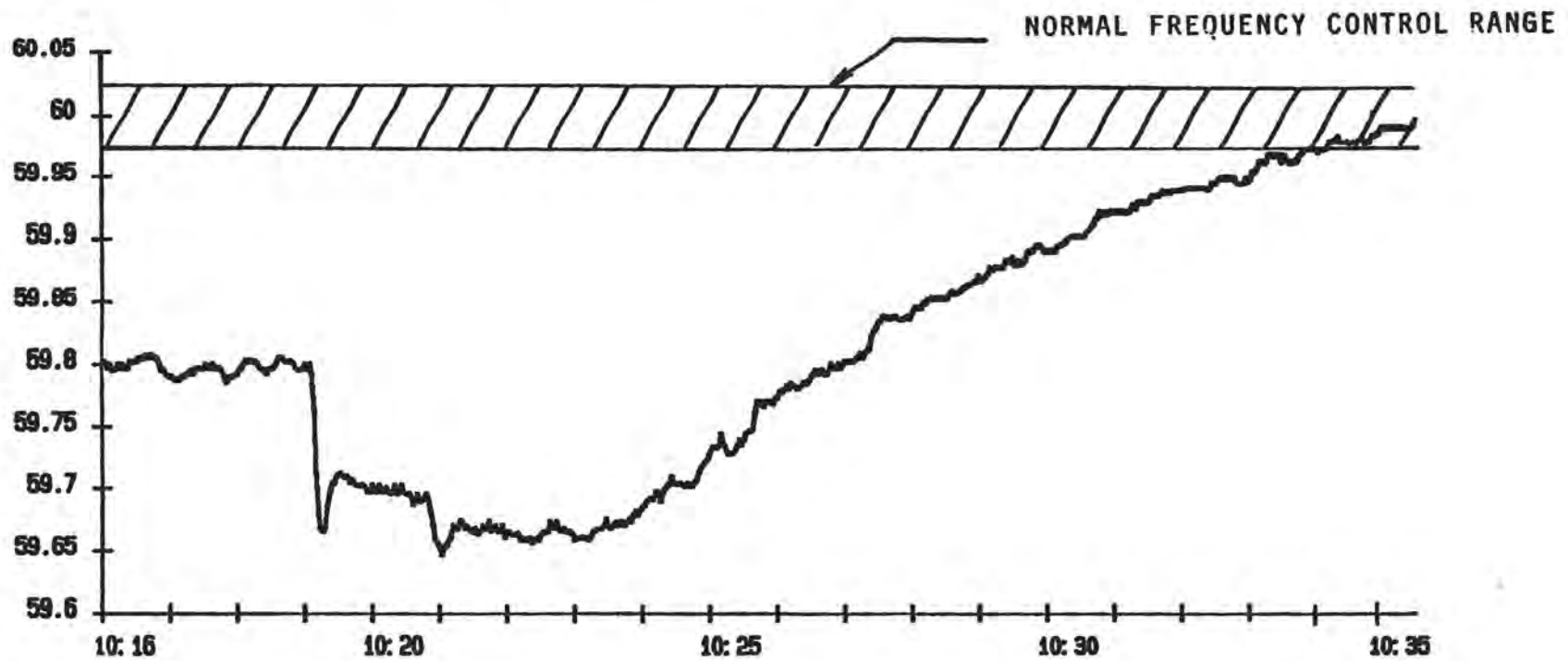
Attachment No. 1 Sequence of Major Events

10:31 AM	Frequency recovers to 60.05. ERCOT requests all utilities not in trouble to pick up firm load. All but HL&P, CPSB and LCRA comply.
10:48 AM	CPSB begins picking up shed firm load.
10:58 AM	HL&P begins picking up shed firm load.
11:02 AM	LCRA begins picking up shed firm load.
12:00 noon	ERCOT requests utilities back to EECF 2.3.1.2.
12:40 AM	EECF canceled.

ERCOT CAPACITY vs: LOAD



ERCOT FREQUENCY - Dec. 23, 1989

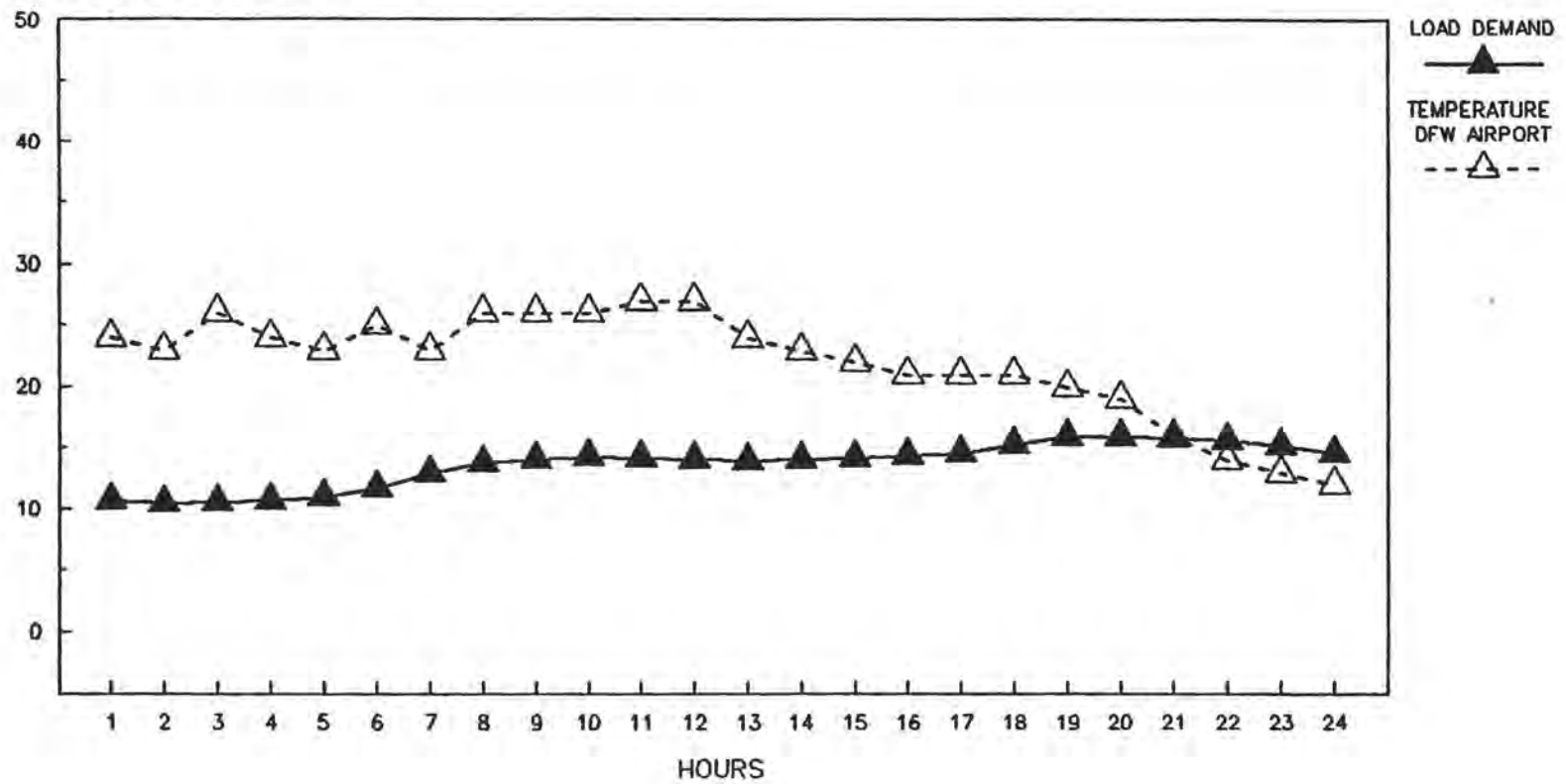


Temperature Variations December 1989
Texas Utilities Electric Company,
DFW Airport Temperatures

Date	Hour	Load	Temp Fdeg	Date	Hour	Load	Temp Fdeg
=====				=====			
12/21/89	1	10658	24	12/23/90	1	15097	3
	2	10529	23		2	14913	3
	3	10586	26		3	14893	2
	4	10697	24		4	14935	2
	5	11029	23		5	15086	0
	6	11688	25		6	15316	0
	7	12966	23		7	15501	-1
	8	13814	26		8	15680	0
	9	14091	26		9	15713	5
	10	14307	26		10	15533	7
	11	14219	27		11	14869	10
	12	14114	27		12	14300	15
	13	14029	24		13	13520	17
	14	14105	23		14	12801	20
	15	14212	22		15	12240	21
	16	14419	21		16	11896	22
	17	14620	21		17	11946	20
	18	15297	21		18	12932	17
	19	15911	20		19	13916	17
	20	15922	19		20	14185	15
	21	15860	16		21	14373	15
	22	15666	14		22	14407	15
	23	15221	13		23	14162	16
	24	14602	12		24	13749	16
12/22/89	1	14271	13	12/24/89	1	13337	16
	2	14184	11		2	13199	16
	3	14246	10		3	13214	16
	4	14349	9		4	13087	17
	5	14622	8		5	12909	16
	6	15142	7		6	13259	16
	7	16029	7		7	13528	17
	8	16749	6		8	13895	17
	9	17063	7		9	14082	22
	10	16995	8		10	13706	25
	11	16937	9		11	12955	29
	12	16489	11		12	12087	33
	13	15906	14		13	11386	35
	14	15663	12		14	10663	38
	15	15505	12		15	10094	41
	16	15284	13		16	9719	41
	17	15286	13		17	9672	40
	18	15951	11		18	10386	37
	19	16649	10		19	11031	30
	20	16722	10		20	11117	31
	21	16613	7		21	11217	28
	22	16427	6		22	11314	29
	23	16011	4		23	11256	29
	24	15509	3		24	10969	28
=====				=====			

TEXAS UTILITIES ELECTRIC COMPANY
LOAD TEMPERATURE VARIATION
December 21, 1989

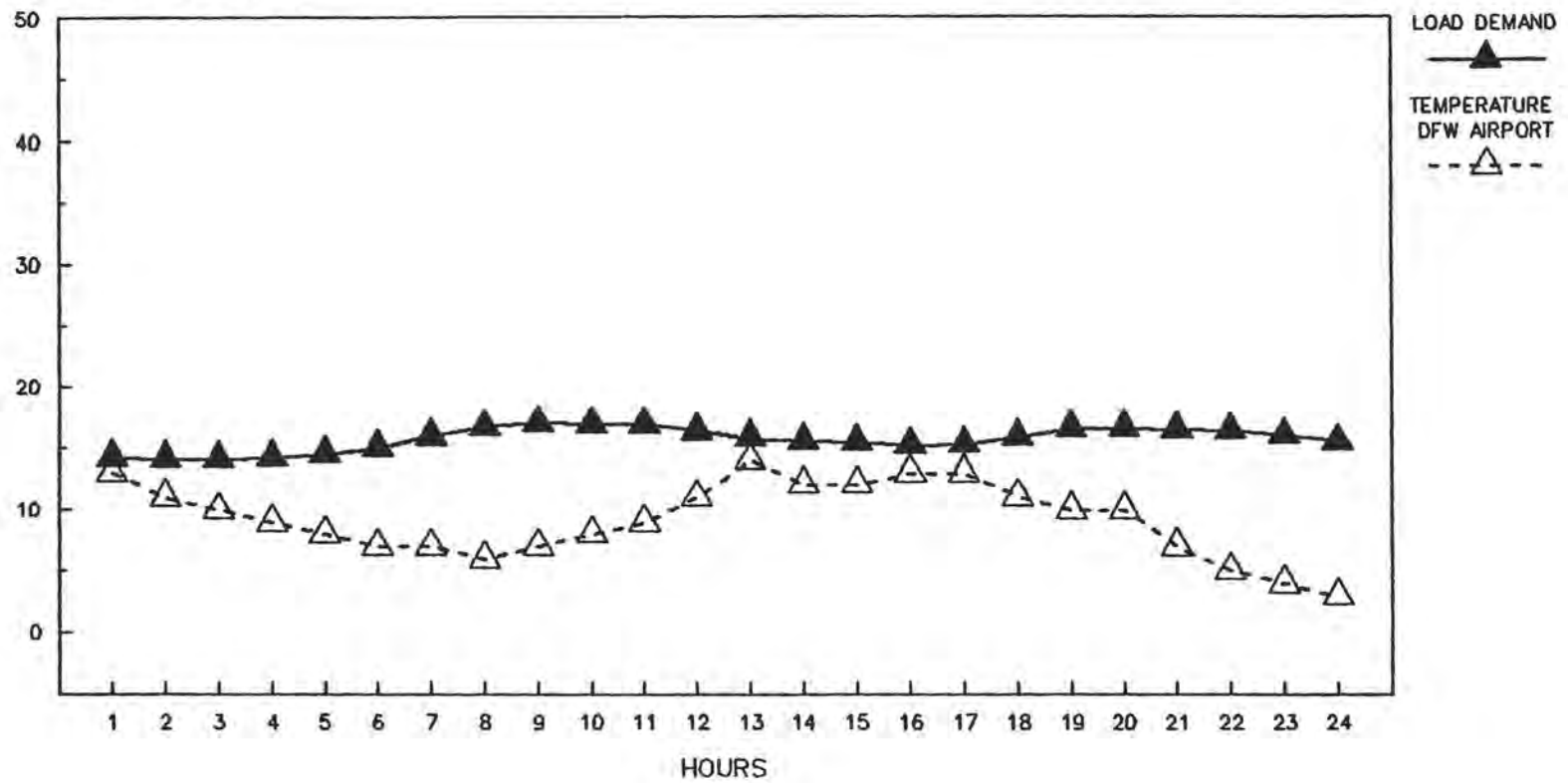
TEMPERATURE AND LOAD DEMAND



LOAD DEMAND IS x 1000.

TEXAS UTILITIES ELECTRIC COMPANY
LOAD TEMPERATURE VARIATION
December 22, 1989

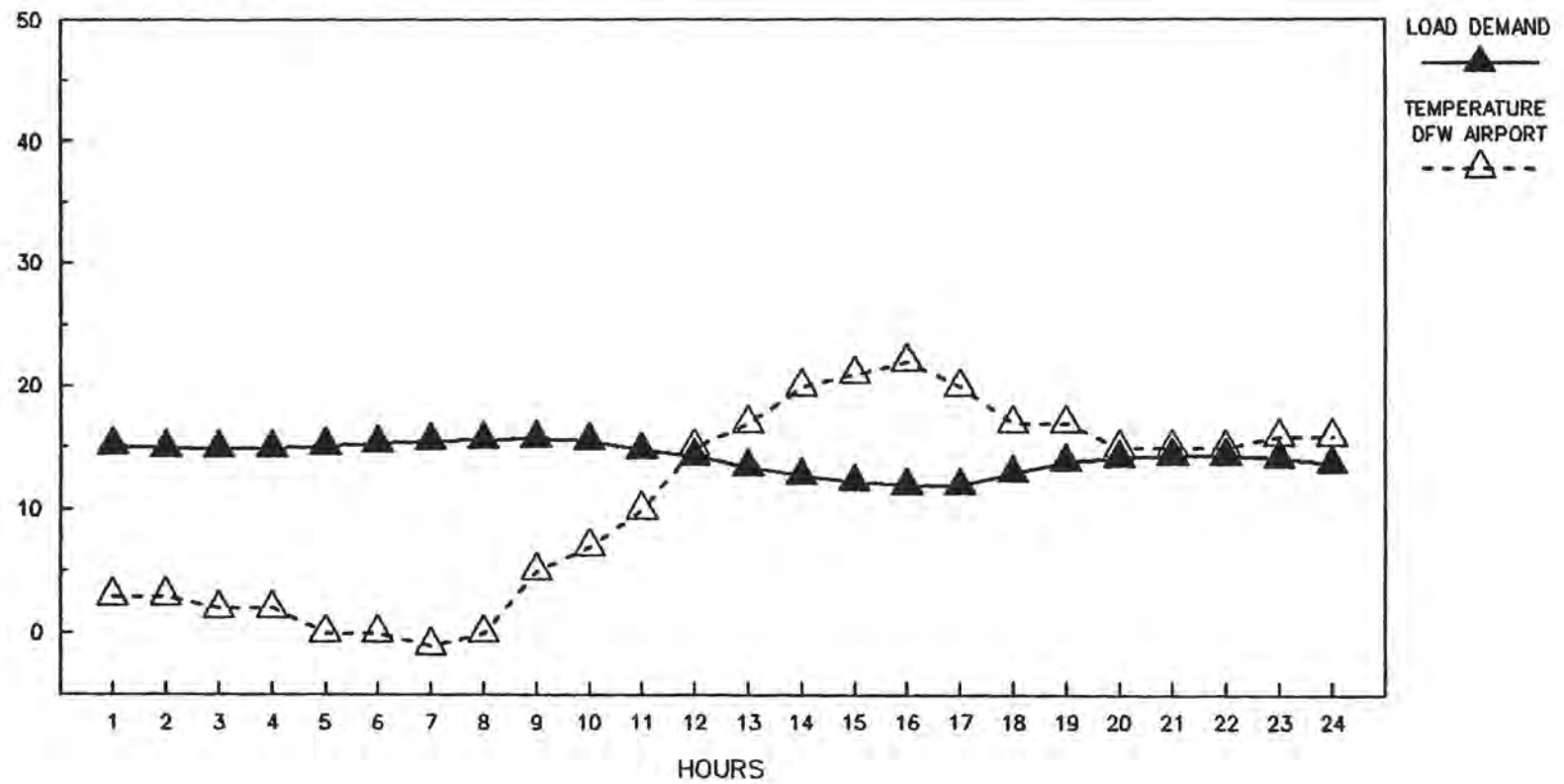
TEMPERATURE AND LOAD DEMAND



LOAD DEMAND IS x 1000.

TEXAS UTILITIES ELECTRIC COMPANY
LOAD TEMPERATURE VARIATION
December 23, 1989

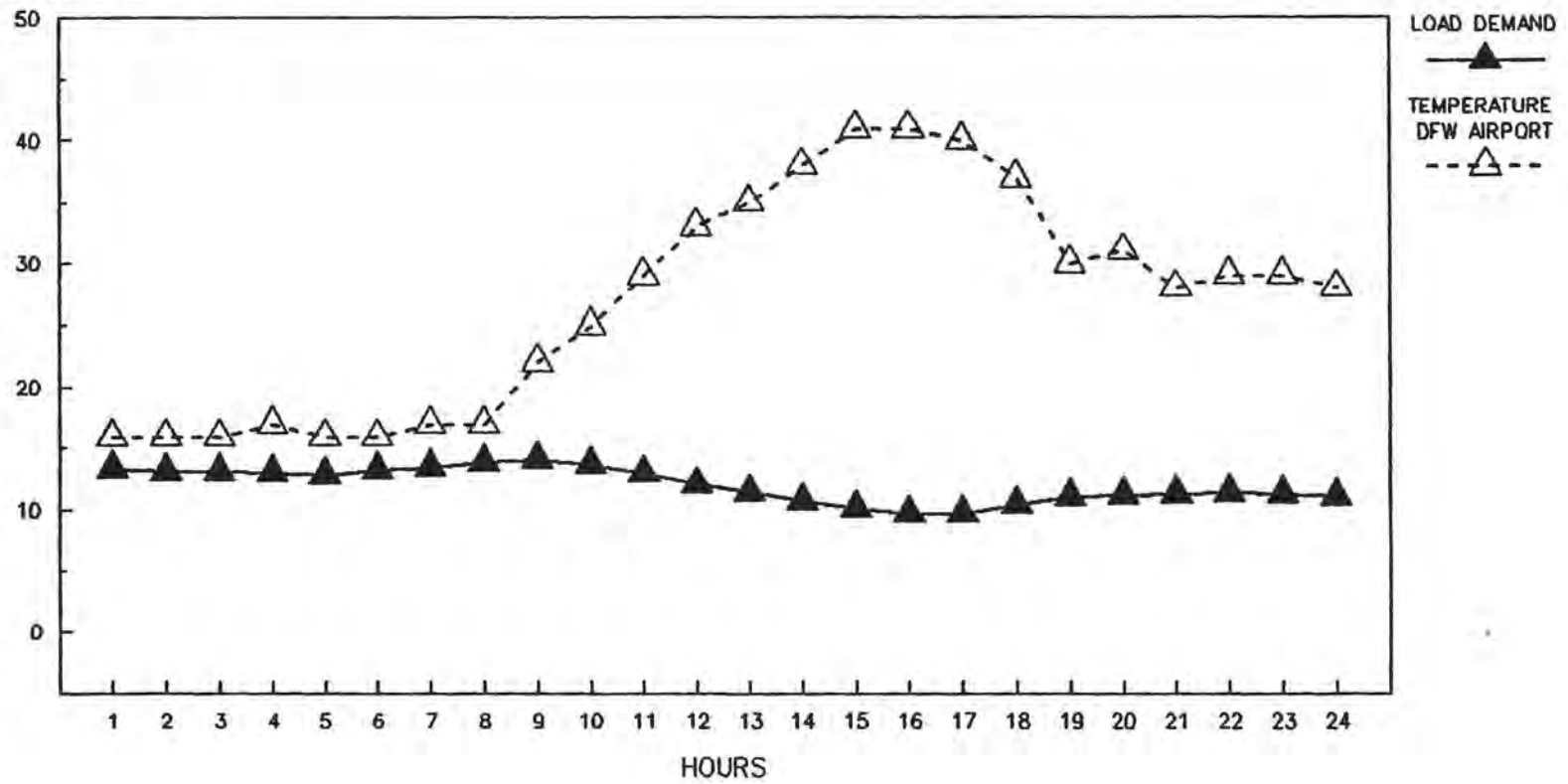
TEMPERATURE AND LOAD DEMAND



LOAD DEMAND IS x 1000.

TEXAS UTILITIES ELECTRIC COMPANY
LOAD TEMPERATURE VARIATION
December 24, 1989

TEMPERATURE AND LOAD DEMAND



LOAD DEMAND IS x 1000.

ATTACHMENT NO. 2

**CAUSES OF PLANT SHUTDOWNS
and
CORRECTIVE ACTION COSTS (SUMMARY)**

ATTACHMENT No. 2

CAUSES OF PLANT SHUTDOWNS AND CORRECTIVE ACTION COSTS (SUMMARY)

Unit Name	Cause	Date Compl.	Expenses O & M	Capital
Central Power and Light (CPL)				
Barney Davis 1			3,500	50,000
Barney Davis 2			3,500	50,000
Caleto Creek 1			55,200	50,000
E. S. Joslin 1*	Frozen instrumts	11/90	92,500	50,000
J. L. Bates 1			18,400	50,000
J. L. Bates 2			1,500	50,000
La Palma 6			32,200	50,000
Laredo 1				50,000
Laredo 2			4,000	50,000
Laredo 3			34,400	50,000
Lon C. Hill 3*	Frozen instrumts	12/90	65,600	50,000
Lon C. Hill 4*	Boiler tube leak	12/89	47,600	50,000
Nueces Bay 6 *	Frozen instrumts	11/90	37,600	50,000
Nueces Bay 7			32,200	50,000
Victoria 6			52,400	50,000
=====				
Total CPL			\$ 480,600	\$ 750,000
Grand Total CPL			\$ 1,230,600	

* Tripped off line during cold weather emergency

Preventive and corrective measures include the following:

- Control Air Dryers (Capitalized)
- DC Heater Enclosures (O & M)
- Drum Enclosures (O & M)
- Heat Tracing (O & M)
- Drum Level Instrumentation (O & M)

**Attachment No. 2 Causes of Plant Shutdowns and
Corrective Action Costs (Summary)**

Houston Lighting & Power Company (HL&P)

Unit Name	Cause	Date Compl.	Expenses	
			O & M	Capital
=====				
Cedar Bayou 1	Frozen instrumts	2/90	\$ 4,800	38,000
Cedar Bayou 2				
Cedar Bayou 3	Frozen instrumts	10/90	10,000	90,000
Greens Bayou 5	Frozen instrumts	9/90	15,800(4)	
Limestone 1	Frozen instrumts	9/90	57,700(2)	
Limestone 2	Frozen instrumts	9/90	57,300	
P H Robinson 1	Frozen instrumts	10/90	38,800	38,000
P H Robinson 2			38,800	
P H Robinson 3				38,000
P H Robinson 4			1,100	48,000(3)
S R Bertron 1		3/90	44,000	40,000
S R Bertron 2		9/90		76,000
S R Bertron 3	Frozen instrumts	10/90	3,700	
S R Bertron 4	Ice in boiler fan	12/89		
South Texas 1	Frozen instrumts	10/90	20,000(1)	140,700(5)
South Texas 2		6/90	20,000	213,000(5)
T H Wharton 2	Boiler motor failed	1/90	51,509	
T H Wharton 3	Frozen instrumts	10/90	65,140	
T H Wharton 4	Frozen instrumts	5/90	109,266	
T H Wharton GT21	Frozen instrumts	7/90	1,000	
T H Wharton GT54	Frozen fuel valve	12/89		
W A Parish 1		9/90	63,000(6)	
W A Parish 2				
W A Parish 3				
W A Parish 5	Frozen instrumts	7/90	74,918	57,000
W A Parish 6				
W A Parish 7				
W A Parish 8	Frozen instrumts	8/90	2,500	50,000
W A Parish GT21	Batteries frozen	5/90		
Webster GT	Frozen instrumts	2/90		
=====				
Total HL&P			\$ 679,333	\$ 828,700
Grand Total HL&P			\$ 1,508,033	

**Attachment No. 2 Causes of Plant Shutdowns and
Corrective Action Costs (Summary)**

Notes

- (1) Additional Cost for seal water lines and instrumentation lines to be determined after engineering analysis.
- (2) Maintenance costs for Bottom Ash Hopper and Sluice Gate Pistons included (\$8,400).
- (3) Costs for Aux Boiler Steam Drum End Enclosures.
- (4) Costs for temporary burner deck enclosures not significant.
- (5) Costs for additional freeze protection for auxiliary cooling surge tank and feedwater booster pumps.
- (6) Cost for all Parish units combined.

Included in this list are anticipated cold weather modifications on various HL&P generating units that did not fail in service during the cold weather emergency (See Attachment B of HL&P letter dated June 15, 1990, that has been included in Attachment No. 4.)

**Attachment No. 2 Causes of Plant Shutdowns and
Corrective Action Costs (Summary)**

Texas Utilities Electric Company (TUE)

Unit Name	Cause	Date Compl.	Expenses O & M	Capital
Eagle Mountain 3	Fish plugged intake	1/90		
Handley 5	Human error	1/90		
Martin Lake 2	Frozen instrumts	1/90	2,000	
Monticello 2	Frozen instrumts	1/90	2,000	
Monticello 3	Frozen instrumts	1/90	2,700	
Morgan Creek CT4	Frozen fuel valve	1/90		
Mountain Creek 2	Fish plugged intake	1/90		
Mountain Creek 7	Instrument error	1/90		
River Crest 1	Fish plugged intake	8/90	900	
Stryker Creek 1	Low gas pressure	1/90		
Tradinghouse 1	Frozen instrumts	1/90	500	
Valley 2	Frozen instrumts	1/90	300	
Total TUE			\$ 8,400	

**Attachment No. 2 Causes of Plant Shutdowns and
Corrective Action Costs (Summary)**

Lower Colorado River Authority (LCRA)

Unit Name	Cause	Date Compl.	Expenses	
			O & M	Capital
Sim Gideon 2	Frozen instrumts	2/90	300	
Sam K Seymour 3	Frozen instrumts	5/90	420	
Total LCRA			\$ 720	

Texas Municipal Power Agency (TMPA)

Unit Name	Cause	Date Compl.	Expenses	
			O & M	Capital
Gibbons Creek 1	Frozen instrumts	10/90	25,500	
Total TMPA			\$ 25,500	

GRAND TOTAL, ALL UTILITIES			\$ 1,194,553	\$ 1,578,700
Total			\$ 2,773,253	

ATTACHMENT NO. 3
INDIVIDUAL UTILITY RESPONSES

Utility Responses:

Brazos Electric Power Cooperative, Inc.
Central Power and Light Company
Houston Lighting and Power Company
Lower Colorado River Authority
Texas Municipal Power Agency
Texas Utilities Electric Company

**BRAZOS
ELECTRIC
COOPERATIVE**

BRAZOS ELECTRIC POWER COOPERATIVE, INC.
2404 LaSalle Avenue • P.O. Box 2585
Waco, Texas 76702-2585
(817) 750-6500

June 11, 1990

Mr. Chester R. Oberg
Public Utility Commission of Texas
7800 Shoal Creek Boulevard Suite 400N
Austin, Texas 78757

Re: Cold Weather Operation
Your letter dated, May 10, 1990
PUC Project 9542

Dear Mr. Oberg:

Please recall that, with the exception of Miller 1 which was not designed for oil firing, all of our units were responsive and suffered no outages during the problem cold period.

The following actions have been taken on Miller 3 Unit:

The burner management system was tested making some minor fuel pressure trip adjustments.

Miller 1 unit was not equipped for oil firing because its gas fuel supply was very reliable, and Brazos builds its plants for the lowest first cost. We plan now to install the necessary equipment.

The following activity has been underway on Miller 1 Unit:

- * Specifications have been prepared for the purchase of fuel oil pumps, and the purchasing process is now underway.
- * Specifications are being prepared for the purchase of other associated equipment such as valves, strainers, etc.
- * Specifications will be prepared for piping and installation labor.
- * If new burner controls are needed we will attempt to delay this part of the project until they can be installed along with future replacement BTG controls.

It is hoped that this can be completed in December 1990.

We will make the usual preparations in November for cold weather operations. Such preparations include, but are not limited to, the following inspection and testing:

- * Heating cable survey and inspection
- * Equipment heaters
- * Area Heating equipment
- * Outdoor lube oil systems and oil inspection.
- * Actual brief oil firing on at least one burner
- * All fuel oil tanks full

Please call if we need to discuss this further.

Jack T. Ard

Jack T. Ard P.E.
Manager Power Production

Copy: J.D. Copeland



October 8, 1990

Mr. Chester R. Oberg
Nuclear Projects
Public Utility Commission of Texas
7800 Shoal Creek Boulevard
Suite 400n
Austin, Texas 78757

Subject: December 1989 Weather Problems

Dear Mr. Oberg

Central Power and Light had problems with its generating units just as many other utility company's did. The following information will address the seven question posed in your letter of May 10, 1990 concerning CPL generating units that were lost or unable to respond during the cold weather emergency of December 1989.

Question No. 1 - Unit name and unit MW capacity

Four (4) of CPL's generating units tripped off the line. The units and their capacity were as follows:

<u>Unit Tripped</u>			
<u>Unit</u>	<u>Capacity</u>	<u>Date</u>	<u>Time</u>
E S Joslin 1	257-NMW	12-23-89	0150-Hrs
Nueces Bay 6	172-NMW	12-23-89	0536-Hrs
Lon C. Hill 3	162-NMW	12-23-89	0605-Hrs
Lon C. Hill 4	256-NMW	12-23-89	0656-Hrs

Question No.2 Unit general design temperature limitations (Maximum and minimum), in degrees F.

CPL's Generating Units are designed for a minimum ambient temperature of 10 degrees F with a wind velocity of 30-MPH. A specific maximum temperature is not specified as it is equipment dependant (eg. boiler tube metal may operate at temperatures as high as 1000 degrees F; furnace gas temperatures may be as



A Member of the Central and South West System

Central Power and Light
Corpus Christi, Texas

Public Service Company of Oklahoma
Tulsa, Oklahoma

Southwestern Electric Power
Shreveport, Louisiana

West Texas Utilities
Arlene, Texas

high as 2300 degrees F). Other equipment such as electronic and digital control equipment may require a conditioned area where temperatures are controlled at or near 75 degrees F.

Question No. 3 - List of equipment(s) or plant systems that were adversely affected by the cold weather.

Question No. 4 - For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit.

The following equipment/plant systems were affected by the cold weather at the Power Stations noted above:

<u>Unit Name</u>	<u>No.</u>	(3) <u>Affected Equip.</u>	(4) <u>Failure Mode</u>	(4) <u>Failure Cause</u>	(4) <u>How did failure contribute to overall probs.</u>
E S Joslin	1	Boiler	(A)	(C)	(E)
Nueces Bay	6	Boiler	(A)	(C)	(F)
Lon C Hill	3	Boiler	(A)	(C)	(F)
Lon C Hill	4	Boiler	(B)	(D)	(G)

- (A) Boiler Tripped as a result of low drum level
- (B) Furnace over pressure protection tripped the boiler
- (C) Frozen drum level sensing lines and instrumentation
- (D) Boiler tube failure caused furnace over pressure
- (E) The failure of the drum level instrumentation provided a false signal to the feed water control system which resulted in a reduction in feedwater to the boiler leading to a low water event in the boiler. The low water event caused the failure of several water wall tubes. The failed water wall tubes damaged the radiant section of the reheater. The unit was rendered unable to return to service until extensive NDT was performed and repairs were made.
- (F) The units were tripped by the operator. The instrument problems were corrected and the units were returned to service
- (G) A boiler tube leak caused the furnace over pressure. The tube leak was repaired and the unit returned to service.

Question No. 5 For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure.

In order to prevent recurrence of the system and equipment failure during future adverse weather conditions a complete post critique of power station operation was necessary. The Director of Generation Operation, Mr. Perry A. Beaty, appointed a taskforce to review the operation at each of CPL's Power Stations. The taskforce was charged with identifying all weather related problems and recommending action steps needed to prevent recurrence of weather related problems. The taskforce inspected records, logs, and interviewed the staff at each power station. The following actions were recommended:

- (1) Engineering review of CPL's low temperature design requirements.
- (2) The addition of desiccant type air dryers to the power station control air systems.
- (3) Review power station heat tracing practices.
- (4) Review power station boiler protection systems.
- (5) Review power station boiler drum level instrumentation.
- (6) Review boiler drum enclosures and D C heater instrumentation enclosures.

Stone and Webster Engineering was retained to perform the required design and specification for control air drying. Bath and Assoc. was retained to perform the required design review and specification for the drum enclosures and the DC heater enclosures.

Question No. 6 For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion.

See attached Tables 1, 2, 3, 4, & 5

Question No. 7 For each piece of equipment or system identified

Mr. Chester R. Oberg

-4-


October 8, 1990

above report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense.

See attached Tables 1, 2, 3, 4, & 5

Thank you for your patience. If you have questions concerning the information provided please feel free to call us.

Very truly yours,



Ronald R. Earley
Manager Technical Services
Generation Operations Dept.

RRE:(rre10590)

Attachments

xc: Perry A. Beaty, Jr.

File:998-275.10.00-002

FREEZE PROTECTION
PREVENTATIVE AND CORRECTIVE MEASURES

TABLE NO. 1 CONTROL AIR DRYERS

POWER STATION	UNIT NO.	COMPLETION DATE		COST		MAINT/ CAPITAL
		PROJECTED	ACTUAL	PROJECTED	ACTUAL	
NBPS	6	11/15/91		\$50,000.00		CAPITAL
<i>Nueces Bay</i>	7	11/15/91		\$50,000.00		CAPITAL
LAPPS	6	11/15/92		\$50,000.00		CAPITAL
<i>LaPalma</i>						
LARPS	1	11/15/92		\$50,000.00		CAPITAL
<i>Laurel</i>	2	11/15/92		\$50,000.00		CAPITAL
	3	11/15/92		\$50,000.00		CAPITAL
LCHPS	3	11/15/91		\$50,000.00		CAPITAL
<i>San C. Hill</i>	4	11/15/91		\$50,000.00		CAPITAL
VICPS	6	12/14/90		\$50,000.00		CAPITAL
<i>Victoria</i>						
JLBPS	1	11/15/92		\$50,000.00		CAPITAL
<i>J.L. Bate</i>	2	11/15/92		\$50,000.00		CAPITAL
ESJPS	1	12/14/90		\$50,000.00		CAPITAL
<i>E.S. Joslin</i>						
BMDPS	1	11/15/91		\$50,000.00		CAPITAL
<i>Bonnie Davis</i>	2	11/15/91		\$50,000.00		CAPITAL
COCPS	1	12/14/90		\$50,000.00		CAPITAL
<i>Caleta Creek</i>						
				\$750,000.00		

FREEZE PROTECTION
PREVENTATIVE AND CORRECTIVE MEASURES

TABLE NO.2 DC Htr ENCLOSURES

POWER STATION	UNIT NO.	COMPLETION DATE		COST		MAINT/ CAPITAL
		PROJECTED	ACTUAL	PROJECTED	ACTUAL	
NBPS	6 1	11/15/90		\$7,500.00		MAINT
	7 2	11/15/90		\$1,500.00		MAINT
LAPPS	6 3	11/01/90		\$7,500.00		MAINT
LARPS	1 4	NONE REQUIRED				
	2 5	NONE REQUIRED				
	3 6	12/15/90		\$2,500.00		MAINT
LCHPS	3 7	11/01/90		\$5,000.00		MAINT
	4 8	11/01/90		\$5,000.00		MAINT
VICPS	6 9	11/15/90		\$7,500.00		MAINT
JLBPS	1 10	NONE REQUIRED				
	2 11	NONE REQUIRED				
ESJPS	1 12	11/01/90		\$7,500.00		MAINT
BMDPS	1 13	11/01/90		\$1,000.00		MAINT
	2 14	11/01/90		\$1,000.00		MAINT
COCPS	1 15	11/15/90		\$9,000.00		MAINT
				\$55,000.00		

FREEZE PROTECTION
PREVENTATIVE AND CORRECTIVE MEASURES

TABLE NO.5 DRUM LEVEL INSTRUMENT

POWER STATION	UNIT NO.	COMPLETION DATE		COST		MAINT/ CAPITAL
		PROJECTED	ACTUAL	PROJECTED	ACTUAL	
NBPS	6	10/19/90		\$19,900.00		MAINT
	7	12/07/90		\$19,900.00		MAINT
LAPPS	6	11/23/90		\$19,900.00		MAINT
LARPS	1	NONE REQUIRED				
	2	NONE REQUIRED				
	3	11/30/90		\$19,900.00		MAINT
LCHPS	3	12/07/90		\$19,900.00		MAINT
	4	12/07/90		\$19,900.00		MAINT
VICPS	6	11/30/90		\$19,900.00		MAINT
JLBPS	1	12/14/90		\$15,900.00		MAINT
	2	NONE REQUIRED				
ESJPS	1	NONE REQUIRED				
BMDPS	1	NONE REQUIRED				
	2	NONE REQUIRED				
COCPS	1	NONE REQUIRED				

				\$155,200.00		

FREEZE PROTECTION
PREVENTATIVE AND CORRECTIVE MEASURES

TABLE NO.4 HEAT TRACING

POWER STATION	UNIT NO.	COMPLETION DATE		COST		MAINT/ CAPITAL
		PROJECTED	ACTUAL	PROJECTED	ACTUAL	
NBPS	6	11/15/90		\$6,700.00		MAINT
	7	11/15/90		\$8,300.00		MAINT
LAPPS	6	11/30/90		\$3,000.00		MAINT
LARPS	1	NONE REQUIRED				MAINT
	2	12/01/90		\$500.00		MAINT
	3	11/30/90		\$2,000.00		MAINT
LCHPS	3	11/15/90		\$37,200.00		MAINT
	4	11/15/90		\$7,700.00		MAINT
VICPS	6	12/01/90		\$20,000.00		MAINT
JLBPS	1	12/14/90		\$1,500.00		MAINT
	2	12/14/90		\$1,500.00		MAINT
ESJPS	1	11/17/90		\$70,000.00		MAINT
BMDPS	1	11/30/90		\$1,500.00		MAINT
	2	11/30/90		\$1,500.00		MAINT
COCPS	1	12/01/90		\$28,200.00		MAINT
				\$189,600.00		

FREEZE PROTECTION
PREVENTATIVE AND CORRECTIVE MEASURES

TABLE NO. 3 DRUM ENCLOSURES

POWER STATION	UNIT NO.	COMPLETION DATE		COST		MAINT/ CAPITAL
		PROJECTED	ACTUAL	PROJECTED	ACTUAL	
NBPS	6	11/15/90		\$3,500.00		MAINT
	7	11/30/90		\$2,500.00		MAINT
LAPPS	6	11/01/90		\$15,000.00		MAINT
LARPS	1	NONE REQUIRED				
	2	12/15/90		\$3,500.00		MAINT
	3	12/15/90		\$10,000.00		MAINT
LCHPS	3	11/01/90		\$3,500.00		MAINT
	4	11/01/90		\$15,000.00		MAINT
VICPS	6	11/15/90		\$5,000.00		MAINT
JLBPS	1	12/10/90		\$1,000.00		MAINT
	2	NONE REQUIRED				
ESJPS	1	11/01/90		\$15,000.00		MAINT
BMDPS	1	11/01/90		\$1,000.00		MAINT
	2	11/01/90		\$1,000.00		MAINT
COCPS	1	11/15/90		\$18,000.00		MAINT

				\$94,000.00		

The Light company

Houston Lighting & Power

P.O. Box 1700 Houston, Texas 77251 (713) 228-9211

June 15, 1990

Chester R. Oberg
Public Utility Commission of Texas
7800 Shoal Creek Boulevard
Suite 400N
Austin, Texas 78757



Dear Mr. Oberg:

Your letter of May 10, 1990 requested that Houston Lighting & Power provide information regarding generating units which were lost or were otherwise unable to respond to the cold weather emergency which occurred throughout Texas in December of 1989.

Attachment A to this letter contains a response for each of the generating units which was adversely affected by the cold weather. General design temperature ranges are indicated for each unit. Plants built since the 1970's have included freeze protection design criteria which are indicated in Attachment A for Limestone and the South Texas Project. Although other plants do not have specific freeze protection design criteria established, freeze protection was provided in accordance with operating experience for Houston area plants. The following is offered to further supplement and clarify the information provided in Attachment A.

The Company is taking several administrative measures as a result of the experience gained during the 1989 cold weather emergency. The temperatures experienced were the coldest on record since the Company began building outside generating plants. The Company is re-evaluating its cold weather emergency procedures with regard to all of its plants to insure that they will operate at the weather extremes experienced in December of 1989. This response is consistent with the Company's commitment to the regular review of plans and procedures to insure that they remain current in light of experience. The Company is reviewing guidelines used by operators at the Company's generating plants when cold weather is imminent to insure that freeze protection measures are implemented. The guidelines are being revised to include improved freeze protection measures for equipment which experienced cold weather related problems during the 1989 cold weather emergency. Critical equipment lists are

Chester R. Oberg
Public Utility Commission of Texas
June 15, 1990
Page 2

being reviewed and re-evaluated in light of the experience gained during the emergency. The Company is reviewing its cold weather emergency maintenance staffing levels and may increase crew size during such emergencies. Maintenance crews already provide twenty-four hour coverage during such emergencies. Maintenance crews monitor and activate freeze protection equipment and take necessary corrective action if and when problems arise.

The Company is taking corrective action with respect to equipment which failed and affected unit operation as a result of the 1989 cold weather emergency. Those actions are described in Attachment A. Each failure is being reviewed to determine the failure mode. If the failure resulted from an equipment malfunction, such as heat tracing circuit failure, maintenance is planned or has been undertaken to correct the situation. Most unit failures were of this type and resulted from frozen instrumentation sensing lines or transmitters. If the failure mode indicates the need for design modifications, an engineered modification is being developed. This engineering review has been extended to encompass similar units that did not experience failures during the 1989 cold weather emergency and engineering enhancements are being provided. Examples of modifications resulting from this review include drum-end enclosures to protect water-level sensing lines and moisture-removal devices for instrument air systems. Attachment B summarizes the modifications to generating units which did not experience failures in December 1989.

The Company is attempting to anticipate problems which it might experience in the event that even more extreme weather conditions occur and to take reasonable administrative and corrective actions to prepare for such conditions. The Company does not consider the administrative actions which it is implementing and the corrective steps which it is taking to necessarily be the ultimate answer to extreme cold weather conditions. The Company learns from each weather extreme how better to protect its generating equipment. The Company must emphasize, however, that it would not be prudent to plan for or implement steps which are beyond those needed given the historical weather patterns, including the occasional period of extreme cold weather, to which the Greater Houston area is subject. Generating plants in Amarillo, for example, are built with a level of freeze protection greater than would be reasonable or prudent in Houston.

Houston Lighting & Power Company

Chester R. Oberg
Public Utility Commission of Texas
June 15, 1990
Page 3

The Company has surveyed the larger cogenerators in its service area including those under firm contract. The responses received are included in Attachment C.

The Company hopes that the information provided in this response is useful to the Commission in its review of procedures established by the electric utilities of the state to deal with cold weather emergencies. Should you have any questions regarding this response, please contact the undersigned at (713) 220 5387.

Sincerely,

A handwritten signature in black ink, appearing to read "John C. Houston". The signature is fluid and cursive, with the first name "John" and last name "Houston" clearly distinguishable.

John C. Houston
Manager, Regulatory Activities

JCH/MGB/bg
3861
Encl.

ATTACHMENT A

Generating Plant Reports
December 21-24, 1989

Index

W A Parish	Page 1-3
Limestone	Page 4-6
P H Robinson	Page 7
Cedar Bayou	Page 8-9
S R Bertron	Page 10-12
Greens Bayou	Page 13
Webster	Page 14
T H Wharton	Page 15-19
South Texas Project	Page 20-21

The generating unit reports are formatted to respond to the following questions:

1. Unit Name and Unit MW Capacity
2. Unit general design temperature limitations (Maximum and Minimum), in degrees F.
3. List of equipment(s) (or plant systems) that were adversely affected by the cold weather.
4. For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit.
5. For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure.
6. For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion.
7. For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense.

1. W A Parish Unit 5 : 670 MW
2. Design Temperature Range : 10°F - 105°F
3.
 - a. High Secondary Air Duct Pressure Switch
 - b. Seal Water to Vacuum Pumps
4.
 - a. Failure Mode - False indication of high secondary air duct pressure.

Cause of Failure - Condensation collected in low point of sensing line; condensate froze, causing false indication of high duct pressure.

Contribution to overall failure of unit - High secondary air duct pressure indication that lasts 2 minutes results in a main fuel trip.
 - b. Failure Mode - Low condenser vacuum.

Cause of Failure - Seal water to vacuum pump froze, during outage caused by High Secondary Air Duct Pressure indication. Vacuum pumps require seal water to operate.

Contribution to overall failure of unit - Low condenser vacuum results in automatic trip of unit.
5.
 - a. Pressure sensing line will be re-sloped, heat traced and insulated.
 - b. Low-point drains will be installed to drain seal water line when unit is off-line during freezing conditions. Temporary windbreaks and heaters will be used to protect seal water line during operation in freezing weather.
6.
 - a. Corrective action will be completed by 7/31/90.
 - b. Corrective action will be completed by 7/31/90.
7.
 - a. \$3668 - Maintenance
 - b. \$1250 - Maintenance

1. W A Parish Unit 8 : 570 MW
2. Design Temperature Range : 10°F to 105°F
3.
 - a. Superheat and Reheat Spray Regulator Instrument Lines
 - b. Boiler Water Circulating Pump Differential Pressure Transmitter
4.
 - a. Failure Mode - Superheat and reheat spray valves failed to close.

Cause of Failure - Moisture in instrument air lines to Superheat and Reheat Spray regulators froze, resulting in loss of control of regulators.

Contribution to overall failure of unit - There was no overall failure of unit. Load was reduced to 416 MW to control Superheat and Reheat temperatures. Condition was cleared within three hours.
 - b. Failure Mode - False indication of low Boiler Water Circulating Pump pressure differential.

Cause of Failure - Transmitter sensing lines froze due to failure of freeze protection equipment.

Contribution to overall failure of unit - There was no overall failure of unit. Unit was derated to 420 MW. Condition was cleared within 35 minutes.
5.
 - a. Instrument air system will be modified to allow collected moisture to be drained.
 - b. Heat tracing and insulation will be updated on BWCP pressure transmitter sensing lines.
6.
 - a. Corrective action will be completed by 8/31/90.
 - b. Corrective action was completed on 5/14/90.
7.
 - a. \$50,000 - Capital
 - b. \$2500 - Maintenance

1. W A Parish Gas Turbine Unit 21 : 13 MW
2. Design Temperature Range : 10°F to 105°F
3. Starting motor battery
4. Failure Mode - Battery was not able to start cranking motor.
Cause of Failure - Battery was weakened by exposure to low temperature.
Contribution to overall failure of unit - Gas turbine cannot be started without use of cranking motor.
5. Space heaters will be used in the gas turbine enclosure to maintain temperature of starting motor batteries.
6. Corrective action completed - 5/29/90
7. Negligible cost

1. Limestone Unit 1 : 780 MW
2. Design Temperature Range : 10°F to 110°F
Freeze Protection : 5°F
3. Feedwater Flow Transmitter
4. Failure Mode - Loss of boiler feedwater flow

Cause of Failure - Transmitter sensing lines froze, causing an incorrect control signal to slow boiler feed pumps to zero speed. This caused loss of feedwater flow.

Contribution to overall failure of unit - Loss of feedwater flow resulted in a drop in drum water level. This ultimately caused a main fuel trip on boiler.
5. Heat Tracing and insulation on sensing lines will be upgraded.
6. Corrective action will be completed 9/15/90.
7. \$300 - Maintenance

1. Limestone Unit 2 : 780 MW
2. Design Temperature Range : 10°F to 110°F
Freeze Protection : 5°F
3.
 - a. Boiler Drum Level Instrumentation
 - b. Boiler Water Circulating Pump Differential Pressure Transmitter
 - c. Superheat Spray Flow Transmitter
 - d. Ignitor Gas Valve Actuator
 - e. Circulating Water Pump Seal Water Piping
4.
 - a. Failure Mode - Drum water level sensing lines froze, resulting in incorrect signal on drum water level.

Cause of Failure - Heat tracing and/or insulation on sensing lines failed.

Contribution to overall failure of unit - Drum level indication out of limits caused Main Fuel trip.
 - b. Failure Mode - BWCP sensing lines froze, causing false indication of low pressure differential.

Cause of Failure - Heat tracing and insulation on sensing lines failed.

Contribution to overall failure of unit - False indication of low BWCP flow initiated a Main Fuel Trip.
 - c. Failure Mode - Sensing lines to Superheat Spray Flow transmitter froze, causing indication of low spray flow.

Cause of Failure - Heat tracing and insulation on sensing lines failed.

Contribution to overall failure of unit - This did not contribute to unit failure.
 - d. Failure Mode - Ice on valve prevented valve operation.

Cause of Failure - Moisture collected from prior washdown, froze.

Contribution to overall failure of unit - Caused delay in unit restart following unit trip for other reasons.

(LEGS Unit 2 cont'd)

- e. Failure Mode - Unprotected seal water piping froze and ruptured.

Cause of Failure - Isolation valves to circulating water pump leaked, making it impossible to drain the seal water piping while unit off line.

Contribution to overall failure of unit - This did not contribute to unit failure. Unit was off line for other reasons. Could have prevented unit restart.

- 5.
 - a. Heat tracing and insulation on sensing lines will be upgraded. Also, Drum End Enclosures will be installed to protect from wind and rain.
 - b. Heat tracing and insulation have been replaced.
 - c. Heat tracing and insulation have been replaced.
 - d. Ice was removed from valves. Administrative procedure was instituted to prevent recurrence.
 - e. Seal water piping will be freeze protected.
- 6.
 - a. Corrective action will be completed 9/15/90.
 - b. Corrective action will be completed 9/15/90.
 - c. Corrective action was completed 2/13/90.
 - d. Corrective action was completed 1/2/90.
 - e. Corrective action will be completed 9/15/90.
- 7.
 - a. \$50,400 - Maintenance
 - b. \$ 4,500 - Maintenance
 - c. \$ 500 - Maintenance
 - d. \$ 400 - Maintenance
 - e. \$ 1,500 - Maintenance

1. P H Robinson Unit 1 : 490 MW
2. Design Temperature Range : 10°F to 105°F
3. Boiler Feed Pump Suction Flow Transmitter
4. Failure Mode - Sensing lines to transmitter froze, causing a false signal of Low Feed Pump Flow.

Cause of Failure - Heat tracing and insulation failed to protect sensing lines.

Contribution to overall failure of unit - Unit tripped off line from 325 MW, due to automatic initiation of pump recirculation caused by false signal of low flow thru pump. Result was loss of feedwater flow to boiler and unit trip.

5. Heat tracing and insulation will be upgraded.
6. Corrective action to be completed 10/1/90.
7. \$38,800 - Maintenance

1. Cedar Bayou Unit 1 : 740 MW
2. Design Temperature Range : 10°F to 105°F
3. Boiler Feedwater Flow Transmitter
4. Failure Mode - Loss of feedwater flow signal to feed pump control due to freezing of sensing line.
Cause of Failure - Heat tracing and insulation failed to protect sensing line to transmitter.
Contribution to overall failure of unit - Unit tripped on Low Feedwater Flow signal.
5. Heat tracing and insulation were upgraded.
6. Corrective action was completed 2/15/90.
7. \$4800 - Maintenance

1. Cedar Bayou Unit 3 : 770 MW
2. Design Temperature Range : 10°F to 105°F
3. Fuel Oil Forwarding Pump Recirculation Valve
4. Failure Mode - Recirculation valve failed open on loss of instrument air pressure. This put fuel oil pump in recirculation, reducing fuel oil pressure at unit.

Cause of Failure - Moisture in instrument air supply froze, reducing air pressure at valve.

Contribution to overall failure of unit - Unit was derated 300 MW due to loss of fuel oil supply pressure, for a period of 19 minutes.

5. Install upsized instrument air dryer. Add moisture removal traps in instrument air system.
6. Corrective measures will be designed by 10/1/90. Completion date undetermined.
7. \$90,000 - Capital

1. S R Bertron Unit 3 : 240 MW
2. Design Temperature Range : 10°F to 105°F
3.
 - a. Boiler Water Circulating Pump Differential Pressure Transmitter
 - b. Frozen Gas Valves
 - c. Low Condenser Vacuum
4.
 - a. Failure Mode - False BWCP flow signal initiated a fuel trip.

Cause of Failure - Correct BWCP flow signal lost because sensing lines to BWCP differential pressure transmitter froze.

Contribution to overall failure of unit - Unit tripped on false signal of low BWCP flow.
 - b. Failure Mode - Gas valve could not be operated, which caused fuel supply to be tripped.

Cause of Failure - Lubricant in valve became very stiff at low temperature.

Contribution to overall failure of unit - Unit tripped on loss of fuel supply.
 - c. Failure Mode - Drip pump vent line to condenser froze and broke, causing loss of condenser vacuum.

Cause of Failure - Vent line was not insulated.

Contribution to overall failure of unit - Broken vent line caused unit to trip on loss of condenser vacuum.
5.
 - a. Heat tracing and insulation on BWCP sensing lines will be upgraded.
 - b. Gas valves will be lubricated when freezing conditions are imminent.
 - c. Drip pump vent line and regulator were insulated.

(S R Bertron Unit 3 cont'd)

- 6. a. Corrective action will be completed by 10-01-90.
 b. N/A
 c. Corrective action was completed on 04-27-90.
- 7. a. \$3,000 - Maintenance
 b. N/A
 c. \$700 - Maintenance

1. S R Bertron Unit 4 : 240 MW
2. Design Temperature Range : 10°F to 105°F
3. Forced Draft Fan
4. Failure Mode - Ice formed in fan outlet ducts, fell and blocked fan rotation. Also broke damper.
Cause of Failure - Water leaked into outlet ducts and formed large chunk of ice.
Contribution to overall failure of unit - Unit tripped on loss of forced draft fans.
5. Maintenance action has been taken to prevent water intrusion into ducts.
6. Corrective action has been completed.
7. Negligible cost

1. Greens Bayou Unit 5 : 420 MW
2. Design Temperature Range : 10°F to 105°F
3. a. High-Pressure Turbine Pressure Switch
b. Condensate Flow Control
4. a. Failure Mode - Frozen sensing lines caused false signal for throttle control valve position. This initiated turbine and fuel trips.

Cause of Failure - Heat tracing and insulation failed to protect sensing lines.

Contribution to overall failure of unit - Unit was tripped by turbine and burner controls upon signal that throttle valves were closed.

b. Failure Mode - Instrument sensing lines froze, resulting in the loss of intelligence needed to open the polishing demineralizer bypass valve.

Cause of Failure - Instrument lines were not insulated because the demineralizer is inside a building. The temperature inside the building dropped below freezing.

Contribution to overall failure of unit - Unit tripped on low feedwater flow, resulting from reduced condensate flow.
5. a. Replace heat tracing and insulation on turbine pressure switch sensing lines.
b. Replace heat tracing and insulation on condensate bypass valve. Temporary windbreak to be in use during freezing weather.
6. a. Corrective action scheduled for outage in Fall, 1990.
b. Corrective action to be completed by 9/11/90.
7. a. \$1050 - Maintenance
b. \$ 650 - Maintenance

1. Webster Gas Turbine : 13 MW
2. Design Temperature Range : 10°F to 105°F
3. Lubricating Oil Bypass Valve to Cooler
4. Failure Mode - Lubricating oil temperature was too low to start gas turbine.

Cause of Failure - Moisture in instrument air piping froze, preventing air pressure sufficient to close bypass valve. Oil was bypassed to cooler, negating attempts to warm oil to proper temperature.

Contribution to overall failure of unit - Gas turbine controls will not permit turbine to be started when lube oil temperature is out of range.

5. Add enclosure space heaters to maintain instrument air piping above freezing temperature.
6. Corrective action completed 2/15/90.
7. Negligible cost

1. T H Wharton Gas Turbine Unit 21 : 13 MW
2. Design Temperature Range : 10°F to 105°F
3. Lubricating Oil Cooler Fans
4. Failure Mode - Lubricating oil cooler fans would not start, due to false lube oil temperature signal.

Cause of Failure - Moisture in instrument air line froze, blocking the signal from lube oil temperature transmitter.

Contribution to overall failure of unit - Control system shut down the gas turbine because of high lube oil temperature.

5. Moisture trap will be installed in instrument air line.
6. Corrective action will be completed by 7/1/90.
7. \$1000 - Maintenance

1. T H Wharton Unit 2 : 240 MW
2. Design Temperature Range : 10°F to 105°F
3. Loss of Cooling Air to Boiler Feed Pump Motor
4. Failure Mode - Boiler Feed Pump motor overheated and failed.
Cause of Failure - Feed pump safety valve vent pipe leaked at a union, and water was blown onto motor. Ice formed, and obstructed cooling air intake on motor.
Contribution to overall failure of the unit - When affected feed pump tripped, unit load was reduced 100 MW and unit operated on remaining boiler feed pumps.
5. Vent line was repaired.
6. Repair was completed 1/18/90.
7. \$25,009 - Maintenance

1. T H Wharton Unit 3 : 285 MW
2. Design Temperature Range : 10°F to 105°F
3. a. Drum Water Level Sensing Lines
b. Feed Water Flow Transmitter
4. a. Failure Mode - One Heat Recovery Steam Generator was taken out of service by the control system, due to a false low drum level signal.

Cause of Failure - Drum level sensing lines froze, due to failure of freeze protection measures.

Contribution to overall failure of unit - The unit consists of 4 HRSGs, and 3 remained in operation. Unit was derated 23 MW.

b. Failure Mode - Feedwater flow transmitter received a false low feedwater flow signal.

Cause of Failure - Sensing lines to feedwater flow transmitter froze, which produced an errant signal to be generated by the transmitter. The control system tripped the boiler feed pump to protect the pump.

Contribution to overall failure of unit - Loss of boiler feed pump caused the unit to be derated 85 MW.
5. a. Sensing lines heat tracing and insulation were upgraded. Wind breaks were added.
b. Sensing lines heat tracing and insulation were upgraded.
6. a&b. Wind breaks were completed 2/15/90. Heat tracing and insulation on 2 HRSGs were upgraded by 5/2/90. Remaining heat tracing and insulation work will be completed during outage in Fall, 1990.
7. Wind Breaks - \$6516 to install - Maintenance
Heat Tracing and Insulation - \$58,624 - Maintenance

1. T H Wharton Unit 4 : 285 MW
2. Design Temperature Range : 10°F to 105°F
3.
 - a. Drum Water Level Sensing Lines
 - b. Steam Flow Transmitter
4.
 - a. Failure Mode - One Heat Recovery Steam Generator was taken out of service by the control system, due to a false low drum level signal.

Cause of Failure - Drum level sensing lines froze, due to failure of freeze protection measures.

Contribution to overall failure of unit - The unit consists of 4 HRSGs, and 3 remained in service. Unit was derated 23 MW.
 - b. Failure Mode - False signal of low steam flow resulted in loss of drum water level.

Cause of Failure - Sensing lines to steam flow transmitter froze, causing false low steam flow signal. Boiler feed pump flow was reduced by the control system.

Contribution to overall failure of unit - Unit was tripped by the control system, on low drum level. Unit was derated 85 MW.
5.
 - a. Sensing lines heat tracing and insulation were upgraded. Wind breaks were added.
 - b. Sensing lines heat tracing and insulation were upgraded.
6. a&b. Wind Breaks were completed 2/15/90.
Heat Tracing and Insulation were upgraded 5/2/90.
7. Wind Breaks - \$6516 installed - Maintenance
Heat Tracing and Insulation - \$102,750 - Maintenance

1. T H Wharton Gas Turbine Unit 54 : 58 MW

2. Design Temperature Range : 10°F to 105°F

3. Loss of Fuel Oil Supply

4. Failure Mode - Fuel oil valve could not be operated.

Cause of Failure - Ice formed in and immobilized fuel oil supply valve operator.

Contribution to overall failure of unit - Gas turbine could not be operated without a fuel supply

5. The valve was replaced.

6. Valve was replaced 12/22/89.

7. Negligible cost

1. South Texas Project Unit 1 : 1250 MW

2. Operating Temperature Range : 3°F to 105°F *
Freeze Protection : 3°F

* This represents the maximum ambient conditions under which an engineering evaluation has determined the unit can operate. This evaluation, performed after the cold weather of December 1989, determined that the freeze protection and HVAC systems can operate at ambient temperatures lower than the nominal design minimums of 11°F for freeze protection and 29°F for HVAC systems.

3. a. Feedwater and Feedwater Booster Pumps
b. Makeup Demineralizer System
c. Deaerator Level and Pressure Instrumentation
d. Emergency Cooling Water System Screen Wash Booster Pumps

4. a. Failure Mode - Seal water lines to feedwater and feedwater booster pumps froze, interrupting seal water supply to pumps.

Cause of Failure - Seal water lines are uninsulated, by design.

Contribution to overall failure of unit - Pumps were unable to operate without seal water. Unit could not be started without pumps.

b. Failure Mode - Various level instruments, pumps and water lines froze, causing the demineralizer to be inoperable.

Cause of Failure - Equipment was uninsulated by design, or was de-insulated for maintenance.

Contribution to overall failure of unit - The lack of demineralized makeup water prevented continuation of unit start-up.

c. Failure Mode - Level and pressure sensing lines froze.

Cause of Failure - Sensing lines root valve stems and handles were not insulated.

Contribution to overall failure of unit - Level and pressure indication are required during unit start-up and operation. Unit could not be started.

(STP Unit 1 cont'd)

- d. Failure Mode - Screen wash booster pumps froze.

Cause of Failure - Plant operating procedures required cooling fans to run bringing outside air into pump enclosure which caused the pumps to freeze.

Contribution to overall failure of unit - Station declared Emergency Cooling Water System inoperable when Screen Wash Booster Pumps were found frozen. Plant Technical Specifications require the unit to be shut down when ECW is inoperable.

5. a. Engineering review is in progress to determine corrective action.
b. Engineering review is in progress to determine corrective action.
c. Instrument root valve stems and handles have been insulated.
d. Plant operating procedures were revised to allow ECW cooling fans not to operate automatically in cold weather.
6. a. Corrective action will be completed 10/31/90.
b. Corrective action will be completed 10/31/90.
c. Corrective action was completed 2/16/90.
d. Corrective action was completed 6/15/90.
7. a. Cost to be determined
b. Cost to be determined
c. \$15,000 - Maintenance
d. \$5000 - Maintenance

ATTACHMENT B

ATTACHMENT B

PLANT	CORRECTIVE ACTION	COMPLETION DATE FOR ENGRG OF CORRECTIVE ACTION	COST OF CORRECTIVE ACTION
LEGS 1	Steam Drum End Enclosures	06-30-90	\$10,000 - Maintenance
LEGS 1&2	Electromatic Relief Valve: Pressure Controller Relocation	04-17-90	\$8,000 Maintenance
LEGS 1&2	Sootblower Pressure Reducing Valve Relocation	04-16-90	\$31,400 Maintenance
LEGS 1&2	Bottom Ash Hopper Sluice Gate Pistons	10-31-90	Not Available
WAP 1,2&3	Steam Drum End Enclosures	09-30-90	\$30,000 - Maintenance
WAP 5,6,7&8	Steam Drum End Enclosures	08-31-90	\$40,000 - Maintenance
WAP 5	Turbine Instrument Line Enclosure	09-31-90	\$30,000 - Maintenance
WAP 1,2&3	Turbine Instrument Line Heat Tracing & Insulation: Upgrade	08-31-90	\$33,000 - Maintenance
WAP 5,6&7	Instrument Air Line Moisture Drains	08-31-90	\$57,000 - Capital
PHR 1&2	Instrument Air Line Moisture Drains	06-30-90	\$38,000 - Capital
PHR 2	Throttle Pressure Sensing Lines	10-01-90	\$38,800 - Maintenance
PHR 3&4	Instrument Air Line Moisture Drains	06-30-90	\$38,000 - Capital
PHR 4	Boiler Feed Tank Level Transmitter	09-01-90	\$1,100 - Maintenance
PHR 3&4	Aux Boilers Steam Drum End Enclosures	10-31-90	Not Available
SRB 1,2,3&4	Steam Drum End Enclosures	09-30-90	\$40,000 - Capital
SRB 1,2,3&4	Turbine Instrument Line Heat Tracing & Insulation: Upgrade	03-30-90	\$44,000 - Maintenance

PLANT	CORRECTIVE ACTION	COMPLETION DATE FOR ENGRG OF CORRECTIVE ACTION	COST OF CORRECTIVE ACTION
SRB 1,2,3&4	:Instrument Air Line :Moisture Drains	: 09-30-90	: \$76,000 - : Capital
CBY 1&2 3	:Instrument Air Line :Moisture Drains :Caustic Line Windbreak :Wall	: 09-30-90	: \$38,000 - : Capital : Maintenance
GBY 5	:Steam Drum End Enclosure	: 06-30-90	: \$10,000 - : Maintenance
GBY 5	:BWCP LINE HEAT TRACING :& Insulation Upgrade	: 07-31-90	: \$4,100 - : Maintenance
GBY 5	:Burner Deck Enclosures	: 10-31-90	: Not Available
THW 2	:Steam Drum End Enclosure	: 06-08-90	: \$10,000 - : Maintenance
THW 2	:BWCP Line Heat Tracing :& Insulation Upgrade	: 06-30-90	: \$5,500 - : Maintenance
THW 2	:Turbine Instrument Line :Heat Tracing & Insulation: :Upgrade	: 04-18-90	: \$11,000 - : Maintenance
STP 1&2	:Additional freeze :protection for auxiliary :cooling surge tank	: 10-21-90	: Not Available
STP 2	:Feedwater Booster Pumps	: 10-31-90	: Not Available
STP 2	:Insulate Root Valves	: 02-16-90	: \$15,000 - : Maintenance
STP 2	:ECW Screen Wash :Booster Pumps	: 06-15-90	: \$5,000 - : Maintenance

ATTACHMENT C
Cogenerator Responses

OxyChem®

Irv Kowenski
Manager-Energy

June 12, 1990

Ms. Patricia E. Look
Sr. Contract Administrator
Cogeneration Department
Houston Lighting & Power
P. O. Box 1700
Houston, Texas 77001

Re: PUC Questionnaire

Dear Ms. Look:

Per your request, attached is information you requested concerning the severe cold weather period in December 1989. If you need any more information, please feel free to contact me.

Sincerely,

I. Kowenski
I. Kowenski
Manager-Energy

/ih

attachment



Occidental Chemical Corporation
Corporate Office
Occidental Tower, 5005 LBJ Freeway
P.O. Box 809050, Dallas, TX 75380-9050
214/409-3446

TO: Irv Kowenski - Dallas
FROM: Dwight Howell - Battleground
DATE: June 11, 1990

SUBJECT: PUC Questionnaire

- 1) Unit Name - OxyChem Cogeneration - Battleground Plant
Unit MW Capacity - 200
- 2) The unit site design conditions for capacity considerations are
30° F to 95° F.

The unit design temperature limitations are -25° F with no maximum limitation.
Note: The instrumentation enclosures and heat trace tubing bundles in the plant are rated for a minus 25° F at 3 watts/FT electrical trace and 100 watts per enclosure.

- 3) The No. 2 Gas Turbine (GT)/Heat Recovery Steam Generator (HRSG) was removed from service on December 23, 1989 due to instrumentation problems caused by the severe weather conditions. The power loss was approximately 100 megawatts with the unit being restarted after approximately twelve (12) hours.
- 4) On the No. 2 HRSG, the HP steam drum, pressure and level instruments, the deaerator pressure and level instruments and the high pressure steam flow and boiler feedwater instruments either froze or were erratic due to partial freezing. The GT experienced no failed instruments but is used to produce steam from the HRSG and therefore was shut down in conjunction with the HRSG.

Instruments started to freeze at about +25° F. For this to occur, there are problems with the installation, condition, operation and insulation of the instruments. Some of the problems were identified as tripped electrical circuits supplying heat trace and enclosures that were not completely tight and sealed.

5) and 6)

Corrective actions to ensure the reliability and operations of the instruments essential for the cogeneration plant will include the following:

1. The annual instrument freeze survey should be completed no later than the middle of November. Each installation must be inspected thoroughly.
2. Critical instruments to be upgraded or have new enclosures and heat trace installed as a top priority include:
 - a. High pressure steam flows FT525/FT725 - completed 03/90.
 - b. Boiler feedwater flows FT522/FT722 - completed 03/90.
 - c. High pressure steam pressure PT538/PT738 - completed 04/90.
 - d. High pressure steam drum level LT520/LT720 - expected completion 10/90.
 - e. Low pressure steam drum level LT550/LT750 - expected completion 10/90.
 - f. Deaerator level LT1121/LT1123 - expected completion 10/90.
 - g. Deaerator pressure PT1120 - expected completion 10/90.
3. A method to determine that heat trace bundles are working will be developed, rather than relying on having power at the connections and feeling the temperature of the trace where it enters the bundle.
4. Instrument enclosures must be tight and sealed. This means replacing sealing gaskets and closing/repairing any cracks or holes in any part of the enclosure. This should be done on the survey each year.
5. Use of the fiberglass wrapping tape with the white sealer over it will be discontinued on instrument installations. The protection provided by this material is inadequate.
6. All installations must be inspected thoroughly for any openings or cracks, and must be repaired. The manufacturer's specifications are only valid if the installation is secure from heat loss.
7. Process block valves on the orifice plates, or on pressure outlets, should have the metal jacketed standard insulation installed. This end of the tubing bundle must be inspected carefully each year and all cracks and openings closed.
8. Thermometers should be installed on all critical instrument enclosures. This would eliminate the need for opening the enclosure during cold weather. The thermometer would indicate whether the heat system was operating sufficiently.

Irv Kowenski
PUC Questionnaire
June 11, 1990
Page 3

9. A priority list for upgrade of less critical instruments will be developed.

All of the above items are expected to be completed by November 1, 1990.

- 7) Cost per installation and upgrade will be about \$800.00 plus labor of \$500.00. The total estimated cost is estimated to be approximately \$15,000.00. These corrective action costs will be classified as a maintenance expense.

H. D. Howell
H. D. Howell

HDH:ja

cc: M. Gough
F. Carelli
D. Scholes



Clear Lake Cogeneration

Limited Partnership

9602 Bayport Road Pasadena, Texas 77507-1404 (713) 474-7611

June 8, 1990
CL-DWR-1367

Ms. Patricia Look
HOUSTON LIGHTING & POWER COMPANY
P.O. Box 1700
Houston, Texas 77001

Subject: Freeze Modifications, Clear Lake Cogeneration

Dear Ms. Look,

Clear Lake Cogeneration, which currently supplies nonfirm energy, to HL&P, has taken the following actions as a result of the December 1989 freeze.

1. GT104; 100 MW 501D5 Westinghouse Combustion Turbine

GT104 tripped on a power supply failure to the Woodward Netcon 5000 governor. A computer grade uninterruptible power supply was installed with the existing UPS system becoming a backup power supply. This was completed in January 1990 at a cost of \$15,000.

2. GT103; 100 MW 501D5 Westinghouse Combustion Turbine

GT103 tripped and was removed from service when a lube oil supply pump failed. The pumps were a Buffalo Forge grease lubricated bearing design. All pumps have been modified to an oil lubricated bearing design. This was completed in March 1990 at a cost of \$36,000.

3. ST101; 50 MW Westinghouse Steam Turbine
ST102; 14 MW Westinghouse Steam Turbine

Both units were forced out of service upon loss of boiler feedwater from steam host. They are currently making several modifications to prevent their water plant from freezing.

RECEIVED

JUN 11 1990

REGISTRATION & SMALL POWER
PRODUCTION DEPARTMENT



An **ENRON** Affiliate

Ms. Patricia Look
Page 2

4. Instrumentation Systems

Several transmitters froze in the plant due to inadequate design and installation of the original freeze protection systems. Although no shutdowns occurred due to freezing instrumentation, a complete plant upgrade of the heat tracing and insulation is planned for completion in the fourth quarter of 1990 at an estimated expense of \$300,000. Design criteria used for this upgrade was 5°F.

Should you require any further information feel free to contact me.

Sincerely,

CLEAR LAKE COGENERATION



DeWayne W. Roberts
Plant Manager

/dd





P. O. Box 19398
Houston, Texas 77224

DESTEC ENERGY, INC.
2500 CITYWEST BLVD. SUITE 1700
P.O. BOX 4411
HOUSTON, TEXAS 77210-4411
(713) 974-8200

June 11, 1990

Ms. Patricia E. Look
Senior Contract Administrator
Cogeneration Department
Houston Lighting & Power
P. O. Box 1700
Houston, Tx 77001

Dear Ms. Look:

The attached sheet is our response to the questions requested by the Public Utility Commission Staff. Please inform us if additional information is needed.

Sincerely,

A handwritten signature in cursive script that reads 'Jerry C. Dearing'.

Jerry C. Dearing
Asset Management

JCD:wb

cc: D. K. Mott
W. P. Ruwe



PUBLIC UTILITY COMMISSION OF TEXAS

The following is CoGen Lyondell's response to the PUC questions concerning operating reliability during the December 1989 cold weather emergency.

1. The steam turbine generator 001 was the only unit lost during the period. The unit is rated at 135MW.
2. The unit does not have design ambient temperature limitations.
3. There were several instrumentation failures (i.e. level transmitters) but they did not adversely affect the generating capacity of the plant.
4. The steam turbine generator 001 tripped due to a failed vacuum pump. The cause of the vacuum pump failure was a frozen water seal line. The pump failed causing a loss of a condenser vacuum which tripped the steam turbine generator.
5. A thermal barrier was added near the vacuum pump and heaters will be used in the area.
6. This preventive measure has been completed at minimal cost.

June 8, 1990

Patricia E. Look
Cogeneration Department
Houston Lighting & Power
Box 1700
Houston, Texas 77001

Dear Pat:

Please find attached our response to the questionnaire you forwarded to us in your letter of May 22, 1990, regarding the cold weather experience in December, 1989. Let me know if we can be any further assistance.

Sincerely,



John F. Stauffacher

Attachment



RESPONSE TO HL&P COLD WEATHER QUESTIONS

1. UNIT NAME AND UNIT MW CAPACITY.

ANSWER: Dow Chemical Freeport - Contract MWS - 325

2. UNIT GENERAL DESIGN TEMPERATURE LIMITATIONS (MAXIMUM AND MINIMUM), IN DEGREES F.

ANSWER: All units are designed to operate between 0 and 120 degrees F provided freeze protection on controls and instrumentation is adequate.

3. LIST OF EQUIPMENT(S) (OR PLANT SYSTEMS) THAT WERE ADVERSELY AFFECTED BY THE COLD WEATHER.

ANSWER: Boiler steam drum level controls
Deaerator level controls
Steam pressure controls
Instrument air lines
River water lines
Potable water system
Fire protection system
Division condensate inventories

4. FOR EACH PIECE OF EQUIPMENT OR SYSTEM THAT FAILED, IDENTIFY THE FAILURE MODE, THE CAUSE OF THE FAILURE, AND HOW THE EQUIPMENT OR SYSTEM LOSS CONTRIBUTED TO THE OVERALL FAILURE OF THE UNIT.

ANSWER: Drum level and steam pressure controls were adversely affected in most cases due to inability of the existing heat tracing systems to fully protect from the extreme temperatures and associated high winds experienced during the freeze. Inability to control drum levels caused brief run-back of one unit and a short-term trip of one boiler. Neither had significant effect on production capabilities.

Problems with the various water systems were generally caused by freeze damaged valves and lines at various locations.

Two units tripped when pre-filter pads plugged with snow at the inlet. Once down, associated condensate and cooling water lines froze and the unit could not be restarted until the freeze damage was repaired.

Some level and pressure controls experienced freezing problems when the heating capability of the existing heat tracing systems was exceeded due to the sub-freezing temperatures and high winds. These level and pressure control systems incorporate redundant transmitters and indications; therefore, when a primary control indication was lost a back-up was placed in service or the system was operated manually for a brief period while the primary was repaired. In one isolated case during the early stages of the freeze, the loss of a deaerator level control system caused one high pressure boiler feed pump to trip which resulted in a run-back of one unit. However, the level control was restored and the unit returned to full capacity within approximately 20 minutes.

5. FOR EACH PIECE OF EQUIPMENT OR SYSTEM, IDENTIFY THE NECESSARY CORRECTIVE ACTIONS(S) TO PREVENT RECURRENCE. PLEASE PROVIDE SUFFICIENT DETAIL TO DESCRIBE THE FULL RANGE OF ACTIVITIES NECESSARY TO REASONABLY PRECLUDE FUTURE FAILURE.

ANSWER: The following actions have been taken to prevent failure caused by a freeze of similar magnitude:

- Insulation and heat tracing systems were improved.
- Operating and freeze preparation procedures were modified.
- Temporary freeze protection equipment was purchased and inventoried and incorporated into procedures.
- Improvements were made in many of the existing transmitter locations.

6. FOR EACH PIECE OF EQUIPMENT OR SYSTEM IDENTIFIED ABOVE, REPORT THE ACTUAL OR ANTICIPATED DATE OF CORRECTIVE ACTION COMPLETION.

ANSWER: Implosion dampers on two units - these machines have no dampers to open to provide inlet air to the turbine in the event of plugged inlet filters. A project has been defined to install dampers on these two machines. Projected completion date is second quarter, 1991.

BAYOU COGENERATION PLANT

11777 Bay Area Blvd. / Pasadena, Texas 77507
(713) 474-8220 / Fax: (713) 474-8226

Richard H. Kidder
General Manager

June 1, 1990

Houston Lighting & Power Company
Patricia Look
Sr. Contract Administrator
Cogeneration Department
P. O. Box 1700
Houston, TX 77001

cc: WD Lindberg
BR Milam
RE McGinnis
CP Burckle

SUBJECT: PUC Request Dated May 10, 1990


Dear Ms. Look:

The Bayou Cogeneration Plant maintained 114.5% of our contract power during the 72 hour freeze from 12/22/89 through 12/24/89. We did however have problems with our plant when the temperature fell below 14 degrees Fahrenheit. I have attached the following documentation that will answer the questions asked by the PUC:

1. Net Plant Output vs Ambient Temperature
2. Bayou Cogeneration Plant Performance Characteristics
3. Sequence of Events on Problems
4. Generator Breaker Open and Closed Log
5. Corrective Action, Completion Dates and Estimated Costs

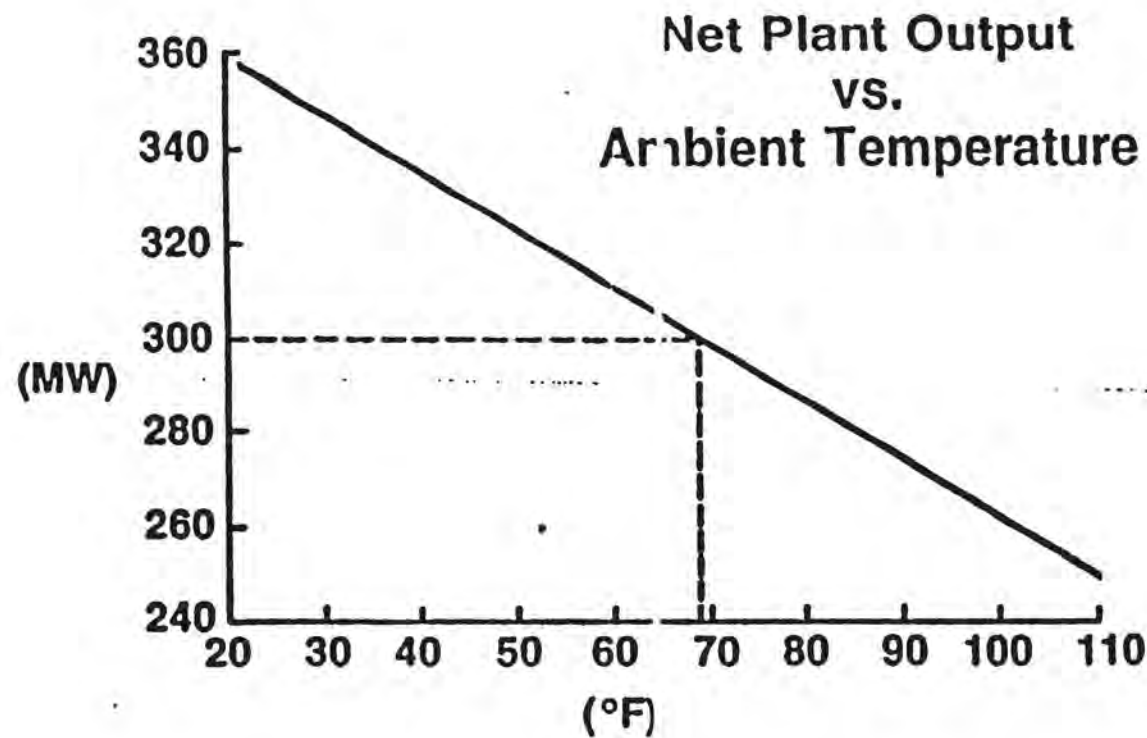
If you need additional information, please contact me.

Regards,


Richard H. Kidder
General Manager

Attachment

kt/506



**Sensitivity to Inlet Temperature is Characteristic
of Gas Turbine Cycles;**



Bayou Cogeneration Plant Performance Characteristics

(4) MS7001 E Gas Turbine/Heat Recovery Steam Generator Trains

Net Power @ 69°F	300.5 MW
Steam to Process	1,380,000 lb/hr
Heat Consumption (HHV)	3726 x 10⁶ Btu/hr Natural Gas
Overall Energy Efficiency (HHV)	70%
Steam Injection for NO_x Control	< 4.0 ppmv NO₂ @ 15% O₂ Dry Basis

PURPA Efficiency	54%
- Thermal Fraction	61%

Attachment #3

SUBJECT: Big Freeze of "89"

The following sequence of events summarizes the Bayou Cogeneration Plant's problems during the freeze from December 22, 1990 through December 24, 1990:

The temperatures at the plant were below freezing for approximately 48 hours with the lowest temperature being 8 degrees F early on the 23rd. Starting about 8:30 a.m. on December 22nd, we started losing all flow and pressure transmitters due to freezing sensing legs. This caused operators to control the plant manually with local; visually drum level readings radioed from the outside operators. All NOX steam transmitters and control valves froze and we were unable to restore NOX steam for the duration of the freeze. At 11:13 p.m. plant feedwater supplied by Big 3 was lost due to pressure instrumentation freezing. This caused trips on units #1, #2, and #3. Units were restarted and loaded as fast as possible after feedwater was restored. Units #1 and #2 each tripped later that night due to false level indication caused by freezing and were immediately restarted.

At 10:50 a.m. on December 34th, unit #1 was shutdown with a leaking cooling water skid. One side of the skid was isolated and the unit restarted after 1.75 hours.

The Bayou Cogeneration Plant normally has a 3 man operating crew. During the over 48 hours of the freeze we utilized our full complement of 20 people to run the plant.

Attachment #4

DATE	UNIT	REASON	BREAKER OPEN	BREAKER CLOSED	
12/22	2	BTI loss of feedwater	2213	0433	12/23
12/22	3	BTI loss of feedwater	2314	0137	12/23
12/22	1	BTI loss of feedwater	2316	2349	12/22
12/23	1	Instrument freeze on level indication	0655	0723	12/23
12/23	1	Instrument freeze on level indication	1016	1046	12/23
12/24	1	Cooling water skid	1050	1235	12/24



Attachment #5

SUBJECT: Corrective Action Taken to Remedy Freeze Problems

The cause of our freeze problems were isolated to our instrument lines from our boilers. These lines were heat traced but could not withstand temperatures below 15 degrees Fahrenheit. The corrective action is as follows:

1. Replace heat tracing and reinsulate 1500 feet of instrument lines to 20 degrees below zero.
2. Heat trace approximately 16 instrument cabinets throughout the plant.
3. This corrective action will be completed by September 1, 1990.
4. The cost of this project will be approximately 100,000 dollars and will be categorized as maintenance expense.

June 11, 1990

**Houston Lighting & Power
P. O. Box 1700
Houston, TX 77001**

**Attn: Ms. Patricia Look
Sr. Contract Administrator
Co-Generation Department**

**Subject: Public Utility Commission Questionnaire -
Freeze Protection**

Dear Ms. Look:

**In response to your request dated May 22, 1990, we would like to
provide the following information:**

(1) Unit Name and Unit MW Capacity

**AES Deepwater, Inc.
160 MW - Gross**

(2) Design Temperature Limitations

**Maximum - 120°F
Minimum - 0°F**

(3) List of Equipment affected by cold weather:

Flow and Level Transmitters - Plant Wide

**The AES Deepwater Cogeneration facility was off line a total of 13.86
hours during the freeze period (Dec. 22 thru Dec. 27) with actual unit
outages occurring Dec. 22 (9.05 Hrs) and Dec. 23 (4.81 hrs). The unit
operated at 49.5% capacity (reduced load) from Dec. 24 thru Dec. 27
with no outages. The facility returned to full load on Dec. 28.**

Specific equipment affected is as follows:

- o Throttle Pressure Transmitter**
- o Mass Blow Down Valve**
- o Drum Level Transmitter**
- o Fan Bearing Housings - Water Cooled**

(4) Equipment Failure

- A. Equipment - Throttle Pressure Transmitter
Failure Mode - Erratic Readings
Cause - Freeze
Contribution to Plant - Unit Trip**



- B. Equipment - Mass Blow Down Valve
Failure Mode - Stuck
Cause - Freeze
Contribution to Plant - Unit Trip
- C. Equipment - Drum Level Transmitter
Failure Mode - Intermittent Operation
Cause - Freezing
Contribution to Plant - Reduced Load
- D. Equipment - Water Cooled Fan Bearings
Failure Mode - Cracked
Cause - Freeze
Contribution to Plant - Reduced Load

5. Corrective Action

- A. Throttle Pressure Transmitter -
Insulate and Heat Trace
- B. Mass Blow Down Valve -
Insulate and Heat Trace
Possible Additional Dryer on Actuating Air
- C. Drum Level Transmitter -
Re-insulate, Additional Heat Tracing,
Glycol in Dead Leg
- D. Fan Bearings -
Install Water Flow and Temperature Monitors
Change Cold Weather Operating and Inspection Procedures

6. The anticipated completion date for all corrections is November 30, 1990.

7. Cost of Corrective Action (Estimated)

A.	Throttle Pressure Transmitter	\$750.00
B.	Mass Blow Down Valve	\$1,000.00
C.	Drum Level Transmitter	\$750.00
D.	Fan Bearings	\$3,000.00

We trust this information will comply with your request.

Sincerely,


J. R. Johnson
Manager, Support Services





Lower Colorado River Authority

Post Office Box 220 Austin, Texas 78767 • (512) 473-3200

June 15, 1990

Mr. Chester R. Oberg
Nuclear Projects
Public Utility Commission of Texas
7800 Shoal Creek Boulevard
Suite 400N
Austin, Texas 78757

RE: Project No. 9542

Dear Mr. Oberg:

Enclosed please find LCRA's response to your request for information regarding LCRA unit outages during the December 1989, cold weather period.

If you need any further assistance, please contact Jim Briley at 385-7131.

Sincerely,

A handwritten signature in dark ink, appearing to read "Walter J. Reid", is written over the typed name.

Walter J. Reid
Executive Director of
Electric Operations

WJR:JB:bcm

Attachment

LCRA RESPONSE - PROJECT 9542

There were two LCRA unit outages during the December 1989, cold weather period attributable to weather-related equipment problems. The requested information for these outages is listed below:

OUTAGE #1

December 22, 1989

1) Unit Name and Unit MW Capacity

Sim Gideon Unit #2; Capacity 140 MW Gross

2) Unit general design temperature limitations (Maximum and minimum), in degrees F.

No temperature design limitations were available; the unit was placed in commercial service in April, 1967.

3) List of equipment(s) or (plant systems) that were adversely affected by the cold weather.

Deaerator Level transmitters.

4) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit.

Water in sensing lines to the deaerator level transmitters froze causing a loss of level indication. The unit operator then tripped the unit according to established procedures.

5) For each piece of equipment of system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure.

At the time of the trip, the sensing lines were wrapped with asbestos-based insulation material. Additional foil-backed blanket duct insulation was added. These lines will be stripped and re-wrapped with new materials at a future time when the asbestos can be dealt with safely.

6) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion.

This work was done on February 8, 1990.

- 7) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense.

This work incurred a maintenance expense of \$300.

OUTAGE #2
December 23, 1989

1) Unit Name and Unit MW Capacity

Sam K. Seymour Unit #3; Capacity 440 MW Gross

2) Unit general design temperature limitations (Maximum and minimum), in degrees F.

General design temperature limitations (taken from Unit Design Specification CP 300(2.3.3), Section E. Temperatures are dry bulb, degrees Fahrenheit.

Temperature

Extreme Maximum	110
Temp. exceeded 1% of the time	101
Mean Daily Maximum	80
Mean	69
Mean Daily Minimum	58
Temp. exceeded 99% of the time	25
Extreme Minimum	1

3) List of equipment(s) (or plant systems) that were adversely affected by the cold weather.

A & B Drum Level transmitters

4) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit.

Water in the A & B Drum Level transmitter sensing lines froze, causing the unit to trip automatically due to loss of level indication.

5) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure.

The sensing lines were re-insulated, leveled and installed in hangers to prevent excess water accumulation.

6) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion.

This work was completed on May 30, 1990.

- 7) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense.

This work incurred a maintenance expense of \$420.



Serving the cities of Bryan, Denton, Garland & Greenville



June 8, 1990

Letter No. SP-90-0074
File Code: 513.75

Chester R. Oberg
Public Utility Commission of Texas
7800 Shoel Creek Blvd., Suite 400N
Austin, Texas 78757-0100

Subject: Winterizing Corrective Actions

Dear Mr. Oberg:

Enclosed is the information you requested concerning winterizing corrective actions.

If additional information or data is required, please advise.

Sincerely,

Gailord M. White
Manager of System
Planning & Operations

GMW/it

cc: Document Control

TEXAS MUNICIPAL POWER AGENCY

1. Gibbons Creek Steam Electric Station Unit #1 - 440 MW

2. Unit Design Temperature Limitation - 150°F minimum

1070°F maximum

3. Actual Equipment Failures:

A) Boiler Drum Level Transmitter (see attached sheet for details)

**B) (BWCP) Boiler Water Circulation Pump Differential Pressure Transmitter
(see attached sheet for details)**

4. Potential Equipment Failures:

**A) (D.A.) Deareator Storage Tank Level Transmitter (see attached sheet
for details)**

**B) Reheat Spray Trip Valve And Control Valves (see attached sheet for
details)**

Actual Equipment Failure: Boiler Drum Level Transmitter

The boiler drum level transmitters are located in a weather enclosed building adjacent to the steam drum. Normally this enclosure has adequate heating supplied by the steam drum. At near 0°F this protection became insufficient. The freezing of these transmitters tripped the boiler on erroneous low drum level indication.

We are in the process of redesigning the steam drum enclosure to provide greater access to the transmitters. We will reinsulate the transmitters, their associated taps and instrument lines.

We will be installing a floor that will reduce/eliminate cold air in leakage.

The operating procedures and the Winter preparedness checklist have been changed to include provisions for an additional heat source to be used whenever the outside ambient air temperature reaches 32°F.

Estimated completion date for redesigning and construction of the drum enclosure is October 1, 1990.

Total Improvement Costs \$20,000.00

Actual Equipment Failure: Boiler Water Circulation Pump Differential Pressure Transmitter

The boiler waterwall circulation pump differential pressure transmitters are housed in an all weather building with an electric heater inside for freeze protection. Due to the freezing weather conditions near 0°F, the protection was insufficient. The transmitters froze creating a false indication of a low waterwall circulation which in turn tripped the boiler.

The heater was returned to service and an additional kerosene heater was placed inside the enclosure.

Operation procedures have since been modified to increase the awareness of all Operations personnel on the possible failure of electrical equipment associated with freeze protection. The Winter preparedness checklist has been changed to include the inspection of all heaters and breakers to insure their reliability.

Total cost \$0.00

Potential Equipment Failure: Deareator Storage Tank Level Transmitter

The Deareator Storage Tank Level transmitter did not contribute (NC) to any unit trips or unit failure but the potential was there if corrective measures had not been taken.

The Deareator Storage Tank Level transmitter is presently enclosed in a insulated housing and is heat traced. The Deareator Storage Tank Level and its transmitter are located on the north side of the boiler structure about 150 feet above the ground. Additional heat tracing and insulation were added several years ago and generally can handle a typical winter cold spell, but the winter of 1989 was not typical. A portable heater was placed near the housing to provide additional protection.

Our long term plan is to enclose the whole Deareator Storage Tank Level area but this is a costly venture. Our short term improvements will be to install a permanent windbreak along the north wall and lay down a solid plate floor (replacing the grating) to protect the area from the bitter windchills.

Total Cost \$2,500 (short term corrective action)

Potential Equipment Failure: Reheat Spray Trip Valve And Control Valves

The superheat and reheat spray trip valves and control valves did not contribute to any unit failures, however, the potential was there for at least a major load reduction due to the failure of the valves. After the unit had tripped on Boiler Water Circulation Pump differential pressure, the valves closed as they are supposed to do. Before the unit was able to return to 20% load, the trip valves froze in the closed position. This limited our capability to spray for high steam temperatures. We erected a temporary wind break and placed a kerosene heater alongside the valve to thaw it out. Plans call for a permanent wind break to be installed before October 1, 1990.

Total Cost \$3,000.00



Dwight Royall
Director
Regulatory Services

June 18, 1990

Mr. Chester R. Oberg
Nuclear Projects
Public Utility Commission of Texas
7800 Shoal Creek Boulevard
Suite 400N
Austin, Texas 78757

RECEIVED
JUN 18 1990
PUBLIC UTILITY COMMISSION
GENERAL COUNSEL BY _____

Dear Mr. Oberg:

Pursuant to your letter dated May 10, 1990, attached is TU Electric's response to your questionnaire concerning the performance of our generating units during the cold weather emergency in December 1989.

Nine (9) TU Electric generating units were identified that had weather related failures and were unable to respond to the emergency conditions. These units were able to return to service soon after the units tripped. Please refer to the January 10, 1990 cold weather filing for the generating unit sequence of events. For clarity, three additional generating unit failures are described although the failures were not weather related. In addition to the above, reports from cogeneration facilities that experienced weather related difficulties are attached.

The effects of the December 1989 freeze were minimized due to the efforts of TU Electric's Freeze Protection Task Force commissioned in 1982 as a result of severe weather during the winter of 1981. The task force identified several areas of concern and developed recommendations to alleviate the causes for unit trips related to cold weather. During the period of time from Fall 1982 through Spring 1984, approximately five million dollars were expended to enhance the reliability of TU Electric generating units during freezing conditions.

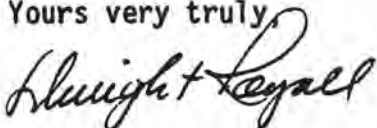
Each Fall, a special effort is made to inspect the freeze protection on each TU Electric generating unit for adequacy in the event of freezing weather. Plant personnel evaluate the heat tracing circuits, wind breaks, fuel oil related equipment and the weather sensitive instrumentation. Operations personnel conduct

Page 2
June 18, 1990

testing and training on fuel oil burning prior to the winter peak period. As the extreme cold weather approaches, additional units are brought on-line for reserve as needed and when natural gas curtailments are imminent, units are transferred to oil burning.

If you have any questions, please let me know.

Yours very truly,

A handwritten signature in cursive script, appearing to read "Blauight Legall".

1d
Attachment

1.) Unit Name and Unit MW Capacity:

River Crest Unit 1; 110 MW.

2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Condenser plugging due to shad runs.

4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - The condenser became plugged.

Cause of the Failure - The condenser became plugged due to an exhorbitant number of shad which entered the intake area, plugged the intake screens and carried over into the waterboxes of the condenser.

Contribution to Unit Failure - Excessive back pressure on the low pressure turbine caused a turbine trip.

5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

The shad were removed from the waterboxes of the condenser. A portable net was installed in front of the intake screens. An improved net will be available for installation during cold weather periods.

6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completion - August, 1990.

7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

Maintenance Expense - \$900.

- 1.) Unit Name and Unit MW Capacity:

Valley Unit 2; 550 MW.

- 2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

- 3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Transmitter sensing pressure to Valve No. 263.

- 4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - Transmitter sensed low feedwater flow.

Cause of the Failure - The freeze protection circuit failed.

Contribution to Unit Failure - The transmitter, sensing low feedwater flow, closed Valve No. 263. The unit tripped on low feedwater flow.

- 5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

The freeze protection circuit has been repaired by plant personnel.

- 6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

- 7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

Maintenance Expense - \$300.

- 1.) Unit Name and Unit MW Capacity:
Morgan Creek Combustion Turbine No 4; 65 MW.
- 2.) Unit general design temperature limitations (maximum and minimum), in degrees F:
Maximum limit: 115 degrees F.
Minimum limit: - 5 degrees F.
- 3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:
Natural Gas Fuel Supply.
- 4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - Minimal natural gas supply pressure.

Cause of the Failure - Minimum natural gas supply pressure necessitated a fuel supply transfer to fuel oil which created a temperature mismatch in the combustion zone.

Contribution to Unit Failure - This temperature mismatch caused a runback to off-line for the combustion turbine.
- 5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

By design, the combustion turbines must operate within temperature mismatch limits in the combustion zone. If a loss of natural gas pressure can be anticipated, a manual fuel transfer at lower loads is preferable to an automatic fuel transfer at full load.
- 6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completion - January, 1990.
- 7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

No significant expense.

1.) Unit Name and Unit MW Capacity:

Mountain Creek Unit 7; 125 MW.

2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Not cold weather related.

4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - An increase in fuel/air flow resulting in high furnace pressure.

Cause of the Failure - While operating at high load, the unit responded to a frequency deviation.

Contribution to Unit Failure - The increase in fuel/air flow led to a high furnace pressure trip. A subsequent trip occurred upon restarting the unit.

5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

A runback has been incorporated into the control system that will drop fuel/air flow a few percent upon a high furnace pressure condition.

6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

No significant expense.

1.) Unit Name and Unit MW Capacity:

Mountain Creek Unit 2; 33 MW.

2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Circulating water screens.

4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - A heavy shad run clogged the revolving and stationary intake screens.

Cause of the Failure - The clogged intake screens caused the circulating water pumps to loose suction.

Contribution to Unit Failure - The unit tripped on low vacuum.

5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

The screens were immediately cleaned and the unit restarted. A new screen wash pump was installed to better wash the revolving screens when in use.

6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

Maintenance Expense - \$13,000.

- 1.) Unit Name and Unit MW Capacity:
Monticello Unit 2; 575 MW.
- 2.) Unit general design temperature limitations (maximum and minimum), in degrees F:
Maximum limit: Designed to meet highest regional temperatures with only minor derations.
Minimum limit: -10 degrees F and 35 MPH wind velocity.
- 3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:
Transmitter sensing waterwall pressure.
- 4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:
Failure Mode - The sensing line to the waterwall pressure transmitter froze.
Cause of the Failure - A pipe hanger, located near the sensing line, propagated low temperatures to the line.
Contribution to Unit Failure - The transmitter sent a high waterwall pressure signal to the control system, which tripped the unit to protect it.
- 5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:
The plant personnel have installed insulating material at these hanger locations to prevent the hangers from propagating low temperatures to the sensing line.
- 6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:
Completed - December, 1989.
- 7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:
Maintenance Expense - \$2,000.

- 1.) Unit Name and Unit MW Capacity:

Tradinghouse Unit 1; 565 MW.

- 2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

- 3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Transmitter sensing boiler convection pass outlet header pressure.

- 4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - The sensing line at the pressure tap root valve froze.

Cause of the Failure - The transmitter enclosure heater was operating, but the heat tracing was found grounded.

Contribution to Unit Failure - The transmitter sent the control system a signal that the boiler convection pass outlet header pressure was high, which tripped the unit.

- 5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

The freeze protection circuit has been repaired and the root valve reinsulated.

- 6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

- 7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

Maintenance Expense - \$500.

- 1.) Unit Name and Unit MW Capacity:
Stryker Creek Unit 1; 175 MW.
- 2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.
Minimum limit: -10 degrees F and 35 MPH wind velocity.
- 3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Not cold weather related.
- 4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - The combustion controls swung which caused low burner gas header pressure.

Cause of the Failure - While the unit was firing a combination of natural gas and fuel oil, a control upset caused the combustion controls to swing.

Contribution to Unit Failure - The low burner gas header pressure caused a low pressure trip.
- 5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

The low gas block setting has been increased.
- 6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.
- 7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

No significant expense.

- 1.) Unit Name and Unit MW Capacity:

Monticello Unit 3; 750 MW.

- 2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

- 3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Transmitter sensing primary superheater outlet pressure.

- 4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - A sensing line to the primary superheater outlet transmitter froze.

Cause of the Failure - Freeze protection, heat tracing wiring on the sensing line failed.

Contribution to Unit Failure - The transmitter sent a false indication to the control system that the unit was operating below supercritical pressure, which trip the unit.

- 5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

The plant personnel replaced the failed freeze protection, heat tracing wiring on the sensing line.

- 6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

- 7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

Maintenance Expense - \$2,700.

- 1.) Unit Name and Unit MW Capacity:

Martin Lake Unit 2; 750 MW.

- 2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

- 3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Transmitter sensing low differential pressure on the boiler water circulation pump.

- 4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - A sensing line to the low boiler water circulation pump differential pressure transmitter froze.

Cause of the Failure - Additional freeze protection was needed.

Contribution to Unit Failure - The transmitter sent a false indication to the control system for boiler circulation pump differential pressure, which tripped the unit.

- 5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

Additional freeze protection has been added to this circuit. Plant personnel have added valves and drip legs in the sensing lines. During a freeze alert, the Instrument and Control technicians will drip these lines to allow water to flow to help prevent freezing. This will be monitored hourly during the freezing conditions.

- 6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

- 7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

Maintenance Expense - \$2,000.

1.) Unit Name and Unit MW Capacity:

Eagle Mountain Unit 3; 375 MW.

2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Condenser plugging caused by shad and fish.

4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - A heavy shad and fish run plugged one condenser while the other was being cleaned.

Cause of the Failure - The reduced circulating water flow through the condenser caused excessive back pressure.

Contribution to Unit Failure - Excessive back pressure on the low pressure turbine caused a low vacuum trip.

5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

Operations will closely monitor waterbox pressure and vacuum to minimize excessive plugging during shad and fish run. The use of a portable net during extreme cold weather conditions will be considered to avoid condenser plugging due to shed runs.

6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

No significant expense.

1.) Unit Name and Unit MW Capacity:

Handley Unit 5; 425 MW

2.) Unit general design temperature limitations (maximum and minimum), in degrees F:

Maximum limit: Designed to meet highest regional temperatures with only minor derations.

Minimum limit: -10 degrees F and 35 MPH wind velocity.

3.) List of equipment(s) (or plant systems) that were adversely affected by the cold weather:

Not cold weather related.

4.) For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

Failure Mode - An air flow transmitter feedback signal error was being investigated by plant personnel.

Cause of the Failure - The transmitter along with the air flow trip switch were inadvertently valved out.

Contribution to Unit Failure - When the trip switch was valved out the unit tripped.

5.) For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure:

The transmitter has been clearly marked to differentiate the trip switch from the flow transmitters.

6.) For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:

Completed - January, 1990.

7.) For each piece of equipment or system identified above, report the cost of the corrective action, and whether the costs will be capitalized as a necessary plant modification or if the corrective action costs will be categorized as a maintenance expense:

No significant expense.

Texasgulf Cogeneration Facility
Newgulf (Wharton County) Texas
June 4, 1990
77 MW Capacity - 100F
96 MW Capacity - 20F
Design temperature range - 20F to 100F

Numerous control devices and systems were adversely affected by the extreme cold weather but only one failed and contributed to reduction in output. It is believed that the facility would have remained at maximum capacity and all other systems would have remained operative if the raw water supply had not been interrupted.

Raw Water Supply - Raw water which provides feedwater to Heat Recovery Unit, make-up to Cooling Tower, and process water to mining operation is gravity fed from a 265 acre reservoir through two 30" underground lines. Intake screens on each line prevent fish and debris from entering plant. At time of December freeze, reservoir level was about 5 feet lower than normal (dry weather), and the intake screens were dirty. Freezing temperatures caused slush and ice to be swept into screens interrupting flow of incoming water. It was necessary to take steam turbine off line and cease mine water production in order to conserve the small amount of water available and keep feedwater to the HRU.

Corrective action

1. Clean screens. - Completed
2. Maintain water level in reservoir higher. - Pump installed behind reservoir to capture water which leaks out of reservoir. - Completed
3. Provide tempering water at intakes to thaw slush. - Pipe run from abandoned water well (74F water). - Completed

Intake water flow was reestablished after about three hours, but steam turbine could not be returned to service until ambient temperatures rose above freezing.

Additional systems or equipment adversely affected but not contributing in the December 1989 freeze are listed below:

Raw Water

- * In-line strainers became plugged with ice, fish, silt, etc. after intake screens were lifted. 12" valves and lines froze while cleaning the three strainers. - Wind barrier and homemade space heater to be installed - 12/01/90.
- * Gas turbine lube oil cooling water heat exchanger, El-A or B, which is out of service will be cracked into service to prevent freezing. - Operating procedure
- * Insulation and heat tracing on all flow and pressure transmitters to be inspected and repaired. Critical transmitters are PI-25002, LIT-25101. - 12/01/90
- * Wind barrier to be erected near Pumps, P2, where cold air tunnels through opening. - 12/01/90

June 4, 1990

Treated Feedwater

- * No significant problems on main line, but bleeders to be tagged on backwash line, brine dilution line, and drain. - Operating procedure - 12/01/90
- * Low Pressure HRU drum level has three control devices, LIT-40302 & LI-40305 on the south side and LIT-40303 on north side. All are critical transmitters, but operator selects which transmitter is in control. Problems occurred with LIT-40303 on north side; control tubing insulation and heat tracing to be inspected. Additional blanket & heat tracing installed in O'Brien enclosure to prevent freezing, but will cause boiling if activated when ambient temperature is above 25F and/or wind is idle. Completed
- * Medium Pressure HRU drum level has three control devices, LIT-41302 & LI-41305 on the south side and LIT-41303 on north side. Ditto low pressure drum. Completed
- * 3-Sided enclosure to be erected around boiler chemical feed tank and pumps, D-11, P-114 A&B. - Completed

Steam System

- * Critical transmitters to have tubing lines insulation and heat tracing inspected - 12/01/90
 - PIT-40304 LP Drum pressure
 - PIT-403 LP Drum pressure
 - PIT-40405 135 psig header
 - PIT-30303 Boiler 4 Master pressure
 - PIT-30304 Boiler 4 Master pressure
- * 3-Sided enclosure to be erected around neutralizing amine tank and pumps, T-111, P-111 A&B. - 12/01/90

Condensate

- * Deaerator level control, LIT-27123, insulation and heat tracing to be inspected - 12/01/90
- * Feedwater transfer pump, P-271 A or B, which is out of service to have valves cracked permitting flow of water - Operating procedure

Cooling Tower

- * Make-up water level transmitter, LIC-57002, to have insulation and heat trace inspected, plus enclosure to keep spray and resultant ice off. 12/01/90
- * By-pass around flow control valve, LCV-57002, to be cracked. - Operating Procedure
- * Chlorinator injection water to be placed on manual with continuous flow. - Operating procedure
- * Blowdown to be placed on manual with by-pass cracked. - Operating procedure
- * 3-Sided enclosure to be erected around Inhibitor feed tank & pumps, T-114, P-114 A&B. 12/01/90

Items marked with 12/01/90 completion dates will be completed as part of normal winterization. When temperatures are expected to fall below 20F, special operating procedures will be enacted.

Dow CHEMICAL

6/8/90

RESPONSE TO TUEC COLD WEATHER QUESTIONS

1. UNIT NAME AND UNIT MW CAPACITY.

ANSWER: Dow Chemical Freeport - Contract MWs - 300

2. UNIT GENERAL DESIGN TEMPERATURE LIMITATIONS (MAXIMUM AND MINIMUM), IN DEGREES F.

ANSWER: All units are designed to operate between 0 and 120 degrees F provided freeze protection on controls and instrumentation is adequate.

3. LIST OF EQUIPMENT(S) (OR PLANT SYSTEMS) THAT WERE ADVERSELY AFFECTED BY THE COLD WEATHER.

ANSWER: Boiler steam drum level controls
Deaerator level controls
Steam pressure controls
Instrument air lines
River water lines
Potable water system
Fire protection system
Division condensate inventories

4. FOR EACH PIECE OF EQUIPMENT OR SYSTEM THAT FAILED, IDENTIFY THE FAILURE MODE, THE CAUSE OF THE FAILURE, AND HOW THE EQUIPMENT OR SYSTEM LOSS CONTRIBUTED TO THE OVERALL FAILURE OF THE UNIT.

ANSWER: Drum level and steam pressure controls were adversely affected in most cases due to inability of the existing heat tracing systems to fully protect from the extreme temperatures and associated high winds experienced during the freeze. Inability to control drum levels caused brief run-back of one unit and a short-term trip of one boiler. Neither had significant effect on production capabilities.

Problems with the various water systems were generally caused by freeze damaged valves and lines at various locations.

Two units tripped when pre-filter pads plugged with snow at the inlet. Once down, associated condensate and cooling water lines froze and the unit could not be restarted until the freeze damage was repaired.

Some level and pressure controls experienced freezing problems when the heating capability of the existing heat tracing systems was exceeded due to the sub-freezing temperatures and high winds. These level and pressure control systems incorporate redundant transmitters and indications; therefore, when a primary control indication was lost a back-up was placed in service or the system was operated manually for a brief period while the primary was repaired. In one isolated case during the early stages of the freeze, the loss of a deaerator level control system caused one high pressure boiler feed pump to trip which resulted in a run-back of one unit. However, the level control was restored and the unit returned to full capacity within approximately 20 minutes.

5. FOR EACH PIECE OF EQUIPMENT OR SYSTEM, IDENTIFY THE NECESSARY CORRECTIVE ACTIONS(S) TO PREVENT RECURRENCE. PLEASE PROVIDE SUFFICIENT DETAIL TO DESCRIBE THE FULL RANGE OF ACTIVITIES NECESSARY TO REASONABLY PRECLUDE FUTURE FAILURE.

ANSWER: The following actions have been taken to prevent failure caused by a freeze of similar magnitude:

- Insulation and heat tracing systems were improved.
- Operating and freeze preparation procedures were modified.
- Temporary freeze protection equipment was purchased and inventoried and incorporated into procedures.
- Improvements were made in many of the existing transmitter locations.

6. FOR EACH PIECE OF EQUIPMENT OR SYSTEM IDENTIFIED ABOVE, REPORT THE ACTUAL OR ANTICIPATED DATE OF CORRECTIVE ACTION COMPLETION.

ANSWER: Implosion dampers on two units - these machines have no dampers to open to provide inlet air to the turbine in the event of plugged inlet filters. A project has been defined to install dampers on these two machines. Projected completion date is second quarter, 1991.

ATTACHMENT #1

COGEN LYONDELL

Unit Name	Unit Capacity (mw)	Temperature Limitations (F)	Failure mode	Equipment Affected	Cause of failure	Affect on overall system	Preventive measures
GTG101	75	N/A	N/A	N/A	N/A	N/A	N/A
GTG201	75	N/A	N/A	N/A	N/A	N/A	N/A
GTG301	75	N/A	N/A	N/A	N/A	N/A	N/A
GTG401	75	N/A	N/A	N/A	N/A	N/A	N/A
GTG501	75	N/A	N/A	N/A	N/A	N/A	N/A
STG001	135.	N/A	TRIP	VACUUM PUMP	WATER SEAL FROZE	LOSS OF CONDENSOR VACUUM (TRIP CONDITION)	ADDITION OF THERMAL BARRIER IN THE FORM OF HEATERS (COMPLETE) N/A
HRSG	101	N/A	N/A	N/A	N/A	N/A	N/A
HRSG	201	N/A	N/A	N/A	N/A	N/A	N/A
HRSG	301	N/A	N/A	N/A	N/A	N/A	N/A
HRSG	401	N/A	N/A	N/A	N/A	N/A	N/A
HRSG	501	N/A	N/A	N/A	N/A	N/A	N/A

Design Temperatures = 0°F min.
= 100°F max.

WICHITA FALLS ENERGY CO., LTD.

(A Limited Partnership)

Wichita Falls Energy Investments, Inc.

(Managing General Partner)

614 Ridglea Bank Building
Fort Worth, Texas 76116

817-731-7271 (Ft. Worth)
817-696-3270 (Wichita Falls)

P.O. Box 9349
Fort Worth, Texas 76147

Telecopy 817-732-8984 (Ft. Worth)
Telecopy 817-692-9018 (Wichita Falls)

June 5, 1990

TU Electric
Skyway Tower
400 N. Olive Street, L.B. 81
Dallas, Texas 75201

Attn: Mr. Kevin Delcarson
Cogeneration Department

Gentlemen:

In response to inquiry dated May 22, 1990 with respect to our plant's performance during the cold weather experienced in December, 1989, the following information is submitted in the same numbered order as set forth in the May 22 request.

1. Unit name and unit MW capacity:

Wichita Falls Energy Co., Ltd. cogeneration facility;
74 megawatts.

2. Unit general design temperature limitations (maximum and minimum), in degrees F.:

General design parameters were 0° Farenheit minimum and 120° Farenheit maximum. Added heat tracing has been implemented over and above design specs.

3. List of equipment (or plant systems) that were adversely affected by the cold weather [Dates specified]:

- 12/21/89 - (1) HRSG B level transmitter froze at 0520 hours.
(2) House service water tank level transmitter froze at 1938 hours.
(3) HRSG B superheater outlet pressure transmitter froze at 1955 hours.

- 12/22/89 - (1) HRSG superheater outlet pressure transmitter froze at 0522 hours.

RECEIVED

JUN 6 1990

COGENERATION

- (2) Unit requested to curtail gas consumption by transportation company (Lone Star Gas) at 1004 hours; honoring this request resulted in reduced output.

12/23/89 - (1) Unit had to operate at reduced load from 1030 hours to 1247 hours due to high system frequency (60.00 to 60.14 Hz).

- 4. For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit:

12/21/89 - (1) HRSG B level transmitter froze. No shutdown or reduction in output occurred. Operator took manual control of HRSG until transmitter was thawed out and additional insulation added.

- (2) House service water tank level transmitter froze. No shutdown or reduction in output occurred. Operator manually controlled tank level until transmitter was thawed out and additional insulation added.

- (3) HRSG B superheater outlet pressure transmitter froze. Failure of the pressure transmitter caused the HRSG damper to close resulting in a 2 megawatt drop in hourly averages. Efforts to thaw the transmitter failed and unit was subsequently disconnected so HRSG could be placed back in service before further freeze-ups occurred.

12/22/89 - (1) HRSG C superheater outlet pressure transmitter froze. Failure of the pressure transmitter caused the HRSG damper to close resulting in a 4 megawatt drop in hourly averages. Efforts to thaw the transmitter failed and unit was subsequently disconnected so HRSG could be placed back in service before further freeze-ups occurred.

- (2) Unit requested to curtail gas consumption by transportation company (Lone Star Gas); honoring this request resulted in reduced output. At 1020 hours, the standby LPG system was activated, but the blending air compressors tripped on high discharge air temperature. Upon testing, it was

determined that the lubricant used in the blending air compressors was not adequate for existing ambient conditions (-5°F to -7°F). Compressors were reset and re-started without using the lube oil cooler fans until the lubricant warmed up and the units stabilized. LPG was then introduced and utilized until curtailment was lifted at 1430 hours, whereupon the unit went back on natural gas (100%).

- 12/23/89 - (1) Unit operated at reduced load from 1030 hours to 1247 hours due to high system frequency (60.00 to 60.14 Hz). Unit is designed to reduce output when the frequency rises above the 60.00 Hz range.
5. For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence:
- 12/21/89 - (1) Although the HRSG B level transmitter was adequately heat traced, the insulation was not sufficient to withstand the conditions (-35°F windchill factor) at the time it froze. Additional insulation, as well as the installation of weatherproof/windproof enclosures, required.
- (2) Although the house service water tank level transmitter was heat traced and insulated, it was not adequate enough to withstand the conditions at the time. Additional heat trace and insulation required.
- (3) Although the HRSG B superheater outlet pressure transmitter was adequately heat traced, the insulation around the transmitter was not sufficient to withstand the conditions at the time it froze. Insulation needed to be upgraded along with installation of weatherproof/windproof enclosures.
- 12/22/89 - (1) Although the HRSG C superheater outlet pressure transmitter was adequately heat traced, the insulation around the transmitter was not sufficient to withstand the conditions at the time it froze.

Insulation needed to be upgraded along with installation of weatherproof/windproof enclosures.

- (2) The unit's gas supplier (Coastal) has a firm delivery transportation agreement with the transporter (Lone Star Gas). Prior to the cold weather period in December, the supplier was delivering quantities of natural gas to the transporter less than the unit's contract requirements in order to balance a previous oversupply scenario. Overlooking or mistaking this balancing agreement, the transporter's dispatcher contacted the unit's operator on duty requesting a consumption cut-back to the level or quantities the supplier was then furnishing the transporter. The unit's operator felt that he had no choice but to comply with this request, mistaken as it was. When this curtailment request was brought to the immediate attention of the supplier, supplier contacted transporter and the matter was resolved. With respect to LPG blending air compressor lubricant, the existing lubricant needed to be replaced with a lubricant which would allow operation of the compressors at ambient temperatures below -10°F.

- 12/23/89 - (1) No action required with respect to the design parameters of the unit wherein outputs reduce when frequency increases over 60.00 Hz.
6. For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion:
- 12/21/89 - (1) Additional insulation and weatherproof/windproof enclosures completed in April, 1990.
(2) Additional heat trace and insulation was completed in April, 1990.
(3) Insulation upgraded and weatherproof/windproof enclosures completed in April, 1990.
- 12/22/89 - (1) Insulation upgraded and weatherproof/windproof enclosures completed in April, 1990.

- (2) Operators were instructed in January, 1990 not to comply with a curtailment request from the transporter except in cases of pipeline emergency on the transporter's system, but to refer any future weather-related curtailment request, if one should occur, directly to the supplier for appropriate action. Furthermore, cogeneration facility's personnel will routinely contact the supplier in the late fall of each year (beginning in 1990) to remind supplier that natural gas supply requirements must be met to contract limits throughout cold weather months to avoid a repeat of the December '89 mixup. With respect to the LPG blending air compressor lubricant, the lubricant was changed to a Mobil brand synthetic in January, 1990 rated to cope with the ambient conditions experienced in December, 1989.

12/23/89 - (1) No action was required.

Very truly yours,

WICHITA FALLS ENERGY INVESTMENTS, INC.

Gerald N. Craig
President

GNC:sz



June 4, 1990

Mr. Kevin Delcarson
T.U. Electric
400 N. Olive
Suite 3118
Dallas, TX 75201

Dear Kevin:

The following comments are in reply to your correspondence of May 22nd, 1990, "Severe Cold Weather Operation":

1. Unit name and unit MW capacity.
 1. "Power Resources, Inc. " 200 MW
2. Unit general design temperature limitations (maximum & minimum), in degrees F.
 2. Summer Design Dry Bulb Temperature = 100°F.
Winter Design Dry Bulb Temperature = 16°F.
3. List of equipment(s) (or plant systems) that were adversely affected by the cold weather.
 3. * Gas Turbine liquid fuel system (not directly due to cold weather)
* Boiler instrumentation
4. For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit.
 4. Gas Turbine liquid fuel system - Purge air check valves mechanically failed allowing liquid fuel to bypass the burner. This caused starving of some of the burners which resulted in a high exhaust temperature spread. The unit was able to operate at a reduced output. The failure mode of the check valve, in our opinion, is caused by continuous vibration due to being hard piped to the gas turbine. This causes the "poppett" and seat to wear prematurely.

Boiler Instrumentation - One level transmitter on each high pressure boiler drum was out of service due to the freezing. We are however, equipped with redundant level indicators and this caused no production problems. A few other instruments were out of service due to freezing but these did not affect production or plant safety and are therefore considered unimportant. Instrumentation freezups are caused by inadequate heat tracing and insulation of the process side instrument tubing and inadequate protection of the transmitter section of the instrument loop.

5. For each piece of equipment or system, identify the necessary corrective action(s) to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure.

5. Gas Turbine liquid fuel system -

- a. Isolation of each of 10 purge air check valves from the vibration caused by the gas turbine. We have accomplished this by installing "flexhose" between the check valve and turbine.
- b. Frequent wintertime testing of the liquid fuel system to be as confident as possible that all systems function properly.

Boiler Instrumentation

- a. Provide heated instrument boxes for all critical instrument transmitters. We have budgeted to install 18 of these on the critical instruments before winter operation this year.
- b. Confirm proper operation of heat trace circuits before predicted cold weather.
- c. After maintenance activities, which involved tearing away of insulation and/or heat tracing, repair such immediately.
- d. Provide protection from the elements by using tarps or temporary buildings. This year we will enclose the ends of our boiler drums with buildings designed to be put up in the winter and removed during the summer. This will protect the ends of the drums where most of the critical boiler instrumentation is located.

6. For each piece of equipment or system identified above, report the actual or anticipated date of corrective action completion.

6. * Liquid fuel system modifications completed 5/15/90.
* Instrumentation protection-completion of all projects by 11/15/90.

Ken Hamby
Ken Hamby

KH:sc



**Lone Star Energy
Company**

P.O. Box 548
Sweetwater, Texas 79556
915-235-4921

**JAMES E. PACK
MANAGER**

June 4, 1990

REF. DOC. NO.: 380

Kevin Delcarson
TU Electric
Skyway Tower
400 N. Olive St., L. B. 81
Dallas, TX 75201

RE: Severe Cold Weather Operation

Dear Mr. Delcarson:

This letter is in response to your letter dated May 22, 1990, which requested information on plant operations during severe cold weather experienced in December, 1989. Following are the specific requests, each accompanied by our response.

1. Unit name and unit MW capacity.

Unit Name: Encogen One
Unit Capacity: Nominal 255 MW
Unit Location: Sweetwater, Texas

2. Unit general design temperature limitations (maximum and minimum), in degrees F.

Maximum Design Temperature: Plant will operate at all summer ambient temperatures. Successful operation is expected at ambient temperatures somewhat above 115 degrees F.

Minimum Design Temperature: Plant will operate at winter ambient temperatures of -10 degrees F and lower.

3. List of equipment or systems that were adversely affected by the cold weather.

- a. Steam turbine-generator / 87 MW
- b. Air cooled steam condenser

Kevin Delcarson

Page 2

June 4, 1990

4. For each piece of equipment or system that failed, identify the failure mode, the cause of the failure, and how the equipment or system loss contributed to the overall failure of the unit.
 - a. Steam turbine-generator tripped due to freezing of turbine exhaust backpressure transmitters.
 - b. Air cooled steam condenser experienced freeze problems due to extremely low steam loads. The steam turbine was not available due to previous freezing of exhaust pressure transmitters, and bypass steam loading did not provide sufficient load to keep the condenser free from ice.
5. For each piece of equipment or system, identify the necessary corrective actions to prevent recurrence. Please provide sufficient detail to describe the full range of activities necessary to reasonably preclude future failure.
 - a. Steam turbine-generator:
 1. Heat tracing of backpressure transmitters and piping.
 2. Installation of additional variable speed controls to allow variable speed control of 12 fans instead of 6.
 3. Installation of additional steam jet ejector capacity to keep the condenser coils free from non-condensables.
6. For each piece of equipment or system identified above, report the actual or anticipated date corrective action completion.
 - a. Steam turbine-generator:
 1. Heat tracing of backpressure transmitters and piping is complete.

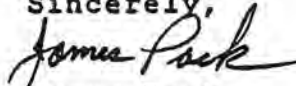
Kevin Delcarson
Page 3
June 4, 1990

b. Air cooled steam condenser/steam turbine-generator:

1. Heat tracing of condensate hotwell and drain piping for each condenser tube bundle is complete.
2. Installation of additional variable speed controls to allow variable speed control of 12 fans instead of 6 will be completed prior to winter operation, 1990.
3. Installation of additional steam jet ejector capacity to keep the condenser coils free from non-condensables will be completed prior to winter operation, 1990.

Should you have any further questions, please do not hesitate to contact me.

Sincerely,


James Pack
Plant Manager

JP/kdp

cc: D. Martin
N. Perry

Cogenron Inc.

3221 5th Avenue South Texas City, Texas 77590 (409) 945-7324

June 12, 1990

JJK-065-90

Mr. Kevin Delcarson
TU Electric
400 North Olive Street
Dallas, TX 75201

RE: Response to PUC requested freeze information.

Dear Kevin:

Question 1:

Enron Cogeneration One Company
3221 5th Avenue South
Texas City, TX 77590

MW Capacity: 400 MW

Question 2:

-Minimum Design Temperature: 8°F
-Maximum Design Temperature: 101°F

Question 3,4,5,6:

Deaerator instrumentation:

Deaerator instrumentation froze on all units until more insulation was added at which time the electric heat trace thawed the lines and they stayed in service. The 'B' unit deaerator level was lost for a short period of time and during this the safety valve lifted and would not reseal. This necessitated a unit shutdown to replace with the spare safety valve. Plant output was reduced by one hundred twenty megawatts.

To prevent this from happening again the wattage for the deaerator electric heat tracing was doubled and the insulation was increased. In addition, an internal electronic level indicator was added for additional reliability for level control. All projects are 95% complete and will be complete by the end of September.

Demineralization Plant:

The demineralization plant had frozen lines since it is not enclosed in a building. This reduced the amount of water that could be produced and the quality of the water suffered since regenerations were difficult. The result of this was that plant output had to be reduced because steam injection to the gas turbines was reduced.

It was not until a week after the freeze had occurred that we experienced tube problems with our boiler that were a result of the water quality produced during the freeze. Sections of high pressure boiler tubing needed replacing on the two boilers that ran thru the freeze.

By the end of July, bids for adding a heated enclosure around the demineralization plant will be received and by the end of August a decision will be made on the enclosure. This should eliminate the majority of problems associated with the freeze that this facility incurred.

Regards,


James J. Keegan
Plant Manager

JJK/cw

TENASKA III TEXAS PARTNERS

General Office:
407 North 117 Street
Omaha, NE 68154
Telephone: (402) 691-9500
Telecopy: (402) 691-9526

Plant Office:
301 Lake Crook Road
Paris, TX 75460
Telephone: (214) 785-2992
Telecopy: (214) 785-1360

June 08, 1990

Mr. Kevin Delcarson
Cogeneration Department
TU ELECTRIC
Skyway Tower
400 N. Olive St., L.B. 81
Dallas, TX 75201

RE: Severe Cold Weather Operation (Letter Dated 05/22/90)

Question: Unit name and MW capacity.

Answer: TENASKA III (Nominal Capacity)
2 ea Gas Turbines @ 80 MW ea - 160 MW
1 ea Steam Turbine @ 90 MW ea - 90 MW
Plant Rating - 223,200 KW Total

Question: Unit general design temperature limitations

Answer: Minimum - 0°F
Maximum - 98°F dry bulb

Question: List of equipment or plant systems that were adversely affected by the cold weather.

Answer: a. Heat Recovery Steam Generator #1
b. Heat Recovery Steam Generator #2
c. Plant Instrumentation
d. Assorted Water Lines

Question: For each piece of equipment or system that failed, identify failure mode, the cause of failure, and how the equipment or system loss contributed to the overall failure of the unit.

Answer: During the severe cold weather time frame December 21, 22, 23, 24 the TENASKA III Site was in the process of converting from a simple cycle (gas turbines only) operation to a combined cycle operation (gas turbines and steam turbine). In preparation for combined cycle commissioning, certain construction measures were taken that prevented running simple cycle and combined cycle equipment was still being debugged. Therefore, the entire plant was not available for service.

During the shutdown, it was discovered that an economized header on HRSG #1 was not drained due to a plugged drain valve. Several other boiler drain valves were also discovered plugged.

Heat tracing for a lot of the plant instruments was also incomplete.

Since the severe cold weather, the plant has been commissioned for combined cycle operation. All plant heat tracing has been completed and insulated houses were built around each plant transmitter.

Question: For each piece of equipment or system, identify the necessary corrective action(s) to prevent the recurrence.

Answer: If Plant is operating, follow the Freeze Protection Checklist.

If Plant is not operating then make sure that the Heat Recovery Steam Generator is drained and also follow the Freeze Protection Sheet if applicable.

Question: For each piece of equipment or system identified above, report actual or anticipated date of corrective action completion.

Answer: The Plant was restarted on Dec. 28, 1989 as a combined cycle plant. The plant heat tracing and new transmitter boxes were completed by March 1990.

All freeze damage on the Heat Recovery Steam
Generators was completed by December 28, 1989.

If I may be of further assistance, please do not hesitate to
call.

Sincerely,

Mike

Mike Hart, P.E.
Plant Manager

MH/se

cc: Tony Fontana
Duke Cockfield
Leo Finnegan
File

ATTACHMENT NO. 4

COGENERATOR RESPONSES

ATTACHMENT NO. 4

COGENERATOR RESPONSES

The following is a listing of cogeneration units that experienced problems during the December 1989 freeze. The cogenerator reports were submitted through HL&P and TU Electric.

Occidental Chemical Corporation.

Battleground Plant, 200 MW Capacity
No. 2 Gas Turbine/Heat Recovery Steam Generator(HRSG)

Corrective actions to frozen instruments included instrument upgrading, installing heat tracing and enclosures, and instituting an annual instrument freeze survey.

Maintenance Costs: \$ 15,000

Clear Lake Cogeneration

GT 104; 100 MW Westinghouse Combustion Turbine

Power supply failed. Installed upgraded power supply with backup capability.

Maintenance Costs: \$ 15,000

GT 103 100 MW Westinghouse Combustion Turbine

Lub oil supply pump failed. Replaced bearings with oil lubricated design.

Maintenance Costs: \$ 36,000

ST 101; 50 MW Westinghouse Steam Turbine

ST 102; 14 MW Westinghouse Steam Turbine

Both units force out of service upon loss of boiler feedwater.

Maintenance Costs: (not provided)

Several instrument transmitters froze in the plant due to inadequate design and installation of the original freeze protection systems. An upgrading is planned for fourth quarter, 1990.

Maintenance Costs: \$ 300,000

Attachment No. 4 Cogenerator Responses

Destec Energy, Inc.

CoGen Lyondell
Steam Turbine Generator 001, 135 MW

Unit tripped due to loss of condenser vacuum pump, frozen seal water line. Thermal barrier added near vacuum pump.

Maintenance Costs: (minimal)

Dow Chemical

Dow Chemical Freeport, 325 MW

Unit tripped when pre-filter pads plugged with snow at inlet. Once down associated water lines froze and could not be restarted until freeze damage was repaired. Existing heat tracing systems were unable to fully protect instruments. Corrective actions include installation of implosion dampers to bypass plugged inlet filters (second quarter 1991), and improved insulation and heat tracing systems.

Maintenance Costs: (not provided)

Bayou Cogeneration Plant

Four MS7001 E Gas Turbine/Heat Recovery
Steam Generator Trains 300.5 MW

Heat tracing systems were inadequate to prevent instrumentation lines from freezing. Corrective measures include replacement of heat tracing and insulation (1500 feet of lines and 16 instrument cabinets).

Maintenance Costs: \$ 100,000

AES Deepwater Cogeneration

AES Deepwater Cogeneration Facility; 160 MW

Freezing weather caused the failure of the Throttle Pressure Transmitter, Mass Blow Down Valve, Drum Level Transmitter, and Water Cooled Fan Bearing Housings. Corrective actions include insulation and heat tracing and water temperature and flow monitors, and changes to operating procedures.

Maintenance Costs: \$ 5,500

Attachment No. 4 Cogenerator Responses

Texasgulf Cogeneration Facility

Newgulf (Warton County) Texas

Gas Turbine and Steam Turbine with Heat Recovery Unit, 77 MW

Clogged and frozen intake screens interrupted the supply of raw water (feedwater) to heat recovery unit. Corrective actions include replacement or repair of heat tracing systems and insulation on raw water system and instrumentation. (No costs reported)

Wichita Falls Energy Investments, Inc.

Wichita Falls Energy Co., Ltd. Cogeneration Facility
74 MW Capacity

Primary problems with instrumentation freezing due to lack or inadequate heat tracing and insulation protection. Had limited gas curtailment problems. (No corrective action costs provided)

Power Resources, Inc.

Power Resources, Inc. (PRI)
Gas Turbine, 200 MW

Problems encountered with the GT liquid fuel system and boiler instrumentation. Instrumentation problems caused by inadequate heat tracing and insulation. (No corrective action costs provided.)

Lone Star Energy Company

Encogen One, 255 MW
Steam Turbine generator 87 MW

Weather caused freezing of instrumentation and controls for the steam turbine and air cooled steam condenser. Corrective actions included heat tracing, additional insulation, and additional steam jet ejector capacity. (No corrective action costs provided.)

Attachment No. 4 Cogenerator Responses

Cogenron, Inc.

Enron Cogeneration One Company
400 MW Capacity

Freezing problems occurred in the deaerator instrumentation and demineralizer plant water lines. Corrective actions included adding a heated enclosure around the demineralizing plant and additional heat tracing and insulation on instrumentation lines. (No corrective action costs were provided.)

Tenaska III Texas Partners

Tenaska III
Two gas turbines, 160 MW; One steam turbine 90 MW; Total Capacity of plant: 250 MW (Combined Cycle Plant)

Freezing problems were encountered with steam generator heat recovery systems, plant instrumentation and water lines. The plant was in the process of being "debugged" and heat tracing system was not complete. The plant has been completed and the heat tracing and insulation has been completed. (No corrective action costs were provided.)

ATTACHMENT NO. 3
INDIVIDUAL UTILITY RESPONSES

Utility Responses:

Brazos Electric Power Cooperative, Inc.
Central Power and Light Company
Houston Lighting and Power Company
Lower Colorado River Authority
Texas Municipal Power Agency
Texas Utilities Electric Company

ATTACHMENT NO. 5

PLANT DESIGN TEMPERATURES

ATTACHMENT NO. 5
PLANT DESIGN TEMPERATURES

Central Power and Light Company

Unit Name	Design Temperature Ranges (Degrees F)
Barney Davis 1	All units designed to operate at 10 degrees F, with wind velocity of 30 MPH.
Barney Davis 2	
Caleto Creek 1	
E. S. Joslin 1	
J. L. Bates 1	
J. L. Bates 2	
La Palma 6	
Laredo 1	
Laredo 2	
Laredo 3	
Lon C Hill 3	
Lon C Hill 4	
Nueces Bay 6	
Nueces Bay 7	
Victoria 6	

Attachment No. 5 Plant Design Temperatures**Houston Light & Power Company**

Unit Name	Design Temperature Range (Degrees F.)
Cedar Bayou 1	10 - 105
Cedar Bayou 2	
Cedar Bayou 3	
Greens Bayou 5	10 - 105
Limestone 1	10 - 110
Limestone 2	(Freeze Protection to 5)
P H Robinson 1	10 - 105
P H Robinson 2	
P H Robinson 3	
P H Robinson 4	
S R Bertron 1	10 - 105
S R Bertron 2	
S R Bertron 3	
S R Bertron 4	
South Texas 1	3 - 105*
South Texas 2	
T H Wharton 2	10 - 105
T H Wharton 3	
T H Wharton 4	
T H Wharton GT21	10 - 105
T H Wharton GT54	
W A Parish 1	10 - 105
W A Parish 2	
W A Parish 3	
W A Parish 5	
W A Parish 6	
W A Parish 7	
W A Parish 8	
W A Parish GT21	
Webster GT	10 - 105

* This represents the maximum ambient conditions under which and engineering evaluation has determined the unit can operate. This evaluation, performed after the cold weather of 1989, determined that the freeze protection and HVAC systems can operate at ambient temperatures lower than the nominal design minimums of 11 degrees F for freeze protection and 29 degrees F for HVAC systems.

Attachment No. 5 Plant Design Temperatures

Texas Utilities Electric Company (TU Electric)

Unit Name	Design Temperature Range (Degrees F)
Eagle Mountain 3	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
Handley 5	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
Martin Lake 2	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
Monticello 2 Monticello 3	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
Morgan Creek CT4	-5 to 115
Mountain Creek 2 Mountain Creek 7	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
River Crest 1	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
Stryker Creek 1	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
Tradinghouse 1	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures
Valley 2	-10 - and 35 MPH wind velocity to (Highest Regional Temperatures

Attachment No. 5 Plant Design Temperatures

Lower Colorado River Authority (LCRA)

Unit Name	Design Temperature Range (Degrees F)
Sim Gideon 2	No design temperature limitations available.
Sam K Seymour 3	1 to 110

Texas Municipal Power Agency (TMPA)

Unit Name	Design Temperature Range (Degrees F)
Gibbons Creek 1	15 - 107

Exhibit G

**Complaint of Michael Mabee Related to
Mandatory Reliability Standards
in the Texas Grid Collapse of 2021**

Analysis of OE-417 Data

2010 -2020

Utility companies and grid operators are required to submit reports¹ on electric disturbance events to the Department of Energy (DOE) on a form known as an OE-417. The publicly available information from these reports is difficult to find, incomplete and confusing.

I did an analysis of all the publicly available OE-417 data from January 1, 2010 through December 31, 2020. First of all, there were 166 different “event types” reported many of which were either duplicates or related. For example, there were at least 24 different “event types” that denoted a physical attack. There were at least 50 “event types” that denoted a disturbance caused by weather. I grouped these 166 “event types” into 15 categories (actually “causes”) so that we could get a sense of what has actually threatened the electric grid in the past 10 years.

Unfortunately, the public OE-417 data is so bad that there were 496 electric disturbance events where I was unable to identify a cause. These are highlighted in yellow in the chart. I was able to identify a cause in 1827 electric disturbance events, or 80% of the OE-417 reports filed. Moreover, some data such as the number of “customers affected” does not appear accurate in some cases. Many OE-417’s do not appear to be updated. Reports from years ago show “unknown” under the number of customers affected, or show “0” when we know there were blackouts associated with those events.

I included separate charts for the TRE Region (Texas Reliability Entity a.k.a. Texas RE) in order to give the public better access to what has caused electric disturbances in Texas.

Electric disturbance events where I was unable to identify a cause are highlighted in yellow in the charts. The underlying data from the charts is also included for reference. This is available in a searchable database and CSV format on my website: <https://michaelmabee.info/oe-417-database/>

¹ See: <https://www.oe.netl.doe.gov/oe417.aspx>

OE-417 Analysis 2010-2020

All NERC Regions		
Events From 2010-2020	Total	%
Weather	961	52.6%
Cyber Attack	37	2.0%
Physical Attack	721	39.5%
Fuel Supply Deficiency	74	4.1%
Equipment	15	0.8%
Natural Disaster	14	0.8%
Wildfire	5	0.3%
Generation Interruption	17	3.4%
Transmission Interruption	113	22.8%
Distribution Interruption	9	1.8%
Operations	185	37.3%
Islanding	67	13.5%
Load Shed	30	6.0%
Public Appeal	65	13.1%
?	10	2.0%
Total OE-417 Reports	2323	
Cause Known from OE-417	1827	
Cannot Determine Cause	496	

Texas RE Only		
Events From 2010-2020	Total	%
Weather	83	70.9%
Cyber Attack	3	2.6%
Physical Attack	28	23.9%
Fuel Supply Deficiency	3	2.6%
Equipment	0	0.0%
Natural Disaster	0	0.0%
Wildfire	0	0.0%
Generation Interruption	4	7.1%
Transmission Interruption	17	30.4%
Distribution Interruption	2	3.6%
Operations	11	19.6%
Islanding	1	1.8%
Load Shed	0	0.0%
Public Appeal	21	37.5%
?	0	0.0%
Total OE-417 Reports	173	
Cause Known from OE-417	117	
Cannot Determine Cause	56	

OE-417 Analysis 2010-2020

All NERC Regions												
Event	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	Total
Weather	161	92	94	80	42	65	82	55	82	133	75	961
Cyber Attack	7	2	4	3	5	0	3	2	3	8	0	37
Physical Attack	94	80	58	44	49	44	73	79	86	114	0	721
Fuel Supply Deficiency	7	7	5	7	7	2	18	6	6	6	3	74
Equipment	0	0	0	0	0	0	0	7	2	3	3	15
Natural Disaster	4	0	8	0	0	0	1	0	0	1	0	14
Wildfire	0	0	0	0	0	0	3	0	0	0	2	5
Generation Interruption	0	2	0	4	4	0	0	0	0	7	0	17
Transmission Interruption	42	36	10	9	4	0	0	3	2	2	5	113
Distribution Interruption	0	3	0	0	2	0	1	2	0	1	0	9
Operations	67	56	31	1	16	13	1	0	0	0	0	185
Islanding	0	0	2	1	7	10	15	13	6	4	9	67
Load Shed	0	0	0	0	1	4	2	4	4	5	10	30
Public Appeal	1	0	8	1	4	5	11	0	4	17	14	65
?	0	0	0	0	0	0	4	3	1	0	2	10
Total OE-417 Reports	383	278	220	150	141	143	214	174	196	301	123	2323
Cause Known from OE-417	273	181	169	134	103	111	180	149	179	265	83	1827
Cannot Determine Cause	110	97	51	16	38	32	34	25	17	36	40	496

Texas RE Only												
Event	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	Total
Weather	20	17	5	9	5	8	2	3	4	5	5	83
Cyber Attack	2	0	0	0	0	0	0	0	1	0	0	3
Physical Attack	9	6	3	2	2	1	0	0	2	3	0	28
Fuel Supply Deficiency	0	0	0	0	0	0	1	1	1	0	0	3
Equipment	0	0	0	0	0	0	0	0	0	0	0	0
Natural Disaster	0	0	0	0	0	0	0	0	0	0	0	0
Wildfire	0	0	0	0	0	0	0	0	0	0	0	0
Generation Interruption	0	0	0	0	2	0	0	0	0	2	0	4
Transmission Interruption	7	8	2	0	0	0	0	0	0	0	0	17
Distribution Interruption	0	1	0	0	1	0	0	0	0	0	0	2
Operations	6	2	2	0	0	1	0	0	0	0	0	11
Islanding	0	0	0	0	0	0	1	0	0	0	0	1
Load Shed	0	0	0	0	0	0	0	0	0	0	0	0
Public Appeal	0	0	0	0	3	4	9	0	0	5	0	21
?	0	0	0	0	0	0	0	0	0	0	0	0
Total OE-417 Reports	44	34	12	11	13	14	13	4	8	15	5	173
Cause Known from OE-417	31	23	8	11	7	9	3	4	8	8	5	117
Cannot Determine Cause	13	11	4	0	6	5	10	0	0	7	0	56

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2010-01-06	6:00 p.m.	6:00 p.m. January 08		Southwest Louisiana	SERC		Made Public Appeals	N/A	N/A	Public Appeal
	2010-01-11	3:45 a.m.	9:57 a.m. January 11		Northern and Central Florida	FRCC/SERC		Interruptible Load Shed/Made Public Appeals	N/A	N/A	Load Shed
	2010-01-18	11:30 a.m.	8:00 a.m. January 28		Northern and Central California	WECC		Severe Storm	290	1,700,000	Weather
	2010-01-19	2:30 p.m.	3:00 p.m. January 20		San Diego and Orange Counties	WECC		Severe Storm	2,650	50,000	Weather
	2010-01-19	7:30 a.m.	12:24 p.m. January 19		San Francisco	WECC		Severe Storm	300	30,000	Weather
	2010-01-20	1:00 p.m.	6:10 p.m. January 24		City of Los Angeles, California	WECC		Severe Storm	N/A	147,223	Weather
	2010-01-28	12:00 p.m.	12:00 p.m. February 02		Oklahoma	SPP		Ice Storm	N/A	68,705	Weather
	2010-02-01	2:32 p.m.	5:00 p.m. February 01		Oklahoma	SPP		Ice Storm/Electrical System Separation	30	0	Weather
	2010-02-05	10:30 p.m.	12:00 p.m. February 12		Southwestern Pennsylvania	RFC		Winter Storm	N/A	57,000	Weather
	2010-02-05	11:30 p.m.	2:38 a.m. February 07		Indiana, Ohio, W. Virginia and Virginia	RFC		Winter Storm	N/A	102,225	Weather
	2010-02-05	3:00 p.m.	4:00 p.m. February 13		Southern NJ	RFC		Winter Storm	N/A	221,000	Weather
	2010-02-05	6:48 p.m.	5:00 p.m. February 07		North and South Carolina	SERC		Winter Storm	500	74,000	Weather
	2010-02-05	7:00 p.m.	3:46 p.m. February 12		District of Columbia, Prince Georges and Montgomery Co. MD	RFC		Winter Storm	N/A	97,651	Weather
	2010-02-06	2:30 a.m.	7:00 a.m. February 07		Virginia, North Carolina	SERC		Winter Storm	600	104,736	Weather
	2010-02-06	8:00 a.m.	9:00 a.m. February 06		Delmarva Peninsula	RFC		Winter Storm	N/A	58,491	Weather
	2010-02-09	6:00 p.m.	4:00 p.m. February 14		Southeastern Pennsylvania	RFC		Winter Storm	N/A	223,000	Weather
	2010-02-11	12:00 p.m.	9:00 p.m. February 15		Dallas/Fort Worth and East Texas	TRE		Winter Storm	N/A	500,000	Weather
	2010-02-12	5:00 a.m.	5:00 p.m. February 12		East Texas, Western Arkansas, Northern Louisiana	SPP		Winter Storm	N/A	52,999	Weather
	2010-02-14	10:00 a.m.	12:00 p.m. February 14		Western Pennsylvania and Northeast Central WV	RFC		Winter Storm	900	190,000	Weather
	2010-02-19	8:30 p.m.	4:01 a.m. February 20		San Joaquin Field Division/Bakersfield, CA	WECC		Firm System Load Shed	1,000	N/A	Load Shed

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2010-02-23	10:00 p.m.	4:00 p.m. February 25		Upstate New York	NPCC		Winter Storm	N/A	150,000	Weather
	2010-02-25	11:53 p.m.	4:40 p.m. March 01		Southern Maine and New Hampshire	NPCC		Winter Storm	510	509,606	Weather
	2010-02-25	12:01 a.m.	9:00 p.m. February 26		Southeastern New York, Northern New Jersey	NPCC		Winter Storm	N/A	65,000	Weather
	2010-02-25	5:00 p.m.	7:00 p.m. March 02		New York City	NPCC		Winter Storm	N/A	55,000	Weather
	2010-03-13	1:00 a.m.	6:40 p.m. March 16		Southeastern Pennsylvania	RFC		High Winds and rain	N/A	177,528	Weather
	2010-03-13	12:00 p.m.	8:05 p.m. March 15		Connecticut	NPCC		High Winds and Rain	50	50,246	Weather
	2010-03-13	3:00 p.m.	4:00 p.m. March 17		Long Island	NPCC		High Winds and Rain	N/A	153,000	Weather
	2010-03-13	4:00 p.m.	12:00 a.m. March 16		Central New Jersey and Northern New Jersey	RFC		High Winds and Flooding	N/A	180,000	Weather
	2010-03-13	6:00 p.m.	12:59 p.m. March 20		Southern, Central and Northern New Jersey	RFC		High Winds and Rain	100	360,000	Weather
	2010-03-13	6:00 p.m.	9:00 a.m. March 20		New York City and Westchester County	NPCC		High Winds and Rain	N/A	173,000	Weather
	2010-03-31	11:59 p.m.	12:55 a.m. April 01		San Diego and Orange Counties	WECC		Shed Firm Load	324	290,000	Load Shed
	2010-03-31	11:59 p.m.	12:38 a.m. April 01		San Diego	WECC		Shed Firm Load	324	N/A	Load Shed
	2010-04-16	5:15 p.m.	5:00 p.m. April 18		Southwestern Pennsylvania	RFC		Severe Thunderstorms	15	120,000	Weather
	2010-04-21	3:05 p.m.	8:00 p.m. April 21		Iberville, Parish, Louisiana	SERC		Generator Tripped	N/A	N/A	Equipment
	2010-04-27	2:55 p.m.	2:55 p.m. April 27		Rocky Mount, NC	SERC		Transmission System Interruption	N/A	29,376	Transmission Interruption
	2010-05-02	2:40 p.m.	7:30 p.m. May 09		Tennessee and Mississippi	SERC		Thunderstorms	N/A	50,500	Weather
	2010-05-18	8:15 a.m.	10:46 p.m. May 18		Central California	WECC		Breakers Tripped	318	N/A	Equipment
	2010-05-26	11:45 a.m.	3:00 p.m. May 26		Maryland, Pennsylvania, West Virginia, Virginia	RFC, SERC		Made Public Appeal - System Drill	N/A	N/A	Public Appeal
	2010-06-01	10:03 p.m.	12:30 a.m. June 18		Southwestern Indiana	RFC		Firm Load Shed	500	1	Load Shed
	2010-06-02	8:18 p.m.	8:00 a.m. June 04		San Antonio, TX	TRE		Severe Weather	N/A	126,000	Weather
	2010-06-06	4:45 a.m.	5:35 a.m. June 06		Northern California	WECC		Electric System Separation	3	2,650	Islanding
	2010-06-07	6:29 p.m.	1:00 a.m. June 08		Denver Metropolitan Area	WECC		Firm Load Shed	300	31,000	Load Shed

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2010-06-08	11:00 a.m.	5:00 p.m. June 08		Southeastern Texas	TRE		Thunderstorms	N/A	79,741	Weather
	2010-06-09	2:18 p.m.	3:00 p.m. June 09		Edenton, NC	SERC		Transmission System Interruption	N/A	4,196	Transmission Interruption
	2010-06-16	11:11 a.m.	11:32 a.m. June 16		New York (Rockland and Orange Counties)	NPCC		Voltage Reduction (System Test)	N/A	N/A	?
	2010-06-17	10:49 a.m.	11:02 a.m. June 17		Eastern Montana	MRO		Electrical System Separation	N/A	N/A	Islanding
	2010-06-17	8:30 a.m.	5:47 p.m. June 17		Morgan City, LA	SPP		Made Public Appeal	N/A	N/A	Public Appeal
	2010-06-17	9:30 a.m.	5:17 p.m. June 17		Southern Louisiana	SERC		Made Public Appeal	N/A	N/A	Public Appeal
	2010-06-17	9:30 a.m.	4:40 p.m. June 17		Southern Louisiana	SERC		Made Public Appeal	N/A	N/A	Public Appeal
	2010-06-17	9:30 a.m.	4:40 p.m. June 17		Southwestern Louisiana	SPP		Made Public Appeal	N/A	N/A	Public Appeal
	2010-06-18	3:30 p.m.	12:30 a.m. June 20		Northwest Indiana	RFC		Thunderstorms	N/A	94,345	Weather
	2010-06-18	4:00 p.m.	1:00 p.m. June 20		Chicago, IL	RFC		Severe Weather	N/A	400,000	Weather
	2010-06-18	7:00 p.m.	5:00 a.m. June 19		Southern Portion of Lower Michigan	RFC		Thunderstorms	N/A	100,000	Weather
	2010-06-18	8:00 p.m.	10:45 a.m. June 21		Indiana, Michigan	RFC		Severe Weather	N/A	79,000	Weather
	2010-06-18	8:00 p.m.	7:30 p.m. June 22		Detroit, MI	RFC		Severe Weather	N/A	150,000	Weather
	2010-06-21	1:48 p.m.	8:31 p.m. June 22		Cincinnati, OH	RFC		Thunderstorms	400	50,636	Weather
	2010-06-22	3:34 p.m.	7:00 p.m. June 22		West/Central Arkansas	SERC		Made Public Appeal/Transmission Equipment Failure	84	25,159	Transmission Interruption
	2010-06-23	5:00 p.m.	1:40 p.m. June 25		Chicago, IL	RFC		Severe Weather	N/A	300,000	Weather
	2010-06-23	5:48 p.m.	2:21 a.m. June 24		Northwest Indiana	RFC		Thunderstorms	N/A	53,000	Weather
	2010-06-24	3:00 p.m.	12:00 p.m. June 29		Southwestern New Jersey	RFC		Thunderstorms	N/A	150,000	Weather
	2010-06-24	3:30 p.m.	11:59 p.m. June 29		Southeastern Pennsylvania	RFC		Thunderstorms	N/A	355,000	Weather
	2010-06-25	11:36 p.m.	1:38 a.m. June 26		Northern California	WECC		Electrical System Separation	N/A	N/A	Islanding
	2010-07-06	3:47 a.m.	4:37 a.m. July 06		Newark, DE	RFC		Transformer Outage	95	18,400	Equipment
	2010-07-07	4:13 p.m.	10:29 p.m. July 07		York, South Central Pennsylvania	RFC		Loss of Transmission Equipment	N/A	43,903	Transmission Interruption
	2010-07-15	7:00 p.m.	11:30 p.m. July 19		Southeastern Michigan	RFC		Severe Weather	540	127,534	Weather
	2010-07-17	8:30 p.m.	10:00 p.m. July 19		Minnesota	MRO		Strong Winds, Tornadoes	N/A	63,000	Weather
	2010-07-21	6:44 p.m.	8:00 p.m. July 21		Connecticut	NPCC		Thunderstorms	N/A	50,100	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2010-07-23	10:00 a.m.	11:55 p.m. July 24		Northern Utah	WECC		Made Public Appeals	8-Jun	N/A	Public Appeal
	2010-07-23	7:30 p.m.	6:30 p.m. July 26		Southeastern Michigan	RFC		Severe Weather	400	82,000	Weather
	2010-07-25	3:10 p.m.	11:30 p.m. July 30		Washington, DC Region	RFC		Severe Weather	N/A	297,700	Weather
	2010-07-25	3:20 p.m.	6:00 p.m. July 27		Central Maryland	RFC		Severe Weather	480	124,000	Weather
	2010-07-25	4:11 p.m.	8:06 p.m. July 25		Northern Virginia	SERC		Severe Weather	900-1000	81,000	Weather
	2010-07-29	5:43 p.m.	8:07 p.m. July 29		Virginia	SERC		Thunderstorms	N/A	55,000	Weather
	2010-07-29	6:39 p.m.	7:26 p.m. July 29		Southern California	WECC		Shed Interruptible Load, Wildfire	522	N/A	Wildfire
	2010-07-29	6:39 p.m.	7:26 p.m. July 29		Southern California	WECC		Shed Interruptible Load, Wildfire	522	N/A	Wildfire
	2010-08-02	12:00 p.m.	11:00 p.m. August 02		Central California	WECC		Fuel Supply Deficiency (Hydro)	N/A	N/A	Fuel Supply Deficiency
	2010-08-02	12:45 p.m.	11:00 a.m. August 04		Southern Louisiana	SERC		Made Public Appeals	N/A	N/A	Public Appeal
	2010-08-02	12:45 p.m.	11:00 a.m. August 04		Southern Louisiana	SERC		Made Public Appeals	N/A	N/A	Public Appeal
	2010-08-02	12:45 p.m.	11:00 a.m. August 04		Southwestern Louisiana	SERC		Made Public Appeals	N/A	N/A	Public Appeal
	2010-08-02	12:45 p.m.	11:00 a.m. August 04		Southern Louisiana	SPP		Made Public Appeals	N/A	N/A	Public Appeal
	2010-08-04	12:00 p.m.	10:00 p.m. August 04		Northern Texas, Eastern New Mexico	SPP		Made Public Appeals	N/A	N/A	Public Appeal
	2010-08-04	4:45 p.m.	12:00 a.m. August 07		Western Pennsylvania, Northwestern and Central West Virginia	RFC		Thunderstorms	60	11,186	Weather
	2010-08-04	5:00 p.m.	4:00 a.m. August 06		Ohio, West Virginia, Kentucky	RFC		Severe Weather	N/A	37,000	Weather
	2010-08-05	3:30 p.m.	10:00 p.m. August 05		District of Columbia, Maryland	RFC		Thunderstorms	N/A	76,729	Weather
	2010-08-05	3:54 p.m.	12:00 a.m. August 08		Northern Virginia	RFC		Thunderstorms	N/A	145,157	Weather
	2010-08-09	12:00 p.m.	12:00 p.m. August 16		Upstate New York	RFC		Fuel Supply Deficiency	N/A	N/A	Fuel Supply Deficiency
	2010-08-11	3:21 p.m.	12:12 p.m. August 11		Ohio	RFC		Severe Weather	N/A	57,000	Weather
	2010-08-12	3:42 p.m.	10:10 p.m. August 12		City of Oshkosh, Wisconsin	MRO		Made Public Appeals	30	7,600	Public Appeal
	2010-08-12	8:21 a.m.	11:00 a.m. August 12		Central Nebraska	SPP		Made Public Appeals	65	N/A	Public Appeal
	2010-08-12	6:45 a.m.	9:00 p.m. August 12		District of Columbia, Maryland	RFC		Severe Weather	N/A	101,003	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2010-08-19	6:00 p.m.	3:30 p.m. August 23		Southeastern Michigan	RFC		Severe Weather	340	80,000	Weather
	2010-08-23	5:50 p.m.	9:30 a.m. August 24		Houston, Texas	TRE		Severe Weather	746	81,586	Weather
	2010-09-01	10:20 a.m.	12:44 p.m. September 01		Pittsburg (Bay Area), California	WECC		Electrical System Separation (Islanding)	31	15,000	Islanding
	2010-09-07	2:02 p.m.	1:27 a.m. September 08		San Antonio, Texas	TRE		Tropical Storm	N/A	340,350	Weather
	2010-09-20	5:00 p.m.	5:30 p.m. September 20		King George County, Virginia	SERC		Low Flying Helicopter	N/A	N/A	?
	2010-09-21	9:31 p.m.	2:30 p.m. September 22		Central and Southern Michigan	RFC		Thunderstorms	N/A	138,000	Weather
	2010-09-22	6:12 a.m.	11:00 p.m. September 22		Bakersfield, California	WECC		Firm Load Shed	526	N/A	Load Shed
	2010-09-22	4:08 p.m.	12:00 a.m. September 26		City of Pittsburgh, Pennsylvania	RFC		Thunderstorms	156	52,000	Weather
	2010-09-22	5:38 p.m.	11:30 p.m. September 24		Western Pennsylvania	RFC		Thunderstorms	389	82,861	Weather
	2010-09-27	3:15 p.m.	6:12 p.m. September 27		Central and Southern California	WECC		Interruptible Load Shed	595	N/A	Load Shed
	2010-10-05	5:45 a.m.	6:00a.m. October 07		City of Los Angeles, California	WECC		Rain and High Winds	N/A	73,514	Weather
	2010-10-26	8:00 p.m.	10:00 p.m. October 28		Minnesota	MRO		High Winds	N/A	70,000	Weather
	2010-10-26	9:00 a.m.	11:00 a.m. October 28		Northern Illinois	RFC		Thunderstorms	N/A	192,106	Weather
	2010-10-27	5:16 p.m.	5:27 p.m. October 27		Northern California	WECC		Electrical System Separation-Islanding	16	2,674	Islanding
	2010-10-27	4:00 a.m.	12:00 p.m. October 27		Northeast and North Central Wisconsin	MRO		High Winds	N/A	63,000	Weather
	2010-10-27	5:00 p.m.	4:00 a.m. October 29		Northern Illinois	RFC		High Winds	N/A	127,000	Weather
	2010-10-27	8:00 a.m.	7:00 a.m. October 29		Michigan's Northerly Lower Peninsula	RFC		High Winds	240	285,000	Weather
	2010-10-31	10:26 p.m.	1:45 a.m. November 01		Bakersfield, California	WECC		Firm System Load Loss	500	N/A	Load Shed
	2010-11-04	9:46 a.m.	10:47 a.m. November 04		Rock Springs, Wyoming	WECC		Transmission Equipment Failure/Interruptible Load Shed	N/A	N/A	Transmission Interruption
	2010-11-06	3:53 p.m.	6:08 p.m. November 06		Northern California	WECC		Electrical System Separation - Islanding	20	4	Islanding
	2010-11-08	6:47 a.m.	6:00 p.m. November 08		Maine	NPCC		Snow and High Winds	N/A	60,863	Weather
	2010-11-13	3:00 p.m.	10:00 p.m. November 14		Minnesota	MRO		Winter Storm	N/A	60,000	Weather
	2010-11-15	11:00 p.m.	2:14 a.m. November 16		Puget Sound Region	WECC		High Winds	391	149,256	Weather
	2010-11-21	1:39 a.m.	4:46 p.m. November 24		Northern and Central California	WECC		Winter Storm	75	60,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2010-11-22	11:00 p.m.	8:00 p.m. November 24		Puget Sound Region, Washington	WECC		Winter Storm	420	123,535	Weather
	2010-11-23	2:01 p.m.	6:12 p.m. November 23		Northern California	WECC		Electrical System Separation - Islanding	22	7,077	Islanding
	2010-12-03	9:32 p.m.	2:00 a.m. December 04		California	WECC		Electrical System Separation - Islanding	22	7,077	Islanding
	2010-12-12	4:30 p.m.	2:00 p.m. December 15		Southeastern Michigan	RFC		Severe Weather	210	60,175	Weather
	2010-12-14	7:20 a.m.	7:25 a.m. December 14		California	WECC		Electrical System Separation - Islanding	9	6,635	Islanding
	2010-12-14	7:36 a.m.	9:00 a.m. December 15		Southern California	WECC		Transmission Equipment/Firm System Load	464	N/A	Load Shed
	2010-12-18	5:00 a.m.	10:00 p.m. December 19		Redmond, Washington	WECC		Severe Weather	184	92,090	Weather
	2010-12-26	8:15 a.m.	4:15 p.m. December 26		Carolina	SERC		Severe Weather	N/A	42,000	Weather
	2010-12-30	2:00 p.m.	6:00 a.m. January 12		New York	RFC		Fuel Supply Deficiency	300	N/A	Fuel Supply Deficiency
	2011-01-12	6:00 AM	1/12/2011	2:00 PM	Massachusetts	NPCC		Winter Storm	N/A	80,000	Weather
	2011-01-13	7:21 AM	1/13/2011	8:13 AM	North Florida	FRCC		Firm System Load Shed	150	20,900	Load Shed
	2011-01-18	2:00 PM	1/18/2011	2:00 PM	Whitman, Auburn St Substation, Massachusetts	NPCC		Vandalism	0	0	Physical Attack
	2011-01-23	7:00 AM	1/23/2011	1:00 PM	Franklin County, Idaho	WECC		Vandalism	0	0	Physical Attack
	2011-01-24	1:20 PM	1/24/2011	1:30 PM	Newman Power Plant, Texas	WECC		Suspicious Activity	0	0	Physical Attack
	2011-01-25	3:23 AM	1/25/2011	11:00 AM	Newark, Delaware	RFC		Vandalism	0	0	Physical Attack
	2011-01-26	9:25 AM	1/27/2011	5:00 PM	Carson City, Nevada	WECC		Suspected Telecommunications Attack	0	0	Cyber Attack
	2011-01-26	9:33 AM	1/27/2011	3:03 PM	Michigan	RFC		Vandalism	0	0	Physical Attack
	2011-01-26	5:00 PM	1/31/2011	8:00 AM	Montgomery and Prince George's County, Maryland and District of Columbia	RFC		Winter Storm	N/A	210,000	Weather
	2011-01-26	6:28 PM	1/29/2011	5:00 PM	Maryland	RFC		Winter Storm	N/A	234,326	Weather
	2011-01-26	7:43 PM	1/27/2011	6:18 PM	Northern Virginia	SERC		Winter Storm	600	150,084	Weather
	2011-01-27	5:00 PM	1/30/2011	5:00 AM	Central New York	NPCC		Fuel Supply Deficiency (Coal)	108	N/A	Fuel Supply Deficiency
	2011-01-27	9:30 AM	1/27/2011	9:30 AM	Hockessin, Delaware	RFC		Vandalism	0	0	Physical Attack
	2011-01-31	10:00 PM	2/3/2011	12:00 PM	Southwestern Ohio and Indiana	RFC		Ice Storm	996	272,880	Weather
	2011-02-01	3:00 PM	2/3/2011	12:00 PM	Indiana, Ohio	RFC		Winter Storm	UNK	158,013	Weather
	2011-02-02	5:00 PM	2/3/2011	10:00 PM	Texas Panhandle, Southeastern New Mexico	SPP		Fuel Supply Deficiency (Natural Gas)	UNK	UNK	Fuel Supply Deficiency
	2011-02-02	5:43 AM	2/3/2011	10:00 AM	Texas	TRE		Generation Inadequacy/Load Shed	4,000	1,069,730	Generation Interruption
	2011-02-02	6:22 AM	2/2/2011	9:57 AM	Central Arizona	WECC		Generation Inadequacy/Load Shed	3,963	69,000	Generation Interruption

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-02-02	7:24 AM	2/2/2011	10:23 PM	Dona Ana and El Paso Counties, Texas and Hudspeth County, New Mexico	WECC		Generation Inadequacy/Load Shed	280	178,000	Generation Interruption
	2011-02-02	3:00 AM	2/4/2011	11:59 PM	Philadelphia area, Pennsylvania	RFC		Winter Storm	UNK	213,000	Weather
	2011-02-03	2:30 PM	2/3/2011	2:30 PM	Bowie, Maryland	RFC		Suspected Cyber Attack	N/A	0	Cyber Attack
	2011-02-03	3:00 PM	2/4/2011	12:00 PM	San Diego area, California	WECC		Fuel Supply Deficiency (Natural Gas)	N/A	UNK	Fuel Supply Deficiency
	2011-02-03	10:04 PM	2/4/2011	12:32 PM	Texas	TRE		Generation Inadequacy/Load Shed	400	86,013	Generation Interruption
	2011-02-09	2:54 PM	2/9/2011	5:00 PM	University Place, Washington	WECC		Vandalism	0	0	Physical Attack
	2011-02-09	3:45 AM	2/9/2011	9:12 AM	Western Houston, Texas	TRE		Winter Storm	399	60,000	Weather
	2011-02-09	4:30 PM	2/10/2011	12:33 PM	Texas	TRE		Cold Weather Event	N/A	N/A	Weather
	2011-02-10	1:00 PM	2/10/2011	1:00 PM	LaGrande, Washington	WECC		Vandalism	0	0	Physical Attack
	2011-02-17	1:00 PM	2/23/2011	4:53 PM	Roseville, California	WECC		Suspected Cyber Attack	0	0	Cyber Attack
	2011-02-17	1:25 AM	2/19/2011	10:13 AM	Northern and Central California	WECC		Major Storm	91	80,000	Weather
	2011-02-19	4:34 PM	2/19/2011	4:34 PM	Harrington, Delaware	RFC		Vandalism	0	0	Physical Attack
	2011-02-19	12:30 PM	2/20/2011	4:00 AM	Philadelphia area, Pennsylvania	RFC		Major Storm	UNK	118000	Weather
	2011-02-20	4:00 PM	2/23/2011	4:00 PM	Southern Lower Peninsula, Michigan	RFC		Winter Storm	262	160,000	Weather
	2011-02-24	4:51 PM	2/24/2011	4:54 PM	Arkansas	SPP		Electrical System Separation (Islanding)	4	UNK	Islanding
	2011-02-25	10:30 AM	2/25/2011	10:45 AM	Salt Lake City, Utah	WECC		Vandalism	0	0	Physical Attack
	2011-02-25	8:00 AM	2/28/2011	5:30 PM	Northern and Central California	WECC		Winter Storm	91	80,000	Weather
	2011-02-25	3:20 PM	2/25/2011	6:00 PM	Virginia	SERC		Severe Weather	UNK	50000	Weather
	2011-02-25	3:23 PM	2/27/2011	6:00 PM	Maryland	RFC		Severe Weather	UNK	93000	Weather
	2011-03-01	8:00 AM	3/5/2011	9:30 AM	Western New York	NPCC		Fuel Supply Deficiency (Coal)	675	UNK	Fuel Supply Deficiency
	2011-03-06	2:54 AM	3/8/2011	8:00 AM	Salt Lake City Region, Utah	WECC		Vandalism	UNK	0	Physical Attack
	2011-03-10	12:03 PM	3/11/2011	6:00 AM	Texas	TRE		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-03-11	7:02 AM	3/11/2011	9:15 AM	Humboldt and Eureka, California	WECC		Generation Inadequacy/Load Shed	15	6,800	Generation Interruption
	2011-03-13	2:20 PM	3/14/2011	3:46 PM	Oregon	WECC		Severe Weather	UNK	9,000	Weather
	2011-03-14	7:30 AM	3/14/2011	4:55 PM	Baltimore, Maryland	RFC		Suspected Cyber Attack	N/A	N/A	Cyber Attack
	2011-03-15	6:00 PM	3/15/2011	7:14 PM	The Woodlands, Texas	TRE		Suspected Physical Attack	N/A	N/A	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-03-17	7:40 AM	3/17/2011	11:00 AM	Deerfield, New Hampshire	NPCC		Vandalism	N/A	N/A	Physical Attack
	2011-03-18	9:54 AM	3/18/2011	3:34 PM	Greene County, Ohio	RFC		Vandalism	N/A	N/A	Physical Attack
	2011-03-19	11:56 PM	3/24/2011	7:10 PM	Northern and Central California	WECC		Major Storm	91	128,000	Weather
	2011-03-20	9:44 AM	3/21/2011	10:00 AM	Los Angeles, California	WECC		Major Storm	UNK	79,000	Weather
	2011-03-21	12:57 AM	3/21/2011	2:29 AM	Deerfield, New Hampshire	NPCC		Vandalism	N/A	N/A	Physical Attack
	2011-03-21	12:35 PM	3/21/2011	2:45 PM	Southern California	WECC		Major Storm	150	54,332	Weather
	2011-03-23	6:30 PM	3/24/2011	4:55 AM	Indiana, Kentucky, Michigan, Ohio, Tennessee, Virginia, West Virginia	RFC		Major Storm	UNK	60,596	Weather
	2011-03-27	1:27 PM	3/27/2011	5:00 PM	Sonoma and Central Valley, California	WECC		Transmission Level Outage	295	165,000	Transmission Interruption
	2011-03-31	11:30 AM	3/31/2011	8:30 PM	Greater Tampa Bay, Florida	FRCC		Severe Weather	206	87,000	Weather
	2011-03-31	2:30 PM	4/1/2011	11:59 PM	Central and Western Florida	FRCC		Severe Weather	UNK	50,000	Weather
	2011-04-03	8:23 PM	4/5/2011	3:00 PM	Unknown	SERC		Suspected Cyber Attack	0	0	Cyber Attack
	2011-04-04	11:47 AM	4/8/2011	12:01 AM	Memphis, Tennessee	SERC		Severe Weather	359	63,000	Weather
	2011-04-04	1:00 PM	4/5/2011	12:00 AM	Shelby County, Tennessee	SERC		Severe Weather	300	63,000	Weather
	2011-04-04	7:00 PM	4/5/2011	8:00 PM	Southeast Arkansas, Southeast Louisiana, Western Mississippi, Eastern Texas	SERC		Severe Weather	UNK	74,645	Weather
	2011-04-04	7:00 PM	4/5/2011	12:00 PM	Kentucky, West Virginia	RFC		Severe Weather	UNK	52,920	Weather
	2011-04-04	9:00 PM	4/5/2011	11:30 PM	Alabama, Florida, Georgia, Mississippi	SERC		Severe Weather	674	303,434	Weather
	2011-04-05	2:00 AM	4/7/2011	11:00 PM	North Carolina, South Carolina	SERC		Severe Weather	1,200	256,000	Weather
	2011-04-06	10:50 AM	4/6/2011	10:50 AM	Felton, Delaware	RFC		Vandalism	0	0	Physical Attack
	2011-04-11	5:40 PM	4/11/2011	5:51 PM	Salt Lake City, Utah	WECC		Suspicious Activity	0	0	Physical Attack
	2011-04-16	2:16 PM	4/17/2011	4:30 PM	Central and Eastern North Carolina	SERC		Severe Weather	UNK	220,000	Weather
	2011-04-19	2:01 PM	4/19/2011	4:04 PM	Graham, Washington	WECC		Vandalism	0	0	Physical Attack
	2011-04-19	8:00 PM	4/19/2011	10:00 PM	Illinois	SERC		Severe Weather	UNK	80,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-04-19	10:44 PM	4/20/2011	2:00 AM	Memphis, Tennessee	SERC		Severe Weather	100	64,000	Weather
	2011-04-19	11:02 PM	4/21/2011	5:32 PM	Memphis, Tennessee	SERC		Severe Weather	300	105,000	Weather
	2011-04-19	11:13 PM	4/20/2011	7:14 PM	Osceola, Arkansas	SERC		Severe Weather	22	UNK	Weather
	2011-04-20	8:07 AM	4/20/2011	8:14 AM	Ruston, Louisiana	SERC		Equipment Malfunction	33	11,000	Equipment
	2011-04-20	2:00 AM	4/21/2011	12:00 PM	Indiana, Kentucky, Ohio	RFC		Severe Weather - High Winds	UNK	165,711	Weather
	2011-04-21	7:15 AM	4/21/2011	4:50 PM	Oquirrh Substation, Salt Lake City, Utah	WECC		Vandalism	0	0	Physical Attack
	2011-04-21	7:00 PM	4/29/2011	7:05 PM	Trenton, Michigan	RFC		Suspicious Activity	UNK	UNK	Physical Attack
	2011-04-22	9:00 PM	4/22/2011	11:00 PM	Metro St. Louis area, Missouri	SERC		Severe Weather	0	55,000	Weather
	2011-04-25	4:33 PM	4/25/2011	5:19 PM	Northeast Tennessee	SERC		Equipment Malfunction	140	UNK	Equipment
	2011-04-25	5:30 PM	4/27/2011	6:00 PM	Arkansas, Louisiana, Mississippi	SPP		Severe Weather	UNK	141,700	Weather
	2011-04-26	1:04 PM	4/26/2011	2:00 PM	Salt Lake City, Utah	WECC		Vandalism	0	0	Physical Attack
	2011-04-26	5:49 AM	4/27/2011	9:59 AM	Southern Louisiana	SPP		Severe Weather	120	UNK	Weather
	2011-04-26	9:51 AM	4/28/2011	9:51 AM	Alabama, Georgia, Mississippi, Tennessee	SERC		Severe Weather	UNK	55,000	Weather
	2011-04-26	6:14 PM	4/28/2011	5:00 PM	Eastern Arkansas	SPP		Severe Weather	50	13,000	Weather
	2011-04-27	8:00 AM	5/2/2011	4:03 PM	Alabama, Florida, Georgia, Mississippi	SERC		Severe Weather	1,422	426,640	Weather
	2011-04-27	10:00 AM	4/29/2011	4:29 PM	Alabama, Georgia, Mississippi, Tennessee	SERC		Severe Weather	UNK	612,000	Weather
	2011-04-27	10:00 PM	4/28/2011	10:00 AM	Ohio, Tennessee, Virginia	SERC		Severe Weather	0	69,000	Weather
	2011-04-28	4:09 PM	4/28/2011	4:10 PM	Phoenix, Arizona	WECC		Equipment Malfunction	960	UNK	Equipment
	2011-04-28	5:00 AM	4/30/2011	6:30 PM	Cleveland area, Ohio	RFC		Severe Weather	UNK	86,000	Weather
	2011-05-02	8:52 AM	5/2/2011	10:46 AM	N. Ogden Substation, Ogden, Utah	WECC		Vandalism	0	0	Physical Attack
	2011-05-02	2:00 PM	5/2/2011	2:00 PM	West River Substation, New Haven, Connecticut	NPCC		Suspected Physical Attack	0	0	Physical Attack
	2011-05-02	5:06 PM	5/2/2011	8:00 PM	Hawaii	N/A		Severe Weather	220	62,000	Weather
	2011-05-03	12:00 PM	5/5/2011	12:00 PM	St. Lawrence Power Dam, New York	NPCC		Suspected Physical Attack	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-05-04	12:20 PM	5/4/2011	3:40 PM	Michigan	RFC		Suspected Sabotage	0	0	Physical Attack
	2011-05-05	9:15 AM	5/5/2011	9:15 AM	New Hampshire	NPCC		Vandalism	0	0	Physical Attack
	2011-05-06	6:56 AM	5/6/2011	10:30 AM	Alderwood Substation, Portland, Oregon	WECC		Vandalism	0	0	Physical Attack
	2011-05-08	7:35 PM	5/8/2011	7:35 PM	New York	NPCC		Vandalism	UNK	0	Physical Attack
	2011-05-09	4:08 AM	5/9/2011	6:40 AM	Holtwood, Pennsylvania	RFC		Suspected Physical Attack	630	UNK	Physical Attack
	2011-05-09	1:11 PM	5/9/2011	1:11 PM	Milton, New Hampshire	NPCC		Vandalism	0	0	Physical Attack
	2011-05-10	3:25 AM	5/11/2011	2:10 PM	Upper Peninsula, Michigan	RFC		Generation Inadequacy; Load Shed; Electrical System Separation (Islanding)	585	78,213	Islanding
	2011-05-10	1:45 PM	5/10/2011	3:00 PM	New Hampshire	NPCC		Vandalism	0	0	Physical Attack
	2011-05-10	10:21 PM	5/11/2011	2:25 PM	Kentucky, West Virginia	RFC		Severe Weather	UNK	58,000	Weather
	2011-05-11	11:00 AM	5/11/2011	11:30 AM	North Chelsea Substation, New York	NPCC		Vandalism	0	0	Physical Attack
	2011-05-11	1:35 PM	5/11/2011	1:35 PM	Green River, Wyoming	WECC		Vandalism	0	0	Physical Attack
	2011-05-11	3:55 PM	5/12/2011	1:57 PM	Colbyville, Haines Road and Arrowhead Substations, Minnesota	MRO		Vandalism	0	0	Physical Attack
	2011-05-11	12:15 AM	5/11/2011	5:20 PM	Charlotte, North Carolina	SERC		Severe Weather	300	71,000	Weather
	2011-05-13	6:00 AM	5/13/2011	6:00 AM	Salt Lake, Utah	WECC		Vandalism	0	0	Physical Attack
	2011-05-21	5:00 PM	5/22/2011	6:34 PM	Dixie Valley Area, Nevada	WECC		Physical Attack	56	UNK	Physical Attack
	2011-05-22	5:09 PM	5/31/2011	12:01 PM	Joplin, Sarcoxie, and Wentworth, Missouri	SPP		Severe Weather	200	20,000	Weather
	2011-05-23	12:30 PM	5/25/2011	12:30 PM	St. Louis County, Missouri	SERC		Severe Weather	UNK	70,000	Weather
	2011-05-23	4:45 PM	5/25/2011	11:59 PM	Central, Indiana	RFC		Severe Weather	1,024	215,387	Weather
	2011-05-24	9:00 AM	5/25/2011	9:10 AM	Chicago, Illinois	RFC		Physical Attack	0	0	Physical Attack
	2011-05-24	4:35 PM	5/25/2011	12:40 PM	Eastern Virginia	SERC		Severe Weather	790	175,000	Weather
	2011-05-24	4:45 PM	5/26/2011	5:00 PM	Central Oklahoma	SPP		Severe Weather	UNK	54,000	Weather
	2011-05-25	10:14 PM	5/28/2011	11:00 AM	Central Indiana	RFC		Severe Weather	200	141,000	Weather
	2011-05-26	1:00 AM	5/26/2011	6:00 AM	Greenwood, Mississippi	SERC		Transmission Level Interruption	30	10,000	Transmission Interruption
	2011-05-26	6:30 PM	5/28/2011	4:44 AM	Southern Balancing Area, Georgia	SERC		Severe Weather	729	218,783	Weather
	2011-05-26	7:56 PM	5/27/2011	6:00 PM	Central Pennsylvania	RFC		Severe Weather	150	120,001	Weather
	2011-05-29	6:30 PM	5/31/2011	10:00 PM	Mid and Southern Lower Peninsula, Michigan	RFC		Severe Weather	250	113,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-06-02	11:45 PM	6/4/2011	4:00 PM	Greater Columbia, South Carolina	SERC		Severe Weather	0	50,465	Weather
	2011-06-04	1:17 AM	6/4/2011	3:25 AM	Midway, California	WECC		Vandalism	UNK	420	Physical Attack
	2011-06-05	8:02 PM	6/5/2011	8:55 PM	Melones, California	WECC		Electrical System Separation (Islanding)	10	5,314	Islanding
	2011-06-05	5:30 AM	6/6/2011	1:30 AM	Houston Metro-Area, Texas	TRE		Severe Thunderstorms	473	78,000	Weather
	2011-06-06	12:13 AM	6/6/2011	3:15 AM	El Paso County, Texas; Dona Ana County, New Mexico	SPP		Load Shed/ Automatic undervoltage relay action	450	162,000	Load Shed
	2011-06-07	2:00 PM	6/8/2011	6:00 AM	Ohio	RFC		Severe Weather	UNK	52,747	Weather
	2011-06-08	12:58 PM	6/8/2011	12:58 PM	Fredrickson Substation, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-06-09	2:15 PM	6/9/2011	2:15 PM	San Antonio Dam Area, Los Angeles County, California	WECC		Suspected Physical Attack	0	0	Physical Attack
	2011-06-09	4:30 AM	6/9/2011	12:00 PM	Illinois	RFC		Severe Thunderstorms	UNK	169,000	Weather
	2011-06-09	5:51 PM	6/10/2011	12:00 PM	Western, Massachusetts; Connecticut	NPCC		Severe Thunderstorms	0	100,000	Weather
	2011-06-12	7:00 PM	6/12/2011	8:30 PM	Virginia	RFC		Severe Thunderstorms	250	56,000	Weather
	2011-06-15	4:00 PM	6/16/2011	6:30 AM	Bingham County, Idaho	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-06-15	7:15 PM	6/16/2011	6:00 AM	Georgia	SERC		Severe Thunderstorms	563	169,000	Weather
	2011-06-15	7:17 PM	6/16/2011	1:45 AM	Piedmont, North Carolina	SERC		Severe Thunderstorms	300	70,135	Weather
	2011-06-18	4:45 PM	6/20/2011	11:59 PM	Eastern, Arkansas	SPP		Public Appeal to Reduce Electricity Usage	UNK	UNK	Public Appeal
	2011-06-18	3:30 PM	6/19/2011	3:42 PM	Northern, Georgia	SERC		Severe Thunderstorms	312	93,828	Weather
	2011-06-18	5:00 PM	6/18/2011	9:33 PM	North Carolina; South Carolina	SERC		Severe Thunderstorms	300	70,000	Weather
	2011-06-20	10:36 AM	6/20/2011	10:36 AM	Collins Substation, Washington	WECC		Vandalism	0	0	Physical Attack
	2011-06-21	6:30 PM	6/22/2011	7:00 AM	AEP Region	RFC		Severe Weather	UNK	56,000	Weather
	2011-06-21	9:45 PM	6/23/2011	2:00 AM	Illinois	RFC		Severe Thunderstorms	UNK	300,000	Weather
	2011-06-22	8:12 PM	6/22/2011	8:12 PM	Knoble Substation, Spanaway, Washington	WECC		Vandalism	0	0	Physical Attack
	2011-06-22	9:46 AM	6/22/2011	9:46 AM	Knoxville, Tennessee	SERC		Severe Weather	UNK	106,300	Weather
	2011-06-22	7:00 PM	6/23/2011	1:00 AM	Alabama; Georgia	SERC		Severe Thunderstorms	316	75,101	Weather
	2011-06-23	8:10 AM	6/23/2011	9:00 AM	Highgate, Vermont	NPCC		Vandalism	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-06-24	6:30 PM	6/25/2011	1:30 AM	North/North Central Alabama; Georgia	SERC		Severe Thunderstorms	340	102,275	Weather
	2011-06-26	4:46 PM	6/27/2011	7:59 AM	Southwest Kansas	SPP		Public Appeal to Reduce Electricity Usage	UNK	UNK	Public Appeal
	2011-06-26	6:00 PM	6/27/2011	1:00 PM	Alabama; Georgia	SERC		Severe Thunderstorms	300	90,160	Weather
	2011-06-27	6:55 PM	6/27/2011	6:55 PM	Olympic Pipeline Substation, Washington	WECC		Vandalism	UNK	UNK	Physical Attack
	2011-06-27	3:00 PM	6/27/2011	7:00 PM	Texas	TRE		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-06-27	12:00 AM	6/29/2011	1:00 AM	Illinois; Missouri	SERC		Severe Thunderstorms	UNK	80,000	Weather
	2011-06-29	11:30 AM	6/29/2011	6:04 PM	Panhandle and Muleshoe, Texas	SPP		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-06-30	2:11 PM	6/30/2011	11:25 PM	Phoenix, Arizona	WECC		Major System Interruption/Load Shed	5,299	160,000	Load Shed
	2011-06-30	10:31 PM	6/30/2011	10:31 PM	Olympic Pipeline Substation, Washington	WECC		Vandalism	0	0	Physical Attack
	2011-06-30	10:30 PM	7/1/2011	5:00 PM	Illinois	RFC		Severe Weather	UNK	121,000	Weather
	2011-07-01	8:00 AM	7/1/2011	8:01 AM	CONVEX Local Control Center, Connecticut	NPCC		Vandalism	0	0	Physical Attack
	2011-07-01	4:38 PM	7/1/2011	10:38 PM	Greene County Ohio	RFC		Vandalism	N/A	0	Physical Attack
	2011-07-01	5:00 PM	7/3/2011	8:00 PM	Southwest and South Central Minnesota	MRO		Severe Weather	UNK	70,000	Weather
	2011-07-02	8:15 PM	7/6/2011	10:00 PM	South East, Lower Peninsula, Michigan	RFC		Severe Weather	UNK	182,000	Weather
	2011-07-04	6:00 PM	7/4/2011	9:00 PM	Virginia	SERC		Severe Weather	150	51,580	Weather
	2011-07-05	10:40 AM	7/5/2011	11:37 AM	West Valley Substation Utah	WECC		Vandalism	0	0	Physical Attack
	2011-07-06	9:51 AM	7/6/2011	9:52 AM	Vermont	NPCC		Vandalism	N/A	N/A	Physical Attack
	2011-07-08	10:00 AM	7/11/2011	9:00 AM	PJM Corporate Office, Pennsylvania	RFC		Suspected Cyber Attack	UNK	UNK	Cyber Attack
	2011-07-08	10:00 AM	7/8/2011	10:00 AM	Saginaw, Minnesota	MRO		Vandalism	0	0	Physical Attack
	2011-07-11	1:13 PM	7/11/2011	1:13 PM	Southwest Ohio	RFC		Vandalism	0	0	Physical Attack
	2011-07-11	1:30 PM	7/11/2011	1:30 PM	Maine	NPCC		Vandalism	N/A	0	Physical Attack
	2011-07-11	9:00 AM	7/11/2011	9:00 AM	Illinois	RFC		Severe Weather	UNK	500,000	Weather
	2011-07-11	9:00 AM	7/11/2011	10:25 AM	Michigan	RFC		Severe Weather	254	103,000	Weather
	2011-07-11	11:15 AM	7/12/2011	8:15 AM	Western and Southern Lower Peninsula Michigan	RFC		Severe Weather	UNK	85,000	Weather
	2011-07-11	2:27 PM	7/12/2011	3:50 PM	Indiana, Michigan, Ohio	RFC		Severe Weather	UNK	120,000	Weather
	2011-07-12	12:00 PM	7/12/2011	12:00 PM	Maine	NPCC		Vandalism	N/A	0	Physical Attack
	2011-07-12	8:20 PM	7/12/2011	9:30 PM	California	WECC		Suspected Physical Attack	UNK	UNK	Physical Attack
	2011-07-13	5:19 PM	7/13/2011	10:03 PM	Pueblo, Colorado	WECC		Load Shed	580	N/A	Load Shed

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-07-14	11:00 AM	7/14/2011	7:00 PM	Texas	TRE		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-07-18	5:00 PM	7/24/2011	1:30 PM	Southeast Michigan	RFC		Severe Weather	N/A	197,166	Weather
	2011-07-19	11:45 AM	7/19/2011	3:00 PM	Maine	NPCC		Vandalism	N/A	N/A	Physical Attack
	2011-07-20	9:10 AM	7/20/2011	4:30 PM	Frederickson Substation, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-07-21	12:32 PM	7/22/2011	6:30 AM	Lower Peninsula, Michigan	RFC		Public Appeal to Reduce Electricity Usage	8,881	N/A	Public Appeal
	2011-07-21	1:00 PM	7/21/2011	3:00 PM	Springfield, Illinois	SERC		Public Appeal to Reduce Electricity Usage	N/A	N/A	Public Appeal
	2011-07-22	11:34 AM	7/22/2011	5:26 PM	Ohio	RFC		Load Shed	206	23,000	Load Shed
	2011-07-22	11:00 AM	7/22/2011	6:00 PM	Upstate, New York	NPCC		Public Appeal to Reduce Electricity Usage	N/A	N/A	Public Appeal
	2011-07-23	2:30 AM	7/24/2011	9:00 AM	Illinois	RFC		Severe Weather	UNK	169,000	Weather
	2011-07-24	2:34 PM	7/24/2011	3:47 PM	Southern, New Hampshire	NPCC		Vandalism	0	0	Physical Attack
	2011-07-26	12:01 PM	7/26/2011	12:01 PM	Backup Control Center, Oklahoma	SPP		Vandalism	0	0	Physical Attack
	2011-07-27	12:07 PM	7/27/2011	12:08 PM	Fife, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-07-28	7:26 AM	7/29/2011	7:26 AM	Daviess County, Kentucky	SERC		Fuel Supply Deficiency (Coal)	N/A	N/A	Fuel Supply Deficiency
	2011-07-28	1:32 PM	7/28/2011	1:32 PM	Indiana	RFC		Vandalism	N/A	N/A	Physical Attack
	2011-07-28	7:25 PM	7/28/2011	7:25 PM	Spanaway, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-07-28	12:14 AM	7/29/2011	12:00 PM	Entire ComEd Territory, Indiana	RFC		Severe Weather	UNK	201,000	Weather
	2011-07-29	11:46 AM	7/29/2011	5:00 PM	Fredrickson, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-07-29	8:45 PM	8/1/2011	4:24 AM	Central New Jersey	RFC		Severe Weather	N/A	67,900	Weather
	2011-08-01	2:18 PM	8/1/2011	2:18 PM	Jefferson, Oregon	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-08-01	3:00 PM	8/5/2011	7:00 PM	Texas	TRE		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-08-02	10:15 AM	8/3/2011	9:16 AM	Oklahoma	SPP		Public Appeal to Reduce Electricity Usage	N/A	N/A	Public Appeal
	2011-08-02	9:30 PM	8/3/2011	7:00 PM	Northeast, Illinois	RFC		Severe Weather	UNK	71,500	Weather
	2011-08-03	10:00 AM	8/19/2011	10:00 AM	Western New York	NPCC		Fuel Supply Deficiency (Coal)	675	UNK	Fuel Supply Deficiency
	2011-08-03	4:29 PM	8/3/2011	11:40 PM	Northeast Oklahoma	SPP		Public Appeal to Reduce Electricity Usage	300	N/A	Public Appeal
	2011-08-03	4:30 PM	8/3/2011	9:00 PM	Central Arkansas	SPP		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-08-04	10:30 AM	8/4/2011	4:00 PM	Arkansas, Oklahoma, Texas	SPP		Public Appeal to Reduce Electricity Usage	N/A	N/A	Public Appeal
	2011-08-08	7:36 PM	8/9/2011	12:00 PM	Oklahoma	SPP		Electrical System Separation (Islanding)	92	14,500	Islanding
	2011-08-08	9:30 AM	8/8/2011	9:30 AM	Greene County, Ohio	RFC		Suspected Physical Attack	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-08-08	9:35 AM	8/8/2011	4:00 PM	Collins Substation, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-08-08	8:58 PM	8/10/2011	4:30 PM	Northern and Central Oklahoma	SPP		Severe Weather	N/A	54,000	Weather
	2011-08-09	10:26 AM	8/9/2011	5:00 PM	Polk Substation, Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-08-13	4:41 PM	8/14/2011	7:00 PM	Kentucky	SERC		Severe Weather	UNK	181,700	Weather
	2011-08-15	2:05 AM	8/15/2011	3:40 AM	Utah	WECC		Vandalism	0	0	Physical Attack
	2011-08-18	9:51 AM	8/18/2011	4:00 PM	Collins Substation, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-08-20	5:42 PM	8/23/2011	8:00 PM	Southeastern Michigan	RFC		Severe Weather	254	65,000	Weather
	2011-08-21	10:45 PM	8/23/2011	10:45 PM	Puerto Rico	N/A		Severe Weather	2,200	931,000	Weather
	2011-08-22	10:05 AM	8/22/2011	4:00 PM	Collins Substation, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-08-23	1:51 PM	8/23/2011	1:51 PM	Virginia	RFC		Earthquake	0	0	Natural Disaster
	2011-08-23	10:30 AM	8/23/2011	4:54 PM	Southeastern New Mexico, Texas Panhandle	SPP		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-08-23	3:43 PM	8/23/2011	7:00 PM	Texas	TRE		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-08-24	1:20 PM	8/29/2011	7:00 PM	Texas	TRE		Public Appeal to Reduce Electricity Usage	0	0	Public Appeal
	2011-08-24	7:45 AM	8/25/2011	6:00 AM	Houston area, Texas	TRE		Severe Weather	485	79,000	Weather
	2011-08-24	2:51 PM	8/24/2011	10:00 PM	Arkansas, Louisiana, Texas	SPP		Severe Weather	N/A	53,064	Weather
	2011-08-25	12:01 AM	8/25/2011	12:01 AM	Maine	NPCC		Suspected Physical Attack	0	0	Cyber Attack
	2011-08-25	12:30 AM	8/28/2011	8:00 PM	Cleveland area, Ohio	RFC		Severe Weather	N/A	107,833	Weather
	2011-08-26	12:30 AM	8/28/2011	12:30 AM	Pennsylvania	RFC		Severe Weather	N/A	200,717	Weather
	2011-08-27	2:00 AM	8/27/2011	5:15 AM	Wilson County North Carolina	SERC		Distribution System Interruption	2	1,200	Distribution Interruption
	2011-08-27	2:57 AM	8/29/2011	11:30 PM	Eastern North Carolina	SERC		Severe Weather	UNK	285,465	Weather
	2011-08-27	10:33 AM	8/29/2011	2:00 PM	North Carolina; Virginia	SERC		Severe Weather	UNK	1,000,000	Weather
	2011-08-27	1:00 PM	8/29/2011	1:00 PM	Delaware; Maryland	RFC		Severe Weather	N/A	165,000	Weather
	2011-08-27	7:00 PM	8/29/2011	1:31 PM	Eastern North Carolina	SERC		Severe Weather	200	136,000	Weather
	2011-08-27	8:30 PM	9/4/2011	11:30 PM	Maryland	RFC		Severe Weather	1,114	760,113	Weather
	2011-08-27	10:00 PM	8/29/2011	4:00 PM	Southern New Jersey	RFC		Severe Weather	320	140,000	Weather
	2011-08-27	10:00 PM	8/29/2011	10:00 PM	Pennsylvania	RFC		Severe Weather	N/A	264,000	Weather
	2011-08-27	11:00 PM	8/29/2011	8:00 AM	Maryland	RFC		Severe Weather	UNK	108,000	Weather
	2011-08-27	11:05 PM	8/29/2011	3:30 PM	District of Columbia; Maryland	RFC		Severe Weather	N/A	220,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-08-28	8:55 PM	8/28/2011	11:39 PM	Calapooya Substation, Oregon	WECC		Suspected Physical Attack	0	0	Physical Attack
	2011-08-28	12:01 AM	8/30/2011	12:01 AM	Mid-Hudson, New York	NPCC		Severe Weather	N/A	180,000	Weather
	2011-08-28	12:23 AM	8/30/2011	12:23 AM	New Jersey	RFC		Severe Weather	500	665,000	Weather
	2011-08-28	12:30 AM	8/30/2011	12:30 AM	Northern and Central New Jersey	RFC		Severe Weather	N/A	650,000	Weather
	2011-08-28	2:58 AM	8/30/2011	2:58 AM	Eastern and Northeastern Pennsylvania	RFC		Severe Weather	110	284,000	Weather
	2011-08-28	5:00 AM	8/30/2011	5:00 AM	Long Island, New York	NPCC		Severe Weather	UNK	152,261	Weather
	2011-08-28	5:01 AM	9/3/2011	5:01 AM	Borough's and Westshester County New York	NPCC		Severe Weather	N/A	50000	Weather
	2011-08-28	7:00 AM	9/3/2011	12:01 AM	New York	NPCC		Severe Weather	UNK	99,700	Weather
	2011-08-28	7:40 AM	8/29/2011	7:40 AM	Southwest Connecticut	NPCC		Severe Weather	N/A	158,000	Weather
	2011-08-28	9:42 AM	8/30/2011	12:01 AM	Eastern New York	NPCC		Severe Weather	N/A	100,000	Weather
	2011-08-28	12:10 PM	8/28/2011	12:11 PM	Eastern Massachusetts	NPCC		Severe Weather	N/A	50,000	Weather
	2011-08-28	12:30 PM	8/28/2011	12:31 PM	New York	NPCC		Severe Weather	N/A	116,000	Weather
	2011-08-31	12:52 PM	8/31/2011	12:52 PM	Southwest Ohio	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-09-01	8:13 AM	9/1/2011	4:00 PM	Graham Substaion, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-09-03	2:00 PM	9/8/2011	6:00 PM	Southeast Lower Peninsula, Michigan	RFC		Severe Weather	UNK	105,000	Weather
	2011-09-05	4:30 PM	9/7/2011	3:45 PM	Alabama; Georgia	SERC		Severe Weather	177	53,295	Weather
	2011-09-07	12:08 AM	9/7/2011	10:50 AM	Western Connecticut; New York	NPCC		Actual Physical Attack	0	0	Physical Attack
	2011-09-08	3:28 PM	9/10/2011	3:30 PM	Arizona; California	WECC		Transmission/Distribution Interruption; Load Shed; Generation Inadequacy	7,000	2,000,000	Generation Interruption
	2011-09-08	7:53 PM	9/9/2011	4:00 PM	Collins Substation, Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-09-12	9:15 AM	9/12/2011	3:30 PM	English Creek, New Jersey	RFC		Vandalism	0	0	Physical Attack
	2011-09-13	11:43 AM	9/14/2011	4:00 PM	Lacamas Substation, Roy, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-09-13	2:03 PM	9/13/2011	6:21 PM	Saranac, New York	NPCC		Vandalism	N/A	0	Physical Attack
	2011-09-14	9:00 AM	9/14/2011	2:00 PM	Salt Lake County, Utah	WECC		Vandalism	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-09-20	12:55 PM	9/20/2011	5:00 PM	Lacamas Substaion, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-09-21	2:37 PM	9/21/2011	3:47 PM	Puerto Rico	N/A		Generation Inadequacy; Load Shed	600	319,616	Generation Interruption
	2011-09-21	10:30 AM	9/21/2011	10:30 AM	Hockessin, Delaware	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-09-22	2:50 PM	9/22/2011	2:51 PM	Montgomery County, Ohio	RFC		Vandalism	N/A	0	Physical Attack
	2011-09-23	9:04 AM	9/23/2011	9:04 AM	North Haven, Connecticut	NPCC		Vandalism	0	0	Physical Attack
	2011-09-24	4:17 PM	9/25/2011	4:00 PM	Collins Substation, Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-09-26	10:15 AM	9/26/2011	10:15 AM	McKee City, New Jersey	RFC		Vandalism	0	0	Physical Attack
	2011-09-28	9:30 AM	9/28/2011	1:00 PM	Watertown, Connecticut	NPCC		Vandalism	N/A	N/A	Physical Attack
	2011-09-28	2:59 PM	9/28/2011	2:59 PM	Dorothy, New Jersey	RFC		Vandalism	0	0	Physical Attack
	2011-09-28	4:41 PM	9/28/2011	4:41 PM	Bethany Beach, Delaware	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-09-29	6:44 PM	9/30/2011	4:00 PM	Collins Substation, Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2011-09-29	5:00 AM	9/30/2011	6:00 AM	Houston metro area, Texas	TRE		Severe Weather	N/A	65000	Weather
	2011-09-30	8:22 AM	9/30/2011	8:22 AM	Wilmington, Delaware	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-10-06	11:07 AM	10/6/2011	11:07 AM	Oquirrh Substation, Utah	WECC		Vandalism	0	0	Physical Attack
	2011-10-07	8:04 AM	10/7/2011	4:00 PM	Olympic Pipeline, Spanaway, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-10-14	2:20 PM	10/14/2011	2:20 PM	English Creek, New Jersey	RFC		Vandalism	0	0	Physical Attack
	2011-10-17	3:34 AM	10/17/2011	10:42 AM	Seat Pleasant, Maryland	RFC		Vandalism	0	0	Physical Attack
	2011-10-17	3:44 PM	10/17/2011	3:44 PM	Southwest Ohio	RFC		Vandalism	7	2,000	Physical Attack
	2011-10-18	3:45 AM	10/18/2011	5:25 AM	Holmesburg Substation, Philadelphia, Pennsylvania	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-10-20	7:15 AM	10/20/2011	7:15 AM	McKee, New Jersey	RFC		Vandalism	0	0	Physical Attack
	2011-10-24	11:37 PM	10/26/2011	11:00 PM	Holmesburg Substation, Philadelphia, Pennsylvania	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-10-26	5:00 AM	10/27/2011	3:00 PM	Denver; Ft. Collins, Colorado	WECC		Severe Weather	UNK	204,000	Weather
	2011-10-27	1:00 AM	10/27/2011	2:36 AM	Munster, Indiana	RFC		Vandalism	N/A	N/A	Physical Attack
	2011-10-29	8:59 AM	11/7/2011	7:58 PM	Pennsylvania	RFC		Severe Weather	UNK	312,359	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-10-29	8:59 AM	11/7/2011	3:00 PM	Pennsylvania	RFC		Severe Weather	UNK	50,000	Weather
	2011-10-29	9:59 AM	11/7/2011	1:00 PM	Northwest and Central New Jersey	RFC		Severe Weather	UNK	379,000	Weather
	2011-10-29	11:18 AM	11/4/2011	12:00 AM	Southeast New York	NPCC		Severe Weather	UNK	161,151	Weather
	2011-10-29	12:57 PM	11/3/2011	11:00 PM	Harrisburg, Lehigh Valley, Lancaster Region Pennsylvania	RFC		Severe Weather	UNK	146,721	Weather
	2011-10-29	2:00 PM	10/31/2011	14:00	Southeast Pennsylvania	RFC		Severe Weather	UNK	109,335	Weather
	2011-10-29	2:30 PM	11/6/2011	12:00 PM	New Jersey	RFC		Severe Weather	125	197,000	Weather
	2011-10-29	3:00 PM	11/2/2011	8:15 AM	Mid-Hudson Valley Region, New York	NPCC		Severe Weather	N/A	145,000	Weather
	2011-10-29	4:14 PM	11/7/2011	4:00 PM	Connecticut; Maine; Massachusetts; New Hampshire; Rhode Island	NPCC		Severe Weather	UNK	1,418,100	Weather
	2011-10-29	4:16 PM	11/2/2011	9:30 PM	New York City area	NPCC		Severe Weather	UNK	50,000	Weather
	2011-10-29	8:00 PM	10/31/2011	8:00 PM	New Jersey; New York	NPCC, RFC		Severe Weather	N/A	74,000	Weather
	2011-11-04	10:46 AM	11/4/2011	10:46 AM	Sweetwater County, Wyoming	WECC		Vandalism	0	0	Physical Attack
	2011-11-13	11:30 AM	11/13/2011	12:00 PM	Cate Road, Deerfield, New Hampshire	NPCC		Vandalism	0	0	Physical Attack
	2011-11-14	2:24 PM	11/14/2011	2:24 PM	McKee, New Jersey	RFC		Vandalism	0	0	Physical Attack
	2011-11-22	11:16 PM	11/22/2011	11:16 PM	Indiana	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-11-30	10:00 AM	11/30/2011	11:00 AM	Orchard Substation, Washington	WECC		Vandalism	0	0	Physical Attack
	2011-11-30	4:56 PM	12/2/2011	10:00 AM	City of Los Angeles, California	WECC		Severe Weather	UNK	150,000	Weather
	2011-12-01	12:45 AM	12/7/2011	9:00 PM	Southern California	WECC		Severe Weather	UNK	91,690	Weather
	2011-12-01	3:29 AM	12/2/2011	1:05 PM	Northern California	WECC		Severe Weather	300	100,000	Weather
	2011-12-01	10:00 AM	12/2/2011	1:11 PM	Wasatch Front Area Utah	WECC		Severe Weather	UNK	60,000	Weather
	2011-12-02	4:15 PM	12/2/2011	8:30 PM	Rusk County Texas	TRE		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-12-05	2:00 PM	12/6/2011	5:00 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-12-06	5:38 PM	12/7/2011	11:04 AM	Montague, Michigan	RFC		Suspected Physical Attack	0	0	Physical Attack
	2011-12-06	8:00 AM	12/6/2011	8:00 PM	Bismarck-Mandan, North Dakota	MRO		Public Appeal to Reduce Electricity Usage	155	34,500	Public Appeal

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2011-12-07	7:29 PM	12/7/2011	10:57 PM	Central Virginia	SERC		Severe Weather	240	60,000	Weather
	2011-12-08	8:45 AM	12/8/2011	4:30 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-12-13	3:19 AM	12/14/2011	3:19 AM	Clinton County Ohio	RFC		Suspected Physical Attack	N/A	0	Physical Attack
	2011-12-19	8:48 AM	12/19/2011	4:00 PM	Croft Substation, Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-12-20	7:45 AM	12/20/2011	8:45 AM	Sweet Home, Oregon	WECC		Suspected Physical Attack	12	2,500	Physical Attack
	2011-12-20	9:30 AM	12/20/2011	9:31 AM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2011-12-21	10:30 AM	12/21/2011	10:30 AM	Boise, Idaho	WECC		Suspected Cyber Attack	0	0	Cyber Attack
	2011-12-31	9:26 PM	12/31/2011	9:26 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-01-04	12:14 PM	1/4/2012	12:14 PM	Tacoma, Washington	WECC		Suspected physical attack	N/A	N/A	Physical Attack
	2012-01-05	10:28 AM	1/5/2012	12:25 PM	Creek County, Oklahoma	SPP		Suspected physical attack	N/A	N/A	Physical Attack
	2012-01-05	10:35 AM	1/5/2012	12:25 PM	CSWS/AEP West territory, Oklahoma	SPP		Sabotage	0	0	Physical Attack
	2012-01-09	1:36 PM	1/11/2012	1:05 AM	Louisiana	SERC		Load Shed	150	1	Load Shed
	2012-01-09	2:30 PM	1/9/2012	3:30 PM	Watertown, Connecticut	NPCC		Vandalism	N/A	N/A	Physical Attack
	2012-01-10	9:30 PM	1/10/2012	9:30 PM	Rusk County, Texas	TRE		Vandalism	N/A	N/A	Physical Attack
	2012-01-11	7:19 AM	1/11/2012	9:07 AM	Nevada	WECC		Suspected Physical Attack	0	0	Physical Attack
	2012-01-12	8:26 AM	1/12/2012	8:26 AM	Newark, Delaware	RFC		Physical Attack	0	0	Physical Attack
	2012-01-13	9:20 AM	1/13/2012	9:20 AM	Newark, Delaware	RFC		Physical Attack	0	0	Physical Attack
	2012-01-15	9:35 AM	1/15/2012	9:35 AM	Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2012-01-17	10:31 AM	1/17/2012	5:21 PM	Austin, Texas	TRE		Suspected Cyber Attack	N/A	0	Cyber Attack
	2012-01-19	7:00 AM	1/20/2012	3:00 PM	King, Pierce and Thurston Counties, Washington	WECC		Severe Weather - Winter Storm	1,600	426,000	Weather
	2012-01-24	11:22 AM	1/24/2012	11:22 AM	Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2012-01-27	9:40 AM	1/27/2012	9:40 AM	Frederickson Substation, Spanaway, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2012-01-29	12:45 PM	1/29/2012	12:45 PM	Roosevelt Substation, Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2012-02-11	8:47 AM	2/11/2012	10:30 AM	Lamar, Colorado	WECC		Suspected Physical Attack	0	0	Physical Attack
	2012-02-11	8:55 AM	2/11/2012	8:55 AM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-02-13	7:02 AM	2/13/2012	4:25 PM	Asheville, North Carolina	SERC		Suspected Physical Attack	N/A	N/A	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2012-02-14	7:20 PM	2/15/2012	4:00 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-02-15	5:33 AM	2/15/2012	5:30 PM	Port Orchard, Washington	WECC		Suspected Physical Attack	0	0	Physical Attack
	2012-02-17	3:00 AM	2/17/2012	11:33 AM	Little Rock, Arkansas	SERC		Suspected Cyber Attack	UNK	UNK	Cyber Attack
	2012-02-19	5:00 PM	2/21/2012	7:33 AM	Kentucky, Virginia, West Virginia	SERC		Severe Weather - Winter Storm	UNK	90,000	Weather
	2012-02-23	5:45 AM	2/23/2012	3:02 PM	South East College Station, Texas	TRE		Suspected Physical Attack	0	0	Physical Attack
	2012-02-23	11:12 PM	2/24/2012	1:00 AM	Londonderry, New Hampshire	NPCC		Suspected Physical Attack	0	0	Physical Attack
	2012-02-24	11:24 AM	2/24/2012	11:49 AM	Spanaway, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-02-28	2:59 AM	2/28/2012	6:12 AM	Sacramento, California	WECC		Electrical System Separation (Islanding)	1	1	Islanding
	2012-02-28	7:00 AM	2/28/2012	7:00 AM	Coos County Oregon	WECC		Suspected Physical Attack	UNK	UNK	Physical Attack
	2012-03-02	1:45 PM	3/2/2012	3:30 PM	Piggott, Arkansas	SERC		Operational Failure/Equipment Malfunction	N/A	N/A	Equipment
	2012-03-02	12:37 PM	3/5/2012	12:01 PM	Northern Alabama; Southeast Tennessee	SERC		Severe Weather - Tornadoes	500	UNK	Weather
	2012-03-02	9:00 PM	3/5/2012	4:30 PM	Southeastern, Michigan	RFC		Severe Weather - Winter Storm	371	130,000	Weather
	2012-03-02	9:00 PM	3/4/2012	5:30 PM	Lower Peninsula, Michigan	RFC		Severe Weather - Winter Storm	50	140,000	Weather
	2012-03-04	1:27 AM	3/4/2012	6:58 AM	Prince Georges County, Maryland	RFC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-03-04	1:38 PM	3/5/2012	11:00 AM	Texas	SERC		Suspected Physical Attack	UNK	UNK	Physical Attack
	2012-03-16	4:00 PM	3/16/2012	4:00 PM	New Castle, Delaware	RFC		Suspected Physical Attack	0	0	Physical Attack
	2012-03-20	8:00 AM	3/20/2012	1:00 PM	Houston, Texas	TRE		Severe Weather - Thunderstorms	N/A	96,000	Weather
	2012-03-23	7:34 PM	3/23/2012	7:34 PM	Newark, Delaware	RFC		Suspected Physical Attack	0	0	Physical Attack
	2012-03-26	1:24 PM	3/26/2012	1:24 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-03-28	10:17 AM	3/28/2012	10:17 AM	Graham, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-03-29	12:01 PM	3/29/2012	12:02 PM	Lansing, Michigan	RFC		Electrical System Separation (Islanding)	UNK	0	Islanding
	2012-03-30	11:10 AM	3/30/2012	11:30 AM	Vermont	NPCC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-04-01	8:27 PM	4/3/2012	8:28 AM	Council Bluffs, Iowa	MRO		Vandalism	0	0	Physical Attack
	2012-04-03	11:10 AM	4/3/2012	11:25 AM	West Rutland, Vermont	NPCC		Vandalism	0	0	Physical Attack
	2012-04-03	3:33 PM	4/3/2012	8:25 PM	Seattle, Washington	WECC		Physical Attack	0	0	Physical Attack
	2012-04-04	3:32 PM	4/6/2012	3:30 PM	WAPA-SNR Regional Office, California	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2012-04-07	9:31 AM	4/7/2012	9:32 AM	Newark, Delaware	RFC		Physical Attack	0	0	Physical Attack
	2012-04-07	12:25 PM	4/7/2012	12:26 PM	Newark, Delaware	RFC		Physical Attack	0	0	Physical Attack
	2012-04-07	2:35 PM	4/7/2012	2:36 PM	Newark, Delaware	RFC		Physical Attack	0	0	Physical Attack
	2012-04-11	9:00 AM	4/11/2012	9:00 AM	North Attleboro, Massachusetts	NPCC		Vandalism	0	0	Physical Attack
	2012-04-12	8:08 AM	4/12/2012	4:30 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-04-15	7:38 PM	4/15/2012	9:26 PM	Georgia	SERC		Suspected Physical Attack	UNK	UNK	Physical Attack
	2012-04-16	3:46 PM	4/19/2012	2:00 AM	Southeast, Michigan	RFC		Severe Weather - High Winds	218	111,393	Weather
	2012-04-17	6:11 AM	4/17/2012	5:48 PM	San Diego County, California	WECC		Suspected Physical Attack	0	0	Physical Attack
	2012-04-19	7:53 AM	4/19/2012	4:00 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-04-20	2:27 PM	4/21/2012	4:27 AM	Metropolitan Houston, Texas	TRE		Severe Weather - Thunderstorms	N/A	120,377	Weather
	2012-04-21	3:02 PM	4/21/2012	8:09 PM	East Bridgewater, Massachusetts	NPCC		Physical Attack	N/A	N/A	Physical Attack
	2012-04-21	8:55 PM	4/23/2012	4:30 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-04-23	8:11 AM	4/23/2012	12:47 PM	Northwest Indiana	RFC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-04-23	11:56 AM	4/23/2012	3:35 PM	Snohomish County, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-05-07	12:50 PM	5/7/2012	2:00 PM	Williston, Vermont	NPCC		Vandalism	0	0	Physical Attack
	2012-05-07	5:45 PM	5/7/2012	6:06 PM	Eastern Ohio	RFC		Load Shed/Severe Weather - Lightning Storm	420	1	Weather
	2012-05-11	11:05 AM	5/11/2012	11:20 AM	Lakewood, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2012-05-24	3:20 PM	5/25/2012	5:29 PM	Tyngsborough, Massachusetts	NPCC		Physical Attack	UNK	UNK	Physical Attack
	2012-05-29	6:30 PM	5/29/2012	7:40 PM	Alder Dam, Pierce County, Washington	WECC		Physical Attack	N/A	N/A	Weather
	2012-05-29	8:35 PM	5/31/2012	10:00 AM	Oklahoma City Metro Area, Oklahoma	SPP		Severe Weather - Thunderstorms	UNK	112,000	Weather
	2012-05-31	11:45 PM	6/1/2012	4:30 AM	Columbus, Ohio	RFC		Physical Attack	0	0	Physical Attack
	2012-06-02	7:30 AM	6/2/2012	11:35 AM	San Francisco, California	WECC		Vandalism	N/A	N/A	Physical Attack
	2012-06-06	8:00 AM	6/6/2012	8:00 AM	Delhi, New York	NPCC		Vandalism	N/A	N/A	Physical Attack
	2012-06-06	12:37 PM	6/6/2012	12:37 PM	Columbia Heights, NW, Washington DC	RFC		Vandalism	0	0	Physical Attack
	2012-06-08	5:20 PM	6/8/2012	5:25 PM	Denver Metro Area, Colorado	WECC		Load Shed	120	30,379	Load Shed

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2012-06-11	7:50 PM	6/12/2012	3:00 PM	North/Central Alabama; North/Central Georgia	SERC		Severe Weather - Thunderstorms	368	110,591	Weather
	2012-06-12	3:57 PM	6/14/2012	4:57 AM	Houston, Texas	TRE		Severe Weather - Thunderstorms	920	175,000	Weather
	2012-06-13	4:55 PM	6/13/2012	10:09 PM	San Juan County, New Mexico	WECC		Vandalism	0	0	Physical Attack
	2012-06-19	5:30 AM	6/21/2012	5:30 AM	CAISO Territory California	WECC		Fuel Supply Deficiency (Water)	UNK	UNK	Fuel Supply Deficiency
	2012-06-19	4:30 AM	6/20/2012	11:00 PM	Minneapolis/St. Paul, Minnesota	MRO		Severe Weather - Thunderstorms	UNK	68,200	Weather
	2012-06-23	6:57 PM	6/23/2012	7:28 PM	North Shore, Massachusetts	NPCC		Load Shed	51	29,250	Load Shed
	2012-06-25	4:04 PM	6/26/2012	1:45 PM	Central Virginia	SERC		Severe Weather - Wind & Rain	600	190,000	Weather
	2012-06-29	12:10 PM	6/29/2012	5:02 PM	Puerto Rico	N/A		Equipment Trip & Failure	1,800	900,000	Equipment
	2012-06-29	10:45 AM	6/29/2012	10:45 AM	New Castle, Delaware	RFC		Physical Attack	0	0	Physical Attack
	2012-06-29	4:00 PM	6/29/2012	9:00 PM	Eastern, Arkansas	SERC		Public Appeal to Reduce Electricity Usage	45	7,935	Public Appeal
	2012-06-29	2:10 PM	7/4/2012	6:00 PM	Dayton, Ohio	RFC		Severe Weather - Thunderstorms	500	175,000	Weather
	2012-06-29	4:00 PM	7/2/2012	4:00 PM	Indiana; Michigan; Ohio; West Virginia	RFC		Severe Weather - Thunderstorms	UNK	1,355,919	Weather
	2012-06-29	5:15 PM	7/2/2012	11:59 PM	Eastern Indiana; Northern Kentucky; Greater Cincinnati area Ohio	RFC		Severe Weather - Thunderstorms	2,946	4,645,572	Weather
	2012-06-29	6:24 PM	7/6/2012	10:00 AM	West Virginia	RFC		Severe Weather - Thunderstorms	700	265,000	Weather
	2012-06-29	7:00 PM	7/7/2012	7:43 PM	Maryland; West Virginia	RFC		Severe Weather - Thunderstorms	UNK	145,000	Weather
	2012-06-29	10:15 PM	7/5/2012	12:52 PM	Montgomery and Prince Georges Counties, Maryland; District of Columbia	RFC		Severe Weather - Thunderstorms	3,000	425,000	Weather
	2012-06-29	10:29 PM	7/4/2012	3:36 PM	Virginia	SERC		Severe Weather - Thunderstorms	5,000	880,000	Weather
	2012-06-29	10:43 PM	7/5/2012	11:50 AM	Greater Baltimore area, Maryland	RFC		Severe Weather - Thunderstorms	1,465	600,000	Weather
	2012-06-29	11:30 PM	6/30/2012	2:00 AM	Northeast Illinois	RFC		Severe Weather - Thunderstorms	UNK	109,000	Weather
	2012-06-30	3:00 PM	7/2/2012	12:00 PM	Northeast Tennessee	SERC		Public Appeal to Reduce Electricity Usage	UNK	UNK	Public Appeal
	2012-06-30	1:00 AM	7/3/2012	1:00 AM	Delaware; Maryland	RFC		Severe Weather - Thunderstorms	0	86,390	Weather
	2012-06-30	1:15 AM	7/7/2012	5:33 PM	Atlantic City Electric Service Territory New Jersey	RFC		Severe Weather - Thunderstorms	UNK	205,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2012-06-30	10:30 PM	7/2/2012	8:11 AM	Calvert, Charles, St. Mary's, Prince Georges Counties Maryland	RFC		Severe Weather - Thunderstorms	354	60,000	Weather
	2012-07-01	1:00 PM	7/3/2012	3:00 PM	Illinois	RFC		Severe Weather - Thunderstorms	Unknown	320,000	Weather
	2012-07-01	4:47 PM	7/1/2012	11:00 PM	Tarboro, North Carolina	SERC		Operational Failure; Storm Damage	48	6,100	Weather
	2012-07-01	5:45 PM	7/1/2012	10:15 PM	Northern, Central and Eastern North Carolina	SERC		Severe Weather	Unknown	69,106	Weather
	2012-07-05	12:00 AM	7/6/2012	8:30 PM	Lower Peninsula Michigan	RFC		Severe Weather - Thunderstorms	Unknown	111,000	Weather
	2012-07-05	7:00 PM	7/6/2012	4:00 PM	Northeast Tennessee	SERC		Severe Weather - Wind & Storms	N/A	50,001	Weather
	2012-07-06	3:05 PM	7/6/2012	3:06 PM	Tacoma, Washington	WECC		Vandalism	N/A	N/A	Physical Attack
	2012-07-07	4:00 AM	7/10/2012	4:00 AM	CAISO California	WECC		Fuel Supply Deficiency (Water)	Unknown	0	Fuel Supply Deficiency
	2012-07-07	6:06 AM	7/9/2012	11:00 PM	Lower Valley, Central, Susquehanna Regions Pennsylvania	RFC		Severe Weather - Thunderstorms	N/A	64,500	Weather
	2012-07-07	6:00 PM	7/9/2012	7:01 PM	Central and Northern New Jersey	RFC		Severe Weather - Thunderstorms	N/A	95,400	Weather
	2012-07-09	12:15 PM	7/9/2012	4:14 PM	Alberta, Canada	WECC		Energy Deficiency Alert	9896	Unknown	Fuel Supply Deficiency
	2012-07-16	11:27 AM	7/16/2012	12:29 PM	Little Rock, Arkansas	SPP		Public Appeal to Reduce Energy Usage	N/A	N/A	Public Appeal
	2012-07-18	2:16 PM	7/19/2012	11:58 PM	Southeast Ohio, Northern Kentucky, Southern Indiana	RFC		Severe Weather - Thunderstorms	480	103,000	Weather
	2012-07-18	4:20 PM	7/18/2012	7:05 PM	Eastern Ohio	RFC		Severe Weather - Thunderstorms	Unknown	67,000	Weather
	2012-07-18	11:00 PM	7/19/2012	6:00 AM	Northern Illinois	RFC		Severe Weather - Thunderstorms	Unknown	181,000	Weather
	2012-07-19	10:30 AM	7/31/2012	11:00 AM	Niagara County, New York	NPCC		Fuel Supply Deficiency (Coal)	675	Unknown	Fuel Supply Deficiency
	2012-07-19	12:32 PM	7/19/2012	12:33 PM	Newark, Delaware	RFC		Vandalism	N/A	N/A	Physical Attack
	2012-07-21	2:19 AM	7/21/2012	5:20 AM	City of Lubbock, Texas	SPP		Severe Weather; Equipment Failure	220	70,000	Weather
	2012-07-24	7:01 AM	7/24/2012	4:30 PM	Northern Indiana	RFC		Severe Weather - Thunderstorms	N/A	82,621	Weather
	2012-07-24	7:30 AM	7/24/2012	10:00 PM	Northern Illinois	RFC		Severe Weather - Thunderstorms	Unknown	330,000	Weather
	2012-07-26	6:14 PM	7/27/2012	6:14 PM	Western Pennsylvania	RFC		Severe Weather - Thunderstorms	N/A	65,112	Weather
	2012-07-26	6:21 PM	7/28/2012	11:30 PM	North/Central Pennsylvania	RFC		Severe Weather - Thunderstorms	N/A	65,000	Weather
	2012-07-26	6:30 PM	7/27/2012	5:22 PM	Eastern Ohio	RFC		Severe Weather - Thunderstorms	Unknown	57,054	Weather
	2012-07-27	5:19 PM	7/28/2012	5:19 PM	Central Indiana	RFC		Severe Weather - Thunderstorms	Unknown	52,702	Weather
	2012-08-01	12:00 PM	8/1/2012	12:00 PM	Oklahoma, Arkansas	SPP		Public Appeal to Reduce Electricity Usage	Unknown	Unknown	Public Appeal

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2012-08-04	3:55 AM	8/4/2012	4:21 AM	Temblor Substation in McKittrick, California	WECC		Electrical System Separation (Islanding)	5	127	Islanding
	2012-08-04	4:00 AM	8/4/2012	7:20 AM	Northern Indiana	RFC		Severe Weather - Thunderstorms	N/A	61,413	Weather
	2012-08-04	5:30 PM	8/5/2012	12:10 PM	Northeast Illinois	RFC		Severe Weather - Thunderstorms	Unknown	325,000	Weather
	2012-08-11	12:45 PM	8/11/2012	5:00 PM	Tacoma, Washington	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-08-13	1:15 PM	8/13/2012	1:15 PM	Knoxville, Tennessee	SERC		Vandalism	Unknown	Unknown	Physical Attack
	2012-08-13	3:52 PM	8/13/2012	7:44 PM	CFE (Mexico & U.S.)	WECC		Severe Weather - Dust Storm; Load Shed Event	655	Unknown	Weather
	2012-08-16	1:13 PM	8/16/2012	1:13 PM	Northern Indiana	RFC		Vandalism	0	0	Physical Attack
	2012-08-19	8:42 AM	8/19/2012	12:08 PM	El Paso, Texas	WECC		Suspected Physical Attack	12	3,314	Physical Attack
	2012-08-26	10:04 PM	8/27/2012	2:04 AM	Florida	FRCC		Severe Weather - TS Isaac	N/A	440,000	Weather
	2012-08-28	6:00 AM	9/4/2012	8:00 AM	Arkansas, Louisiana, Mississippi	SERC		Severe Weather - Hurricane Isaac	Unknown	770,000	Weather
	2012-08-29	6:53 AM	8/30/2012	2:00 PM	Louisiana	SERC		Severe Weather - Hurricane Isaac	150	68,018	Weather
	2012-08-29	9:00 AM	8/31/2012	12:00 PM	Louisiana	SERC		Severe Weather - Hurricane Isaac	300	50,000	Weather
	2012-08-29	9:48 AM	8/31/2012	12:55 PM	Louisiana	SPP		Severe Weather - Hurricane Isaac	Unknown	95,000	Weather
	2012-09-05	10:56 AM	9/5/2012	11:27 AM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	0	0	Islanding
	2012-09-06	4:45 AM	Ongoing	Ongoing	Oroville, California	WECC		Fuel Supply Deficiency (Water)	N/A	N/A	Fuel Supply Deficiency
	2012-09-07	9:30 PM	9/8/2012	1:00 AM	Arkansas	SERC		Severe Weather - Thunderstorms	UNK	64,951	Weather
	2012-09-08	3:40 PM	9/8/2012	6:45 PM	Prince George's County, Montgomery County Maryland; D.C.	RFC		Severe Weather - Thunderstorms	UNK	65,000	Weather
	2012-09-08	3:53 PM	9/9/2012	7:46 PM	Virginia	SERC		Severe Weather - Thunderstorms	475	119,000	Weather
	2012-09-11	1:00 PM	9/11/2012	1:58 PM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	0	0	Islanding
	2012-09-24	12:00 AM	9/25/2012	12:00 AM	Brighton, Maryland	RFC		Suspected Physical Attack	0	0	Physical Attack
	2012-09-26	9:16 PM	9/26/2012	10:18 PM	Puerto Rico	N/A		Voltage Reduction	600	371,526	?
	2012-10-05	5:30 PM	10/5/2012	5:50 PM	Greater Sacramento, California	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-10-09	12:00 AM	10/9/2012	12:01 AM	Seat Pleasant, Maryland	RFC		Vandalism	0	0	Physical Attack
	2012-10-11	12:00 AM	10/11/2012	12:01 AM	Seat Pleasant, Maryland	RFC		Vandalism	0	0	Physical Attack
	2012-10-14	10:36 AM	10/14/2012	10:50 AM	Northern California	WECC		Electrical System Separation (Islanding)	3	2,035	Islanding
	2012-10-15	2:15 PM	10/15/2012	2:16 PM	Southeast Vermont	NPCC		Vandalism; Theft	0	0	Physical Attack
	2012-10-22	12:00 AM	10/22/2012	12:01 AM	Norbeck, Maryland	RFC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-10-23	9:10 AM	10/23/2012	9:16 AM	Crawfordsville, Indiana	RFC		Transmission System Interruption	49	9,800	Transmission Interruption

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2012-10-24	12:00 AM	10/24/2012	12:01 AM	Kingswood, Maryland	RFC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-10-24	12:00 AM	10/24/2012	12:01 AM	Brighton, Maryland	RFC		Suspected Physical Attack	0	0	Physical Attack
	2012-10-24	3:15 PM	10/24/2012	3:16 PM	Frankford, Delaware	RFC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-10-25	12:00 AM	10/25/2012	12:01 AM	West Lanham, Maryland	RFC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2012-10-25	2:39 PM	10/25/2012	6:00 PM	Pueblo, Colorado	WECC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-10-25	6:51 PM	10/25/2012	7:30 PM	Newark, Delaware	RFC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-10-29	12:00 AM	11/9/2012	11:59 PM	West Virginia	RFC		Severe Weather - Hurricane Sandy	0	208,000	Weather
	2012-10-29	8:00 AM	11/4/2012	11:00 PM	New Jersey	RFC		Severe Weather - Hurricane Sandy	Unknown	Unknown	Weather
	2012-10-29	9:00 AM	10/29/2012	9:01 AM	LaGrande, Washington	WECC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-10-29	9:00 AM	11/2/2012	6:00 PM	Delaware, Maryland	RFC		Severe Weather - Hurricane Sandy	Unknown	70,000	Weather
	2012-10-29	12:00 PM	11/4/2012	11:00 PM	New Jersey	RFC		Severe Weather - Hurricane Sandy	Unknown	217,000	Weather
	2012-10-29	1:00 PM	11/12/2012	2:00 PM	Long Island, New York	NPCC		Severe Weather - Hurricane Sandy	0	632,816	Weather
	2012-10-29	2:40 PM	10/30/2012	6:16 PM	Boston, Southeast Massachusetts	NPCC		Severe Weather - Hurricane Sandy	Unknown	50,000	Weather
	2012-10-29	2:45 PM	11/1/2012	1:30 AM	Eastern Massachusetts	NPCC		Severe Weather - Hurricane Sandy	Unknown	50,000	Weather
	2012-10-29	3:00 PM	10/29/2012	3:01 PM	Las Vegas, Nevada	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2012-10-29	3:15 PM	11/4/2012	8:00 PM	Connecticut, Western Massachusetts	NPCC		Severe Weather - Hurricane Sandy	0	649,075	Weather
	2012-10-29	4:00 PM	11/7/2012	11:48 PM	Eastern Pennsylvania	RFC		Severe Weather - Hurricane Sandy	0	270,000	Weather
	2012-10-29	4:00 PM	11/8/2012	5:08 PM	Maryland; West Virginia	RFC		Severe Weather - Hurricane Sandy	Unknown	150,000	Weather
	2012-10-29	4:00 PM	11/5/2012	11:59 PM	Greater Cleveland Ohio	RFC		Severe Weather - Hurricane Sandy	0	346,000	Weather
	2012-10-29	4:01 PM	11/8/2012	7:00 PM	Greater New York City, New York	NPCC		Severe Weather - Hurricane Sandy	0	818,000	Weather
	2012-10-29	4:03 PM	11/6/2012	12:00 PM	New Jersey	NPCC		Severe Weather - Hurricane Sandy	Unknown	50,000	Weather
	2012-10-29	4:45 PM	10/31/2012	11:00 AM	New Hampshire	NPCC		Severe Weather - Hurricane Sandy	N/A	50,000	Weather
	2012-10-29	5:13 PM	10/31/2012	11:00 AM	Greater Baltimore Maryland	RFC		Severe Weather - Hurricane Sandy	0	219,000	Weather
	2012-10-29	5:30 PM	11/6/2012	12:00 AM	Greater Philadelphia Pennsylvania	RFC		Severe Weather - Hurricane Sandy	Unknown	850,000	Weather
	2012-10-29	6:11 PM	11/4/2012	10:50 PM	Central Pennsylvania	RFC		Severe Weather - Hurricane Sandy	Unknown	400,000	Weather
	2012-10-29	6:12 PM	10/30/2012	7:35 PM	Virginia	RFC		Severe Weather - Hurricane Sandy	520	156,000	Weather
	2012-10-29	6:46 PM	11/3/2012	10:45 AM	Southeast New York; New Jersey	NPCC; RFC		Severe Weather - Hurricane Sandy	Unknown	200,000	Weather
	2012-10-29	6:48 PM	11/4/2012	11:36 AM	New York	NP		Severe Weather - Hurricane Sandy	Unknown	371,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2012-10-29	7:00 PM	11/2/2012	5:00 AM	Indiana; Kentucky; Michigan; Ohio	RFC; SERC		Severe Weather - Nor'easter	Unknown	173,273	Weather
	2012-10-29	7:15 PM	10/30/2012	3:02 PM	Southeast and Seacoast Maine	NPCC		Severe Weather - Hurricane Sandy	Unknown	50,000	Weather
	2012-10-30	12:00 AM	10/30/2012	12:02 AM	Hyattsville, Maryland	RFC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-10-30	2:00 AM	11/1/2012	10:00 PM	Greater Detroit Michigan	RFC		Severe Weather - Nor'easter	Unknown	133,777	Weather
	2012-10-30	1:20 PM	10/30/2012	1:25 PM	Fitzwilliam, New Hampshire	NPCC		Vandalism	0	0	Physical Attack
	2012-10-30	3:00 PM	10/30/2012	3:01 PM	Pueblo, Colorado	WECC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2012-11-02	9:30 AM	11/2/2012	12:10 PM	Concord, Vermont	NPCC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-11-07	2:21 PM	11/7/2012	2:48 PM	New Hampshire	NPCC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-11-08	9:34 AM	11/8/2012	9:35 AM	Bishopville, Maryland	RFC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-11-15	9:09 PM	11/15/2012	9:26 PM	Iowa; Michigan	MRO		Suspected Cyber Attack	Unknown	Unknown	Cyber Attack
	2012-11-15	5:38 AM	11/15/2012	5:39 AM	Southeast Massachusetts	NPCC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-11-17	10:00 AM	11/18/2012	10:00 AM	Comanche Peak, Texas	TRE		Fuel Supply Deficiency	1,231	0	Fuel Supply Deficiency
	2012-11-21	2:50 PM	11/21/2012	2:51 PM	Bethany Beach, Delaware	RFC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2012-11-26	12:37 PM	11/26/2012	12:38 PM	Frankfort, Delaware	RFC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-11-26	3:07 PM	11/26/2012	3:08 PM	Georgetown, Delaware	RFC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2012-11-27	1:07 PM	11/27/2012	1:40 PM	New Hampshire	NPCC		Physical Attack; Vandalism	0	0	Physical Attack
	2012-12-02	5:20 AM	12/4/2012	9:00 AM	Northern California	WECC		Severe Weather - Winter Storm	250	125,000	Weather
	2012-12-03	12:02 PM	12/3/2012	12:30 PM	Tacoma, Washington	WECC		Suspected Physical Attack	0	0	Physical Attack
	2012-12-06	9:18 PM	12/6/2012	9:31 PM	Greater San Jose, California	WECC		Load Shed	390	Unknown	Load Shed
	2012-12-17	6:55 AM	12/17/2012	7:00 AM	Tacoma, Washington	WECC		Suspected Physical Attack	0	0	Physical Attack
	2012-12-25	12:45 AM	12/28/2012	4:15 PM	Arkansas; Louisiana; Mississippi; Texas	SPP		Severe Weather - Winter Storm	Unknown	242,509	Weather
	2012-12-25	9:28 AM	12/26/2012	4:28 PM	Houston, Texas	TRE		Severe Weather - Cold Front, High Winds	294	262,000	Weather
	2012-12-26	2:50 PM	12/26/2012	7:40 PM	Stantonsburg, North Carolina	SERC		Severe Weather - Thunderstorm	3	1,200	Weather
	2012-12-31	2:21 PM	12/31/2012	4:30 PM	North Carolina	SERC		Transmission Interruption	40	12,000	Transmission Interruption
	2013-01-07	10:43 AM	1/7/2013	10:43 AM	Denton, Maryland	RFC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-01-16	7:41 AM	1/17/2013	10:58 AM	Webster County, Iowa	MRO		Physical Attack	N/A	N/A	Physical Attack
	2013-01-16	2:25 PM	1/16/2013	2:25 PM	Denton, Maryland	RFC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-01-16	4:45 PM	1/16/2013	7:26 PM	San Juan County, New Mexico	WECC		Suspected Physical Attack	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2013-01-17	8:35 PM	1/17/2013	9:20 PM	Elizabeth City, North Carolina	SERC		Distribution Interruption	40	12,000	Distribution Interruption
	2013-01-17	6:07 PM	1/20/2013	7:30 PM	Southwest Virginia, Southern West Virginia	RFC		Severe Weather - Winter Storm	Unknown	127,000	Weather
	2013-01-17	7:02 PM	1/19/2013	6:00 PM	Northeast Tennessee	SERC		Severe Weather - Winter Storm	Unknown	80,000	Weather
	2013-01-20	3:30 AM	1/23/2013	6:15 AM	Southeastern Michigan	RFC		Severe Weather - Wind Storm	Unknown	146,500	Weather
	2013-01-28	4:46 PM	1/28/2013	6:00 PM	Tacoma Narrows Crossing, Washington	WECC		Physical Attack	Unknown	Unknown	Physical Attack
	2013-01-31	3:05 AM	1/31/2013	4:48 AM	Central and Eastern Virginia	SERC		Severe Weather - Wind Storm	188	119,000	Weather
	2013-01-31	6:30 AM	1/31/2013	10:00 AM	Connecticut	NPCC		Severe Weather - Wind Storm	75	75,000	Weather
	2013-02-02	9:15 PM	2/2/2013	10:15 PM	El Paso, New Mexico	WECC		Vandalism	N/A	N/A	Physical Attack
	2013-02-07	8:32 AM	2/7/2013	9:47 AM	Cincinnati, Ohio	RFC		Vandalism	Unknown	0	Physical Attack
	2013-02-08	11:38 AM	2/8/2013	2:17 PM	District of Columbia; Prince George's County Maryland	RFC		Equipment Trip & Failure	140	52,000	Equipment
	2013-02-08	8:00 PM	2/11/2013	8:30 PM	Central and eastern Massachusetts; Rhode Island	NPCC		Severe Weather - Winter Storm Nemo	N/A	50,000	Weather
	2013-02-08	8:55 PM	2/12/2013	4:00 AM	Boston area and Southeast Massachusetts	NPCC		Severe Weather - Winter Storm Nemo	Unknown	50,000	Weather
	2013-02-09	8:30 AM	2/9/2013	3:00 PM	El Paso, New Mexico	WECC		Vandalism; Equipment Fault	Unknown	Unknown	Physical Attack
	2013-02-10	7:46 PM	2/10/2013	8:15 PM	Puerto Rico	N/A		Generator Trip; Voltage Reduction	350	Unknown	Equipment
	2013-02-13	5:39 PM	2/15/2013	5:50 PM	Eastern Massachusetts	NPCC		Fuel Supply Emergency - Petroleum	1	1	Fuel Supply Deficiency
	2013-02-13	9:30 AM	2/13/2013	9:30 AM	Fort Washington, Maryland	RFC		Vandalism	1	1	Physical Attack
	2013-02-15	12:00 AM	2/15/2013	12:01 AM	Tuxedo, Maryland	RFC		Vandalism	N/A	N/A	Physical Attack
	2013-02-16	7:54 AM	2/16/2013	7:54 AM	Prince George's County Maryland	RFC		Vandalism	1	1	Physical Attack
	2013-02-19	4:01 PM	2/20/2013	12:55 PM	Stockton, California	WECC		Electrical System Separation (Islanding)	13,850	6,810	Islanding
	2013-02-21	11:00 AM	2/21/2013	11:30 AM	Las Cruces, New Mexico	WECC		Vandalism	Unknown	Unknown	Physical Attack
	2013-02-26	1:00 PM	3/1/2013	10:00 AM	Northern Missouri	SERC		Severe Weather - Winter Storm Nemo	Unknown	56,444	Weather
	2013-03-03	4:27 PM	3/3/2013	6:20 PM	Tacoma Park, Maryland	RFC		Vandalism	Unknown	Unknown	Physical Attack
	2013-03-03	6:39 AM	3/3/2013	10:29 AM	Merced County, California	WECC		Transmission System Interruption	300	58,850	Transmission Interruption
	2013-03-04	9:49 AM	3/4/2013	10:00 PM	Metropolitan area Puerto Rico	N/A		Equipment Failure; Transmission System Interruption	Unknown	Unknown	Transmission Interruption

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2013-03-06	8:22 AM	3/7/2013	10:27 AM	Northwest Virginia	SERC		Severe Weather - Winter Storm	400	233,000	Weather
	2013-03-18	5:21 AM	3/18/2013	5:41 AM	Systemwide Puerto Rico	N/A		Generator Trip; Load Shed	350	262,937	Equipment
	2013-03-18	5:50 PM	3/18/2013	6:07 PM	Northeast Florida	FRCC		Suspected Physical Attack	0	0	Physical Attack
	2013-03-18	7:30 PM	3/20/2013	2:30 PM	North/Central Alabama; Georgia	SERC		Severe Weather - Thunderstorms	800	240,000	Weather
	2013-03-23	7:00 AM	3/23/2013	9:00 AM	Connecticut	NPCC		Vandalism	Unknown	Unknown	Physical Attack
	2013-03-27	10:25 AM	3/27/2013	12:19 PM	Western Massachusetts	NPCC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-03-28	1:01 PM	3/28/2013	1:02 PM	Wilmington, Delaware	RFC		Vandalism	Unknown	Unknown	Physical Attack
	2013-03-29	10:16 AM	3/29/2013	10:17 AM	Maryland	RFC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2013-04-01	8:40 AM	4/1/2013	8:41 AM	Connecticut	NPCC		Vandalism - Copper Wire Theft	Unknown	Unknown	Physical Attack
	2013-04-03	11:05 AM	4/3/2013	2:00 PM	Colorado Springs, Colorado	WECC		Sabotage; Vandalism	0	0	Physical Attack
	2013-04-09	11:30 AM	4/9/2013	11:31 AM	Delaware City, Delaware	RFC		Vandalism	N/A	N/A	Physical Attack
	2013-04-16	1:47 AM	4/18/2013	3:25 PM	California	WECC		Loss of Part of a High Voltage Substation, Physical Attack	N/A	0	Physical Attack
	2013-04-17	3:36 PM	4/17/2013	4:53 PM	Colbert Steam Plant in Cherokee, Alabama	SERC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2013-04-18	3:00 PM	4/21/2013	3:30 AM	Southeast Michigan, Michigan	RFC		Severe Weather - Storms and Wind	Unknown	99,188	Weather
	2013-04-21	2:11 AM	4/21/2013	12:30 PM	East Tennessee	SERC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2013-04-23	12:49 AM	4/23/2013	4:04 AM	South of Humboldt, California	WECC		Electrical System Separation (Islanding)	80	1	Islanding
	2013-04-23	11:00 AM	4/23/2013	11:01 AM	Newark, Delaware	RFC		Vandalism	Unknown	Unknown	Physical Attack
	2013-04-25	4:00 PM	4/26/2013	10:55 AM	Sunol, California	WECC		Vandalism	0	0	Physical Attack
	2013-05-01	9:22 AM	5/1/2013	9:24 AM	Northeast Colorado	WECC		Electrical System Separation (Islanding)	123	35,230	Islanding
	2013-05-02	6:52 AM	5/2/2013	10:07 AM	Unknown	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2013-05-09	1:21 PM	5/9/2013	4:21 PM	Alberta, Canada; Washington State	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2013-05-13	12:52 PM	Ongoing	Ongoing	Central California	WECC		Fuel Supply Emergency - Hydro	176	Unknown	Fuel Supply Deficiency
	2013-05-14	12:01 AM	5/14/2013	1:59 PM	Portland, Oregon	WECC		Vandalism/Theft	N/A	N/A	Physical Attack
	2013-05-14	10:25 AM	5/14/2013	11:42 AM	New Hampshire	NPCC		Vandalism	N/A	N/A	Physical Attack
	2013-05-15	2:11 PM	5/15/2013	2:12 PM	Wilmington, Delaware	RFC		Vandalism	Unknown	Unknown	Physical Attack
	2013-05-17	8:35 AM	5/17/2013	8:36 AM	Newcastle, Delaware	RFC		Vandalism	Unknown	Unknown	Physical Attack
	2013-05-20	5:22 PM	5/20/2013	9:09 PM	Gonzales Area Louisiana	SERC		Generator Trip; Load Shed 100+ MW	103	21,800	Equipment

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	2013-05-20	3:00 PM	5/22/2013	5:00 PM	Moore, Oklahoma	SPP		Severe Weather - Tornadoes	Unknown	41,306	Weather
	2013-05-22	10:51 AM	5/22/2013	10:57 AM	System wide Puerto Rico	N/A		System Wide Voltage Reduction	280	197,287	?
	2013-05-28	1:00 PM	5/28/2013	6:00 PM	Maine	NPCC		Vandalism/Theft	None	None	Physical Attack
	2013-05-29	12:00 AM	5/29/2013	12:02 AM	Henrico County, Virginia	SERC		Physical Attack	Unknown	Unknown	Physical Attack
	2013-05-29	9:52 AM	5/29/2013	9:53 AM	Wilmington, Delaware	RFC		Vandalism/Theft	N/A	N/A	Physical Attack
	2013-05-29	8:58 PM	5/31/2013	2:53 PM	Central and Eastern New York	NPCC		Severe Weather - Thunderstorms	Unknown	61,795	Weather
	2013-05-30	10:15 AM	5/30/2013	10:16 AM	Saranac, New York	NPCC		Vandalism	N/A	N/A	Physical Attack
	2013-05-31	7:07 PM	6/1/2013	2:15 PM	Southeast Kansas, Northeast Oklahoma	MRO		Transmission System Interruption	102	6,300	Transmission Interruption
	2013-05-31	1:00 AM	5/31/2013	1:30 AM	Maumelle, Arkansas	SPP		Severe Weather - Lightning	N/A	N/A	Weather
	2013-05-31	6:00 PM	6/4/2013	10:30 AM	El Reno, S. Oklahoma City, Oklahoma	SPP		Severe Weather - Tornadoes	Unknown	127,000	Weather
	2013-05-31	7:30 PM	6/1/2013	8:00 PM	St. Louis Metro Area Missouri	SERC		Severe Weather - Thunderstorms	Unknown	100,000	Weather
	2013-06-03	12:50 PM	6/3/2013	1:36 PM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2013-06-13	1:17 PM	6/14/2013	5:35 PM	Western Piedmont North Carolina	SERC		Severe Weather - Thunderstorms	1,000	175,000	Weather
	2013-06-13	3:20 PM	6/14/2013	9:10 PM	Ohio; Virginia; West Virginia	RFC; SERC		Severe Weather - Thunderstorms	Unknown	90,247	Weather
	2013-06-13	3:30 PM	6/13/2013	4:00 PM	District of Columbia; Maryland	RFC		Loss of 300+ MW Load; Severe Weather - Thunderstorms	700	40,000	Weather
	2013-06-13	4:08 PM	6/14/2013	5:16 PM	Richmond Metro area, Virginia	SERC		Severe Weather - Thunderstorms	900	283,000	Weather
	2013-06-13	5:45 PM	6/14/2013	6:30 PM	Central and Eastern North Carolina	SERC		Severe Weather - Thunderstorms	Unknown	53,000	Weather
	2013-06-13	8:47 PM	6/14/2013	10:47 PM	Southern Company Territory	SERC		Severe Weather - Thunderstorms	550	165,798	Weather
	2013-06-17	4:17 PM	6/17/2013	6:49 PM	Hillsborough County Florida	FRCC		Load Shed of 100+ MW Under Emergency Operational Policy	180	37	Load Shed
	2013-06-18	3:51 PM	6/18/2013	4:23 PM	Wyoming	WECC		Electrical System Separation (Islanding)	6	Unknown	Islanding
	2013-06-19	7:57 PM	6/19/2013	8:09 PM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2013-06-20	6:00 PM	6/21/2013	10:00 AM	Richie Station (No. 123), Maryland	RFC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-06-21	8:31 AM	10/30/2013	2:09 PM	Michigan, Iowa	MRO		Suspected Cyber Attack	Unknown	Unknown	Cyber Attack
	2013-06-21	7:40 AM	6/21/2013	12:14 PM	Pahrump Nevada	WECC		Physical Attack; Vandalism & Sabotage	Unknown	1,100	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2013-06-21	11:14 PM	6/21/2013	11:15 PM	New Castle Delaware	RFC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-06-21	3:00 AM	6/26/2013	12:00 PM	Minnesota	MRO		Severe Weather - Hailstorm	Unknown	193,000	Weather
	2013-06-21	5:39 PM	6/24/2013	6:00 AM	Minneapolis/St. Paul area Minnesota	MRO		Severe Weather - Hailstorm	Unknown	400,000	Weather
	2013-06-22	4:59 AM	6/22/2013	9:28 PM	Medford Oregon	WECC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2013-06-22	4:12 PM	6/22/2013	5:45 PM	Eastern Montana	WECC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2013-06-23	9:20 PM	6/24/2013	1:35 AM	Central Coast California	WECC		Severe Weather - Fog	Unknown	148,000	Weather
	2013-06-24	7:30 PM	6/25/2013	5:46 PM	Illinois	RFC		Severe Weather - Thunderstorms	Unknown	283,451	Weather
	2013-06-24	7:30 PM	6/26/2013	5:00 PM	Indiana	RFC		Severe Weather - Thunderstorms	Unknown	86,615	Weather
	2013-06-27	1:10 AM	6/27/2013	2:45 AM	Richie Substation, Seat Pleasant, Maryland	RFC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-06-27	5:00 PM	6/28/2013	12:00 AM	South Eastern Michigan	RFC		Severe Weather - Thunderstorms	Unknown	138,000	Weather
	2013-06-28	6:02 PM	6/28/2013	8:46 PM	Los Angeles and Orange Counties, California	WECC		Equipment Failure	240	65,255	Equipment
	2013-06-28	1:00 PM	6/28/2013	1:01 PM	Vermont	NPCC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-06-28	5:14 PM	6/28/2013	5:15 PM	New Castle Delaware	RFC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-07-02	2:20 PM	7/5/2013	3:30 PM	Alberta, Canada	WECC		Load Shed 100+MW	200	Unknown	Load Shed
	2013-07-03	12:04 PM	7/3/2013	12:48 PM	System-wide Puerto Rico	N/A		Voltage Reduction; Line and Generator Trip	480	393,000	Equipment
	2013-07-03	9:34 AM	7/3/2013	10:52 AM	Sacramento California	WECC		Suspected Physical Attack	0	0	Physical Attack
	2013-07-05	12:05 AM	7/5/2013	1:51 AM	California	WECC		Physical Attack; Vandalism	Unknown	2,500	Physical Attack
	2013-07-10	2:30 PM	7/10/2013	2:45 PM	Boston, Massachusetts	NPCC		Physical Attack; Copper Theft	0	0	Physical Attack
	2013-07-10	5:30 PM	7/11/2013	8:00 PM	AEP Ohio Power Footprint	RFC		Severe Weather - Thunderstorms	N/A	122,314	Weather
	2013-07-11	11:20 PM	7/14/2013	3:22 PM	Arizona	WECC		Physical Attack; Vandalism	455	Unknown	Physical Attack
	2013-07-12	10:00 AM	7/12/2013	10:01 AM	Washington	WECC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-07-17	3:30 PM	7/19/2013	6:45 AM	Holtsville, New York	NPCC		Fuel Supply Emergency (Natural Gas)	417	Unknown	Fuel Supply Deficiency
	2013-07-18	11:45 PM	7/19/2013	10:05 AM	Southern Orange County California	WECC		Equipment Failure	200	123,000	Equipment
	2013-07-18	3:15 AM	7/18/2013	3:59 AM	Utah	WECC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2013-07-18	11:30 AM	7/19/2013	5:30 PM	Upstate New York	NPCC		Public Appeal - Heatwave	Unknown	Unknown	Weather
	2013-07-19	6:00 PM	7/20/2013	9:00 AM	Michigan	RFC		Severe Weather - Thunderstorms	Unknown	156,627	Weather
	2013-07-19	10:30 PM	7/21/2013	8:00 PM	New York	NPCC		Severe Weather - Thunderstorms	Unknown	74,300	Weather
	2013-07-22	7:00 AM	7/22/2013	3:00 PM	California	WECC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-07-23	11:38 PM	7/25/2013	4:30 AM	Tulsa, Oklahoma	SPP		Severe Weather - Thunderstorms	500	92,748	Weather
	2013-07-25	1:10 PM	7/25/2013	1:15 PM	Polk Substation, Tacoma Washington	WECC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2013-08-01	11:19 PM	8/2/2013	12:49 AM	Daytona Beach Florida	FRCC		Loss of 300+ MW Load	297	104,498	?
	2013-08-01	6:54 PM	8/1/2013	7:37 PM	Western British Columbia	WECC		Electrical System Separation (Islanding)	420	Unknown	Islanding

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	2013-08-01	11:00 AM	8/1/2013	4:00 PM	Newburgh, New York	NPCC		Physical Attack; Copper Theft	N/A	N/A	Physical Attack
	2013-08-04	3:00 AM	8/4/2013	4:00 AM	Utah	WECC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2013-08-05	6:35 PM	8/5/2013	6:45 PM	Vancouver, British Columbia	WECC		Electrical System Separation (Islanding); Severe Weather	Unknown	Unknown	Islanding
	2013-08-06	4:00 PM	8/6/2013	5:32 PM	Holloman Air Force Base, New Mexico	WECC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-08-07	7:30 AM	8/7/2013	9:14 AM	Green Bay, Wisconsin	MRO		Fuel Supply Emergency (Natural Gas & Fuel Oil)	Unknown	Unknown	Fuel Supply Deficiency
	2013-08-07	2:30 PM	8/8/2013	1:00 PM	Arlington, Oregon	WECC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-08-07	12:15 AM	8/7/2013	9:27 PM	Eastern Central Wisconsin	MRO		Severe Weather - Thunderstorms	220	51,160	Weather
	2013-08-12	11:55 AM	8/12/2013	11:59 AM	Portland, Oregon	WECC		Suspicious Activity	Unknown	Unknown	Physical Attack
	2013-08-16	4:58 PM	8/17/2013	11:58 PM	Houston Service Area Texas	TRE		Severe Weather - Thunderstorms	Unknown	219,681	Weather
	2013-08-19	7:06 PM	8/20/2013	6:02 AM	Central California	WECC		Severe Weather - Lightning Strike	685	124,000	Weather
	2013-08-21	2:00 PM	8/21/2013	2:01 PM	Cabot, Arkansas	SERC		Physical Attack; Sabotage	N/A	N/A	Physical Attack
	2013-08-22	8:40 AM	8/22/2013	11:49 AM	Gila River, Arizona	WECC		Physical Attack; Sabotage	N/A	N/A	Physical Attack
	2013-08-22	12:55 PM	8/22/2013	2:45 PM	New Castle, Delaware	RFC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-08-23	7:30 AM	8/23/2013	7:31 AM	New Castle, Delaware	RFC		Physical Attack; Vandalism	Unknown	N/A	Physical Attack
	2013-08-26	8:15 PM	8/26/2013	8:16 PM	Tacoma Washington	WECC		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-08-28	9:30 AM	8/28/2013	9:31 AM	Sweetwater County Wyoming	WECC		Physical Attack; Vandalism	N/A	N/A	Physical Attack
	2013-08-29	2:57 PM	8/29/2013	3:29 PM	Ashland, Wisconsin	MRO		Electrical System Separation (Islanding); Severe Weather	15	7,000	Islanding
	2013-08-29	9:50 AM	8/29/2013	9:50 AM	Joplin, Missouri	N/A		Physical Attack; Vandalism	Unknown	Unknown	Physical Attack
	2013-08-30	7:30 PM	8/31/2013	1:30 AM	Entire ComEd territory Illinois	RFC		Severe Weather - Thunderstorms	Unknown	157,000	Weather
	2013-09-10	5:42 PM	9/11/2013	12:02 AM	Erie, Pennsylvania	RFC		Load Shed of 100+ MW	105	Unknown	Load Shed
	2013-09-11	4:00 PM	9/15/2013	4:00 PM	Southeastern Michigan	RFC		Severe Weather - Thunderstorms	400	75,000	Weather
	2013-09-29	12:00 AM	9/29/2013	1:00 AM	Cabot Arkansas	SERC		Physical Attack; Sabotage	Unknown	Unknown	Physical Attack
	2013-10-06	7:25 AM	10/6/2013	9:15 AM	Jacksonville, Arkansas	SPP		Physical Attack	Unknown	9,200	Physical Attack
	2013-10-11	2:30 PM	10/11/2013	6:30 PM	Keo, Arkansas	SERC		Physical Attack	Unknown	Unknown	Physical Attack
	2013-10-16	11:15 AM	10/16/2013	6:00 PM	Roxboro Plant, North Carolina	SERC		Cyber Event with Potential to Cause Impact	0	0	Cyber Attack
	2013-10-19	2:32 PM	10/19/2013	10:00 PM	California	WECC		Physical Attack	Unknown	Unknown	Physical Attack
	2013-10-21	5:18 AM	10/21/2013	5:33 AM	Location Unknown	WECC		Electrical System Separation (Islanding)	115	433	Islanding
	2013-10-26	7:13 AM	10/26/2013	7:14 AM	Arizona	WECC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2013-10-27	4:27 AM	10/27/2013	10:27 PM	Houston, Texas	TRE		Severe Weather - Hailstorm	Unknown	171,117	Weather
	2013-11-01	1:26 PM	11/1/2013	1:27 PM	Wilmington, Delaware	RFC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2013-11-02	8:25 AM	11/2/2013	8:26 AM	Salt Lake City, Utah	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2013-11-02	12:00 AM	11/4/2013	6:00 AM	King, Whatcom, and Skagit, Washington	WECC		Severe Weather - Heavy Winds	Unknown	105,000	Weather
	2013-11-04	9:04 AM	11/4/2013	9:05 AM	Connecticut	NPCC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2013-11-05	10:10 AM	11/7/2013	10:10 AM	Indiana	RFC		Physical Attack	Unknown	Unknown	Physical Attack
	2013-11-12	9:14 AM	11/12/2013	10:30 AM	Eastern Central New Mexico	SPP		Loss of Power from Wholesale Provider; Major Distribution Disruption	Unknown	Unknown	Distribution Interruption
	2013-11-12	2:04 PM	11/12/2013	2:05 PM	Valle, California	WECC		Electrical System Separation (Islanding)	55	48,400	Islanding
	2013-11-16	3:15 PM	11/16/2013	3:16 PM	Salt Lake County, Utah	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2013-11-17	12:35 PM	11/17/2013	1:40 PM	Rochelle, Indiana	RFC		System-wide voltage reductions of 3 percent or more	38	7,500	?
	2013-11-17	7:00 AM	11/20/2013	6:54 PM	Michigan	RFC		Severe Weather - Ice and Snow Storm	Unknown	325,325	Weather
	2013-11-17	12:35 PM	11/20/2013	11:00 AM	Central Missouri, Central Illinois	SERC		Severe Weather - Tornadoes	Unknown	200,000	Weather
	2013-11-17	1:06 PM	11/20/2013	1:06 PM	North Central Indiana	RFC		Severe Weather - Thunderstorms	Unknown	75,065	Weather
	2013-11-17	2:31 PM	11/17/2013	10:30 PM	Entire ComEd Territory Illinois	RFC		Severe Weather - Thunderstorms	Unknown	190,000	Weather
	2013-11-17	4:19 PM	11/18/2013	6:00 PM	Indiana, Michigan	RFC		Severe Weather - Thunderstorms	Unknown	77,346	Weather
	2013-11-17	4:45 PM	11/21/2013	4:45 PM	Entire Lower Peninsula Michigan	RFC		Severe Weather - Thunderstorms	Unknown	50,000	Weather
	2013-11-17	4:47 PM	11/20/2013	4:47 PM	Central Indiana	RFC		Severe Weather - Thunderstorms	Unknown	61,705	Weather
	2013-11-17	4:47 PM	11/20/2013	11:59 AM	Central Indiana	RFC		Severe Weather - Tornadoes	535	61,705	Weather
	2013-11-20	3:08 AM	11/20/2013	3:09 AM	Salt Lake County Utah	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2013-11-21	7:45 PM	11/22/2013	3:20 AM	Northern California	WECC		Severe Weather - Wind Storm	150	89,500	Weather
	2013-11-24	7:38 AM	11/24/2013	7:39 AM	Salt Lake County Utah	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2013-12-04	5:00 AM	12/4/2013	4:17 PM	Idaho Falls Area Idaho, Utah-Idaho Border Utah	WECC		Load Shed 100+ MW	150	Unknown	Load Shed
	2013-12-06	8:47 AM	12/6/2013	8:49 AM	Saratoga, Utah	WECC		Physical Attack - Vandalism, Theft	N/A	N/A	Physical Attack
	2013-12-06	1:51 AM	12/11/2013	12:00 PM	Greater Houston, Texas	TRE		Severe Weather - Ice/Snow	Unknown	881,000	Weather
	2013-12-09	6:54 AM	12/9/2013	2:22 PM	Virginia Service Territory	SERC		Severe Weather - Ice/Snow	293	88,000	Weather
	2013-12-10	1:01 AM	12/11/2013	1:01 AM	Arizona	WECC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2013-12-13	11:00 AM	12/27/2013	11:00 AM	Texas	TRE		Fuel Supply Emergencies (Coal)	Unknown	Unknown	Fuel Supply Deficiency
	2013-12-13	11:00 AM	12/27/2013	11:00 AM	Texas	TE		Fuel Supply Emergencies (Coal)	Unknown	Unknown	Fuel Supply Deficiency
	2013-12-22	3:28 AM	12/28/2013	11:45 PM	Southern Lower Peninsula, Michigan	RFC		Severe Weather - Ice/Snow	Unknown	50,000	Weather
	2013-12-22	6:16 AM	12/24/2013	11:59 PM	Frontier/Genesee/Northern New York	NPCC		Severe Weather - Ice/Snow	Unknown	59,000	Weather
	2013-12-22	6:30 AM	12/25/2013	5:12 AM	Michigan	RFC		Severe Weather - Ice/Snow	350	140,735	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2013-12-23	3:20 PM	12/25/2013	11:32 AM	Central Maine Maine	NPCC		Severe Weather - Ice/Snow	Unknown	52,500	Weather
	2013-12-27	9:43 AM	12/27/2013	12:43 PM	Gilabend Arizona	WECC		Physical Attack	N/A	N/A	Physical Attack
	2013-12-30	11:00 AM	12/30/2013	11:01 AM	Salt Lake County Utah	WECC		Physical Attack	N/A	N/A	Physical Attack
	2013-12-30	11:00 AM	1/1/2014	8:00 AM	North of Roosevelt lake Arizona	WECC		Physical Attack	N/A	N/A	Physical Attack
	2014-01-06	2:37 PM	1/6/2014	2:38 PM	Utah	RFC		Vandalism	N/A	N/A	Physical Attack
	2014-01-06	7:01 AM	1/7/2014	9:00 AM	Texas	TRE		Public Appeal due to Severe Weather - Cold	N/A	N/A	Public Appeal
	2014-01-06	8:45 PM	1/7/2014	9:00 PM	Unknown	RFC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Public Appeal
	2014-01-06	10:00 PM	1/6/2014	10:01 PM	Kentucky	RFC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Public Appeal
	2014-01-06	7:50 PM	1/6/2014	8:44 PM	District of Columbia	RFC		Voltage Reduction due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-06	7:50 PM	1/6/2014	8:44 PM	Unknown	RFC		Voltage Reduction due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-06	7:50 PM	1/6/2014	8:49 PM	Pennsylvania	RFC		Voltage Reduction due to Severe Weather - Cold	200	62,000	Weather
	2014-01-06	7:50 PM	1/6/2014	8:44 PM	Pennsylvania	RFC		Voltage Reduction due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-06	7:52 PM	1/6/2014	8:45 PM	Delaware	RFC		Voltage Reduction due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-07	9:30 AM	1/8/2014	9:30 AM	Piedmont North Carolina, Piedmont South Carolina	SERC		Fuel Supply Emergency due to Severe Weather - Cold	Unknown	Unknown	Fuel Supply Deficiency
	2014-01-07	10:59 AM	1/9/2014	9:00 AM	Illinois	RFC		Fuel Supply Emergency - Natural Gas	N/A	N/A	Fuel Supply Deficiency
	2014-01-07	6:00 AM	1/7/2014	8:30 AM	Northeast Tennessee	SERC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-07	6:00 AM	1/7/2014	8:30 AM	Tennessee	SERC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-07	6:18 AM	1/7/2014	6:19 AM	Pennsylvania	RFC		Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-07	7:58 AM	1/7/2014	11:00 AM	North Carolina	SERC		Voltage Reduction; Public Appeal due to Severe Weather - Cold	14,435	Unknown	Weather
	2014-01-07	4:15 PM	1/8/2014	1:20 PM	North Carolina	SERC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-07	6:00 PM	1/7/2014	11:00 PM	South Carolina	SERC		Voltage Reduction; Public Appeal; Load Shed 100+MW due to Severe Weather - Cold	4,853	677,858	Weather
	2014-01-07	9:00 PM	1/8/2014	9:00 AM	Unknown	RFC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-08	5:00 AM	1/8/2014	6:30 AM	Unknown	RFC		Voltage Reduction due to Severe Weather - Cold	576	Unknown	Weather
	2014-01-08	6:00 AM	1/8/2014	9:00 AM	South Carolina	SERC		Voltage Reduction; Public Appeal; Load Shed 100+MW due to Severe Weather - Cold	4,545	677,858	Weather
	2014-01-13	4:44 PM	1/13/2014	4:45 PM	Arizona	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-01-15	2:32 PM	1/15/2014	2:45 PM	Utah	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-16	12:30 PM	1/16/2014	1:57 PM	Arizona	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-01-17	10:30 AM	1/28/2014	9:00 AM	Illinois	RFC		Fuel Supply Emergency - Natural Gas	Unknown	Unknown	Fuel Supply Deficiency
	2014-01-17	12:20 PM	1/17/2014	12:20 PM	Ohio	RFC		Suspected Physical Attack	Unknown	Unknown	Physical Attack

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	2014-01-18	5:39 PM	Unknown	Unknown	Unknown	RFC		Electrical System Islanding	Unknown	Unknown	Islanding
	2014-01-18	9:00 AM	1/18/2014	9:45 AM	Texas	TRE		Public Appeal to Reduce Electricity Usage	Unknown	Unknown	Public Appeal
	2014-01-21	12:14 PM	1/21/2014	12:39 PM	Missouri	SERC		Physical Attack - Vandalism	10	Unknown	Physical Attack
	2014-01-21	5:00 PM	Unknown	Unknown	New Jersey	RFC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-22	12:30 AM	1/22/2014	2:45 AM	Wisconsin	MRO		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-22	9:45 AM	1/22/2014	8:19 PM	Ohio	RFC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-22	1:55 PM	1/22/2014	2:55 PM	Wisconsin	MRO		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-22	9:15 PM	1/23/2014	3:08 AM	Burlington County, New Jersey	RFC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2014-01-23	9:17 PM	1/24/2014	5:00 PM	Wynoochee, Washington	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-23	4:00 AM	1/24/2014	12:00 PM	Tennessee	SERC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-23	1:04 PM	1/24/2014	9:00 AM	Maryland	RFC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-23	4:00 PM	1/24/2014	12:00 PM	Tennessee	SERC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-24	12:00 AM	4/9/2014	11:53 AM	Wisconsin	RFC		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-01-24	3:30 PM	1/24/2014	5:00 PM	Wisconsin	MRO		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-25	10:00 AM	1/25/2014	11:00 AM	Madison, Wisconsin	MRO		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-26	9:00 PM	1/27/2014	11:00 AM	Oregon	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-01-26	11:00 PM	Unknown	Unknown	New Jersey	RFC		Physical Attack	Unknown	Unknown	Physical Attack
	2014-01-27	2:20 PM	1/28/2014	9:00 PM	Maryland	RFC		Public Appeal due to Severe Weather - Cold	Unknown	Unknown	Weather
	2014-01-29	4:00 PM	1/29/2014	4:44 PM	Unknown	MRO		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-01-30	3:00 PM	Unknown	Unknown	Arizona	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-02-05	7:00 AM	2/23/2014	7:00 AM	New York	NPCC		Fuel Supply Emergency - Coal	300	Unknown	Fuel Supply Deficiency
	2014-02-05	12:00 AM	2/9/2014	6:00 PM	Maryland, West Virginia	RFC		Severe Weather - Snow/Ice	Unknown	101,580	Weather
	2014-02-05	1:00 AM	2/9/2014	8:40 PM	Pennsylvania	RFC		Severe Weather - Snow/Ice	Unknown	144,000	Weather
	2014-02-05	5:00 AM	2/5/2014	5:01 AM	Pennsylvania	RFC		Severe Weather - Snow/Ice	Unknown	715,000	Weather
	2014-02-05	7:35 AM	2/7/2014	4:03 AM	Lancaster Region, Pennsylvania	RFC		Severe Weather - Snow/Ice	Unknown	62,159	Weather
	2014-02-05	8:05 AM	2/5/2014	8:06 AM	Baltimore, Maryland	RFC		Severe Weather - Ice	800	181,000	Weather
	2014-02-06	1:00 PM	2/6/2014	10:00 PM	California	WECC		Fuel Supply Emergency - Natural Gas	4,000	Unknown	Fuel Supply Deficiency
	2014-02-06	1:05 PM	2/6/2014	7:15 PM	Northern California	WECC		Fuel Supply Emergency - Natural Gas	160	Unknown	Fuel Supply Deficiency
	2014-02-06	2:15 PM	2/6/2014	7:39 PM	California	WECC		Fuel Supply Emergency - Natural Gas	611	Unknown	Fuel Supply Deficiency
	2014-02-06	1:58 PM	2/6/2014	8:40 PM	Rio Grande Valley Texas	TRE		Public Appeal to Reduce Electricity Usage	Unknown	Unknown	Public Appeal
	2014-02-06	3:35 PM	2/7/2014	11:30 AM	ERCOT Region Texas	TRE		Public Appeal to Reduce Electricity Usage	Unknown	Unknown	Public Appeal
	2014-02-07	7:00 AM	3/21/2014	8:00 AM	Niagara County New York	NPCC		Fuel Supply Emergency - Coal	675	Unknown	Fuel Supply Deficiency
	2014-02-07	4:30 PM	2/8/2014	9:00 AM	ERCOT Region Texas	TRE		Public Appeal to Reduce Electricity Usage	Unknown	Unknown	Public Appeal
	2014-02-07	4:50 PM	2/7/2014	8:30 PM	Texas	TRE		Public Appeal to Reduce Electricity Usage	Unknown	Unknown	Public Appeal
	2014-02-12	2:15 PM	2/12/2014	2:16 PM	Vermont	NPCC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2014-02-12	7:48 AM	2/15/2014	4:30 AM	Northern/Northeastern Georgia	SERC		Severe Weather - Snow/Ice	1,246	373,835	Weather
	2014-02-12	11:03 AM	2/15/2014	8:40 AM	South Carolina	SERC		Severe Weather - Snow/Ice	700	120,124	Weather
	2014-02-12	12:10 PM	2/15/2014	3:20 PM	North Carolina	SERC		Severe Weather - Snow/Ice	Unknown	200,000	Weather
	2014-02-14	1:00 PM	2/14/2014	3:00 PM	Portland, Oregon	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-02-18	6:43 PM	2/18/2014	6:44 PM	Bend, Oregon	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-02-20	4:40 PM	2/21/2014	11:59 PM	Missouri, Illinois	SERC		Severe Weather - Snow/Ice	Unknown	66,000	Weather
	2014-02-21	2:53 AM	2/21/2014	9:00 PM	Northern/Northeastern Georgia	SERC		Severe Weather - Thunderstorms/High Winds	221	66,445	Weather
	2014-03-02	7:00 PM	3/4/2014	9:00 AM	ERCOT Region Texas	TRE		Public Appeal due to Severe Weather - Cold	N/A	N/A	Islanding
					Mid-Columbia River Generation, Washington	WECC		Fuel Supply Emergency - Hydro	630	Unknown	Fuel Supply Deficiency
	2014-03-03	5:25 PM	3/3/2014	5:25 PM	New York	NPCC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2014-03-03	6:40 AM	3/3/2014	3:28 PM	Tennessee	SERC		Severe Weather - Winter Storm	Unknown	65,904	Weather
	2014-03-04	9:06 AM	3/17/2014	9:06 AM	Weston, Wisconsin	MRO		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-03-05	5:06 PM	3/5/2014	5:07 PM	Salt Lake City, Utah	WECC		Physical Attack	Unknown	Unknown	Physical Attack
	2014-03-07	3:30 AM	3/7/2014	9:00 PM	Triad, North Carolina	SERC		Severe Weather - Winter Storm	1500	370,900	Weather
	2014-03-11	12:00 AM	3/13/2014	12:00 AM	Boone County, Iowa	MRO		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2014-03-12	7:35 PM	3/13/2014	12:00 PM	North Carolina	SERC		Severe Weather - High Winds	250	61,377	Weather
	2014-03-14	12:34 PM	3/14/2014	4:45 PM	Boone County, Iowa	MRO		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-03-17	5:25 PM	3/18/2014	12:56 AM	Glendale, Arizona	WECC		Physical Attack - Sabotage	N/A	N/A	Physical Attack
	2014-03-20	12:00 AM	3/20/2014	12:01 AM	New York	NPCC		Suspected Cyber Attack	Unknown	Unknown	Cyber Attack
	2014-03-24	11:07 AM	3/24/2014	11:08 AM	Salt Lake City, Utah	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-03-26	1:37 PM	3/26/2014	2:33 PM	Montana	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2014-03-26	4:00 PM	4/10/2014	12:00 PM	Iowa	MRO		Physical Attack	N/A	N/A	Physical Attack
	2014-03-31	3:41 PM	3/31/2014	8:08 PM	Puerto Rico	N/A		System Wide Voltage Reduction	Unknown	Unknown	?
	2014-04-03	12:00 AM	Unknown	Unknown	Texas	TRE		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-04-03	2:45 PM	4/9/2014	11:53 AM	Wisconsin	MRO		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-04-04	3:30 AM	4/4/2014	8:15 AM	Central Arkansas	SERC		Severe Weather - Wind	Unknown	57,200	Weather
	2014-04-08	11:09 AM	4/8/2014	11:20 AM	Puerto Rico	N/A		Voltage Reduction	Unknown	Unknown	?
	2014-04-08	1:00 PM	4/8/2014	1:01 PM	Davis, California	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-04-12	6:15 PM	4/14/2014	9:00 AM	Western and Central Michigan	RFC		Severe Weather - Thunderstorms	Unknown	50,000	Weather
	2014-04-12	8:00 PM	4/15/2014	7:30 PM	Michigan	RFC		Severe Weather	Unknown	164,000	Weather
	2014-04-23	7:45 PM	4/23/2014	8:37 PM	Baton Rouge, Louisiana	SERC		Load shedding of 100 Megawatts	163	28,000	Load Shed
	2014-04-24	3:02 PM	4/24/2014	5:13 PM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2014-04-25	7:00 AM	4/25/2014	7:30 AM	Delaware	RFC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-04-27	9:15 AM	Unknown	Unknown	Alberta, Canada	WECC		Electrical System Separation (Islanding)	9750	4,000,000	Islanding
	2014-04-27	12:07 PM	4/27/2014	12:09 PM	Albany, Oregon	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack

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	2014-04-29	9:37 AM	5/1/2014	9:00 AM	Northeastern Mississippi, Northern Alabama	SERC		Severe Weather - Thunderstorms	Unknown	57,000	Weather
	2014-04-29	11:30 PM	4/29/2014	12:30 PM	Mississippi, Alabama	SERC		Severe Weather - Thunderstorms	355	106,648	Weather
	2014-04-30	3:50 AM	4/30/2014	2:00 PM	Alabama, Florida, Georgia	SERC		Severe Weather - Thunderstorms	296	89,000	Weather
	2014-05-08	1:00 AM	5/8/2014	1:01 AM	Mississippi	SERC		Physical Attack	Unknown	Unknown	Physical Attack
	2014-05-08	8:39 AM	5/8/2014	8:40 AM	Imperial Valley, California	WECC		Physical Attack	Unknown	Unknown	Physical Attack
	2014-05-09	6:00 PM	5/11/2014	1:00 PM	Indiana	RFC		Severe Weather - Heavy Winds	Unknown	56,000	Weather
	2014-05-11	6:38 PM	5/11/2014	6:39 PM	MISO North, Minnesota	MRO		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-05-12	1:14 PM	5/12/2014	1:15 PM	Layton, Utah	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-05-14	3:34 PM	Unknown	Unknown	San Diego & Orange Counties, California	WECC		Public Appeal to Reduce Electricity Usage - Wild Fires	N/A	426	Wildfire
	2014-05-15	12:10 PM	5/15/2014	12:13 PM	Whiting, Indiana	RFC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2014-05-15	10:43 AM	Unknown	Unknown	San Diego & Orange Counties, California	WECC		Public Appeal to Reduce Electricity Usage - Wild Fires	3,300	1,400,000	Wildfire
	2014-05-16	10:43 AM	5/16/2014	9:00 PM	San Diego & Orange Counties, California	WECC		Public Appeal to Reduce Electricity Usage - Wild Fires	3,900	1,400,000	Wildfire
	2014-05-20	7:01 AM	5/20/2014	7:02 AM	Duchesne County, Utah	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-05-23	3:00 PM	5/25/2014	7:00 PM	North Carolina	SERC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-05-26	12:31 PM	5/26/2014	1:18 PM	British Columbia & Alberta, Canada	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2014-05-27	11:00 AM	5/27/2014	4:53 PM	Phoenix, Arizona	WECC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-06-03	3:32 PM	6/3/2014	3:59 PM	Alberta, Canada	WECC		Electrical System Islanding	338	N/A	Islanding
	2014-06-03	1:38 AM	6/3/2014	1:43 AM	Texas	ERCOT		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-06-05	3:00 AM	6/7/2014	11:45 PM	Shelby County, Tennessee	SERC		Severe Weather - Thunderstorms	494	38,500	Weather
	2014-06-05	1:06 PM	6/5/2014	1:07 PM	West Tennessee	SERC		Severe Weather - Thunderstorms	Unknown	56,475	Weather
	2014-06-06	1:00 PM	Unknown	Unknown	Texas	ERCOT		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-06-07	11:00 PM	6/8/2014	5:30 AM	North and Central , Alabama	SERC		Severe Weather - Thunderstorms	217	65,000	Weather
	2014-06-09	11:07 AM	6/9/2014	11:30 AM	Alberta, Canada	WECC		Electrical System Islanding	Unknown	Unknown	Islanding
	2014-06-10	9:50 AM	6/11/2014	2:30 PM	West Virginia	RFC		Severe Weather - Thunderstorms	Unknown	66,383	Weather
	2014-06-11	9:30 AM	6/11/2014	9:31 AM	Nogales, Arizona	WECC		Suspected Physical Attack	N/A	N/A	Physical Attack
	2014-06-11	4:00 PM	6/11/2014	4:30 PM	Southern Mississippi	SERC		Physical Attack - Vandalism	N/A	N/A	Physical Attack
	2014-06-12	9:10 AM	6/12/2014	9:11 AM	Somervell County, Texas	ERCOT		Suspected Physical Attack	Unknown	Unknown	physical Attack
	2014-06-15	12:00 AM	6/15/2014	1:00 AM	Central Minnesota	MRO		Severe Weather - Thunderstorms	Unknown	55,951	Weather
	2014-06-18	9:52 AM	6/18/2014	7:00 PM	Washington	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-06-18	5:00 PM	6/20/2014	3:00 PM	Southeast Michigan	RFC		Severe Weather - Thunderstorms	Unknown	138,802	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2014-06-19	8:47 AM	6/19/2014	8:48 AM	Nashville, Tennessee	SERC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-06-24	2:54 PM	6/24/2014	2:55 PM	Nashville, Tennessee	SERC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-06-27	1:21 PM	Unknown	Unknown	Wisconsin	MRO		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-06-30	5:55 PM	7/1/2014	2:53 AM	Southeast Wisconsin	MRO		Severe Weather - Thunderstorms	424	120,000	Weather
	2014-06-30	8:00 PM	7/2/2014	6:30 PM	Illinois	RFC		Severe Weather - Thunderstorms	Unknown	420,000	Weather
	2014-06-30	11:20 PM	7/1/2014	5:00 PM	North Central Indiana	RFC		Severe Weather - Thunderstorms	Unknown	127,000	Weather
	2014-07-01	3:30 AM	Unknown	Unknown	Southwest Michigan	RFC		Severe Weather - Thunderstorms	Unknown	51,000	Weather
	2014-07-01	4:00 AM	7/3/2014	11:30 PM	Southeast Michigan	RFC		Severe Weather - Thunderstorms	Unknown	140,000	Weather
	2014-07-01	5:00 AM	7/2/2014	2:00 AM	Indiana, Michigan	RFC		Severe Weather - Thunderstorms	Unknown	57,237	Weather
	2014-07-02	8:39 AM	7/28/2014	3:13 PM	Wisconsin	MRO		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-07-03	6:00 PM	7/6/2014	12:00 PM	Pennsylvania	RFC		Severe Weather - Thunderstorms	Unknown	298,165	Weather
	2014-07-03	10:55 PM	7/4/2014	1:50 AM	Vermont, New Hampshire, Maine, Rhode Island, Massachusetts, Connecticut	NPCC		Severe Weather - Thunderstorms	Unknown	64,000	Weather
	2014-07-08	5:30 PM	7/12/2014	11:20 PM	Maryland, West Virginia	RFC		Severe Weather - Thunderstorms	Unknown	96,000	Weather
	2014-07-08	5:30 PM	7/12/2014	11:30 PM	West Virginia	RFC		Severe Weather - Thunderstorms	Unknown	71,000	Weather
	2014-07-08	5:30 PM	7/10/2014	3:00 PM	Central and Northeastern Pennsylvania	RFC		Severe Weather - Thunderstorms	Unknown	66,000	Weather
	2014-07-08	6:00 PM	7/11/2014	5:53 PM	Eastern Pennsylvania	RFC		Severe Weather - Thunderstorms	Unknown	69,000	Weather
	2014-07-08	7:21 PM	7/11/2014	7:00 AM	Upstate New York	NPCC		Severe Weather - Thunderstorms	Unknown	65,000	Weather
	2014-07-08	8:30 PM	7/11/2014	11:00 PM	Pennsylvania	RFC		Severe Weather - Thunderstorms	Unknown	260,000	Weather
	2014-07-08	9:31 PM	Unknown	Unknown	Maryland	RFC		Severe Weather - Thunderstorms	Unknown	56,600	Weather
	2014-07-14	4:00 PM	7/14/2014	4:15 PM	Washington	WECC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2014-07-23	7:14 PM	7/24/2014	12:23 AM	Arkansas, Louisiana	SERC		Severe Weather - Thunderstorms	Unknown	57,299	Weather
	2014-07-24	4:29 PM	7/24/2014	11:32 PM	California	WECC		Load shedding of 100 Megawatts	126	26,856	Load Shed
	2014-07-27	11:00 PM	7/28/2014	4:00 AM	Central California	WECC		Uncontrolled Loss of 300 Megawatts	480	1	?
	2014-07-27	5:00 PM	7/28/2014	11:00 PM	Southeast Michigan	RFC		Severe Weather - Thunderstorms	Unknown	156,611	Weather
	2014-08-01	3:03 PM	8/1/2014	3:04 PM	Utah	WECC		Physical Attack	Unknown	Unknown	Physical Attack
	2014-08-13	6:08 AM	8/13/2014	6:34 AM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	370	Unknown	Islanding
	2014-08-20	1:21 AM	8/20/2014	1:41 AM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2014-08-23	4:39 PM	8/24/2014	1:46 AM	City of Highland, Illinois	RFC		Operational Failure of Electrical System	31	6,549	Operations
	2014-08-24	3:20 AM	8/25/2014	7:05 AM	North of San Francisco, California	WECC		Earthquake	95	70,000	Natural Disaster

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2014-08-26	3:30 PM	Unknown	Unknown	Southeast Michigan	RFC		Severe Weather - Thunderstorms	Unknown	Unknown	Weather
	2014-08-27	12:49 PM	8/27/2014	1:30 PM	Delaware	RFC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2014-08-30	3:30 PM	9/1/2014	2:30 PM	Luzerne County, Pennsylvania	RFC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2014-09-05	4:30 PM	9/6/2014	2:00 PM	Illinois	RFC		Severe Weather - Thunderstorms	Unknown	180,400	Weather
	2014-09-05	7:14 PM	9/6/2014	1:00 PM	Lower Peninsula of Michigan	RFC		Severe Weather - Thunderstorms	50	60,000	Weather
	2014-09-05	8:00 PM	Unknown	Unknown	Michigan	RFC		Severe Weather - Thunderstorms	Unknown	324,000	Weather
	2014-09-09	8:18 AM	9/9/2014	11:59 PM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2014-09-11	4:56 AM	9/11/2014	5:37 AM	Alberta, Canada	WECC		Electrical System Separation (Islanding)	Unknown	Unknown	Islanding
	2014-09-14	9:50 PM	9/17/2014	3:08 PM	Oregon	WECC		Electrical System Separation (Islanding)	1	123	Islanding
	2014-09-16	11:56 AM	9/16/2014	11:57 AM	California	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-09-17	1:30 PM	9/17/2014	2:00 PM	Michigan	RFC		Suspected Physical Attack - Suspicious Activity	Unknown	Unknown	Physical Attack
	2014-09-19	2:20 PM	9/23/2014	1:10 PM	Estacada, Oregon	WECC		Electrical System Separation (Islanding)	1	123	Islanding
	2014-09-21	1:30 PM	Unknown	Unknown	New York	NPCC		Physical Attack - Suspicious Activity	Unknown	Unknown	Physical Attack
	2014-09-22	11:00 AM	9/22/2014	11:01 AM	Northeast Minnesota	MRO		Fuel Supply Emergency - Coal	1,000	140,000	Fuel Supply Deficiency
	2014-09-23	1:13 AM	9/23/2014	3:00 AM	New York	NPCC		Physical Attack - Suspicious Activity	N/A	N/A	Physical Attack
	2014-09-24	11:30 AM	9/24/2014	3:43 PM	Washington	WECC		Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-02	3:00 PM	10/2/2014	3:01 PM	Cave Junction, Oregon	WECC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-02	4:00 PM	10/7/2014	10:00 AM	Texas	TRE		Severe Weather - Thunderstorms	Unknown	500,000	Weather
	2014-10-02	10:15 PM	Unknown	Unknown	Arkansas	SERC		Severe Weather - Thunderstorms	Unknown	67,300	Weather
	2014-10-06	10:52 AM	10/7/2014	12:52 AM	Houston, Texas	TRE		Severe Weather - Thunderstorms	292	129,237	Weather
	2014-10-07	12:00 PM	10/7/2014	12:01 PM	Maryland	RFC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-08	4:47 PM	10/8/2014	6:29 PM	Rio Grande Valley Texas	TRE		Public Appeal to Reduce Electricity Usage; Load Shed of 100 MW	Unknown	Unknown	Public Appeal
	2014-10-08	4:49 PM	10/8/2014	6:23 PM	Rio Grande Valley Texas	TRE		Public Appeal to Reduce Electricity Usage; Load Shed of 100 MW	585	120,000	Public Appeal
	2014-10-09	9:27 AM	Unknown	Unknown	Rio Grande Valley Texas	TRE		Public Appeal to Reduce Electricity Usage	Unknown	2,800	Public Appeal
	2014-10-13	12:45 PM	10/13/2014	4:15 PM	Louisiana	SERC		Severe Weather - Thunderstorms	Unknown	68,600	Weather
	2014-10-14	6:20 PM	10/14/2014	6:28 PM	Puerto Rico	N/A		Voltage Reduction	Unknown	Unknown	?
	2014-10-14	7:33 AM	10/14/2014	7:34 AM	Oregon	WECC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-14	5:44 AM	10/14/2014	5:50 PM	Alabama, Florida, Georgia	SERC		Severe Weather - Thunderstorms	191	57,475	Weather
	2014-10-15	7:46 AM	10/15/2014	7:47 AM	Oregon	WECC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-16	9:12 AM	10/17/2014	3:00 PM	Garden City, Kansas	MRO		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-16	1:25 PM	10/16/2014	5:26 PM	Manitoba	MRO		Suspected Physical Attack	129	Unknown	Physical Attack
	2014-10-20	12:00 AM	Unknown	Unknown	Howard County, Texas	MRO		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-21	8:25 AM	10/21/2014	10:08 AM	Carmel, Indiana	MRO		Suspected Cyber Attack	Unknown	Unknown	Cyber Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2014-10-22	10:46 PM	10/22/2014	10:47 PM	New Hampshire, Maine, Massachusetts, Rhode Island, Connecticut, Vermont	NPCC		Severe Weather	Unknown	66,650	Weather
	2014-10-24	4:00 PM	10/24/2014	5:50 PM	Howard County, Texas	MRO		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-24	6:16 PM	10/25/2014	1:51 PM	Enfield, Connecticut	NPCC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-10-25	4:00 PM	10/25/2014	10:00 PM	Greater Portland and Salem, Oregon	WECC		Severe Weather - Wind	216	78,000	Weather
	2014-10-25	6:00 PM	Unknown	Unknown	King County, Thurston County and Kitsap County, Washington	WECC		Severe Weather - Wind	154	96,000	Weather
	2014-11-01	1:00 AM	11/1/2014	1:01 AM	Portland, Oregon	WECC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-11-02	1:46 PM	Unknown	Unknown	Massachusetts, Maine, Vermont, New Hampshire, Rhode Island, Connecticut	NPCC		Severe Weather - Winter Storm	Unknown	63,719	Weather
	2014-11-11	6:00 PM	11/14/2014	3:00 PM	Washington	WECC		Severe Weather - Wind	132	68,000	Weather
	2014-11-12	2:59 AM	11/12/2014	3:00 AM	Unknown	SERC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-11-13	7:07 AM	11/13/2014	7:08 AM	Howard County, Texas	MRO		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-11-14	9:50 AM	11/14/2014	1:18 PM	Estacada, Oregon	WECC		Electrical System Islanding	1	123	Islanding
	2014-11-19	2:44 PM	11/19/2014	2:45 PM	Victorville, California	WECC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-11-21	11:26 AM	11/23/2014	5:20 PM	Sand Springs - Fort Rock, Oregon	WECC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-11-21	8:29 PM	11/23/2014	12:16 AM	Twin Falls, Idaho	WECC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-11-24	12:00 AM	Unknown	Unknown	Nebraska, Kansas, Texas, Arkansas, Louisiana, New Mexico	SPP		Fuel Supply Emergency - Coal	Unknown	Unknown	Fuel Supply Deficiency
	2014-11-24	12:00 PM	11/27/2014	1:00 PM	Michigan	RFC		Severe Weather - Wind	Unknown	186,154	Weather
	2014-11-26	5:50 PM	11/28/2014	7:00 AM	New Hampshire, Massachusetts, Maine, Rhode Island, Connecticut, Vermont	NPCC		Severe Weather - Winter Storm	Unknown	79,530	Weather
	2014-12-01	10:44 AM	12/1/2014	10:45 AM	Fayetteville, North Carolina	SERC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack
	2014-12-03	12:15 PM	12/3/2014	12:16 PM	Maine	NPCC		Suspected Physical Attack - Vandalism	Unknown	Unknown	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
	2014-12-11	7:21 AM	12/11/2014	9:53 PM	San Francisco, California	WECC		Distribution Interruption - Unknown Cause	225	75,000	Distribution Interruption
	2014-12-11	6:40 AM	Unknown	Unknown	Northern California	WECC		Severe Weather- High Winds	Unknown	Unknown	Weather
	2014-12-11	4:05 PM	12/11/2014	9:00 PM	Portland, Oregon	WECC		Severe Weather- High Winds	250	85,470	Weather
	2014-12-11	5:00 PM	12/12/2014	10:00 AM	Kitsap, Thurston, Whatcom counties Washington	WECC		Severe Weather- High Winds	116	264,000	Weather
	2014-12-11	11:15 PM	Unknown	Unknown	Northern California	WECC		Severe Weather- High Winds	Unknown	Unknown	Weather
	2014-12-17	11:00 AM	12/17/2014	12:15 PM	Washington	WECC		Suspected Physical Attack	Unknown	Unknown	Physical Attack
	2014-12-30	3:50 PM	12/31/2014	11:00 AM	New Hampshire, Massachusetts, Maine, Rhode Island, Connecticut, Vermont	NPCC		Suspected Cyber Attack	Unknown	Unknown	Cyber Attack
	2014-12-30	1:08 PM	1/1/2015	4:50 PM	Northern California	WECC		Severe Weather- High Winds	127	84,500	Weather
January	2015-01-07	5:00 PM	1/8/2015	8:35 AM	Tennessee	SERC	Public appeal to reduce the use of electricity	Severe Weather - Winter	Unknown	Unknown	Weather
January	2015-01-07	5:00 PM	1/8/2015	8:35 AM	Tennessee, Kentucky, Virginia, North Carolina, Georgia, Alabama, Missouri	SERC	Public appeal to reduce the use of electricity	Severe Weather - Winter	Unknown	Unknown	Weather
January	2015-01-22	4:24 AM	1/22/2015	5:55 AM	Portland, Oregon	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
January	2015-01-26	2:39 PM	1/26/2015	2:40 PM	Cave Junction, Oregon	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
January	2015-01-27	10:30 AM	1/27/2015	10:31 AM	Kountze, Texas	SERC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
February	2015-02-01	11:24 AM	2/1/2015	11:44 AM	Weber County, Utah	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
February	2015-02-02	9:40 AM	2/2/2015	9:41 AM	Conroe, Texas	TRE	Suspected Physical Attack	Sabotage	Unknown	Unknown	Physical Attack
February	2015-02-04	11:55 AM	2/4/2015	11:56 AM	Vollmers, California	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
February	2015-02-05	8:15 AM	2/5/2015	8:17 AM	Cameron, Arizona	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
February	2015-02-05	11:20 AM	2/5/2015	11:21 AM	Dunsmuir, California	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
February	2015-02-06	8:58 PM	Unknown	Unknown	Northern California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Wind	Unknown	65,000	Weather
February	2015-02-09	11:30 AM	2/9/2015	1:15 PM	Colorado Springs, Colorado	WECC	Suspected Physical Attack	Sabotage	Unknown	Unknown	Physical Attack
February	2015-02-16	9:00 PM	2/18/2015	2:00 PM	Tennessee, Kentucky, Virginia, North Carolina, Georgia, Alabama, Missouri	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Winter	Unknown	67,189	Weather
February	2015-02-16	9:41 PM	2/18/2015	7:00 AM	Northern/North Eastern, Georgia	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Winter	620	186,035	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
February	2015-02-17	6:20 AM	2/17/2015	7:30 AM	Prescott Valley, Arizona	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
February	2015-02-17	2:12 AM	2/18/2015	4:00 PM	North Carolina, South Carolina	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Winter	Unknown	68,000	Weather
February	2015-02-17	9:00 AM	2/18/2015	11:00 PM	North Carolina, South Carolina	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Winter	Unknown	52,000	Weather
February	2015-02-18	3:00 PM	2/20/2015	9:00 AM	Tennessee, Kentucky, Virginia, North Carolina, Georgia, Alabama, Missouri	SERC	Public appeal to reduce the use of electricity	Severe Weather - Winter	Unknown	Unknown	Weather
February	2015-02-19	2:30 PM	2/19/2015	3:20 PM	Winslow, Arizona	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
February	2015-02-20	6:00 AM	2/20/2015	10:00 AM	North Carolina, South Carolina	SERC	System-wide voltage reductions of 3 percent or more	Severe Weather - Winter	Unknown	Unknown	Weather
February	2015-02-21	8:34 AM	2/21/2015	12:45 PM	Fentress County, Tennessee	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Winter	Unknown	50,000	Weather
February	2015-02-26	3:12 AM	2/26/2015	8:00 PM	North Carolina, South Carolina	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Winter	Unknown	124,000	Weather
February	2015-02-26	3:30 AM	2/27/2015	12:00 PM	North Carolina	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Winter	400	103,776	Weather
March	2015-03-04	9:05 AM	3/4/2015	2:15 PM	Johnson City , Tennessee	SERC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
March	2015-03-09	11:50 PM	3/10/2015	10:53 AM	Washington	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
March	2015-03-15	3:30 PM	3/15/2015	7:00 PM	Greater Portland & Salem , Oregon	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Wind	210	71,000	Weather
March	2015-03-16	7:31 AM	3/16/2015	10:06 AM	Winona , Minnesota	MRO	Suspected Physical Attack	Sabotage	20	5,941	Physical Attack
March	2015-03-19	6:30 PM	3/19/2015	9:37 PM	Southwest Kansas	SPP	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
March	2015-03-22	4:25 PM	3/22/2015	4:26 PM	West Virginia	RFC	Suspected Physical Attack	Vandalism	24	0	Physical Attack
March	2015-03-26	3:21 PM	3/26/2015	4:59 PM	Contra Costa County, California	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	15	Unknown	Islanding
March	2015-03-29	4:26 AM	3/29/2015	9:21 AM	California	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
April	2015-04-01	6:25 PM	4/1/2015	6:26 PM	San Juan County, Utah	WECC	Suspected Physical Attack	Vandalism	Unknown	37	Physical Attack
April	2015-04-02	7:04 AM	4/2/2015	8:57 AM	San Juan County, Utah	WECC	Suspected Physical Attack	Vandalism	6	5,763	Physical Attack
April	2015-04-03	2:00 AM	4/3/2015	7:48 AM	Harvey, Reno, and Sedgwick Counties, Kansas	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather - Thunderstorms	Unknown	70,000	Weather
April	2015-04-06	8:12 AM	4/6/2015	12:08 PM	Butte County, California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	System Operations	Unknown	80,000	Operations
April	2015-04-07	3:34 PM	4/7/2015	3:46 PM	California	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	0	0	Islanding
April	2015-04-07	12:30 PM	4/7/2015	5:34 PM	Unknown	RFC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	Unknown	Unknown	Operations

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April	2015-04-17	9:16 AM	4/17/2015	11:00 AM	Canada	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	9,300	Unknown	Islanding
April	2015-04-17	9:30 PM	4/19/2015	11:50 PM	Houston, Texas	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	280,982	Weather
April	2015-04-18	9:00 PM	4/21/2015	4:00 AM	Dallas, Fort Worth, Texas	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	89,000	Weather
April	2015-04-24	7:10 PM	4/26/2015	4:00 PM	Dallas, Fort Worth, Texas	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	57,000	Weather
April	2015-04-27	10:30 AM	4/28/2015	6:45 PM	Louisiana and Texas	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	199,000	Weather
May	2015-05-02	10:51 PM	5/3/2015	12:26 AM	Franklin County, Tennessee	SERC	Suspected Physical Attack	Vandalism	1	215	Physical Attack
May	2015-05-04	3:25 PM	5/4/2015	3:26 PM	Salt Lake County, Utah	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
May	2015-05-11	8:32 AM	5/11/2015	8:33 AM	Shasta County, California	WECC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
May	2015-05-12	12:40 AM	5/12/2015	12:45 AM	Coahoma County, Mississippi	SERC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
May	2015-05-18	3:28 PM	5/18/2015	3:47 PM	Washington	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	Severe Weather	275	0	Weather
May	2015-05-25	6:00 PM	5/29/2015	7:15 AM	North Texas	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	454,000	Weather
May	2015-05-25	8:30 PM	5/26/2015	6:30 PM	Texas	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	57,531	Weather
May	2015-05-25	8:30 PM	Unknown	Unknown	Texas, Louisiana, Arkansas	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	57,351	Weather
May	2015-05-25	10:45 PM	5/28/2015	1:25 AM	Fort Bend County, & Harris County, Texas	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	61,000	Weather
May	2015-05-26	5:30 AM	5/27/2015	7:00 PM	Texas, Louisiana, Arkansas, Mississippi	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	78,515	Weather
June	2015-06-01	7:19 PM	6/2/2015	8:36 AM	California	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	5	484	Islanding
June	2015-06-01	12:27 AM	6/1/2015	2:15 AM	Daviess County, Kentucky	SERC	Suspected Physical Attack	Vandalism	2	110	Physical Attack
June	2015-06-02	6:58 PM	6/2/2015	7:24 PM	California	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	5	727	Islanding
June	2015-06-03	3:00 PM	6/5/2015	5:00 PM	Texas	TRE	Public appeal to reduce the use of electricity	System Operations	Unknown	Unknown	Public Appeal
June	2015-06-07	1:52 PM	6/7/2015	2:13 PM	Tennessee	SERC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	Unknown	Unknown	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
June	2015-06-07	1:54 PM	6/7/2015	2:13 PM	Shelby County, Tennessee	SERC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident System-wide voltage reductions of 3 percent or more	System Operations	926	Unknown	Operations
June	2015-06-08	12:00 AM	Unknown	Unknown	Merced County, California	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	System Operations	176	Unknown	Fuel Supply Deficiency
June	2015-06-20	1:52 PM	6/20/2015	3:30 PM	Solano County, California	WECC	Suspected Physical Attack	Vandalism	Unknown	0	Physical Attack
June	2015-06-23	6:18 PM	6/23/2015	8:30 PM	New Jersey	RFC	Load shedding of 100 Megawatts or more implemented under emergency operational policy Loss of electric service to more than 50,000 customers for 1 hour or more	System Operations	198	156,338	Load Shed
June	2015-06-23	5:06 PM	6/26/2015	4:00 PM	New Castle County, Delaware	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	65,000	Weather
June	2015-06-23	5:30 PM	6/23/2015	7:00 PM	Delaware County, PA; Chester County, PA	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	200,000	Weather
June	2015-06-23	6:00 PM	6/30/2015	6:00 PM	Gloucester County, Burlington County, Atlantic County, Cape May County, New Jersey	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	263,000	Weather
June	2015-06-23	6:26 PM	Unknown	Unknown	New Jersey	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	90	73,000	Weather
June	2015-06-23	6:30 PM	6/24/2015	5:00 AM	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	62,442	Weather
June	2015-06-26	2:00 AM	Unknown	Unknown	Kansas	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	110,000	Weather
June	2015-06-27	5:00 PM	6/30/2015	5:18 PM	Wayne County, Michigan	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	68,000	Weather
June	2015-06-29	7:21 PM	6/29/2015	7:42 PM	Washington	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	Severe Weather	0	0	Weather
June	2015-06-30	10:50 AM	7/1/2015	9:00 PM	California	WECC	Public appeal to reduce the use of electricity	Severe Weather	Unknown	Unknown	Weather
June	2015-06-30	2:00 PM	6/30/2015	9:00 PM	California	WECC	Public appeal to reduce the use of electricity	Severe Weather	Unknown	Unknown	Weather
July	2015-07-03	5:17 PM	7/3/2015	11:30 PM	Texas	TRE	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	350	30,000	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
July	2015-07-03	8:30 AM	7/3/2015	2:30 PM	Butte County, California	WECC	Suspected Physical Attack	Suspicious Activity	0	0	physical Attack
July	2015-07-13	2:14 PM	7/16/2015	6:00 AM	Ohio, Kentucky	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	480	68,339	Weather
July	2015-07-13	7:40 PM	7/15/2015	12:15 PM	Virginia	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	52,739	Weather
July	2015-07-14	3:29 PM	7/15/2015	11:55 AM	Arkansas	SPP	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Severe Weather	Unknown	Unknown	Weather
July	2015-07-14	8:00 PM	7/15/2015	9:23 AM	Alabama	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	366	111,644	Weather
July	2015-07-15	2:00 AM	7/15/2015	2:55 AM	California	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	360	0	Operations
July	2015-07-16	4:45 PM	7/16/2015	5:48 PM	Texas	SPP	Load shedding of 100 Megawatts or more implemented under emergency operational policy	System Operations	117	17,311	Load Shed
July	2015-07-18	6:26 PM	7/18/2015	9:03 PM	California	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	30	70	Islanding
July	2015-07-18	2:00 AM	7/19/2015	7:00 AM	Henepin and Ramsey County, Minnesota	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	250	250,000	Weather
July	2015-07-18	7:59 PM	7/18/2015	10:45 PM	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	160	78,164	Weather
July	2015-07-21	12:47 PM	7/21/2015	1:12 PM	Washington	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	System Operations	200	Unknown	Load Shed
July	2015-07-27	3:52 AM	7/27/2015	4:36 AM	California	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	Unknown	484	Islanding
July	2015-07-28	12:05 PM	7/28/2015	12:26 PM	Puerto Rico	N/A	System-wide voltage reductions of 3 percent or more	System Operations	150	Unknown	Operations
July	2015-07-29	4:45 PM	7/29/2015	9:00 PM	New York	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability	System Operations	500	0	Fuel Supply Deficiency
July	2015-07-30	1:00 PM	Unknown	Unknown	Tennessee	SERC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
July	2015-07-30	9:50 AM	7/30/2015	7:00 PM	Texas	TRE	Public appeal to reduce the use of electricity	System Operations	Unknown	Unknown	Public Appeal
July	2015-07-31	10:55 AM	Unknown	Unknown	Washington	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	System Operations	9	0	Islanding

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2015-08-02	5:45 PM	8/4/2015	3:00 AM	Michigan: Emmet County; Grand Traverse County; Leelanau County; Kalkaska County; Benzie County; Manistee County; Wexford County; Missaukee County; Mecosta County;	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	162,000	Weather
August	2015-08-03	8:27 AM	8/4/2015	1:18 AM	Arizona: New Mexico	WECC	Suspected Physical Attack	Sabotage	0	Unknown	Physical Attack
August	2015-08-03	12:30 AM	8/3/2015	2:00 AM	Illinois	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	115,000	Weather
August	2015-08-03	1:00 AM	8/5/2015	12:00 AM	Michigan	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	72,520	Weather
August	2015-08-04	7:17 AM	8/5/2015	12:52 PM	Massachusetts: Rhode Island;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	132,000	Weather
August	2015-08-11	7:30 PM	8/13/2015	4:05 AM	Texas: Houston;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	100,000	Weather
August	2015-08-13	3:15 PM	8/13/2015	7:00 PM	Texas: Williamson County;	TRE	Public appeal to reduce the use of electricity	Other	Unknown	Unknown	Public Appeal
August	2015-08-27	9:51 PM	8/28/2015	6:00 PM	Puerto Rico	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident / Loss of electric service to more than 50,000 customers for 1 hour or more	System Operations	360	Unknown	Operations
August	2015-08-29	10:00 AM	Unknown	Unknown	Washington	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	500,000	Weather
August	2015-08-29	11:00 AM	9/4/2015	3:00 PM	King County, Skagit County, Whatcom County, Kitsap County, Pierce County, Thurston County, Island County, Washington	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	250	250,000	Weather
August	2015-08-29	1:00 PM	8/31/2015	7:00 AM	Washington: King County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	1,200	64,000	Weather
September	2015-09-03	2:33 AM	9/3/2015	6:25 AM	Michigan	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	50,114	Weather
September	2015-09-13	5:56 PM	9/13/2015	8:37 PM	New York: Dutchess County;	NPCC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
September	2015-09-20	1:12 PM	9/20/2015	1:44 PM	California	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	System Operations	150	Unknown	Load Shed
September	2015-09-29	3:40 PM	9/29/2015	3:41 PM	Oregon	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
October	2015-10-13	6:30 AM	10/13/2015	8:30 AM	Utah: Emery County;	WECC	Suspected Physical Attack	Vandalism	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2015-10-13	10:25 AM	10/13/2015	6:00 PM	Texas	TRE	Public appeal to reduce the use of electricity	Other	Unknown	Unknown	Public Appeal
October	2015-10-13	4:32 PM	10/13/2015	8:39 PM	California	WECC	Public appeal to reduce the use of electricity	Other	41,788	Unknown	Public Appeal
October	2015-10-16	12:25 PM	10/16/2015	12:56 PM	Utah	WECC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
October	2015-10-18	7:00 AM	10/18/2015	11:29 PM	California: Central Coast area;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	88	55,677	Weather
October	2015-10-23	9:42 AM	10/23/2015	1:26 PM	Puerto Rico	N/A	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational / Load shedding of 100 Megawatts or more implemented under emergency operational policy / System-wide voltage reductions of 3 percent of more / Loss of electric service to more than 50,000 customers for 1 hour or more	System Operations	500	300,000	Islanding
October	2015-10-28	1:38 PM	10/29/2015	5:00 PM	Pennsylvania: Columbia County; Montour County; Northumberland County;	RFC	Suspected Physical Attack	Other	Unknown	35,000	physical Attack
October	2015-10-30	3:00 PM	10/30/2015	4:00 PM	Oregon: Josephine County;	WECC	Suspected Physical Attack	Other	0	0	physical Attack
October	2015-10-31	12:45 AM	11/1/2015	4:05 PM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	130,252	Weather
November	2015-11-01	11:53 AM	11/1/2015	12:00 PM	Ohio: Hamilton County;	RFC	Suspected Physical Attack	Vandalism	0	0	physical Attack
November	2015-11-02	5:37 PM	11/4/2015	9:00 AM	Arkansas: Hot Spring County;	SERC	Suspected Physical Attack	Sabotage	4	0	physical Attack
November	2015-11-10	12:00 PM	11/10/2015	2:00 PM	Indiana: Dearborn County;	RFC	Suspected Physical Attack	Sabotage	0	0	physical Attack
November	2015-11-13	11:30 AM	11/13/2015	11:35 AM	New York	NPCC	Suspected Physical Attack	Suspicious Activity	Unknown	Unknown	physical Attack
November	2015-11-17	9:00 AM	Unknown	Unknown	Washington: Snohomish County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	900	89,000	Weather
November	2015-11-17	10:00 AM	Unknown	Unknown	Washington	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	300,000	Weather
November	2015-11-17	1:30 PM	Unknown	Unknown	Washington: Stevens County, Lincoln County, Adams County, Whitman County, Spokane County; Idaho: Bonner County, Kootenai County, Shoshone County, Benewah County, Idaho County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	182,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
November	2015-11-21	8:30 PM	11/23/2015	1:00 AM	Michigan	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	60,000	Weather
November	2015-11-28	6:00 AM	11/30/2015	1:00 PM	Oklahoma	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	55,609	Weather
November	2015-11-28	6:00 AM	Unknown	Unknown	Oklahoma	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	35,000	Weather
November	2015-11-29	4:48 PM	11/29/2015	6:20 PM	Puerto Rico	N/A	System-wide voltage reductions of 3 percent or more	System Operations	0	0	Operations
November	2015-11-30	6:18 AM	11/30/2015	9:18 PM	Puerto Rico	N/A	System-wide voltage reductions of 3 percent or more	System Operations	100	86,559	Operations
December	2015-12-02	1:03 PM	12/3/2015	12:29 PM	Kansas: Thomas County;	SPP	Suspected Physical Attack	Vandalism	0	0	Physical Attack
December	2015-12-05	7:22 PM	12/6/2015	5:27 AM	New York: Orange County, Sullivan County; Pennsylvania: Pike County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Other	110	52,476	Operations
December	2015-12-05	9:00 PM	12/5/2015	10:30 PM	Kansas	SPP	Suspected Physical Attack	Vandalism	0	0	Physical Attack
December	2015-12-08	2:00 PM	12/8/2015	2:01 PM	Nevada: Clark County;	WECC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
December	2015-12-09	6:06 PM	12/9/2015	9:52 PM	Puerto Rico		System-wide voltage reductions of 3 percent or more	System Operations	0	0	Operations
December	2015-12-09	4:00 AM	12/9/2015	11:00 AM	Washington	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	115	76,300	Weather
December	2015-12-10	3:53 AM	12/10/2015	4:08 AM	California: Plumas County	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	Severe Weather	24	9,956	Islanding
December	2015-12-10	9:25 PM	12/10/2015	10:30 PM	Missouri: New Madrid County;	SERC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	400	1	Operations
December	2015-12-10	5:55 PM	12/10/2015	5:56 PM	California: Stanislaus County;	WECC	Suspected Physical Attack	Vandalism	Unknown	Unknown	Physical Attack
December	2015-12-10	6:01 AM	12/10/2015	7:13 AM	California: Northern;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational	Severe Weather	29	9,956	Weather
December	2015-12-24	3:00 AM	12/26/2015	12:00 AM	Michigan: Antrim County, Charlevoix County, Manistee County, Mecosta County, Kalkaska County, Grand Traverse County, Osceola County, Lake County, Newaygo County, Clare County, Isabella County;	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	168,000	Weather
December	2015-12-26	6:00 PM	12/30/2015	6:00 AM	Texas: Oklahoma;	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	116,800	Weather
December	2015-12-26	7:30 PM	Unknown	Unknown	Texas	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	70,000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2015-12-27	5:00 PM	Unknown	Unknown	Oklahoma	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	50,500	Weather
December	2015-12-27	11:38 PM	12/28/2015	5:00 PM	Oklahoma	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	54,476	Weather
December	2015-12-29	8:30 AM	12/29/2015	8:31 AM	Maine	NPCC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
December	2015-12-31	11:00 AM	Unknown	Unknown	Missouri	SERC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
December	2015-12-31	5:00 PM	12/31/2015	9:40 PM	Oklahoma: Blaine County;	SPP	Public appeal to reduce the use of electricity	Severe Weather	8	1,500	Weather
January	2016-01-04	5:15 AM	1/5/2016	8:00 AM	Wisconsin: Milwaukee County;	MRO	Suspected Physical Attack	Sabotage	0	0	Physical Attack
January	2016-01-10	8:46 PM	1/11/2016	5:25 AM	Maine: Connecticut: Massachusetts: Vermont: New Hampshire: Rhode Island:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	59,859	Weather
January	2016-01-11	8:16 PM	1/11/2016	11:00 PM	Pennsylvania: Chester County;	RFC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
January	2016-01-14	8:27 AM	1/14/2016	12:00 PM	Delaware:	RFC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
January	2016-01-17	12:00 PM	1/17/2016	1:00 PM	Utah: Salt Lake County;	WECC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
January	2016-01-22	3:52 PM	1/24/2016	12:30 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	150,000	Weather
January	2016-01-23	7:49 AM	1/23/2016	9:05 AM	New Jersey:	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	50,900	Weather
February	2016-02-05	11:21 AM	2/6/2016	3:48 PM	Connecticut: Massachusetts: Rhode Island:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	115057	Weather
February	2016-02-07	11:30 AM	Unknown	Unknown	New York: Orange County	NPCC	Suspected Cyber Attack	Cyber Attack	Unknown	Unknown	Cyber Attack
February	2016-02-07	1:21 PM	2/7/2016	1:42 PM	Utah: Salt Lake County	WECC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
February	2016-02-07	2:58 PM	Unknown	Unknown	Oregon: Klamath County	WECC	Suspected Physical Attack	Sabotage	Unknown	Unknown	Physical Attack
February	2016-02-13	12:44 PM	2/13/2016	4:27 PM	California	SERC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Islanding	7	4300	Islanding
February	2016-02-16	8:35 AM	2/16/2016	5:28 PM	Virginia: Roanoke County, Montgomery County; West Virginia: Kanawha County, Cabell County; Tennessee: Sullivan County;	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	52640	Weather
February	2016-02-19	10:00 PM	2/20/2016	11:13 PM	Michigan	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	145314	Weather
February	2016-02-21	3:54 PM	2/21/2016	5:07 PM	Oregon: Klamath County	WECC	Suspected Physical Attack	Sabotage	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
February	2016-02-24	9:10 AM	2/24/2016	10:15 AM	Delaware	RFC	Suspected Physical Attack	Vandalism	0	0	physical Attack
February	2016-02-24	2:45 PM	2/25/2016	5:00 AM	North Carolina: South Carolina	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	400	284610	Weather
February	2016-02-25	1:44 AM	2/25/2016	2:45 PM	Connecticut: Maine: Massachusetts: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	114190	Weather
February	2016-02-26	12:01 AM	Unknown	Unknown	California: San Bernardino County	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
February	2016-02-26	4:35 PM	2/26/2016	8:22 PM	Arizona: Maricopa County	WECC	Suspected Physical Attack	Sabotage - Operator Action(s)	2	2713	physical Attack
March	2016-03-01	1:35 PM	Unknown	Unknown	Idaho: Ada County;	WECC	Suspected Physical Attack	Vandalism	0	0	physical Attack
March	2016-03-01	3:00 PM	Unknown	Unknown	Washington: King County, Whatcom County, Kitsap County, Skagit County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	56000	Weather
March	2016-03-03	11:00 AM	4/6/2016	7:47 PM	California: San Bernardino County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
March	2016-03-08	12:00 AM	3/8/2016	12:00 AM	Idaho: Bannock County;	WECC	Suspected Physical Attack	Sabotage	0	0	physical Attack
March	2016-03-10	4:00 AM	3/11/2016	11:59 AM	Washington: Kitsap County, King County, Whatcom County, Island County, Skagit County;	WECC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
March	2016-03-13	2:00 PM	Unknown	Unknown	Washington: Island County, Skagit County, Whatcom County, King County, Kitsap County, Pierce County, Thurston County;	WECC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
March	2016-03-13	4:55 PM	Unknown	Unknown	Washington:	WECC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
March	2016-03-23	5:00 AM	3/25/2016	11:59 PM	Colorado: Denver, City and County of[12];	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	0	0	Weather
March	2016-03-27	12:00 PM	3/27/2016	1:00 PM	Nevada: Clark County;	WECC	Suspected Physical Attack	Sabotage	Unknown	110000	Physical Attack
March	2016-03-30	9:12 PM	3/31/2016	3:00 PM	Massachusetts: Middlesex County[13];	NPCC	Suspected Physical Attack	Sabotage	200	50500	Physical Attack
April	2016-04-01	4:37 PM	4/1/2016	6:00 PM	Florida: Hillsborough County	FRCC	Suspected Physical Attack	Sabotage	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
April	2016-04-02	11:08 AM	4/2/2016	11:33 AM	California	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	360	0	Operations
April	2016-04-12	11:30 AM	4/12/2016	4:43 PM	Washington: Pend Oreille County	WECC	Suspected Cyber Attack	Cyber Attack	0	0	Cyber Attack
April	2016-04-14	4:49 PM	4/15/2016	8:42 PM	Maryland: Baltimore County	RFC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
April	2016-04-15	10:00 AM	4/15/2016	11:00 AM	Utah: Weber County	WECC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
April	2016-04-18	5:05 AM	4/20/2016	7:55 AM	Texas: Harris County	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	415103	Weather
April	2016-04-27	1:36 PM	Unknown	Unknown	Tennessee	SERC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
April	2016-04-27	6:00 PM	4/27/2016	6:05 PM	Texas: Rusk County	TRE	Suspected Physical Attack	Sabotage	0	0	Physical Attack
April	2016-04-27	5:50 AM	4/28/2016	1:35 AM	Texas: Harris County	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	214864	Weather
May	2016-05-07	7:49 AM	5/7/2016	9:02 AM	New York: Dutchess County;	NPCC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
May	2016-05-08	9:12 AM	Unknown	Unknown	Washington: Clark County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Islanding	Unknown	Unknown	Islanding
May	2016-05-10	8:45 PM	5/13/2016	3:00 AM	Texas: Dallas County, Tarrant County, Parker County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Distribution Interruption	Unknown	85000	Distribution Interruption
May	2016-05-14	9:25 PM	5/15/2016	5:24 PM	Missouri:	SERC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
May	2016-05-19	9:36 PM	5/20/2016	1:00 AM	Utah:	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	461	85179	Operations
May	2016-05-20	12:00 AM	5/22/2016	5:00 AM	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Distribution Interruption	Unknown	85000	Distribution Interruption
May	2016-05-20	1:15 AM	Unknown	Unknown	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	Unknown	57184	Weather
May	2016-05-24	8:00 AM	Unknown	Unknown	Missouri:	SERC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
May	2016-05-26	9:29 PM	5/27/2016	12:40 AM	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Transmission Interruption	82	56645	Transmission Interruption
May	2016-05-31	7:30 AM	6/13/2016	7:27 AM	New York: Tompkins County;	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	150	Unknown	Fuel Supply Deficiency
June	2016-06-07	12:00 PM	6/7/2016	12:15 PM	Utah	WECC	Suspected Physical Attack	Sabotage	0	0	Physical Attack
June	2016-06-14	7:59 AM	6/14/2016	8:00 AM	New Jersey	RFC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
June	2016-06-17	4:30 AM	6/17/2016	4:31 AM	Delaware	RFC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
June	2016-06-17	3:40 PM	6/18/2016	8:34 AM	Georgia, Alabama, Mississippi, Florida	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather	304	91260	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
July	2016-07-02	4:00 AM	7/4/2016	12:40 AM	Oregon: Multnomah County	WECC	Suspected Physical Attack	Actual Physical Event	0	0	Physical Attack
July	2016-07-05	2:45 AM	7/6/2016	3:00 AM	Texas: Dallas County, Tarrant County	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	52000	Weather
July	2016-07-05	5:30 PM	7/6/2016	4:00 PM	Minnesota, Wisconsin	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	250000	Weather
July	2016-07-07	5:53 AM	7/7/2016	8:40 AM	North Carolina: New Hanover County	SERC	Actual Physical Attack	Vandalism	0	0	Physical Attack
July	2016-07-07	4:20 AM	7/7/2016	8:00 AM	Kansas: Johnson County; Missouri: Jackson County, Platte County, Cass County, Buchanan County, Atchison County, Andrew County, Clay County, Nodaway County	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	58500	Weather
July	2016-07-08	6:00 PM	Unknown	Unknown	West Virginia: Virginia	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	62961	Weather
July	2016-07-08	7:00 PM	7/9/2016	12:00 AM	Michigan: Wayne County, Oakland County, Macomb County, St. Clair County, Lapeer County, Tuscola County, Sanilac County, Huron County	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	160895	Weather
July	2016-07-08	8:50 PM	7/9/2016	7:25 PM	North Carolina	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	600	203345	Weather
July	2016-07-09	5:45 PM	7/11/2016	2:00 PM	Texas: Dallas County	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	62000	Weather
July	2016-07-12	2:10 PM	7/12/2016	8:33 PM	Puerto Rico	PR	Voltage Reduction	System Operations	450	218000	Operations
July	2016-07-13	1:00 PM	7/13/2016	1:01 PM	Washington	WECC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
July	2016-07-13	3:00 PM	Unknown	Unknown	Tennessee: Shelby County	SERC	Public Appeal	System Operations	Unknown	Unknown	Public Appeal
July	2016-07-14	2:44 PM	7/15/2016	4:00 AM	Oklahoma	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	96966	Weather
July	2016-07-14	4:30 PM	7/16/2016	12:00 AM	Arkansas: Louisiana; Mississippi: Texas	SPP, SERC, TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	170244	Weather
July	2016-07-14	5:30 PM	7/16/2016	8:00 PM	Oklahoma: Arkansas	SPP	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	7300	Weather
July	2016-07-19	3:45 PM	7/19/2016	7:29 PM	Idaho	WECC	Islanding, Uncontrolled Loss 300+ MW	System Operations	290	Unknown	Operations
July	2016-07-19	3:45 PM	7/19/2016	7:25 PM	Idaho	WECC	Islanding, Uncontrolled Loss 300+ MW	System Operations	485	Unknown	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
July	2016-07-21	7:21 PM	7/22/2016	12:09 AM	Puerto Rico	PR	Load Shed 100+ MW, Voltage Reduction	System Operations	200	266000	Load Shed
July	2016-07-21	6:18 AM	7/21/2016	2:45 PM	Delaware: New Castle County	RFC	Suspected Physical Attack	Suspicious Activity	0	0	Physical Attack
July	2016-07-22	11:50 PM	7/23/2016	9:10 AM	Massachusetts: Connecticut: Rhode Island: New Hampshire: Vermont: Maine	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	57058	Weather
July	2016-07-23	3:15 PM	7/23/2016	7:53 PM	Pennsylvania: Cambria County	RFC	Voltage Reduction	System Operations	87	Unknown	Operations
July	2016-07-23	7:30 PM	7/24/2016	7:30 AM	Connecticut: Massachusetts: New Hampshire: Vermont: Rhode Island	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	101073	Weather
July	2016-07-25	6:51 PM	7/26/2016	2:19 AM	Puerto Rico	PR	Voltage Reduction	System Operations	0	0	Operations
July	2016-07-26	6:51 PM	7/27/2016	1:45 AM	Puerto Rico	PR	Voltage Reduction	System Operations	25	37100	Operations
July	2016-07-27	6:50 PM	7/28/2016	1:38 AM	Puerto Rico	PR	Voltage Reduction	System Operations	80	106300	Operations
July	2016-07-28	6:51 PM	7/29/2016	2:02 AM	Puerto Rico	PR	Voltage Reduction	System Operations	22	21600	Operations
July	2016-07-29	7:09 PM	7/29/2016	7:57 PM	Puerto Rico	PR	Voltage Reduction	System Operations	0	0	Operations
August	2016-08-04	2:15 PM	8/4/2016	2:23 PM	Delaware: New Castle County;	RFC	Suspected Physical Attack	Vandalism	0	0	Physical Attack
August	2016-08-07	6:39 PM	8/7/2016	8:27 PM	New Mexico: Bernalillo County;	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	Unknown	Unknown	Operations
August	2016-08-10	6:00 AM	Unknown	Unknown	California: Butte County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
August	2016-08-11	4:30 PM	8/11/2016	7:15 PM	Ohio:	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	62140	Weather
August	2016-08-13	11:42 AM	8/13/2016	2:07 PM	South Carolina:	SERC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	506	0	Operations
August	2016-08-20	2:18 PM	8/20/2016	9:19 PM	New York:	NPCC	Actual Physical Attack	Actual Physical Event	Unknown	40000	Physical Attack
August	2016-08-23	5:00 PM	8/24/2016	12:05 AM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	72200	Weather
August	2016-08-24	7:18 PM	8/24/2016	7:47 PM	Washington: King County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Islanding	9232	Unknown	Islanding
August	2016-08-24	6:13 PM	8/24/2016	7:14 PM	Puerto Rico:	PR	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	System Operations	600	400000	Operations
August	2016-08-25	6:40 PM	8/26/2016	6:19 PM	Oregon: Crook County;	WECC	Suspected Physical Attack	Vandalism	0	0	Physical Attack

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August	2016-08-31	2:52 PM	Unknown	Unknown	Washington: Clark County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Islanding	0	0	Islanding
August	2016-08-31	9:45 AM	8/31/2016	9:55 AM	Colorado:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Transmission Interruption	0	0	Transmission Interruption
September	2016-09-01	10:00 PM	Unknown	Unknown	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	100	Unknown	Weather
September	2016-09-02	12:40 AM	9/4/2016	8:00 PM	Florida: Leon County, Wakulla County;	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	450	75000	Weather
September	2016-09-02	4:00 AM	9/2/2016	4:00 PM	Florida: Alachua County, Bay County, Citrus County, Columbia County, Dixie County, Franklin County, Gilchrist County, Gulf County, Hamilton County, Hardee County, Hernando County, Highlands County, Jefferson County, Lafayette County, Lake County, Levy County, Madison County, Marion County, Orange County, Osceola County, Pasco County, Pinellas County, Polk County, Seminole County, Sumter County, Suwannee County, Taylor County, Volusia County, Wakulla County;	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	225	90000	Weather
September	2016-09-02	5:45 AM	9/3/2016	12:30 AM	Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	57000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
September	2016-09-06	6:12 PM	9/6/2016	9:24 PM	Washington: Clark County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Islanding	300	Unknown	Islanding
September	2016-09-08	8:30 AM	9/25/2016	12:00 AM	New York: Tompkins County;	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	210	Unknown	Fuel Supply Deficiency
September	2016-09-08	2:49 PM	9/8/2016	3:03 PM	Washington:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Islanding	0	0	Islanding
September	2016-09-10	9:42 AM	9/10/2016	9:57 AM	Washington: Clark County;	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	Generation Inadequacy	135	Unknown	Generation Interruption
September	2016-09-11	12:05 PM	9/11/2016	3:10 PM	Connecticut: Massachusetts: New Hampshire: Rhode Island: Vermont: Maine:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	57960	Weather
September	2016-09-12	12:30 PM	9/12/2016	5:56 PM	New Mexico: Bernalillo County, Sandoval County, Santa Fe County, Valencia County;	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	Generation Inadequacy	110	53753	Generation Interruption
September	2016-09-21	2:30 PM	9/24/2016	2:30 AM	Puerto Rico:		Complete operational failure or shut-down of the transmission and/or distribution electrical system	System Operations	2750	1475000	Operations
September	2016-09-21	7:44 PM	9/21/2016	9:17 PM	Texas: Lubbock County;	TRE	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Event	0	0	Physical Attack
September	2016-09-22	10:56 AM	9/22/2016	11:41 AM	Iowa: Black Hawk County;	MRO	Complete operational failure or shut-down of the transmission and/or distribution electrical system	System Operations	69	19124	Operations
September	2016-09-25	12:49 PM	9/25/2016	6:20 PM	Utah: Kane County, Garfield County; Arizona: Coconino County, Mohave County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	20	10000	Physical Attack
October	2016-10-01	12:24 PM	10/02/2016	2:04 AM	California: Mendocino County;	WECC	Physical attack that causes major interruptions or impacts to critical infrastructure facilities or to operations	Actual Physical Event	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2016-10-02	11:30 PM	10/05/2016	8:00 AM	Utah:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Transmission Interruption	50	4000	Transmission Interruption
October	2016-10-03	3:09 PM	10/04/2016	7:00 PM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Public Appeal	Unknown	Unknown	Public Appeal
October	2016-10-05	3:51 PM	Unknown	Unknown	California: Imperial County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2016-10-05	11:32 AM	10/05/2016	7:00 PM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Public Appeal	Unknown	Unknown	Public Appeal
October	2016-10-06	9:50 AM	10/06/2016	7:00 PM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Public Appeal	Unknown	Unknown	Public Appeal
October	2016-10-06	7:30 PM	10/8/2016	6:00 PM	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	5600	1200000	Weather
October	2016-10-07	11:08 AM	10/07/2016	7:00 PM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Generation Inadequacy	Unknown	Unknown	Generation Interruption

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2016-10-07	8:00 AM	10/09/2016	1:00 PM	Florida: Alachua County, Bay County, Citrus County, Columbia County, Dixie County, Franklin County, Gilchrist County, Gulf County, Hamilton County, Hardee County, Hernando County, Highlands County, Jefferson County, Lafayette County, Lake County, Levy County, Madison County, Marion County, Orange County, Osceola County, Pasco County, Pinellas County, Polk County, Seminole County, Sumter County, Suwannee County, Taylor County, Volusia County, Wakulla County;	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	413	165000	Weather
October	2016-10-07	4:22 PM	10/12/2016	11:00 AM	Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	122	36384	Weather
October	2016-10-07	10:45 PM	Unknown	Unknown	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	Unknown	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2016-10-07	11:00 PM	Unknown	Unknown	South Carolina: Allendale County, Bamberg County, Beaufort County, Berkeley County, Charleston County, Chesterfield County, Clarendon County, Colleton County, Darlington County, Dorchester County, Florence County, Georgetown County, Hampton County, Horry County, Jasper County, Kershaw County, Lee County, Marion County, Marlboro County, Orangeburg County, Richland County, Sumter County, Williamsburg County;	SERC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	Unknown	Weather
October	2016-10-08	1:10 AM	Unknown	Unknown	South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	1050	290824	Weather
October	2016-10-08	8:21 AM	10/13/2016	5:30 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	Unknown	Weather
October	2016-10-08	2:05 PM	10/09/2016	6:06 AM	North Carolina:	SERC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Severe Weather	Unknown	44875	Weather
October	2016-10-10	1:15 PM	10/10/2016	7:00 PM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Generation Inadequacy	Unknown	Unknown	Generation Interruption
October	2016-10-12	12:09 PM	10/12/2016	1:16 PM	Nevada: Clark County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	4	1671	Physical Attack

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October	2016-10-18	2:06 PM	10/21/2016	3:00 PM	Oregon: Deschutes County, Lake County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2016-10-20	12:30 PM	10/20/2016	12:31 PM	Oregon:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2016-10-25	7:40 AM	10/27/2016	7:40 AM	Tennessee: Shelby County;	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2016-10-26	5:26 AM	10/26/2016	5:27 AM	Wyoming: Sweetwater County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2016-10-28	1:29 PM	10/28/2016	1:38 PM	California: Plumas County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Islanding	4	482	Islanding
October	2016-10-31	8:06 AM	10/31/2016	3:53 PM	North Carolina: Stokes County;	SERC	Physical attack that causes major interruptions or impacts to critical infrastructure facilities or to operations	Actual Physical Event	0	0	Physical Attack
November	2016-11-01	8:55 PM	Unknown	Unknown	Washington: Clark County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Transmission Interruption	0	0	Transmission Interruption
November	2016-11-09	11:59 AM	11/09/2016	6:15 PM	California: Stanislaus County, San Joaquin County, Alameda County, Tuolumne County;	WECC	Cyber event that could potentially impact electric power system adequacy or reliability	Cyber Attack	0	0	Cyber Attack
November	2016-11-09	6:44 AM	11/09/2016	7:44 AM	California:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2016-12-08	1:00 AM	12/08/2016	2:30 AM	Oregon: Multnomah County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack

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December	2016-12-11	7:45 AM	12/11/2016	7:46 AM	Utah: Utah County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2016-12-13	2:09 PM	12/13/2016	2:30 PM	California: Riverside County;	WECC	Cyber event that could potentially impact electric power system adequacy or reliability	Cyber Event	0	0	Cyber Attack
December	2016-12-15	6:30 AM	Unknown	Unknown	California: Merced County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	Unknown	Unknown	Fuel Supply Deficiency
December	2016-12-16	7:45 AM	12/16/2016	8:45 AM	Oregon: Multnomah County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2016-12-26	4:00 AM	12/26/2016	6:00 AM	Washington:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2016-12-28	4:03 AM	12/31/2016	6:00 AM	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
December	2016-12-30	8:55 AM	12/30/2016	8:56 AM	Vermont: Chittenden County;	NPCC	Cyber event that could potentially impact electric power system adequacy or reliability	Other	0	0	Cyber Attack
December	2016-12-30	2:30 AM	12/30/2016	7:00 PM	Maine:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Weather or Natural Disaster	Unknown	85263	Weather
January	2017-01-05	4:56 PM	01/05/2017	4:57 PM	Florida: Martin County;	FRCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspected Physical Attack	0	0	Physical Attack
January	2017-01-08	11:59 PM	Unknown	Unknown	California	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
January	2017-01-08	9:07 AM	01/13/2017	2:30 PM	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	106000	Weather
January	2017-01-10	7:30 PM	01/13/2017	2:30 PM	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	87000	Weather
January	2017-01-15	6:35 AM	01/15/2017	7:44 AM	California: Los Angeles County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Transmission Disruption	176	126000	Transmission Interruption
January	2017-01-15	9:27 AM	01/17/2017	1:58 AM	Oklahoma: Harper County;	SPP	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Severe Weather	1	788	Weather
January	2017-01-18	6:05 PM	01/19/2017	12:05 AM	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	75000	Weather
January	2017-01-22	6:00 AM	Unknown	Unknown	California	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
January	2017-01-22	4:15 AM	01/24/2017	2:00 PM	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	97	64000	Weather
January	2017-01-22	4:00 PM	01/23/2017	3:26 AM	Alabama: Georgia: Mississippi: Florida:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	100	29965	Weather
February	2017-02-02	1:04 AM	2/2/2017	5:00 AM	New Mexico: Bernalillo County, Santa Fe County;	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Transmission Interruption	396	149223	Transmission Interruption
February	2017-02-02	1:11 AM	Unknown	Unknown	New Mexico: Bernalillo County;	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Transmission Interruption	400	Unknown	Transmission Interruption
February	2017-02-06	1:00 AM	2/6/2017	7:30 PM	Washington: Skagit County, King County, Kitsap County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	103000	Weather
February	2017-02-09	4:05 PM	2/10/2017	5:15 AM	Connecticut: Massachusetts: Rhode Island:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	11525	Weather
February	2017-02-11	3:46 PM	2/11/2017	3:50 PM	Utah	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Attack	0	0	Physical Attack
February	2017-02-13	1:00 PM	2/15/2017	1:35 PM	North Carolina: Union County;	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
February	2017-02-17	4:32 AM	2/17/2017	5:02 AM	Missouri: Arkansas: Oklahoma: Texas:	SPP	Cyber event that could potentially impact electric power system adequacy or reliability	System Operations	0	0	Cyber Attack
February	2017-02-17	1:00 PM	2/17/2017	1:15 PM	Nevada: Clark County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
February	2017-02-17	8:09 AM	2/22/2017	7:30 PM	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	254	169250	Weather
February	2017-02-17	3:00 PM	2/20/2017	11:00 AM	California: Los Angeles County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	111591	Weather
March	2017-03-01	8:30 AM	03/01/2017	2:00 PM	Tennessee: Kentucky:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	58000	Weather
March	2017-03-01	11:49 AM	03/02/2017	9:30 PM	Kentucky: West Virginia:	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	98575	Weather
March	2017-03-02	12:20 PM	03/02/2017	11:45 PM	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	54316	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
March	2017-03-06	8:00 PM	03/07/2017	1:00 AM	Missouri: Jackson County, Platte County, Cass County, Lafayette County, Chariton County, Carroll County, Clay County, Johnson County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	97734	Weather
March	2017-03-08	9:30 AM	03/11/2017	5:00 AM	Michigan: Jackson County, Calhoun County, Ingham County, Hillsdale County, Washtenaw County, Kent County, Ottawa County, Midland County, Saginaw County;	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	343000	Weather
March	2017-03-08	11:30 AM	03/08/2017	7:52 PM	Ohio	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	71012	Weather
March	2017-03-08	12:00 PM	03/11/2017	11:31 AM	Michigan	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	800000	Weather
March	2017-03-08	1:30 PM	03/08/2017	4:30 PM	New York	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather/Transmission Interruption	Unknown	106869	Weather
March	2017-03-08	3:33 PM	Unknown	Unknown	New York	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	50000	Weather
March	2017-03-12	9:56 AM	03/12/2017	11:20 AM	California: Imperial County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	1	Physical Attack
March	2017-03-14	12:32 PM	Unknown	Unknown	Connecticut: Massachusetts: Rhode Island: New Hampshire: Maine: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	69647	Weather
March	2017-03-21	8:00 PM	03/22/2017	9:15 AM	Georgia	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	857	257000	Weather
March	2017-03-24	6:29 AM	03/24/2017	7:13 AM	Oregon: Clatsop County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Sabotage	0	0	Physical Attack
March	2017-03-28	4:07 PM	03/28/2017	4:08 PM	Oregon: Josephine County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspicious Activity	0	0	Physical Attack
March	2017-03-29	3:30 AM	03/31/2017	6:00 AM	Texas	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	175000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
March	2017-03-31	7:15 PM	03/31/2017	9:07 PM	Mississippi: DeSoto County;	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
April	2017-04-03	11:00 AM	04/03/2017	8:00 PM	Alabama, Georgia	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	290	86330	Weather
April	2017-04-06	7:00 PM	Unknown	Unknown	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	100000	Weather
April	2017-04-07	4:16 AM	Unknown	Unknown	California: Fresno County	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
April	2017-04-07	4:33 AM	04/07/2017	8:20 AM	Oregon	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	100	64852	Weather
April	2017-04-07	8:15 AM	04/08/2017	12:14 AM	Oregon: Multnomah County, Washington County, Marion County, Clackamas County	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	153867	Weather
April	2017-04-13	7:50 AM	04/13/2017	8:07 AM	Washington: Pierce County	WECC	Physical attack that causes major interruptions or impacts to critical infrastructure facilities or to operations	Sabotage	53	10000	Physical Attack
April	2017-04-17	9:25 AM	04/17/2017	9:26 AM	Utah: Emery County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Sabotage	0	0	Physical Attack
April	2017-04-20	4:00 PM	04/20/2017	6:00 PM	Wyoming: Converse County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
April	2017-04-21	9:06 AM	04/21/2017	5:45 PM	California: San Francisco, City and County of[10]	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	System Operations	130	88000	Operations
April	2017-04-21	10:34 AM	04/21/2017	3:55 PM	Kentucky: Bullitt County	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
April	2017-04-23	11:55 PM	04/23/2017	11:56 PM	Oregon: Multnomah County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
April	2017-04-24	5:32 AM	04/24/2017	6:33 AM	North Carolina: Mecklenburg County	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	240	74698	Weather

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April	2017-04-30	1:00 AM	04/30/2017	5:45 PM	Arkansas, Louisiana, Mississippi	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	145174	Weather
May	2017-05-01	11:14 PM	05/01/2017	11:34 PM	Ohio	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	92390	Weather
May	2017-05-03	6:58 PM	05/03/2017	9:15 PM	California	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	Generation Inadequacy	572	0	Generation Interruption
May	2017-05-03	7:05 PM	05/03/2017	9:00 PM	California	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	Generation Inadequacy	878	Unknown	Generation Interruption
May	2017-05-03	11:00 PM	Unknown	Unknown	Pennsylvania: Philadelphia County, Montgomery County	RFC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
May	2017-05-04	5:00 AM	05/04/2017	10:00 PM	Alabama: Georgia	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	200	60377	Weather
May	2017-05-07	5:15 AM	Unknown	Unknown	California: Fresno County	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
May	2017-05-07	11:30 PM	05/08/2017	5:00 AM	Kentucky: Daviess County	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Generation Inadequacy	80	0	Generation Interruption
May	2017-05-11	11:05 AM	05/11/2017	1:05 PM	Washington: Yakima County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
May	2017-05-19	5:30 AM	Unknown	Unknown	Missouri: St. Louis County	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	70696	Weather
May	2017-05-21	4:44 PM	05/21/2017	5:43 PM	Idaho: Lincoln County, Jerome County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	21	9598	Physical Attack
May	2017-05-23	5:02 AM	05/23/2017	8:40 AM	Tennessee: Davidson County	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	10	4700	Physical Attack
May	2017-05-27	11:00 PM	Unknown	Unknown	Tennessee: Shelby County, Putnam County, Knox County, Davidson County, Hamilton County; Alabama: Madison County	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	116000	Weather
May	2017-05-27	11:10 PM	Unknown	Unknown	Tennessee: Shelby County	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	391	188000	Weather

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May	2017-05-28	4:27 PM	05/28/2017	4:28 PM	Nevada: Clark County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
May	2017-05-28	7:30 PM	05/29/2017	10:00 PM	Louisiana: Texas	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	103000	Weather
May	2017-05-28	7:30 PM	05/29/2017	10:00 PM	Texas: Louisiana	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	103000	Weather
June	2017-06-07	1:12 PM	06/07/2017	1:13 PM	Washington: Yakima County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
June	2017-06-11	2:39 PM	06/11/2017	5:55 PM	Michigan	RFC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Transmission Interruption	63	Unknown	Transmission Interruption
June	2017-06-11	7:00 AM	06/11/2017	11:22 AM	Minnesota	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	70000	Weather
June	2017-06-11	1:25 PM	06/11/2017	7:15 PM	Wisconsin	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	53610	Weather
June	2017-06-15	5:00 PM	06/15/2017	10:00 PM	Alabama, Georgia	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	275	82713	Weather
June	2017-06-16	8:00 PM	06/17/2017	6:00 AM	Arkansas	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	76000	Weather
June	2017-06-16	8:00 PM	Unknown	Unknown	Nebraska: Cass County, Douglas County, Sarpy County	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	76000	Weather
June	2017-06-17	9:00 PM	06/18/2017	7:00 AM	Kansas, Missouri: Jackson County, Platte County, Clay County, Cass County	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	84737	Weather
June	2017-06-21	12:00 AM	06/21/2017	1:00 AM	Oregon: Baker County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Physical Attack	0	0	Physical Attack
June	2017-06-22	6:00 PM	06/25/2017	12:45 PM	Michigan: Wayne County, Monroe County	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	118631	Weather
June	2017-06-29	4:00 AM	Unknown	Unknown	Louisiana: Orleans Parish	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	130	6467	Physical Attack

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June	2017-06-30	7:45 AM	06/30/2017	7:46 AM	Idaho: Ada County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
July	2017-07-06	12:00 AM	Unknown	Unknown	Idaho: Jerome County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
July	2017-07-07	3:30 AM	07/08/2017	7:30 PM	Michigan: Kent County, Ottawa County, Muskegon County, Barry County, Oceana County, Eaton County	RFC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	160000	Weather
July	2017-07-08	6:52 PM	07/09/2017	8:00 AM	California: Los Angeles County	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Transmission Interruption	645	176867	Transmission Interruption
July	2017-07-11	10:00 AM	07/11/2017	12:00 PM	Minnesota	MRO	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
July	2017-07-12	12:25 PM	07/15/2017	9:00 AM	Tennessee	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
July	2017-07-12	12:25 PM	Unknown	Unknown	Tennessee: Shelby County	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	Unknown	Unknown	Physical Attack
July	2017-07-18	4:03 AM	Unknown	Unknown	Missouri	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Attack	Unknown	700	Physical Attack
July	2017-07-18	4:23 PM	07/18/2017	6:39 PM	Nevada	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Severe Weather	0	0	Weather
July	2017-07-20	1:00 AM	07/20/2017	9:46 AM	Utah: Beaver County	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
July	2017-07-22	10:00 PM	07/23/2017	12:00 PM	Missouri: Clay County, Jackson County, Lafayette County, Platte County; Kansas: Johnson County, Miami County, Wyandotte County	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	112540	Weather
July	2017-07-22	10:00 PM	Unknown	Unknown	Missouri	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	131000	Weather
July	2017-07-22	10:00 PM	Unknown	Unknown	Missouri	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	115000	Weather
July	2017-07-23	4:00 AM	Unknown	Unknown	Missouri: Illinois	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	82000	Weather
July	2017-07-27	6:00 AM	07/27/2017	11:29 AM	California: Butte County	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
August	2017-08-05	1:20 PM	08/05/2017	2:20 PM	California: Humboldt County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
August	2017-08-21	11:41 PM	08/22/2017	12:21 AM	California: Plumas County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	System Operations	1	2	Islanding
August	2017-08-25	6:17 PM	09/02/2017	5:00 PM	Texas: Matagorda County, Nueces County, Aransas County, Refugio County, San Patricio County, Calhoun County, Victoria County, Jackson County, Live Oak County, Jim Wells County, Bee County, Lavaca County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	220400	Weather
August	2017-08-25	6:30 PM	09/05/2017	5:00 PM	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	330000	Weather
August	2017-08-26	12:39 AM	08/26/2017	12:52 AM	Texas:	TRE	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Severe Weather	Unknown	Unknown	Weather
August	2017-08-26	6:26 AM	09/08/2017	12:00 AM	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	1076868	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2017-08-27	5:10 AM	09/08/2017	12:00 AM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	1076868	Weather
August	2017-08-30	2:15 AM	Unknown	Unknown	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	78500	Weather
August	2017-08-31	2:49 PM	08/31/2017	5:14 PM	California: Los Angeles County;	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	Severe Weather	100	0	Weather
September	2017-09-01	3:41 PM	09/01/2017	8:30 PM	California:	WECC	Load shedding of 100 Megawatts or more implemented under emergency operational policy	Severe Weather	337	0	Weather
September	2017-09-09	12:00 AM	Unknown	Unknown	Florida: Hillsborough County, Pasco County, Polk County;	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	1275	425000	Weather
September	2017-09-09	12:30 PM	Unknown	Unknown	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	3500000	Weather
September	2017-09-10	6:35 PM	09/13/2017	5:00 PM	Florida: Alachua County, Bay County, Brevard County, Citrus County, Columbia County, Dixie County, Flagler County, Franklin County, Gilchrist County, Gulf County, Hamilton County, Hardee County, Hernando County, Highlands County, Jefferson County, Lafayette County, Lake County, Leon County, Levy County, Madison County, Marion County, Orange County, Osceola County, Pasco County, Pinellas County, Polk County, Seminole County, Sumter County, Suwannee County, Taylor County, Volusia County, Wakulla County;	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	4500	1000000	Weather
September	2017-09-10	8:37 PM	Unknown	Unknown	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	452555	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
September	2017-09-11	12:30 AM	Unknown	Unknown	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	200	20000	Weather
September	2017-09-11	2:27 AM	09/15/2017	8:44 PM	Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	132	39659	Weather
September	2017-09-11	12:55 PM	09/12/2017	8:00 AM	South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	687	154832	Weather
September	2017-09-11	5:30 PM	09/13/2017	9:30 AM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	365	265729	Weather
October	2017-10-04	1:20 AM	10/04/2017	3:00 AM	Mississippi:	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Attack	Unknown	Unknown	Physical Attack
October	2017-10-04	2:30 AM	Unknown	Unknown	Tennessee: Shelby County;	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2017-10-08	3:00 AM	Unknown	Unknown	Alabama: Florida: Mississippi:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	306	91945	Weather
October	2017-10-09	2:03 AM	10/17/2017	1:30 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather/Transmission Interruption	177	117900	Weather
October	2017-10-09	6:44 AM	Unknown	Unknown	California:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Severe Weather	100	Unknown	Weather
October	2017-10-12	9:09 AM	Unknown	Unknown	Mississippi: Coahoma County;	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	System Operations	Unknown	Unknown	Public Appeal
October	2017-10-16	3:45 PM	10/16/2017	4:09 PM	Washington: Montana:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Transmission Interruption	0	0	Transmission Interruption
October	2017-10-16	3:55 PM	10/16/2017	4:10 PM	Washington:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Transmission Interruption	0	0	Transmission Interruption
October	2017-10-19	4:01 PM	10/19/2017	4:02 PM	Utah: Salt Lake County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspected Physical Attack	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2017-10-20	6:30 PM	10/20/2017	10:22 PM	Texas:	TRE	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2017-10-20	3:44 AM	10/20/2017	3:45 AM	Washington:	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Severe Weather	900	Unknown	Weather
October	2017-10-22	8:45 AM	10/22/2017	2:00 PM	Louisiana: Mississippi: Arkansas: Texas:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	Unknown	Weather
October	2017-10-23	5:50 PM	10/24/2017	6:17 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	440	115144	Weather
October	2017-10-25	12:00 PM	10/25/2017	4:00 PM	California:	WECC	Cyber event that could potentially impact electric power system adequacy or reliability	Suspicious Activity	Unknown	Unknown	Cyber Attack
October	2017-10-26	5:50 PM	Unknown	Unknown	Montana: Big Horn County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Attack	0	0	Physical Attack
October	2017-10-26	8:17 AM	10/26/2017	8:41 AM	Washington: Whatcom County; Montana:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Transmission Interruption	0	0	Transmission Interruption
October	2017-10-26	8:17 AM	10/26/2017	8:41 AM	Washington: Clark County;	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Transmission Interruption	0	0	Transmission Interruption
October	2017-10-29	11:40 PM	11/01/2017	6:08 PM	Connecticut: Massachusetts: New Hampshire: Maine: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	310453	Weather
November	2017-11-01	3:40 PM	11/01/2017	10:00 PM	Kentucky: Daviess County;	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Generation Inadequacy	0	0	Generation Interruption
November	2017-11-05	7:35 PM	11/05/2017	11:09 PM	Ohio:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	89216	Weather
November	2017-11-07	12:29 PM	Unknown	Unknown	Louisiana:	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspicious Activity	0	0	Physical Attack
November	2017-11-09	8:45 AM	11/09/2017	2:00 PM	Colorado: Weld County;	WECC	Cyber event that could potentially impact electric power system adequacy or reliability	System Operations	0	0	Cyber Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
November	2017-11-13	2:00 AM	11/15/2017	8:17 AM	Washington: Island County, King County, Kitsap County, Thurston County, Skagit County, Whatcom County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	236100	Weather
November	2017-11-13	4:33 PM	11/16/2017	6:00 AM	Washington: King County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	85	68430	Weather
November	2017-11-16	3:05 PM	11/16/2017	3:06 PM	Oregon: Tillamook County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
November	2017-11-24	5:06 PM	11/26/2017	5:22 PM	Nevada: Clark County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2017-12-04	9:53 PM	Unknown	Unknown	California:	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Severe Weather/Transmission Interruption	540	263000	Weather
December	2017-12-05	6:50 AM	12/05/2017	9:00 AM	Louisiana:	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2017-12-05	6:30 AM	12/06/2017	10:00 AM	Michigan: Oscoda County, Isabella County, Roscommon County, Ogemaw County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	117500	Weather
December	2017-12-07	8:00 PM	12/08/2017	5:00 PM	Texas: Bexar County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	88000	Weather
December	2017-12-08	9:30 AM	12/08/2017	10:30 PM	Louisiana: Mississippi:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	79000	Weather
December	2017-12-08	10:00 AM	12/10/2017	8:50 PM	Alabama: Georgia: Mississippi:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	865	301872	Weather
December	2017-12-10	1:25 AM	12/10/2017	2:30 AM	California: Ventura County, Santa Barbara County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather/Transmission Interruption	110	51323	Weather
December	2017-12-12	2:22 AM	12/12/2017	2:25 AM	New York: Saratoga County;	NPCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Attack	3	1208	Physical Attack
December	2017-12-13	9:55 AM	12/13/2017	2:45 PM	New York: Suffolk County;	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2017-12-13	8:50 AM	Unknown	Unknown	Connecticut: New Haven County[13];	NPCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspicious Activity	0	0	Physical Attack
December	2017-12-18	1:00 PM	12/18/2017	5:00 PM	Mississippi:	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2017-12-19	8:40 AM	12/19/2017	10:36 AM	Florida: Alachua County;	FRCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
December	2017-12-29	7:00 AM	Unknown	Unknown	New York: Tompkins County;	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	210	Unknown	Fuel Supply Deficiency
December	2017-12-29	6:15 AM	12/29/2017	11:44 AM	Texas: Calhoun County;	TRE	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspicious Activity	Unknown	Unknown	Physical Attack
December	2017-12-31	11:54 PM	01/01/2018	2:14 PM	Colorado:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
January	2018-01-01	9:37 PM	01/02/2018	10:30 AM	Tennessee:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	System Operations	Unknown	Unknown	Public Appeal
January	2018-01-01	5:43 PM	Unknown	Unknown	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Severe Weather	Unknown	Unknown	Weather
January	2018-01-01	6:21 PM	01/02/2018	6:11 PM	Tennessee:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Severe Weather	Unknown	Unknown	Weather
January	2018-01-02	10:00 AM	02/12/2018	8:00 AM	New York: Niagara County;	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	675	Unknown	Fuel Supply Deficiency
January	2018-01-02	6:45 AM	01/02/2018	9:00 AM	North Carolina: South Carolina:	SERC	System-wide voltage reductions of 3 percent or more	Severe Weather	14998	Unknown	Weather
January	2018-01-02	7:30 AM	Unknown	Unknown	South Carolina:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Severe Weather	0	717000	Weather
January	2018-01-04	1:49 AM	01/04/2018	2:09 AM	Texas: Midland County;	TRE	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Attack	Unknown	500	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
January	2018-01-12	1:08 PM	01/12/2018	2:53 PM	Michigan: Midland County, Genesee County;	RF	Cyber event that causes interruptions of electrical system operations	System Operations	41	23007	Cyber Attack
January	2018-01-15	4:20 AM	01/18/2018	5:48 AM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Severe Weather	Unknown	Unknown	Weather
January	2018-01-16	3:00 PM	01/18/2018	1:00 PM	Tennessee: Shelby County;	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	System Operations	Unknown	Unknown	Public Appeal
January	2018-01-16	1:57 PM	01/16/2018	2:32 PM	Texas:	TRE	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Severe Weather	Unknown	Unknown	Weather
January	2018-01-16	3:00 PM	01/18/2018	1:00 PM	Tennessee:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Severe Weather	Unknown	Unknown	Weather
January	2018-01-17	5:10 AM	01/17/2018	1:00 PM	Mississippi:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	System Operations	1788	420000	Public Appeal
January	2018-01-17	6:10 AM	01/17/2018	2:00 PM	Louisiana:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	System Operations	Unknown	Unknown	Public Appeal
January	2018-01-18	5:00 AM	01/18/2018	9:45 AM	Mississippi:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	System Operations	1760	420000	Public Appeal
January	2018-01-18	6:00 AM	Unknown	Unknown	Louisiana:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	System Operations	Unknown	Unknown	Public Appeal
January	2018-01-18	5:00 AM	01/18/2018	11:00 AM	Arkansas: Mississippi: Louisiana: Texas:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Severe Weather	31500	Unknown	Weather
January	2018-01-25	8:19 PM	01/26/2018	2:00 AM	Pennsylvania: Montgomery County;	RF	Cyber event that could potentially impact electric power system adequacy or reliability	Suspicious Activity	Unknown	Unknown	Cyber Attack
February	2018-02-04	1:42 PM	02/04/2018	3:25 PM	California:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	9760	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
February	2018-02-08	1:25 PM	02/08/2018	1:31 PM	California:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	System Operations	30	10900	Islanding
February	2018-02-17	4:33 PM	02/18/2018	12:00 AM	Oregon: Washington: California:	WECC	Physical attack that causes major interruptions or impacts to critical infrastructure facilities or to operations	Vandalism	2330	0	Physical Attack
February	2018-02-17	5:56 PM	02/18/2018	4:11 AM	Oregon: Washington: California:	WECC	Physical attack that causes major interruptions or impacts to critical infrastructure facilities or to operations	Vandalism	2327	0	Physical Attack
February	2018-02-28	12:08 PM	03/01/2018	3:45 PM	Florida:	FRCC	Cyber event that could potentially impact electric power system adequacy or reliability	System Operations	0	0	Cyber Attack
February	2018-02-28	12:08 PM	03/01/2018	3:45 PM	Florida:	FRCC	Cyber event that could potentially impact electric power system adequacy or reliability	System Operations	0	0	Cyber Attack
March	2018-03-01	11:43 AM	03/01/2018	11:56 AM	California:	WECC	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Severe Weather	38	10898	Weather
March	2018-03-01	9:57 PM	03/02/2018	10:14 AM	Ohio:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	86501	Weather
March	2018-03-01	10:20 PM	03/04/2018	8:00 PM	Michigan: Wayne County, Washtenaw County, Oakland County, Macomb County, Monroe County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	95000	Weather
March	2018-03-02	11:17 PM	03/03/2018	12:51 AM	Washington: Clark County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
March	2018-03-02	7:00 AM	Unknown	Unknown	New York: Dutchess County, Orange County, Greene County, Ulster County, Putnam County, Sullivan County, Albany County, Columbia County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	90000	Weather
March	2018-03-02	8:00 AM	03/03/2018	11:00 PM	Virginia: West Virginia:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	65198	Weather
March	2018-03-02	8:42 AM	Unknown	Unknown	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	63331	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
March	2018-03-02	11:34 AM	Unknown	Unknown	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	50000	Weather
March	2018-03-02	11:58 AM	Unknown	Unknown	Pennsylvania: Berks County, Bucks County, Carbon County, Chester County, Clinton County, Columbia County, Cumberland County, Dauphin County, Juniata County, Lackawanna County, Lancaster County, Lebanon County, Lehigh County, Luzerne County, Lycoming County, Monroe County, Montgomery County, Montour County, Northampton County, Northumberland County, Pike County, Schuylkill County, Snyder County;	RF	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system	Severe Weather	Unknown	126000	Weather
March	2018-03-02	12:00 PM	03/05/2018	12:00 AM	Pennsylvania:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	630000	Weather
March	2018-03-02	12:00 PM	Unknown	Unknown	Maryland:	RF	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the electric power system	Severe Weather	670	474019	Weather
March	2018-03-02	1:51 PM	03/05/2018	1:18 PM	Connecticut: Massachusetts: Rhode Island:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	325000	Weather
March	2018-03-02	1:51 PM	03/04/2018	12:11 PM	Pennsylvania:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	233136	Weather
March	2018-03-02	3:10 PM	03/06/2018	4:57 AM	Ohio:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	249322	Weather
March	2018-03-02	3:46 PM	03/04/2018	7:46 PM	New York: New York County, Westchester County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	72353	Weather
March	2018-03-02	5:00 PM	03/06/2018	11:00 AM	Delaware: Maryland:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	60000	Weather
March	2018-03-07	12:00 PM	03/07/2018	5:00 PM	Pennsylvania:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	120000	Weather
March	2018-03-07	4:10 PM	03/10/2018	11:32 AM	New Jersey:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	216800	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
March	2018-03-07	5:15 PM	Unknown	Unknown	New Jersey:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	50	58000	Weather
March	2018-03-07	7:37 PM	03/10/2018	4:35 PM	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	102000	Weather
March	2018-03-12	12:00 AM	04/06/2018	11:00 AM	New York: Dutchess County;	NPCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
March	2018-03-13	12:10 AM	03/13/2018	12:34 AM	Colorado:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspicious Activity	0	0	Physical Attack
March	2018-03-13	8:50 AM	03/14/2018	11:22 PM	Massachusetts: Rhode Island:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	123629	Weather
March	2018-03-19	11:29 PM	03/20/2018	3:37 AM	Alabama: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	261	78220	Weather
March	2018-03-20	7:00 PM	03/25/2018	6:30 AM	New Jersey: Atlantic County, Camden County, Cape May County, Gloucester County, Salem County, Cumberland County, Burlington County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	80	124000	Weather
March	2018-03-24	10:30 PM	03/26/2018	8:00 PM	Virginia: West Virginia:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	81227	Weather
March	2018-03-26	3:05 AM	03/26/2018	3:35 AM	California:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
March	2018-03-28	3:00 PM	03/28/2018	4:00 PM	Washington: Walla Walla County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	12	1185	Physical Attack
April	2018-04-03	11:15 AM	04/03/2018	11:30 AM	California:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
April	2018-04-04	4:42 PM	04/07/2018	6:22 AM	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	72896	Weather

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April	2018-04-05	12:50 AM	04/05/2018	4:00 PM	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	65932	Weather
April	2018-04-09	10:07 AM	04/09/2018	4:00 PM	Washington: Walla Walla County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
April	2018-04-09	11:10 PM	04/10/2018	6:47 AM	Florida: Palm Beach County;	FRCC	Physical attack that causes major interruptions or impacts to critical infrastructure facilities or to operations	Sabotage	55	27000	Physical Attack
April	2018-04-09	11:16 AM	Unknown	Unknown	Utah:	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Transmission Interruption	300	250000	Transmission Interruption
April	2018-04-09	12:16 PM	04/09/2018	1:52 PM	Utah: Salt Lake County;	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for more than 15 minutes from a single incident	Transmission Interruption	806	57000	Transmission Interruption
April	2018-04-14	9:30 AM	04/14/2018	10:00 AM	Louisiana: Arkansas: Mississippi: Texas:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	56350	Weather
April	2018-04-15	7:30 AM	04/18/2018	7:30 AM	Michigan:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	389591	Weather
April	2018-04-15	5:14 PM	04/15/2018	11:25 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	78100	Weather
May	2018-05-02	2:52 PM	05/02/2018	4:14 PM	North Carolina:	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
May	2018-05-04	12:00 PM	05/06/2018	1:00 PM	Michigan:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	300000	Weather
May	2018-05-04	2:00 PM	05/05/2018	9:30 AM	Michigan: Calhoun County, Genesee County, Ingham County, Kent County, Macomb County, Midland County, Saginaw County, Grafton County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	90000	Weather
May	2018-05-04	8:10 PM	Unknown	Unknown	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	106150	Weather
May	2018-05-04	11:10 PM	05/05/2018	12:40 AM	New Hampshire: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	56000	Weather
May	2018-05-05	4:30 AM	05/05/2018	3:30 PM	Vermont: New Hampshire: Maine:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	31900	Weather

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May	2018-05-07	10:30 AM	05/07/2018	10:36 AM	New York: Tompkins County;	NPCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspected Physical Attack	0	0	Physical Attack
May	2018-05-08	4:00 PM	05/08/2018	4:01 PM	Utah: Washington County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Actual Physical Attack	0	0	Physical Attack
May	2018-05-14	7:08 PM	Unknown	Unknown	Virginia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	112000	Weather
May	2018-05-15	3:00 PM	05/18/2018	1:48 PM	Massachusetts:	NPCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
May	2018-05-15	2:50 PM	Unknown	Unknown	Pennsylvania: Lehigh County, Schuylkill County, Cumberland County, Lancaster County, Northampton County, Berks County, Clinton County, Susquehanna County, Bucks County, Carbon County, Chester County, Columbia County, Juniata County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	114000	Weather
May	2018-05-15	4:00 PM	Unknown	Unknown	New York: Dutchess County, Ulster County, Orange County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	72000	Weather
May	2018-05-15	5:15 PM	Unknown	Unknown	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	49999	Weather
May	2018-05-15	5:25 PM	Unknown	Unknown	New Jersey:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	82372	Weather
May	2018-05-15	6:14 PM	05/15/2018	7:00 PM	Pennsylvania:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	52872	Weather
May	2018-05-15	6:35 PM	05/18/2018	3:57 PM	Connecticut: Massachusetts: Rhode Island:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	120000	Weather
May	2018-05-17	1:11 AM	05/18/2018	12:38 AM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Transmission Disruption	124	70000	Transmission Interruption
May	2018-05-17	1:11 AM	Unknown	Unknown	California: Contra Costa County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	70	70000	Weather
May	2018-05-26	6:40 PM	05/27/2018	11:50 PM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	163932	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
June	2018-06-02	5:00 AM	06/02/2018	11:00 AM	Missouri: Jackson County, Clay County, Platte County, Andrew County; Kansas: Johnson County;	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	103535	Weather
June	2018-06-04	8:50 AM	06/04/2018	2:00 PM	Florida: Alachua County;	FRCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
June	2018-06-09	9:54 AM	06/09/2018	12:12 PM	Georgia:	SERC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more	System Operations	0	0	Operations
June	2018-06-10	2:25 PM	06/11/2018	5:58 AM	Kentucky:	SERC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more	System Operations	Unknown	Unknown	Operations
June	2018-06-12	3:00 PM	06/12/2018	3:15 PM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2018-06-12	4:15 PM	Unknown	Unknown	Nevada: Clark County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2018-06-18	6:20 PM	06/19/2018	12:15 AM	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	112927	Weather
June	2018-06-20	10:58 PM	06/21/2018	6:05 AM	Florida: Palm Beach County;	FRCC	Complete operational failure or shut-down of the transmission and/or distribution of electrical system	Transmission Interruption	73	27000	Transmission Interruption
June	2018-06-22	2:38 PM	Unknown	Unknown	Washington:	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system	Severe Weather	10000	4200000	Weather
June	2018-06-27	2:30 PM	06/27/2018	2:33 PM	New York: New York County;	NPCC	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. Or suspicious device or activity at its Bulk Electric System control center	Suspicious Activity	0	0	Physical Attack
June	2018-06-28	2:50 PM	06/29/2018	9:00 AM	Alabama: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	160	48109	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
June	2018-06-28	6:36 PM	07/01/2018	7:00 AM	Missouri: Illinois;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	112000	Weather
June	2018-06-29	3:38 AM	Unknown	Unknown	Kentucky:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more	System Operations	Unknown	Unknown	Operations
June	2018-06-29	7:35 AM	06/29/2018	9:30 AM	Minnesota: St. Louis County;	MRO	Uncontrolled loss of 300 Megawatts or more of firm system loads for 15 minutes or more from a single incident	Severe Weather	350	Unknown	Weather
June	2018-06-30	10:45 AM	06/30/2018	11:28 AM	Texas: Travis County, Williamson County;	TRE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more	System Operations	0	0	Operations
June	2018-06-30	12:30 PM	06/30/2018	12:31 PM	California: Los Angeles County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
July	2018-07-04	5:54 PM	07/04/2018	7:20 PM	Tennessee:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2018-07-04	10:00 PM	07/04/2018	10:30 PM	Colorado: Pueblo County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	5058	Physical Attack
July	2018-07-09	1:10 PM	07/09/2018	2:45 PM	California: Merced County, Kern County; Nevada: Clark County;	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2018-07-11	12:58 AM	Unknown	Unknown	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
July	2018-07-11	3:40 PM	07/11/2018	4:00 PM	Tennessee:	SERC	Uncontrolled loss of 300 Megawatts or more of firm system loads for 15 minutes or more from a single incident	Transmission Interruption	425	26195	Transmission Interruption
July	2018-07-14	10:20 AM	Unknown	Unknown	Ohio:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	Unknown	Unknown	Operations
July	2018-07-16	5:15 AM	Unknown	Unknown	California: Merced County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
July	2018-07-18	4:00 AM	Unknown	Unknown	California: Fresno County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
July	2018-07-18	5:28 PM	07/18/2018	5:31 PM	Oregon:	WECC	Total generation loss, within one minute of: greater than or equal to 2,000 Megawatts in the Eastern or Western Interconnection or greater than or equal to 1,400 Megawatts in the ERCOT Interconnection.	Severe Weather/Transmission Interruption	Unknown	Unknown	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
July	2018-07-19	12:38 PM	07/19/2018	1:22 PM	Louisiana: Rapides Parish;	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2018-07-19	8:25 PM	Unknown	Unknown	Kentucky:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	Unknown	Unknown	Operations
July	2018-07-20	12:46 PM	07/20/2018	1:30 PM	Maine: Hancock County;	NPCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	System Operations	0	0	Physical Attack
July	2018-07-20	4:19 PM	07/20/2018	4:48 PM	Kentucky:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	87833	Weather
July	2018-07-21	4:45 AM	07/21/2018	11:15 AM	Arkansas:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	64930	Weather
July	2018-07-21	7:20 AM	07/21/2018	11:30 AM	Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	143	42901	Weather
July	2018-07-23	4:16 AM	07/23/2018	4:29 AM	Florida: Pinellas County;	FRCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	40	Unknown	Weather
July	2018-07-26	8:24 PM	Unknown	Unknown	California: Shasta County;	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System	Natural Disaster	Unknown	Unknown	Natural Disaster
July	2018-07-27	9:34 AM	07/27/2018	9:51 AM	Washington: Clark County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system	System Operations	Unknown	Unknown	Islanding
July	2018-07-27	4:28 PM	07/27/2018	4:33 PM	New York: New York County;	NPCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	0	0	Weather
July	2018-07-28	11:11 PM	07/29/2018	1:51 AM	Nevada: Nye County;	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2018-07-29	2:33 PM	07/29/2018	6:23 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Natural Disaster	83	57670	Natural Disaster
July	2018-07-30	6:30 AM	07/30/2018	11:00 PM	Arizona: Maricopa County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	82000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
July	2018-07-31	11:44 AM	07/31/2018	2:17 PM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Suspicious Activity	Unknown	Unknown	Physical Attack
August	2018-08-01	9:11 AM	08/01/2018	10:56 AM	Montana:	WECC	Physical attack that causes major interruptions or impacts to critical infrastructure or to operations.	Vandalism	0	0	Physical Attack
August	2018-08-04	8:20 AM	08/04/2018	8:21 AM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	Unknown	Physical Attack
August	2018-08-07	1:22 AM	08/07/2018	1:59 AM	California: Butte County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system.	Natural Disaster	5	485	Natural Disaster
August	2018-08-07	1:22 AM	08/07/2018	7:04 PM	California: Butte County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system.	Natural Disaster	27	11383	Natural Disaster
August	2018-08-14	9:00 PM	08/14/2018	9:01 PM	Virginia: Hanover County;	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
August	2018-08-15	12:00 AM	08/15/2018	1:00 AM	Missouri: Boone County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
August	2018-08-17	1:07 PM	08/17/2018	1:40 PM	California:	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2018-08-19	3:20 PM	08/19/2018	3:21 PM	Utah: Box Elder County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
August	2018-08-20	10:46 PM	08/21/2018	12:14 AM	Louisiana:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2018-08-24	12:24 PM	08/24/2018	12:59 PM	Virginia: Roanoke County;	SERC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2018-08-26	10:00 PM	08/27/2018	4:56 AM	Michigan: Muskegon County, Newaygo County, Oceana County, Mason County, Kent County, Mecosta County, Montcalm County, Isabella County, Midland County, Saginaw County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	67000	Weather
August	2018-08-28	11:41 PM	08/29/2018	12:13 AM	Ohio: Montgomery County;	RF	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2018-08-28	8:00 PM	08/30/2018	2:59 PM	Michigan: Benzie County, Barry County, Grand Traverse County, Kalkaska County, Mason County, Oceana County, Muskegon County, Kent County, Newaygo County, Montcalm County, Mecosta County, Antrim County, Eaton County, Ionia County, Isabella County, Clare County, Saginaw County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	110000	Weather
August	2018-08-29	3:27 AM	08/29/2018	4:00 AM	Maryland: Montgomery County; District of Columbia:	RF	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. OR suspicious device or activity at its Bulk Electric System control center.	Suspicious Activity	0	0	Physical Attack
August	2018-08-29	9:00 AM	08/29/2018	9:06 AM	Arkansas:	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
August	2018-08-29	12:00 AM	08/30/2018	12:00 AM	Illinois:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	100000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2018-08-30	12:00 PM	08/30/2018	12:20 PM	California:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
August	2018-08-31	3:07 PM	08/31/2018	3:31 PM	Oregon:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Natural Disaster/Transmission Interruption	96	50000	Natural Disaster
August	2018-08-31	6:34 PM	08/31/2018	6:40 PM	New York: New York County, Westchester County;	NPCC	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. OR suspicious device or activity at its Bulk Electric System control center.	Suspicious Activity	0	0	Physical Attack
September	2018-09-01	12:00 AM	09/01/2018	3:22 PM	Arkansas:	SPP RE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
September	2018-09-05	1:00 PM	09/05/2018	1:01 PM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	Unknown	Physical Attack
September	2018-09-06	2:26 AM	09/06/2018	2:27 AM	Florida: Hillsborough County;	FRCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
September	2018-09-12	10:00 PM	09/12/2018	10:05 PM	Texas:	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
September	2018-09-13	8:30 PM	09/19/2018	5:00 PM	North Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	300	325000	Weather
September	2018-09-13	8:56 PM	09/20/2018	7:00 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	1457583	Weather
September	2018-09-15	3:00 PM	09/15/2018	6:00 PM	Mississippi: Forrest County;	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	System Operations	1322	420000	Public Appeal

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
September	2018-09-15	3:00 PM	09/15/2018	6:00 PM	Louisiana:	SERC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	System Operations	Unknown	Unknown	Public Appeal
September	2018-09-15	1:05 AM	09/17/2018	4:00 PM	South Carolina: Horry County, Chesterfield County, Dillon County, Georgetown County, Marlboro County, Darlington County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	50100	Weather
September	2018-09-16	8:00 AM	09/18/2018	7:40 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	50000	Weather
September	2018-09-19	11:00 AM	09/20/2018	12:00 PM	Indiana: Benton County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2018-09-20	12:39 PM	Unknown	Unknown	Nevada: Clark County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
September	2018-09-22	3:23 PM	09/22/2018	11:00 PM	California: Los Angeles County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Natural Disaster	3507	2500	Natural Disaster
September	2018-09-25	12:33 AM	09/25/2018	3:10 AM	Illinois:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2018-09-26	1:54 PM	09/26/2018	5:58 PM	Texas: Harris County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
September	2018-09-28	6:58 PM	09/28/2018	7:29 PM	Ohio:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2018-10-01	12:44 PM	10/01/2018	5:32 PM	Ohio: Indiana: Michigan: Kentucky: West Virginia: Virginia:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	Unknown	Unknown	Operations
October	2018-10-03	7:38 AM	10/03/2018	7:48 AM	Illinois:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2018-10-04	6:00 AM	10/04/2018	8:00 AM	Oklahoma: Osage County;	SPP RE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	4	2089	Physical Attack
October	2018-10-04	4:01 PM	10/04/2018	6:25 PM	California:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Suspicious Activity	0	0	Physical Attack
October	2018-10-09	8:12 PM	10/09/2018	9:12 PM	Colorado: El Paso County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more; Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2018-10-10	5:41 AM	10/10/2018	7:54 AM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2018-10-10	5:00 PM	10/15/2018	5:00 AM	Utah:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2018-10-10	11:59 AM	Unknown	Unknown	Florida: Alabama: Georgia:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	152	45604	Weather
October	2018-10-10	2:00 PM	10/11/2018	6:00 AM	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	135	60717	Weather
October	2018-10-10	4:00 PM	10/19/2018	6:00 AM	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	330	55000	Weather
October	2018-10-11	7:21 AM	10/11/2018	3:00 PM	South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	71654	Weather
October	2018-10-11	1:15 PM	Unknown	Unknown	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	240807	Weather
October	2018-10-11	4:42 PM	10/12/2018	9:00 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	170222	Weather
October	2018-10-11	6:55 PM	10/12/2018	12:00 PM	North Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	117000	Weather
October	2018-10-12	3:36 AM	10/12/2018	1:56 PM	Maryland: Garrett County;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2018-10-14	10:11 PM	Unknown	Unknown	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more	Natural Disaster	Unknown	60000	Natural Disaster

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2018-10-16	4:15 AM	10/16/2018	5:11 PM	Connecticut: Rhode Island; Massachusetts: Vermont: New Hampshire: Maine:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	18000	Weather
October	2018-10-21	12:16 AM	10/21/2018	4:14 PM	West Virginia:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	Unknown	63408	Weather
October	2018-10-22	10:25 AM	10/22/2018	10:31 AM	Utah: Salt Lake County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
October	2018-10-24	12:32 PM	10/24/2018	1:33 PM	Michigan: Wayne County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2018-10-29	5:00 AM	11/07/2018	7:00 AM	California: Shasta County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2018-10-29	8:39 AM	Unknown	Unknown	Minnesota: Douglas County;	MRO	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems	Vandalism	0	0	Physical Attack
October	2018-10-30	2:02 PM	10/30/2018	2:42 PM	Maryland: Baltimore, City of;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2018-10-31	7:30 PM	11/01/2018	6:55 PM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more	Severe Weather	402	140932	Weather
November	2018-11-02	9:50 AM	Unknown	Unknown	Minnesota: Douglas County;	MRO	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
November	2018-11-03	5:53 AM	11/03/2018	5:57 AM	Illinois:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2018-11-03	5:20 PM	11/04/2018	2:30 PM	Connecticut: Massachusetts: New Hampshire: Vermont: Maine: Rhode Island:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	62000	Weather
November	2018-11-06	9:49 AM	11/09/2018	2:05 PM	Tennessee:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	61000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
November	2018-11-08	7:16 AM	11/28/2018	4:32 PM	California: Butte County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system	Natural Disaster/Transmission Interruption	32	11844	Natural Disaster
November	2018-11-08	4:00 PM	Unknown	Unknown	Nevada: Carson City, Consolidated Municipality of[19];	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
November	2018-11-09	9:02 AM	11/09/2018	10:23 AM	Iowa: Muscatine County;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2018-11-10	5:02 PM	11/14/2018	3:00 PM	Wisconsin:	MRO	Fuel supply emergencies that could impact electric power system adequacy or reliability	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
November	2018-11-13	6:19 PM	11/13/2018	7:40 PM	Arkansas: Oklahoma: Louisiana: Texas:	SPP RE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2018-11-15	3:23 AM	11/15/2018	5:35 PM	Kentucky:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	150000	Weather
November	2018-11-15	5:28 AM	11/15/2018	8:35 AM	Indiana:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	55000	Weather
November	2018-11-15	5:38 AM	11/16/2018	6:00 AM	Kentucky: Ohio:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	104000	Weather
November	2018-11-15	10:50 AM	11/17/2018	1:12 PM	Virginia: West Virginia:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	50600	Weather
November	2018-11-18	1:10 PM	Unknown	Unknown	Nebraska: Holt County;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	2	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
November	2018-11-25	10:30 PM	11/28/2018	8:17 PM	Illinois: Will County, DuPage County, Kane County, McHenry County, Winnebago County, Ogle County, DeKalb County, Lee County, Grundy County, Lake County, Cook County, Livingston County, Stephenson County, LaSalle County, Kankakee County, Kendall County, Boone County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	313448	Weather
November	2018-11-27	8:00 AM	11/28/2018	4:50 PM	Maine: New Hampshire: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	32000	Weather
December	2018-12-01	4:23 PM	12/01/2018	5:09 PM	Florida: Leon County;	FRCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2018-12-01	9:40 AM	12/04/2018	5:17 PM	Pennsylvania:	RF	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
December	2018-12-02	4:17 PM	12/02/2018	8:30 PM	Maryland:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2018-12-03	3:15 AM	12/03/2018	3:44 AM	Texas:	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	16	Unknown	Transmission Interruption
December	2018-12-05	8:00 AM	12/06/2018	8:00 AM	Alabama: Chambers County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
December	2018-12-05	12:48 PM	12/05/2018	12:49 PM	California: Los Angeles County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2018-12-07	3:10 AM	12/07/2018	4:35 AM	Utah: Weber County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Actual Physical Attack	0	0	Physical Attack
December	2018-12-09	11:28 PM	12/10/2018	1:30 AM	Virginia: Loudoun County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
December	2018-12-09	3:35 AM	12/10/2018	11:45 PM	North Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	Unknown	50000	Weather
December	2018-12-09	8:41 AM	12/09/2018	6:00 PM	North Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	70000	Weather
December	2018-12-09	12:23 AM	12/09/2018	11:54 AM	Alabama: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	137	41126	Weather
December	2018-12-11	9:10 AM	12/11/2018	10:26 AM	Texas: Travis County;	TRE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2018-12-11	7:00 AM	12/13/2018	2:00 PM	Oregon: Josephine County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
December	2018-12-12	10:00 AM	12/12/2018	10:31 AM	Oregon: Gilliam County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
December	2018-12-13	10:00 AM	Unknown	Unknown	California: Stanislaus County, San Joaquin County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
December	2018-12-14	8:40 AM	12/14/2018	10:00 AM	Texas: Jasper County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2018-12-14	4:00 PM	12/17/2018	2:00 AM	Washington: King County, Kitsap County, Island County, Pierce County, Thurston County, Whatcom County, Skagit County, Kittitas County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	150000	Weather
December	2018-12-14	6:00 PM	Unknown	Unknown	Washington: Snohomish County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	200	60000	Weather
December	2018-12-18	8:47 AM	12/18/2018	8:48 AM	Utah: Salt Lake County; California: Oregon:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
December	2018-12-20	9:30 AM	12/20/2018	5:00 PM	Washington: Skagit County, Snohomish County, King County, Kitsap County, Island County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	165000	Weather
December	2018-12-26	1:00 AM	01/03/2019	10:27 AM	California: Kern County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
December	2018-12-27	12:05 AM	12/27/2018	1:05 AM	Maryland: Montgomery County, Prince George's County; District of Columbia:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2018-12-27	12:50 PM	12/27/2018	1:00 PM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
December	2018-12-27	9:12 PM	12/27/2018	9:16 PM	New York: New York County;	NPCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	Unknown	Transmission Interruption
December	2018-12-30	11:41 AM	12/30/2018	1:20 PM	Washington: King County;	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
January	2019-01-05	1:19 PM	01/05/2019	3:07 PM	Washington:	WECC	Complete loss of Interpersonal Communication and Alternative Interpersonal Communication capability affecting its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	Unknown	Operations
January	2019-01-06	1:00 AM	01/06/2019	12:00 PM	Washington: King County, Thurston County, Pierce County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	230000	Weather
January	2019-01-06	3:00 AM	01/09/2019	7:00 AM	Washington:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	230	230000	Weather
January	2019-01-06	5:56 PM	01/06/2019	9:52 PM	California: Sacramento County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	300	90382	Weather
January	2019-01-07	8:57 PM	01/07/2019	9:32 PM	Michigan:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
January	2019-01-09	11:55 AM	01/09/2019	11:56 AM	New Mexico: San Juan County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
January	2019-01-10	12:19 PM	01/10/2019	12:48 PM	Montana: Valley County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	System Operations	11	2	Operations
January	2019-01-11	11:36 AM	01/11/2019	12:43 PM	Maine:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
January	2019-01-12	7:20 PM	01/12/2019	9:38 PM	New Hampshire:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
January	2019-01-12	11:30 AM	01/13/2019	10:00 PM	Missouri: Jackson County; Kansas: Johnson County;	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	112530	Weather
January	2019-01-12	11:30 AM	Unknown	Unknown	Missouri: Nebraska:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	116600	Weather
January	2019-01-13	5:30 AM	01/15/2019	5:00 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	133200	Unknown	Weather
January	2019-01-14	11:10 AM	Unknown	Unknown	Michigan:	RF	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Actual Physical Attack	Unknown	Unknown	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
January	2019-01-15	8:00 AM	01/15/2019	8:02 AM	Pennsylvania:	RF	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
January	2019-01-16	5:19 AM	01/16/2019	7:14 AM	Texas: Nueces County;	TRE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
January	2019-01-16	5:26 PM	01/17/2019	12:19 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	190	126700	Weather
January	2019-01-18	9:54 PM	01/19/2019	12:19 AM	Nebraska:	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	8	Unknown	Transmission Interruption
January	2019-01-23	7:26 AM	01/23/2019	5:05 PM	Colorado: Larimer County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	System Operations	0	0	Operations
January	2019-01-24	4:39 AM	01/24/2019	5:16 AM	Ohio:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
January	2019-01-28	1:35 PM	01/28/2019	1:40 PM	Utah: Iron County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Actual Physical Attack	0	0	Physical Attack
January	2019-01-29	6:34 PM	01/29/2019	6:36 PM	Louisiana: Washington Parish;	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	Unknown	Transmission Interruption
January	2019-01-30	4:23 AM	02/02/2019	9:00 AM	Illinois: Scott County;	SERC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	Unknown	Unknown	Fuel Supply Deficiency
January	2019-01-30	4:30 PM	Unknown	Unknown	Washington:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
January	2019-01-30	7:00 AM	01/30/2019	8:08 AM	Illinois: Pike County;	SERC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Severe Weather	Unknown	Unknown	Weather
January	2019-01-30	9:30 AM	01/31/2019	6:00 PM	Michigan:	RF	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
January	2019-01-31	9:33 PM	01/31/2019	9:34 PM	California:	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
February	2019-02-01	5:35 AM	02/01/2019	6:10 AM	Massachusetts	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
February	2019-02-01	11:57 PM	02/02/2019	8:49 AM	Nevada	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	1	Physical Attack
February	2019-02-02	10:28 AM	02/02/2019	10:29 AM	California	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
February	2019-02-05	6:17 PM	02/05/2019	8:26 PM	California	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system.	Severe Weather	42	33200	Weather
February	2019-02-07	7:39 AM	02/07/2019	7:40 AM	Arkansas	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	3	3370	Weather
February	2019-02-07	8:55 AM	02/09/2019	4:30 PM	Michigan	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	233000	Weather
February	2019-02-08	10:00 AM	02/08/2019	10:30 AM	Pennsylvania	RF	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	0	Physical Attack
February	2019-02-08	6:30 PM	Unknown	Unknown	Washington	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	50940	Weather
February	2019-02-13	2:48 AM	02/15/2019	12:28 AM	California	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	182	121000	Weather
February	2019-02-14	8:50 AM	02/14/2019	12:10 PM	New Jersey	RF	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
February	2019-02-14	12:15 PM	02/14/2019	12:16 PM	Utah	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
February	2019-02-19	9:45 AM	Unknown	Unknown	Texas	TRE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
February	2019-02-20	12:50 PM	02/20/2019	1:32 PM	Wisconsin, Minnesota, Iowa, Illinois	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	740	0	Operations
February	2019-02-23	2:05 PM	Unknown	Unknown	Virginia	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	Unknown	Unknown	Weather
February	2019-02-24	11:21 AM	02/26/2019	5:29 PM	Ohio, Virginia, West Virginia	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	118781	Weather
February	2019-02-24	12:31 PM	02/24/2019	2:57 PM	Ohio	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	157274	Weather
February	2019-02-24	2:33 PM	02/24/2019	6:03 PM	Pennsylvania	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	94048	Weather
February	2019-02-24	6:00 PM	02/25/2019	10:00 PM	Pennsylvania	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	132000	Weather
February	2019-02-24	6:47 PM	02/25/2019	1:55 PM	Pennsylvania	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	137216	Weather
February	2019-02-24	8:02 PM	02/25/2019	2:30 PM	Michigan	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	115000	Weather
February	2019-02-25	7:45 AM	02/25/2019	6:40 PM	Massachusetts	NPCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
February	2019-02-25	1:35 PM	02/26/2019	2:50 AM	Connecticut, Massachusetts, New Hampshire, Maine, Vermont, Rhode Island	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	72332	Weather
February	2019-02-27	9:35 PM	02/27/2019	9:45 PM	South Carolina	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
February	2019-02-27	11:25 AM	02/27/2019	5:39 PM	Iowa	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
February	2019-02-28	7:02 AM	02/28/2019	7:33 AM	Oklahoma, Arkansas, Louisiana	SPP RE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2019-03-04	11:39 AM	03/08/2019	4:52 PM	Oklahoma:	SPP RE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
March	2019-03-05	9:12 AM	03/05/2019	6:57 PM	California: Kern County, Los Angeles County; Utah: Salt Lake County; Wyoming: Converse County;	WECC	Cyber event that causes interruptions of electrical system operations.	System Operations	0	0	Cyber Attack
March	2019-03-13	6:12 AM	03/13/2019	6:13 AM	California: Los Angeles County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
March	2019-03-13	5:50 AM	03/13/2019	10:30 AM	Texas: Midland County, Ector County, Tarrant County, Dallas County, Wichita County, Brown County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	154124	Weather
March	2019-03-13	11:29 AM	03/14/2019	9:11 PM	Colorado: Jefferson County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	58	58379	Weather
March	2019-03-13	3:00 PM	03/14/2019	12:00 AM	Texas: Kansas: Oklahoma:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	Unknown	66000	Weather
March	2019-03-13	3:51 PM	03/16/2019	6:00 PM	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	50	54290	Weather
March	2019-03-19	10:53 PM	03/19/2019	10:54 PM	Oklahoma:	SPP RE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
March	2019-03-21	10:00 AM	03/21/2019	10:05 AM	Utah: Salt Lake County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
March	2019-03-25	7:47 AM	03/25/2019	7:48 AM	Oregon: Lane County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Actual Physical Attack	5	Unknown	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
March	2019-03-29	11:36 PM	03/30/2019	2:00 AM	California: San Diego County, Los Angeles County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Suspicious Activity	0	0	Physical Attack
April	2019-04-01	6:51 AM	04/01/2019	7:53 AM	New York: Broome County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2019-04-01	6:51 AM	04/01/2019	7:53 AM	New York: Monroe County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2019-04-01	2:15 PM	04/06/2019	5:20 PM	Nevada: Carson City, Consolidated Municipality of[19], Washoe County, Churchill County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Actual Physical Attack	0	0	Physical Attack
April	2019-04-02	8:33 AM	04/02/2019	9:00 AM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2019-04-02	10:15 AM	04/02/2019	10:16 AM	Utah: Salt Lake County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
April	2019-04-03	5:15 AM	04/03/2019	12:39 PM	California: Fresno County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
April	2019-04-04	10:13 AM	04/04/2019	12:08 PM	Montana:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
April	2019-04-07	1:46 PM	04/08/2019	5:50 PM	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	537	231956	Weather
April	2019-04-10	11:59 AM	04/10/2019	12:00 PM	Virginia:	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
April	2019-04-11	7:48 PM	04/11/2019	8:00 PM	Oregon: Washington:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
April	2019-04-12	11:20 AM	04/12/2019	12:46 PM	Minnesota: Martin County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
April	2019-04-13	6:15 PM	04/13/2019	11:15 PM	Mississippi: Arkansas: Texas: Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	60467	Weather
April	2019-04-15	10:00 AM	04/15/2019	2:00 PM	Minnesota:	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2019-04-15	4:35 AM	04/15/2019	2:40 PM	Virginia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	75290	Weather
April	2019-04-16	10:30 AM	04/16/2019	11:00 AM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2019-04-17	7:38 PM	04/17/2019	11:52 PM	Arizona:	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2019-04-18	8:08 PM	04/19/2019	11:00 AM	Colorado: Clear Creek County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
April	2019-04-18	7:55 PM	04/19/2019	5:29 PM	Alabama: Mississippi: Georgia: Florida:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	116	34695	Weather
April	2019-04-21	10:40 AM	04/21/2019	10:45 AM	Utah: Salt Lake County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2019-04-25	6:03 PM	04/25/2019	6:32 PM	Arizona: Maricopa County;	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Generation Inadequacy	150	51366	Generation Interruption
April	2019-04-26	1:00 AM	04/26/2019	1:27 PM	Pennsylvania:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	7	5830	Transmission Interruption

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
April	2019-04-26	3:16 PM	04/26/2019	3:17 PM	Massachusetts: Hampden County[13];	NPCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	0	0	Weather
April	2019-04-26	5:46 PM	04/27/2019	11:49 AM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	54071	Weather
April	2019-04-28	1:40 PM	04/28/2019	2:49 PM	South Carolina:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2019-04-28	10:43 AM	04/29/2019	2:06 AM	Ohio:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
April	2019-04-29	5:17 PM	04/30/2019	9:22 AM	Virginia: Surry County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2019-04-30	12:25 PM	04/30/2019	1:11 PM	Indiana:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
May	2019-05-08	9:22 AM	05/08/2019	9:56 AM	Pennsylvania: Mercer County;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	29	1	Transmission Interruption
May	2019-05-08	3:50 PM	05/13/2019	12:00 AM	Louisiana: Texas:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Distribution Interruption	Unknown	65844	Weather
May	2019-05-09	5:55 PM	05/11/2019	8:50 PM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	691	238015	Weather
May	2019-05-09	7:06 PM	05/10/2019	2:57 AM	Texas: Harris County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	0	0	Weather
May	2019-05-10	2:00 AM	05/10/2019	12:15 PM	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	61008	Weather
May	2019-05-11	2:08 PM	05/11/2019	3:00 PM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
May	2019-05-15	12:10 PM	05/15/2019	12:11 PM	West Virginia:	RF	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	Unknown	Unknown	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
May	2019-05-18	1:55 AM	05/18/2019	3:06 PM	Colorado: Wyoming; Nebraska: Utah; Daggett County; New Mexico:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	30	0	Physical Attack
May	2019-05-18	3:45 PM	05/20/2019	4:00 AM	Texas: Ector County, Midland County, Tarrant County, Dallas County, Stephens County, Anderson County, McLennan County, Ellis County, Hunt County, Young County, Bell County, Limestone County, Collin County, Rockwall County, Henderson County, Parker County, Falls County, Freestone County, Kaufman County, Grayson County, Smith County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	68000	Weather
May	2019-05-23	1:11 AM	05/23/2019	12:00 PM	Indiana:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	0	0	Weather
May	2019-05-23	4:55 PM	05/23/2019	11:40 PM	Virginia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	100000	Weather
May	2019-05-24	7:28 AM	05/24/2019	8:30 AM	Kentucky: Shelby County;	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
May	2019-05-24	8:09 PM	05/25/2019	2:23 PM	North Dakota: Minnesota:	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
May	2019-05-24	9:47 PM	05/24/2019	11:58 PM	California:	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system	Severe Weather	20	10961	Weather
May	2019-05-27	10:07 PM	05/28/2019	3:00 AM	Ohio: Montgomery County, Darke County, Mercer County, Miami County, Greene County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	347	70000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
June	2019-06-02	6:19 PM	06/02/2019	8:43 PM	California:	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system.	Severe Weather/Transmission Interruption	Unknown	Unknown	Weather
June	2019-06-04	10:15 AM	06/04/2019	1:15 PM	Nevada: Washoe County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
June	2019-06-05	8:37 AM	06/05/2019	8:40 AM	Idaho: Bannock County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	0	Physical Attack
June	2019-06-05	10:16 AM	06/05/2019	10:17 AM	South Dakota: Lincoln County;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2019-06-05	9:46 AM	06/05/2019	12:00 PM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2019-06-06	6:09 PM	06/06/2019	6:35 PM	Texas: Bexar County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	55017	Weather
June	2019-06-07	2:43 PM	06/07/2019	4:20 PM	Texas: Pecos County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	8	1	Transmission Interruption
June	2019-06-08	3:50 PM	06/08/2019	7:40 PM	Texas: Potter County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
June	2019-06-09	2:45 PM	06/13/2019	10:30 PM	Texas: Collin County, Dallas County, Denton County, Palo Pinto County, Tarrant County, Ellis County, Williamson County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	558000	Weather
June	2019-06-11	3:11 PM	06/11/2019	5:00 PM	North Dakota: Mountrail County, Williams County;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2019-06-11	7:52 AM	06/11/2019	7:53 AM	Utah:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
June	2019-06-12	2:56 PM	06/12/2019	3:50 PM	California: Imperial County, Riverside County;	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Generation Inadequacy	982	30907	Generation Interruption

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
June	2019-06-16	2:00 AM	06/17/2019	11:59 PM	Texas: Dallas County, Tarrant County, Collin County, Denton County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	340000	Weather
June	2019-06-16	3:25 AM	Unknown	Unknown	Oklahoma:	SPP RE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	Unknown	Unknown	Weather
June	2019-06-18	6:21 AM	06/18/2019	6:40 AM	Washington: Grant County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
June	2019-06-19	3:00 PM	Unknown	Unknown	Nevada: Clark County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2019-06-19	11:00 AM	06/19/2019	11:01 AM	Oklahoma:	SPP RE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2019-06-19	10:30 PM	06/20/2019	7:00 PM	Arkansas:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	82045	Weather
June	2019-06-20	4:11 PM	06/21/2019	12:45 PM	Virginia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	60000	Weather
June	2019-06-21	6:36 PM	06/21/2019	7:27 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
June	2019-06-21	10:00 AM	06/21/2019	11:00 AM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2019-06-21	7:15 PM	Unknown	Unknown	Kentucky: Tennessee:	SERC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system.	Severe Weather	Unknown	50000	Weather
June	2019-06-22	8:46 PM	06/23/2019	12:30 AM	Alabama: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	115	34637	Weather
June	2019-06-23	5:13 AM	06/23/2019	10:58 AM	Arkansas:	SPP RE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	47	16199	Transmission Interruption
June	2019-06-23	10:00 PM	06/25/2019	11:00 PM	Texas: Dallas County, Denton County, Ellis County, Collin County, Ellis County, Hood County, Johnson County, Kaufman County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	265000	Weather

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June	2019-06-24	9:40 AM	06/24/2019	3:17 PM	Oklahoma: Oklahoma County;	SPP RE	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
June	2019-06-24	5:30 AM	06/24/2019	8:45 AM	Arkansas:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	56451	Weather
June	2019-06-26	1:58 PM	06/26/2019	2:03 PM	North Dakota: Williams County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	53	0	Transmission Interruption
June	2019-06-28	2:25 PM	Unknown	Unknown	Idaho: Nez Perce County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
June	2019-06-30	3:15 PM	06/30/2019	4:15 PM	New York: Nassau County, Suffolk County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	3189	52498	Weather
June	2019-06-30	3:30 PM	06/30/2019	8:30 PM	Illinois: Cook County, DeKalb County, DuPage County, Grundy County, Iroquois County, Ford County, Lake County, Kendall County, Kankakee County, Kane County, Ogle County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	100000	Weather
July	2019-07-02	1:00 PM	07/02/2019	1:22 PM	Idaho: Ada County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
July	2019-07-06	10:00 PM	07/07/2019	1:57 PM	Mississippi: Panola County;	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	Unknown	3000	Physical Attack
July	2019-07-09	1:59 AM	07/09/2019	3:50 PM	Texas: Louisiana: Arkansas: Mississippi:	SPP RE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
July	2019-07-10	12:00 PM	07/10/2019	12:15 PM	Utah: Salt Lake County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
July	2019-07-10	12:10 PM	07/12/2019	12:30 PM	Texas: Collin County, Dallas County, Denton County, Hood County, Johnson County, Tarrant County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	57000	Weather
July	2019-07-11	11:08 AM	07/11/2019	11:13 AM	Texas: Lynn County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	26	2043	Transmission Interruption

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July	2019-07-13	6:47 PM	07/13/2019	11:37 PM	New York: New York County;	NPCC	Uncontrolled loss of 300 Megawatts or more of firm system loads for 15 minutes or more from a single incident	Transmission Interruption	452	72669	Transmission Interruption
July	2019-07-13	11:55 PM	07/14/2019	1:00 PM	Louisiana: Acadia Parish, Avoyelles Parish, Catahoula Parish, Evangeline Parish, Grant Parish, Iberia Parish, LaSalle Parish, Natchitoches Parish, Rapides Parish, Sabine Parish, St. Landry Parish, St. Martin Parish, St. Mary Parish, St. Tammany Parish, Allen Parish, Beauregard Parish, Calcasieu Parish, Vermillion Parish, De Soto Parish, Jefferson Davis Parish, Red River Parish, Tangipahoa Parish, Vernon Parish, Washington Parish;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	63000	Weather
July	2019-07-13	7:15 AM	07/14/2019	5:00 PM	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	55730	Weather
July	2019-07-17	2:12 PM	07/17/2019	2:30 PM	Oklahoma: Oklahoma County;	SPP RE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
July	2019-07-19	9:55 AM	07/19/2019	1:00 PM	Wisconsin: Dane County;	MRO	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	Unknown	Unknown	Operations
July	2019-07-19	7:00 PM	07/21/2019	8:00 PM	Michigan:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	400000	Weather
July	2019-07-20	7:37 AM	07/20/2019	9:20 AM	Missouri: Boone County;	SERC	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. Or suspicious device or activity at its Bulk Electric System control center.	Suspicious Activity	0	0	Physical Attack
July	2019-07-20	11:55 AM	07/23/2019	12:00 AM	Wisconsin: Michigan:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	200	50000	Weather

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July	2019-07-20	3:00 AM	07/22/2019	7:00 AM	Michigan: Kent County, Newaygo County, Mecosta County, Montcalm County, Isabella County, Ionia County, Allegan County, Barry County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	160000	Weather
July	2019-07-21	11:00 PM	07/22/2019	8:54 PM	New York: Kings County, New York County, Queens County, Bronx County, Westchester County, Richmond County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	60	45000	Weather
July	2019-07-22	4:00 PM	07/24/2019	11:00 PM	Pennsylvania: Bucks County, Delaware County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	165000	Weather
July	2019-07-22	5:50 PM	07/25/2019	1:15 PM	New Jersey: Gloucester County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	49	95600	Weather
July	2019-07-23	3:22 AM	07/23/2019	5:40 AM	California: Santa Cruz County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	25	Physical Attack
July	2019-07-23	11:55 PM	07/23/2019	11:56 PM	Nebraska:	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
July	2019-07-23	11:55 PM	07/24/2019	5:22 AM	Nebraska: Scotts Bluff County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
July	2019-07-23	3:39 PM	07/23/2019	7:00 PM	Massachusetts:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	54	54535	Weather
July	2019-07-24	8:01 AM	07/24/2019	12:49 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2019-07-24	1:30 PM	07/24/2019	1:31 PM	Utah: Iron County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	1	Physical Attack
July	2019-07-28	6:48 PM	07/28/2019	7:18 PM	Michigan:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2019-07-30	8:45 AM	07/30/2019	9:45 AM	Louisiana:	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	Unknown	13720	Weather

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August	2019-08-02	6:24 PM	08/02/2019	7:28 PM	Washington: Clark County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2019-08-02	1:49 AM	08/02/2019	1:55 AM	Minnesota: Chisago County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
August	2019-08-05	5:23 PM	08/06/2019	12:02 AM	Oregon: Umatilla County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	66	Unknown	Transmission Interruption
August	2019-08-07	9:30 AM	08/07/2019	11:15 AM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2019-08-07	3:00 PM	08/07/2019	3:30 PM	California: Kern County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
August	2019-08-07	8:40 AM	Unknown	Unknown	Washington: Pierce County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	0	Physical Attack
August	2019-08-08	4:16 PM	08/08/2019	10:41 PM	Ohio:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	Unknown	5600	Weather
August	2019-08-09	9:53 AM	08/09/2019	10:46 AM	Texas: Travis County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
August	2019-08-10	4:11 PM	08/10/2019	4:46 PM	Michigan:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2019-08-10	7:59 PM	08/10/2019	9:04 PM	Michigan:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2019-08-13	10:00 AM	08/13/2019	11:00 AM	California: Placer County;	WECC	Uncontrolled loss of 300 Megawatts or more of firm system loads for 15 minutes or more from a single incident.	Vandalism	0	0	Physical Attack
August	2019-08-13	12:00 AM	Unknown	Unknown	North Dakota: Mercer County;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	Unknown	Physical Attack
August	2019-08-13	3:10 PM	08/13/2019	5:30 PM	Texas: Williamson County;	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2019-08-15	11:03 PM	08/16/2019	12:37 AM	California: Marin County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Distribution Interruption	80	61318	Distribution Interruption
August	2019-08-15	8:30 AM	Unknown	Unknown	New York: Tompkins County;	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	150	Unknown	Fuel Supply Deficiency
August	2019-08-15	3:07 AM	08/15/2019	3:56 AM	District of Columbia: Maryland;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2019-08-15	11:00 AM	08/15/2019	3:30 PM	Kentucky: Ohio County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
August	2019-08-15	3:11 PM	08/15/2019	6:00 PM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather
August	2019-08-18	4:47 PM	08/18/2018	11:00 PM	Texas:	TRE	Uncontrolled loss of 300 Megawatts or more of firm system loads for 15 minutes or more from a single incident	Distribution Interruption	752	86373	Distribution Interruption
August	2019-08-18	4:30 PM	08/18/2019	10:00 PM	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Transmission Interruption/Distribution Interruption	259	61000	Transmission Interruption
August	2019-08-18	3:59 PM	08/18/2019	11:00 PM	Louisiana: Texas:	SPP RE	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Transmission Interruption	271	86373	Transmission Interruption
August	2019-08-21	7:56 AM	Unknown	Unknown	Ohio:	RF	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	1397	Physical Attack
August	2019-08-21	3:30 PM	Unknown	Unknown	Massachusetts: Middlesex County{13};	NPCC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
August	2019-08-24	4:10 PM	08/24/2019	7:28 PM	Washington:	WECC	Cyber event that could potentially impact electric power system adequacy or reliability.	Suspicious Activity	0	0	Cyber Attack
August	2019-08-25	1:44 AM	08/25/2019	2:20 AM	Washington: King County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
August	2019-08-26	9:09 AM	08/26/2019	1:34 PM	North Dakota:	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
August	2019-08-26	7:00 PM	08/27/2019	3:00 AM	Oklahoma:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	Unknown	95000	Weather
August	2019-08-26	7:00 PM	08/29/2019	1:00 PM	Oklahoma:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	103779	Weather
August	2019-08-29	11:30 PM	08/30/2019	5:30 PM	Michigan:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2019-08-31	3:05 PM	08/31/2019	3:46 PM	Pennsylvania: New Jersey;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2019-08-31	4:00 PM	09/02/2019	6:00 AM	California: Calaveras County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
September	2019-09-04	11:13 AM	09/04/2019	11:57 AM	Maryland: District of Columbia;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2019-09-04	2:30 PM	09/06/2019	6:00 PM	Texas;	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather
September	2019-09-05	10:08 AM	09/05/2019	12:08 PM	Maine;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2019-09-05	10:00 PM	09/06/2019	12:00 PM	North Carolina;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	3	2000	Weather
September	2019-09-05	10:36 PM	09/06/2019	4:00 PM	North Carolina: South Carolina;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	116000	Weather
September	2019-09-05	4:15 AM	09/05/2019	3:17 PM	South Carolina;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	172278	Weather
September	2019-09-06	8:20 AM	Unknown	Unknown	North Carolina;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	77000	Weather
September	2019-09-10	9:22 PM	09/10/2019	9:23 PM	Wyoming: Sweetwater County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	885	0	Transmission Interruption
September	2019-09-11	10:35 PM	09/11/2019	11:59 PM	Michigan: Ionia County, Kent County, Barry County, Montcalm County, Allegan County, Ottawa County, Newaygo County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	54000	Weather
September	2019-09-13	2:31 AM	09/16/2019	5:00 PM	Tennessee;	SERC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2019-09-19	5:55 AM	09/19/2019	2:30 PM	Arizona: Pima County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
September	2019-09-19	6:40 PM	09/19/2019	6:46 PM	Minnesota: Washington County;	MRO	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	0	Physical Attack
September	2019-09-20	12:21 AM	09/20/2019	12:04 PM	Oklahoma: Oklahoma County;	SPP RE	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2019-09-24	3:56 PM	09/26/2019	7:25 PM	Washington: King County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
September	2019-09-25	5:25 PM	09/25/2019	6:16 PM	Wisconsin: Marathon County;	MRO	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
September	2019-09-25	9:59 AM	09/25/2019	10:00 AM	Texas:	TRE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	Unknown	Physical Attack
September	2019-09-25	3:47 AM	09/25/2019	3:40 PM	California: Napa County, Nevada County, Placer County, Plumas County, Sonoma County, Butte County, Yuba County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	25	69524	Weather
September	2019-09-26	2:31 PM	09/26/2019	3:14 PM	Maryland: Baltimore County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2019-09-29	7:38 AM	Unknown	Unknown	California: Alameda County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Distribution Interruption	Unknown	50072	Distribution Interruption
September	2019-09-30	5:35 AM	09/30/2019	8:10 AM	Washington: King County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2019-09-30	12:17 PM	09/30/2019	12:58 PM	Nevada: Clark County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Actual Physical Attack	3736	0	Physical Attack
September	2019-09-30	10:53 AM	09/30/2019	10:54 AM	Idaho: Bonneville County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
October	2019-10-03	12:13 AM	10/03/2019	4:00 AM	Missouri: Reynolds County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
October	2019-10-04	5:15 AM	Unknown	Unknown	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
October	2019-10-06	5:15 AM	Unknown	Unknown	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
October	2019-10-06	2:50 PM	10/06/2019	3:00 PM	Texas: Hidalgo County, Cameron County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	Unknown	Transmission Interruption
October	2019-10-09	12:27 AM	Unknown	Unknown	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	2400	737808	Weather
October	2019-10-10	2:06 AM	10/10/2019	5:05 AM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2019-10-10	12:22 AM	10/10/2019	2:12 AM	Colorado: Jefferson County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations

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October	2019-10-11	10:56 AM	10/11/2019	11:46 AM	Michigan: Wayne County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2019-10-12	3:00 PM	10/12/2019	4:21 PM	Texas:	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2019-10-15	7:57 PM	10/15/2019	8:44 PM	Kansas: Shawnee County;	SPP RE	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2019-10-15	3:19 AM	10/15/2019	6:38 AM	Ohio:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2019-10-16	7:00 AM	Unknown	Unknown	Texas: Louisiana: Arkansas: Mississippi:	SPP RE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
October	2019-10-17	12:45 AM	10/19/2019	9:30 AM	Connecticut: Rhode Island: Massachusetts: Vermont: New Hampshire: Maine:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	101683	Weather
October	2019-10-19	2:00 PM	10/19/2019	9:07 PM	California: Imperial County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2019-10-19	5:57 AM	10/19/2019	1:58 PM	South Dakota: Codington County; Nebraska: Scotts Bluff County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2019-10-20	10:15 PM	10/25/2019	2:00 AM	Texas: Cass County, Cameron County, Collin County, Dallas County, Ellis County, Erath County, Hunt County, Kaufman County, Lamar County, Panola County, Rains County, Rockwall County, Rusk County, Tarrant County, Van Zandt County, Wood County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	400000	Weather
October	2019-10-23	12:49 AM	10/23/2019	4:05 AM	New York: Monroe County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2019-10-23	12:49 AM	10/23/2019	4:05 AM	New York: Broome County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2019-10-23	2:36 PM	Unknown	Unknown	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	Unknown	50000	Weather
October	2019-10-24	5:15 AM	Unknown	Unknown	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
October	2019-10-24	5:02 PM	10/24/2019	5:09 PM	Ohio: Lorain County;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2019-10-25	2:53 AM	10/25/2019	4:37 AM	South Carolina: Cherokee County;	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
October	2019-10-26	8:07 AM	10/26/2019	8:45 AM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2019-10-26	6:20 PM	10/31/2019	1:27 AM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	3190	972000	Weather
October	2019-10-26	5:15 AM	10/26/2019	5:31 PM	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	82124	Weather
October	2019-10-26	6:00 PM	Unknown	Unknown	Tennessee:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	70000	Weather
October	2019-10-29	1:46 PM	10/29/2019	2:49 PM	Wisconsin: Brown County, Manitowoc County, Calumet County, Winnebago County, Kewaunee County, Door County, Oconto County, Marinette County, Forest County, Langlade County, Oneida County, Vilas County, Lincoln County, Oneida County, Portage County;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2019-10-30	6:32 AM	11/01/2019	1:29 PM	California: Los Angeles County, Orange County, Riverside County, San Bernardino County, Ventura County, Kern County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Distribution Interruption	285	114402	Weather
October	2019-10-31	10:00 PM	Unknown	Unknown	Pennsylvania:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Distribution Interruption	Unknown	53943	Weather

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November	2019-11-01	11:45 PM	11/02/2019	12:48 AM	New York: Broome County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2019-11-01	11:45 PM	11/02/2019	12:48 AM	New York: Monroe County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2019-11-01	1:00 AM	11/03/2019	1:00 PM	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	8000	Weather
November	2019-11-01	1:15 AM	11/02/2019	9:30 PM	Connecticut: Maine: Massachusetts: Rhode Island: New Hampshire: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	80066	Weather
November	2019-11-01	2:41 AM	Unknown	Unknown	New York: Broome County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	66325	Weather
November	2019-11-03	10:17 PM	11/04/2019	11:10 AM	Minnesota: Sherburne County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
November	2019-11-05	8:30 AM	11/05/2019	4:16 PM	Indiana:	RF	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
November	2019-11-05	3:40 PM	11/05/2019	5:11 PM	Idaho: Elmore County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	131	Physical Attack
November	2019-11-05	8:56 AM	11/05/2019	11:51 AM	Florida: Duval County;	FRCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	1500	Unknown	Transmission Interruption
November	2019-11-08	5:50 AM	11/08/2019	6:10 AM	Utah: California: Oregon: Wyoming:	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system.	System Operations	72	Unknown	Operations
November	2019-11-16	4:11 PM	11/16/2019	5:01 PM	Oregon: Lane County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
November	2019-11-16	6:00 AM	11/16/2019	5:45 PM	Texas: New York: Dutchess County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
November	2019-11-20	4:55 PM	11/20/2019	5:37 PM	California: Imperial County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations

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November	2019-11-20	9:49 AM	11/20/2019	3:20 PM	California: Colusa County, Lake County, Mendocino County, Napa County, Solano County, Sonoma County, Yolo County, Shasta County, Tehama County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	178	54000	Weather
November	2019-11-22	12:00 AM	11/22/2019	1:10 AM	New York: Broome County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2019-11-22	12:00 AM	11/22/2019	1:10 AM	New York: Monroe County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2019-11-26	6:07 PM	11/27/2019	12:27 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	300	93000	Weather
November	2019-11-27	2:44 AM	11/27/2019	4:00 PM	California: Santa Clara County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	35	2	Physical Attack
November	2019-11-27	12:00 PM	11/30/2019	2:00 AM	Michigan: Tuscola County, Sanilac County, Huron County, St. Clair County, Macomb County, Oakland County, Wayne County, Livingston County, Washtenaw County, Monroe County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	30	107000	Weather
November	2019-11-29	12:00 AM	12/01/2019	12:00 AM	Texas: Dawson County;	TRE	Damage or destruction of a Facility within its Reliability Coordinator Area, Balancing Authority Area or Transmission Operator Area that results in action(s) to avoid a Bulk Electric System Emergency.	Actual Physical Attack	0	0	Physical Attack
December	2019-12-03	7:16 PM	12/03/2019	7:49 PM	Alabama: Covington County;	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2019-12-03	6:55 AM	Unknown	Unknown	California: Fresno County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	Unknown	Physical Attack
December	2019-12-05	4:48 PM	12/09/2019	5:16 AM	Ohio: Kentucky;	RF	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2019-12-05	12:00 AM	Unknown	Unknown	Washington: Chelan County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	Unknown	Unknown	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2019-12-07	6:10 AM	12/08/2019	2:20 AM	Oklahoma: Stephens County;	SPP RE	Physical attack that causes major interruptions or impacts to critical infrastructure or to operations.	Actual Physical Attack	2	400	Physical Attack
December	2019-12-08	1:40 PM	12/08/2019	1:41 PM	Texas: Dallas County;	TRE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
December	2019-12-11	1:22 PM	12/11/2019	4:28 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2019-12-11	8:53 PM	12/11/2019	9:33 PM	Oklahoma: Stephens County;	SPP RE	Physical attack that causes major interruptions or impacts to critical infrastructure or to operations.	Actual Physical Attack	1	392	Physical Attack
December	2019-12-11	1:27 PM	12/11/2019	1:51 PM	North Dakota: Burleigh County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	18	1	Transmission Interruption
December	2019-12-16	11:55 PM	12/17/2019	1:47 AM	Texas:	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
December	2019-12-18	2:30 PM	12/18/2019	3:25 PM	Texas: Nueces County;	TRE	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2019-12-19	2:58 AM	12/19/2019	3:46 AM	Nebraska:	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2019-12-24	3:30 PM	12/24/2019	7:34 PM	Illinois:	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
December	2019-12-31	12:00 PM	12/31/2019	1:00 PM	Washington:	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
December	2019-12-31	11:03 AM	01/01/2020	10:59 AM	Texas: Nueces County;	TRE	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blocked out area or within the partial failure of an integrated electrical system.	Transmission Interruption	25	0	Transmission Interruption
January	2020-01-09	11:07 PM	1/9/2020	11:19 PM	Arkansas: Yell County;	SPP RE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	0	0	Weather
January	2020-01-09	8:45 PM	1/10/2020	9:23 PM	Washington: King County;	WECC	Cyber event that could potentially impact electric power system adequacy or reliability.	Suspicious Activity	0	0	Cyber Attack

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January	2020-01-09	7:40 AM	1/9/2020	8:48 AM	Minnesota: North Dakota: Wisconsin:	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
January	2020-01-09	11:07 PM	1/9/2020	11:18 PM	Arkansas:	SPP RE	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	System Operations	Unknown	Unknown	Operations
January	2020-01-10	2:53 PM	Unknown	Unknown	Tennessee: Hamilton County;	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	Unknown	Unknown	Physical Attack
January	2020-01-11	2:25 AM	1/11/2020	7:56 AM	Arkansas: Cross County;	SPP RE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	22	7541	Weather
January	2020-01-11	11:02 PM	1/12/2020	2:01 AM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	66475	Weather
January	2020-01-11	3:30 AM	1/11/2020	5:30 PM	Arkansas: Texas:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	68138	Weather
January	2020-01-11	1:20 PM	Unknown	Unknown	Tennessee:	SERC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	Severe Weather	4	Unknown	Weather
January	2020-01-11	12:50 PM	1/12/2020	1:33 PM	Alabama: Georgia: Mississippi:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	219	30715	Weather
January	2020-01-12	11:15 AM	1/12/2020	11:18 AM	Texas: Brazos County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
January	2020-01-14	12:00 AM	1/14/2020	1:00 AM	Florida: Alachua County;	FRCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
January	2020-01-16	11:06 AM	1/16/2020	11:36 AM	Texas: Harris County;	TRE	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
January	2020-01-17	5:28 AM	1/17/2020	10:13 AM	California: Humboldt County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	Severe Weather/Transmission Interruption	87	67864	Weather
January	2020-01-20	6:30 AM	1/20/2020	6:31 AM	California: Los Angeles County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
January	2020-01-22	2:57 AM	1/22/2020	3:17 AM	Nevada: Humboldt County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Actual Physical Attack	7	3120	Physical Attack
January	2020-01-23	11:30 PM	1/24/2020	12:39 AM	Florida: Manatee County;	FRCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	0	Physical Attack
January	2020-01-24	4:34 AM	Unknown	Unknown	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
January	2020-01-27	2:10 PM	1/27/2020	6:58 PM	North Dakota: South Dakota; Montana;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	540	130000	Operations
January	2020-01-30	3:01 AM	1/30/2020	4:36 AM	North Dakota: Burleigh County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	75	0	Transmission Interruption
January	2020-01-31	9:50 AM	2/3/2020	10:00 AM	California:	WECC	Cyber event that could potentially impact electric power system adequacy or reliability.	Suspicious Activity	0	0	Cyber Attack
February	2020-02-06	2:29 PM	2/7/2020	12:44 PM	North Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Distribution Interruption	Unknown	284256	Weather
February	2020-02-06	1:30 PM	2/7/2020	8:08 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	Unknown	89500	Weather
February	2020-02-07	4:25 PM	2/8/2020	12:00 PM	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	123359	Weather
February	2020-02-07	2:42 PM	2/10/2020	9:25 AM	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	7500	Weather
February	2020-02-07	11:00 AM	Unknown	Unknown	Pennsylvania:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Distribution Interruption	Unknown	52000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
February	2020-02-07	8:48 AM	Unknown	Unknown	Virginia: North Carolina;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	87000	Weather
February	2020-02-08	1:56 PM	2/8/2020	3:04 PM	California:	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
February	2020-02-09	9:30 AM	2/9/2020	9:40 PM	California: Alameda County, Contra Costa County, El Dorado County, Nevada County, Placer County, Sierra County, Santa Clara County, Napa County, Marin County, Santa Cruz County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	500	145000	Weather
February	2020-02-11	2:53 AM	2/11/2020	1:30 PM	Texas: Sterling County;	TRE	Cyber event that could potentially impact electric power system adequacy or reliability.	System Operations	0	0	Cyber Attack
February	2020-02-11	7:13 AM	2/11/2020	4:00 PM	Oregon: Clackamas County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	0	Transmission Interruption
February	2020-02-12	7:36 AM	2/12/2020	8:53 AM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
February	2020-02-13	8:01 AM	2/13/2020	2:38 PM	Oregon:	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
February	2020-02-17	9:47 AM	2/17/2020	3:31 PM	Alabama: Chambers County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	97	Unknown	Physical Attack
February	2020-02-17	1:18 PM	2/20/2020	9:51 AM	Michigan: Eaton County;	RF	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
February	2020-02-17	4:00 AM	Unknown	Unknown	Northern and Central California;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	91	70000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
February	2020-02-18	1:00 PM	2/18/2020	2:00 PM	California: Kern County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
February	2020-02-25	11:45 AM	2/25/2020	1:00 PM	California: Los Angeles County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
February	2020-02-26	4:30 PM	2/26/2020	5:02 PM	Oklahoma:	SPP RE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
February	2020-02-26	5:00 PM	2/26/2020	6:05 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
February	2020-02-26	11:29 AM	2/26/2020	12:14 PM	South Dakota: Wyoming: Colorado:	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
February	2020-02-29	1:45 AM	2/29/2020	2:30 AM	Nevada: Clark County, Washoe County;	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-01	11:27 AM	03/01/2020	9:47 PM	Mississippi: Rankin County;	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	19	3136	Transmission Interruption
March	2020-03-01	10:15 PM	Unknown	Unknown	New York:	NPCC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
March	2020-03-01	8:00 AM	Unknown	Unknown	Western NY	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	675	Unknown	Fuel Supply Deficiency
March	2020-03-02	1:43 AM	03/02/2020	2:43 AM	Nevada: Clark County, Washoe County;	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-03	2:30 PM	03/03/2020	2:31 PM	Alabama:	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
March	2020-03-08	10:10 PM	03/09/2020	1:02 AM	Texas: Llano County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack

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March	2020-03-12	1:03 AM	03/12/2020	3:00 AM	Pennsylvania:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	40	15864	Transmission Interruption
March	2020-03-16	12:01 PM	03/16/2020	1:10 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	165	110800	Weather
March	2020-03-16	8:00 AM	03/16/2020	8:01 AM	California: Los Angeles County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
March	2020-03-16	8:00 AM	03/16/2020	8:01 AM	California: Los Angeles County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
March	2020-03-17	10:30 AM	03/17/2020	11:41 AM	Michigan: Washtenaw County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	6062	0	Operations
March	2020-03-18	7:09 AM	Unknown	Unknown	Utah:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Natural Disaster	237	73000	Natural Disaster
March	2020-03-19	5:05 PM	03/19/2020	5:43 PM	Minnesota: St. Louis County;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-20	10:20 PM	03/20/2020	11:30 PM	Connecticut: Massachusetts: Rhode Island: Maine: New Hampshire: Vermont:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-20	11:38 PM	03/20/2020	11:59 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-20	11:45 PM	03/21/2020	12:30 AM	Connecticut: Massachusetts:	NPCC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-23	12:15 AM	03/25/2020	5:11 PM	Wisconsin: Columbia County;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
March	2020-03-23	2:15 PM	03/23/2020	4:37 PM	Virginia:	SERC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Sabotage	Unknown	1018	Physical Attack
March	2020-03-24	12:45 PM	03/24/2020	2:00 PM	California: Nevada County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
March	2020-03-24	2:55 AM	03/24/2020	6:50 AM	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	51026	Weather

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March	2020-03-25	10:31 AM	Unknown	Unknown	Nevada: Clark County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
March	2020-03-26	9:29 PM	03/26/2020	9:47 PM	Ohio:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	19	11964	Transmission Interruption
March	2020-03-27	1:06 PM	03/27/2020	1:58 PM	Delaware: Kent County, New Castle County, Sussex County; Maryland: Cecil County, Harford County, Talbot County, Kent County, Queen Anne's County, Dorchester County, Wicomico County, Worcester County, Somerset County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-27	1:06 PM	03/27/2020	1:58 PM	New Jersey: Atlantic County, Cape May County, Cumberland County, Gloucester County, Salem County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
March	2020-03-29	8:27 PM	03/29/2020	11:04 PM	Mississippi: Panola County;	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	4	1558	Transmission Interruption
March	2020-03-31	11:45 AM	03/31/2020	8:00 PM	Alabama: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	412	57744	Weather
April	2020-04-01	9:43 PM	04/01/2020	10:18 PM	Illinois: Williamson County;	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2020-04-02	6:41 PM	04/02/2020	7:23 PM	Texas: Travis County;	TRE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2020-04-02	1:37 PM	04/02/2020	2:43 PM	Nebraska: York County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	5	Unknown	Transmission Interruption
April	2020-04-02	8:45 PM	Unknown	Unknown	Washington: Wallula	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	Unknown	Unknown	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
April	2020-04-03	9:13 AM	Unknown	Unknown	Nevada: Clark County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2020-04-05	2:30 AM	04/05/2020	3:01 AM	Texas: Cameron County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
April	2020-04-05	3:46 PM	04/05/2020	5:35 PM	California: Stanislaus County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	Severe Weather	7	6814	Weather
April	2020-04-07	11:39 PM	04/07/2020	11:46 PM	Washington:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
April	2020-04-08	9:57 PM	04/09/2020	8:59 AM	Ohio: Kentucky;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	78314	Weather
April	2020-04-08	10:03 PM	04/09/2020	7:36 AM	Indiana:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	93000	Weather
April	2020-04-08	1:21 AM	04/08/2020	3:56 AM	Ohio:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	82509	Weather
April	2020-04-09	7:25 PM	04/10/2020	3:30 AM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	95000	Weather
April	2020-04-09	7:40 PM	04/11/2020	10:00 PM	Maine:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	340000	Weather
April	2020-04-09	7:34 AM	04/09/2020	5:40 PM	Wisconsin: Dane County;	RF	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2020-04-10	10:00 AM	04/10/2020	4:19 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
April	2020-04-10	4:00 PM	Unknown	Unknown	Nevada: White Pine County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2020-04-11	11:24 AM	04/11/2020	11:42 AM	Wyoming:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
April	2020-04-11	5:40 PM	04/11/2020	5:51 PM	Utah: Salt Lake City	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Suspicious Activity	Unknown	Unknown	Physical Attack
April	2020-04-12	8:45 PM	Unknown	Unknown	Arkansas:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	95318	Weather

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April	2020-04-12	1:00 PM	04/12/2020	7:27 PM	Louisiana: Acadia Parish, Iberville Parish, Jefferson Davis Parish, Concordia Parish, Winn Parish, Catahoula Parish, Terrebonne Parish, St. Mary Parish;	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	Severe Weather	122	37991	Weather
April	2020-04-12	8:30 PM	04/14/2020	9:00 AM	Arkansas:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	51000	Weather
April	2020-04-12	9:28 PM	04/15/2020	12:00 PM	Virginia: West Virginia:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	104000	Weather
April	2020-04-12	5:00 PM	04/14/2020	1:25 AM	Mississippi: Alabama: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	448	62828	Weather
April	2020-04-12	6:13 PM	04/13/2020	3:23 PM	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	63289	Weather
April	2020-04-13	3:30 AM	04/14/2020	6:18 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	216400	Weather
April	2020-04-13	12:45 AM	04/13/2020	3:00 AM	Tennessee: Hamilton County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	120000	Weather
April	2020-04-13	8:08 AM	Unknown	Unknown	South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	72233	Weather
April	2020-04-13	10:25 AM	04/13/2020	6:55 PM	North Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	95000	Weather
April	2020-04-13	1:05 PM	04/14/2020	4:00 PM	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	68476	Weather
April	2020-04-13	7:31 AM	04/13/2020	2:00 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	Unknown	Weather
April	2020-04-16	11:30 AM	04/16/2020	3:45 PM	Georgia:	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2020-04-18	7:38 PM	Unknown	Unknown	Nevada: Washoe County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2020-04-19	1:14 AM	04/20/2020	11:42 AM	North Dakota: Burleigh County;	MRO	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
April	2020-04-20	12:42 PM	04/20/2020	1:27 PM	South Dakota: Deuel County;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2020-04-20	12:59 AM	04/20/2020	8:40 AM	Alabama: Mississippi: Georgia: Florida:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	552	77341	Weather
April	2020-04-23	4:30 AM	04/23/2020	7:00 AM	Mississippi: Arkansas: Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	55184	Weather
April	2020-04-23	8:00 AM	04/23/2020	11:40 PM	Alabama: Georgia: Mississippi: Florida:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	375	52163	Weather
April	2020-04-24	10:00 PM	Unknown	Unknown	Nevada: White Pine County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack

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April	2020-04-24	9:00 PM	04/24/2020	9:33 PM	California: Placer County, Nevada County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	System Operations	5	945	Operations
April	2020-04-25	9:25 PM	04/25/2020	9:56 PM	Oregon: Multnomah County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
April	2020-04-26	1:38 AM	Unknown	Unknown	Florida:	FRCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	49999	Weather
April	2020-04-28	8:01 PM	04/28/2020	11:21 PM	Texas: Jefferson County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	14	1	Transmission Interruption
April	2020-04-29	6:00 AM	04/29/2020	12:31 PM	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	77933	Weather
April	2020-04-29	5:55 AM	04/29/2020	7:00 PM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	146660	Weather
April	2020-04-30	3:00 PM	Unknown	Unknown	Pennsylvania: Bucks County, Chester County, Delaware County, Montgomery County, Philadelphia County, York County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	78007	Weather
May	2020-05-04	11:59 AM	05/07/2020	8:00 PM	Tennessee: Davidson County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	500	130000	Weather
May	2020-05-08	1:45 PM	05/08/2020	1:46 PM	Nevada: Nye County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
May	2020-05-13	11:16 PM	05/14/2020	1:52 PM	Indiana: Hendricks County;	RF	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
May	2020-05-13	5:12 AM	05/13/2020	2:07 PM	Washington:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
May	2020-05-14	11:23 AM	05/14/2020	11:25 AM	Oregon: Jackson County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
May	2020-05-15	5:55 PM	05/17/2020	6:00 PM	New York: Saratoga County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	52	Weather
May	2020-05-16	12:00 AM	05/16/2020	12:30 AM	Texas: Cameron County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
May	2020-05-18	11:51 PM	05/19/2020	4:37 AM	South Carolina:	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
May	2020-05-18	9:27 AM	05/18/2020	10:15 AM	Oregon: Clackamas County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
May	2020-05-19	8:04 PM	05/19/2020	10:00 PM	Alabama: Jefferson County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	8	6000	Physical Attack
May	2020-05-19	8:17 AM	05/19/2020	8:18 AM	Idaho: Bonneville County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
May	2020-05-19	1:45 PM	05/19/2020	1:46 PM	Arkansas:	SPP RE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
May	2020-05-20	11:41 AM	Unknown	Unknown	Nevada: Clark County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
May	2020-05-22	4:35 PM	05/23/2020	3:29 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	108190	Weather
May	2020-05-24	4:45 PM	Unknown	Unknown	Central Oklahoma	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	54000	Weather
May	2020-05-25	10:58 AM	05/25/2020	1:00 PM	Texas: Kerr County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	8	3745	Transmission Interruption
May	2020-05-27	5:15 PM	05/29/2020	6:30 AM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	382000	Weather
May	2020-05-27	5:20 PM	Unknown	Unknown	Texas:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	273269	Weather
May	2020-05-29	5:01 PM	05/29/2020	6:57 PM	Pennsylvania: Warren County;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
May	2020-05-29	5:30 PM	05/31/2020	6:00 PM	Minnesota: Hennepin County;	MRO	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. Or suspicious device or activity at its Bulk Electric System control center.	System Operations	0	0	Physical Attack
May	2020-05-29	9:37 PM	05/30/2020	4:29 AM	Ohio: Franklin County;	RF	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
May	2020-05-30	10:20 PM	05/30/2020	11:00 PM	Texas: Bexar County;	TRE	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
May	2020-05-31	9:30 PM	06/01/2020	1:00 AM	Alabama: Jefferson County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
May	2020-05-31	12:15 AM	Unknown	Unknown	Pennsylvania:	RF	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. Or suspicious device or activity at its Bulk Electric System control center.	Vandalism	0	0	Physical Attack
June	2020-06-02	2:36 PM	06/02/2020	2:37 PM	Idaho: Blaine County, Jerome County, Minidoka County, Power County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	Unknown	0	Physical Attack
June	2020-06-03	1:00 PM	06/06/2020	4:30 PM	New Jersey;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	80	87000	Weather
June	2020-06-03	12:30 PM	06/03/2020	6:00 PM	Pennsylvania: Bucks County, Chester County, Delaware County, Montgomery County, Philadelphia County, York County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	708000	Weather
June	2020-06-03	4:57 PM	06/03/2020	5:29 PM	North Dakota: Minnesota;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
June	2020-06-03	1:36 PM	06/03/2020	4:30 PM	New Jersey;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	78079	Weather
June	2020-06-09	11:21 AM	06/09/2020	12:01 PM	Washington:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
June	2020-06-10	7:30 PM	Unknown	Unknown	Michigan: Oakland County, Macomb County, Wayne County, Sanilac County, Tuscola County, Huron County, Lapeer County, Livingston County, Monroe County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	237000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
June	2020-06-10	12:22 PM	06/10/2020	5:00 PM	Michigan: Gratiot County, Lake County, Missaukee County, Benzie County, Leelanau County, Manistee County, Wexford County, Montcalm County, Kent County, Ottawa County, Van Buren County, St. Joseph County, Arenac County, Saginaw County, Calhoun County, Branch County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	270000	Weather
June	2020-06-10	5:24 PM	06/11/2020	6:00 PM	Ohio: Indiana: Kentucky: West Virginia:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	85822	Weather
June	2020-06-12	8:21 AM	06/12/2020	8:22 AM	Michigan: Houghton County;	RF	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	0	Physical Attack
June	2020-06-18	12:11 PM	06/22/2020	8:11 AM	Colorado: El Paso County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Actual Physical Attack	0	0	Physical Attack
June	2020-06-18	8:32 PM	06/18/2020	8:35 PM	Kentucky: Gallatin County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Actual Physical Attack	0	0	Physical Attack
June	2020-06-21	1:16 AM	06/21/2020	6:45 PM	Delaware: New Castle County;	RF	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2020-06-22	11:44 AM	06/22/2020	12:42 PM	Pennsylvania: Allegheny County, Beaver County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
June	2020-06-25	9:40 AM	06/25/2020	11:00 AM	Kentucky: Madison County;	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	Unknown	0	Physical Attack
June	2020-06-26	4:20 PM	06/29/2020	3:00 PM	North Dakota: Mountrail County;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
June	2020-06-26	12:47 PM	06/26/2020	1:53 PM	Texas: Travis County;	TRE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
June	2020-06-27	4:00 PM	06/28/2020	2:27 AM	Alabama: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	33480	78109	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
June	2020-06-29	2:32 PM	06/29/2020	4:35 PM	Arkansas: Garland County;	SPP RE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
June	2020-06-30	10:28 AM	06/30/2020	10:29 AM	Oregon:	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	0	Physical Attack
July	2020-07-01	7:26 PM	07/01/2020	7:44 PM	Pennsylvania:	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	32	2013	Transmission Interruption
July	2020-07-02	8:30 PM	Unknown	Unknown	California: Butte County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
July	2020-07-06	12:26 PM	Unknown	Unknown	New York: Kings County;	NPCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
July	2020-07-06	6:45 PM	07/06/2020	7:42 PM	District of Columbia: Maryland:	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2020-07-07	11:38 AM	07/07/2020	6:24 PM	California: Los Angeles County;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
July	2020-07-07	1:09 PM	07/08/2020	8:17 AM	Colorado:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
July	2020-07-07	7:17 PM	07/07/2020	11:49 PM	West Virginia: Wyoming County;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Severe Weather/Transmission Interruption	Unknown	Unknown	Weather
July	2020-07-08	10:04 PM	Unknown	Unknown	Texas:	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Actual Physical Attack	0	0	Physical Attack
July	2020-07-08	6:45 PM	Unknown	Unknown	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency

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July	2020-07-09	3:09 PM	Unknown	Unknown	Washington: Thurston County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
July	2020-07-11	11:30 PM	07/12/2020	6:30 AM	Oklahoma: Arkansas;	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	68000	Weather
July	2020-07-11	9:30 PM	Unknown	Unknown	Oklahoma:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	94700	Weather
July	2020-07-11	4:55 AM	Unknown	Unknown	California:	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
July	2020-07-12	4:30 AM	07/13/2020	5:00 AM	Texas: Collin County, Dallas County, Denton County, Rockwall County, Tarrant County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	48000	Physical Attack
July	2020-07-12	2:08 PM	07/12/2020	8:44 PM	Nevada: Washoe County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Actual Physical Attack	36	10000	Physical Attack
July	2020-07-13	4:30 PM	07/13/2020	4:31 PM	Kentucky: Madison County;	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
July	2020-07-14	2:16 PM	07/14/2020	2:53 PM	California:	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2020-07-15	11:00 AM	07/15/2020	11:20 AM	Kentucky: Madison County;	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	Unknown	0	Physical Attack
July	2020-07-16	8:49 AM	07/16/2020	11:06 AM	North Dakota: Minnesota;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	475	0	Operations
July	2020-07-17	11:00 PM	07/17/2020	11:30 PM	Oklahoma:	SPP RE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
July	2020-07-17	7:24 PM	Unknown	Unknown	New York:	NPCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
July	2020-07-19	2:30 PM	07/21/2020	6:48 PM	Michigan:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	158500	Weather
July	2020-07-19	10:30 AM	Unknown	Unknown	New York: Niagara County	NPCC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	675		Fuel Supply Deficiency

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July	2020-07-20	12:57 AM	07/20/2020	2:34 AM	Texas: Travis County;	TRE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Suspicious Activity	21	14096	Physical Attack
July	2020-07-21	11:53 AM	07/21/2020	1:00 PM	Washington: Pierce County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	19	11000	Physical Attack
July	2020-07-22	11:30 AM	07/22/2020	2:19 PM	West Virginia: Tucker County;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
July	2020-07-24	8:25 AM	Unknown	Unknown	New York: Bronx County;	NPCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
July	2020-07-25	9:00 PM	07/26/2020	4:00 PM	Texas: Hidalgo County, Cameron County, Starr County, Kenedy County, Willacy County, Brooks County, Jim Hogg County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	125	84000	Weather
July	2020-07-25	7:58 PM	07/27/2020	7:00 PM	Texas: Nueces County, Kleberg County, Cameron County, Willacy County, Hidalgo County, Starr County, Kenedy County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	201208	Weather
July	2020-07-28	3:00 PM	07/28/2020	11:00 PM	Michigan: Jackson County;	RF	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
July	2020-07-30	5:54 PM	07/30/2020	8:18 PM	Nebraska: Scotts Bluff County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
August	2020-08-01	11:14 AM	08/10/2020	9:26 PM	Texas: Cameron County, Willacy County, Hidalgo County, Starr County;	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather
August	2020-08-01	8:16 AM	08/01/2020	9:15 AM	California: San Diego County;	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2020-08-01	12:00 AM	08/01/2020	12:01 AM	Texas: Cameron County, Hidalgo County, Starr County, Willacy County;	TRE	Damage or destruction of a Facility within its Reliability Coordinator Area, Balancing Authority Area or Transmission Operator Area that results in action(s) to avoid a Bulk Electric System Emergency.	Severe Weather	Unknown	Unknown	Weather

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August	2020-08-02	7:43 PM	08/02/2020	10:27 PM	Illinois: Rock Island County;	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
August	2020-08-03	8:00 AM	08/03/2020	1:00 PM	Texas: Ector County;	TRE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
August	2020-08-03	11:15 PM	08/06/2020	7:00 AM	North Carolina: South Carolina;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	340000	Weather
August	2020-08-03	11:02 PM	Unknown	Unknown	North Carolina:	SERC	Complete loss of off-site power (LOOP) affecting a nuclear generating station per the Nuclear Plant Interface Requirements.	Severe Weather	Unknown	Unknown	Weather
August	2020-08-04	12:00 PM	08/07/2020	6:00 AM	New York: Rockland County, Orange County, Sullivan County; New Jersey: Bergen County, Passaic County, Sussex County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	160000	Weather
August	2020-08-04	1:00 PM	08/04/2020	11:59 PM	New York: Nassau County, Suffolk County, Queens County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	3907	420000	Weather
August	2020-08-04	11:20 AM	08/07/2020	10:55 AM	New Jersey:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	60	75000	Weather
August	2020-08-04	9:00 AM	08/05/2020	6:00 PM	Delaware:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	100000	Weather
August	2020-08-04	2:00 PM	08/08/2020	12:00 PM	New York: Dutchess County, Orange County, Ulster County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	116818	Weather
August	2020-08-04	4:41 AM	08/05/2020	4:26 PM	Virginia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	508000	Weather
August	2020-08-04	12:18 PM	08/08/2020	5:31 PM	New Jersey:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	788000	Weather
August	2020-08-04	2:35 PM	08/10/2020	11:00 AM	New York: Broome County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	76120	Weather
August	2020-08-04	3:15 PM	08/07/2020	10:27 AM	Connecticut: Massachusetts: New Hampshire: Maine: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	2000	1188247	Weather
August	2020-08-04	1:31 PM	Unknown	Unknown	New York: Bronx County, Richmond County, Queens County, Kings County, Westchester County, New York County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	271119	Weather

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August	2020-08-04	6:01 AM	08/06/2020	3:30 PM	North Carolina: Brunswick County, Columbus County, Pender County, Duplin County, Onslow County, Jones County, Craven County, Jones County, Beaufort County, Bertie County, Chowan County, Gates County, Perquimans County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	311	125987	Weather
August	2020-08-04	12:00 PM	Unknown	Unknown	Pennsylvania: Bucks County, Chester County, Delaware County, Montgomery County, Philadelphia County, York County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	137103	Weather
August	2020-08-04	10:30 AM	Unknown	Unknown	New Jersey:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	70000	Weather
August	2020-08-04	2:35 PM	Unknown	Unknown	New York:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	76120	Weather
August	2020-08-05	5:58 PM	08/05/2020	8:53 PM	Texas: Orange County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	89	19785	Transmission Interruption
August	2020-08-07	5:13 AM	Unknown	Unknown	New York: Queens County, New York County;	NPCC	Uncontrolled loss of 300 Megawatts or more of firm system loads for 15 minutes or more from a single incident.	Severe Weather	500	187068	Weather

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August	2020-08-10	11:00 AM	08/10/2020	4:00 PM	Iowa: Webster County, Greene County, Dallas County, Hamilton County, Boone County, Polk County, Hardin County, Story County, Jasper County, Grundy County, Marshall County, Tama County, Poweshiek County, Benton County, Iowa County, Linn County, Johnson County, Jones County, Cedar County, Muscatine County, Jackson County, Clinton County, Scott County;	MRO	Uncontrolled loss of 200 Megawatts or more of firm system loads for 15 minutes or more from a single incident for entities with previous year's peak demand less than or equal to 3,000 Megawatts.	Severe Weather	550	Unknown	Weather Weather Weather Weather Weather Operations Weather
August	2020-08-10	4:00 PM	08/13/2020	3:00 PM	Illinois: Missouri:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	135000	
August	2020-08-10	12:49 PM	Unknown	Unknown	Iowa:	MRO	Complete loss of off-site power (LOOP) affecting a nuclear generating station per the Nuclear Plant Interface Requirements.	Severe Weather	Unknown	Unknown	
August	2020-08-10	10:39 PM	08/13/2020	3:48 PM	Indiana:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	95300	
August	2020-08-10	2:30 PM	Unknown	Unknown	Illinois: Cook County, Will County, DuPage County, Lake County, Kane County, Grundy County, LaSalle County, DeKalb County, McHenry County, Lee County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	856000	
August	2020-08-10	10:25 PM	08/10/2020	11:02 PM	New York: Onondaga County;	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	
August	2020-08-10	12:38 PM	Unknown	Unknown	Iowa:	MRO	Uncontrolled loss of 300 Megawatts or more of firm system loads for 15 minutes or more from a single incident.	Severe Weather	1400	250000	

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August	2020-08-10	10:00 AM	Unknown	Unknown	Iowa: Dallas County, Polk County, Warren County, Madison County, Johnson County, Scott County; Illinois: Rock Island County, Henry County, Mercer County;	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	950	300000	Weather
August	2020-08-13	1:51 PM	08/13/2020	4:27 PM	Texas: El Paso County;	TRE	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	System Operations	218	57060	Operations
August	2020-08-14	6:36 PM	08/14/2020	8:42 PM	California:	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	System Operations	560	220000	Operations
August	2020-08-14	4:39 PM	08/14/2020	5:42 PM	Louisiana: St. Charles Parish;	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	101	12671	Transmission Interruption
August	2020-08-14	5:15 PM	08/15/2020	9:00 PM	California:	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Severe Weather	1120	Unknown	Weather
August	2020-08-14	6:45 PM	08/14/2020	9:12 PM	California: Kern County, Kings County, Los Angeles County, Orange County, Riverside County, San Bernardino County, Santa Barbara County, Tulare County, Ventura County;	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	System Operations	1419	132000	Operations
August	2020-08-14	8:00 PM	08/16/2020	5:00 PM	Minnesota: Anoka County, Hennepin County, Ramsey County, Washington County;	MRO	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	60000	Weather
August	2020-08-15	6:25 PM	08/15/2020	7:44 PM	California:	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	System Operations	459	220000	Operations
August	2020-08-15	2:53 PM	08/15/2020	8:00 PM	California:	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Severe Weather	795	Unknown	Weather
August	2020-08-15	3:00 PM	08/15/2020	7:45 PM	California: Inyo County, Kern County, Los Angeles County, Orange County, Riverside County, San Bernardino County, Tulare County, Ventura County;	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	System Operations	200	70000	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2020-08-15	5:00 PM	Unknown	Unknown	Washington: Snohomish County;	WECC	Physical attack that could potentially impact electric power system adequacy or reliability; or vandalism which targets components of any security systems.	Vandalism	0	8	Physical Attack
August	2020-08-15	5:41 PM	08/15/2020	6:48 PM	Connecticut: New Haven County[13];	NPCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
August	2020-08-16	8:00 PM	08/18/2020	9:00 PM	Texas: Collin County, Dallas County, Denton County, Tarrant County, Ellis County, Kaufman County, Johnson County, Anderson County, Angelina County, Grayson County, Smith County, Wichita County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	300000	Weather
August	2020-08-16	3:44 AM	08/17/2020	2:18 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	409	124266	Weather
August	2020-08-16	5:30 PM	08/16/2020	7:10 PM	California:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	712	Unknown	Weather
August	2020-08-17	8:21 AM	08/17/2020	9:01 AM	California: Yuba County;	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	Severe Weather	2	2	Weather
August	2020-08-17	3:05 PM	08/17/2020	9:24 PM	California:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	829	Unknown	Weather
August	2020-08-18	7:00 PM	08/18/2020	7:30 PM	California: Kings County;	WECC	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. Or suspicious device or activity at its Bulk Electric System control center.	Potential Physical Attack	0	0	Physical Attack
August	2020-08-18	2:00 PM	08/18/2020	9:00 PM	Nevada:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	7800	1400000	Weather
August	2020-08-18	9:55 PM	08/18/2020	10:10 PM	California: Imperial County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2020-08-18	1:30 PM	08/18/2020	8:30 PM	California:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	917	Unknown	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2020-08-18	2:44 PM	08/18/2020	3:14 PM	Texas: Culberson County, Reeves County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	205	238	Transmission Interruption
August	2020-08-18	2:30 PM	Unknown	Unknown	Arizona:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	0	Unknown	Weather
August	2020-08-19	1:27 AM	08/19/2020	3:03 AM	Ohio: Trumbull County;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	22	16107	Transmission Interruption
August	2020-08-19	2:00 PM	08/19/2020	9:00 PM	Arizona: Maricopa County;	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	1200	0	Weather
August	2020-08-19	2:00 PM	08/19/2020	9:00 PM	Nevada:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	7500	1400000	Weather
August	2020-08-19	12:00 PM	08/19/2020	9:00 PM	California:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather
August	2020-08-20	12:03 AM	08/20/2020	2:05 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2020-08-20	9:17 AM	08/20/2020	1:42 PM	Mississippi: Jasper County;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
August	2020-08-20	3:29 PM	08/20/2020	3:39 PM	Nebraska: Custer County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	60	Unknown	Transmission Interruption
August	2020-08-23	10:12 PM	08/23/2020	10:15 PM	West Virginia: Putnam County;	RF	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Suspicious Activity	0	0	Physical Attack
August	2020-08-23	10:30 AM	Unknown	Unknown	Texas panhandle, SE NM	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather
August	2020-08-24	11:00 PM	08/24/2020	11:59 PM	Texas: Denton County;	TRE	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Potential Physical Attack	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2020-08-25	2:43 AM	08/25/2020	7:43 AM	Colorado: Jefferson County;	WECC	Physical threat to its Bulk Electric System control center, excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the control center. Or suspicious device or activity at its Bulk Electric System control center.	Vandalism	0	0	Physical Attack
August	2020-08-27	5:00 AM	09/03/2020	12:00 PM	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	200	50000	Weather
August	2020-08-27	7:00 AM	08/30/2020	7:00 PM	Louisiana: Rapides Parish;	SERC	Complete operational failure or shut-down of the transmission and/or distribution of electrical system.	Severe Weather	48	Unknown	Weather
August	2020-08-27	12:44 PM	08/27/2020	11:00 PM	Texas:	TRE	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	Unknown	Unknown	Weather
August	2020-08-27	12:06 PM	08/27/2020	10:49 PM	Texas:	TRE	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Severe Weather	581	Unknown	Weather
August	2020-08-27	7:40 AM	08/31/2020	7:40 AM	Louisiana: Texas:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	130000	Weather
August	2020-08-27	1:15 AM	Unknown	Unknown	Texas: Louisiana:	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	615992	Weather
August	2020-08-27	7:40 AM	08/31/2020	3:33 AM	Louisiana: Texas:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	47927	Weather
August	2020-08-27	12:02 PM	08/27/2020	10:54 PM	Texas:	TRE	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Severe Weather	573	Unknown	Weather
August	2020-08-27	12:29 PM	08/27/2020	12:59 PM	Nebraska: Douglas County, Burt County, Washington County, Dodge County, Colfax County, Saunders County, Sarpy County, Cass County, Otoe County, Johnson County, Nemaha County, Pawnee County, Richardson County;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2020-08-27	5:11 PM	08/28/2020	10:00 AM	Connecticut: Massachusetts: New Hampshire: Maine: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	100	60687	Weather
August	2020-08-27	1:24 PM	Unknown	Unknown	Texas: Montgomery County, Liberty County;	TRE	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Severe Weather	208	Unknown	Weather
August	2020-08-27	12:06 PM	Unknown	Unknown	Texas:	TRE	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Severe Weather	350	Unknown	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
August	2020-08-27	6:00 AM	08/27/2020	6:05 AM	West Virginia: Putnam County;	RF	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	2900	Unknown	Physical Attack
August	2020-08-27	3:14 AM	Unknown	Unknown	Louisiana: Calcasieu Parish, Beauregard Parish, Iberia Parish, Acadia Parish, Evangeline Parish, Rapides Parish, St. Landry Parish, Vernon Parish;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	Unknown	Weather
August	2020-08-28	4:27 PM	08/28/2020	7:26 PM	Washington: Oregon;	WECC	Total generation loss, within one minute of: greater than or equal to 2,000 Megawatts in the Eastern or Western Interconnection or greater than or equal to 1,400 Megawatts in the ERCOT Interconnection.	Severe Weather	0	0	Weather
August	2020-08-28	12:25 AM	08/28/2020	1:00 AM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
August	2020-08-29	3:35 AM	08/29/2020	5:45 AM	Texas:	TRE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	Severe Weather	Unknown	Unknown	Weather
August	2020-08-31	9:00 AM	08/31/2020	3:53 PM	Washington:	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
September	2020-09-01	1:04 PM	09/01/2020	1:05 PM	California: Los Angeles County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
September	2020-09-03	1:46 PM	09/03/2020	10:47 PM	Washington:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	Unknown	Transmission Interruption
September	2020-09-04	1:07 AM	09/04/2020	1:37 AM	Florida: Pinellas County;	FRCC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2020-09-05	5:20 PM	09/05/2020	8:37 PM	California:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	986	Unknown	Weather
September	2020-09-05	5:25 PM	09/05/2020	8:55 PM	California: Imperial County;	WECC	Firm load shedding of 100 Megawatts or more implemented under emergency operational policy.	Severe Weather	100	20000	Weather
September	2020-09-06	4:00 PM	09/06/2020	9:00 PM	Nevada:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	Severe Weather	8180	1400000	Weather

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September	2020-09-06	4:30 PM	09/06/2020	9:05 PM	California:	WECC	Public appeal to reduce the use of electricity for purposes of maintaining the continuity of the Bulk Electric System.	System Operations	1071	Unknown	Public Appeal
September	2020-09-06	5:36 PM	09/06/2020	7:27 PM	Washington: Oregon: California:	WECC	Total generation loss, within one minute of: greater than or equal to 2,000 Megawatts in the Eastern or Western Interconnection or greater than or equal to 1,400 Megawatts in the ERCOT Interconnection.	System Operations	0	0	Operations
September	2020-09-06	5:00 PM	09/07/2020	3:00 AM	California: Los Angeles County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	72000	Weather
September	2020-09-07	10:40 PM	09/09/2020	5:24 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Transmission Interruption	610	172000	Transmission Interruption
September	2020-09-07	6:00 PM	09/08/2020	6:00 PM	Washington: Kitsap County, King County, Pierce County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	71500	Weather
September	2020-09-07	9:13 AM	09/08/2020	6:00 AM	Washington:	WECC	Complete operational failure or shut-down of the transmission and/or distribution of electrical system.	Natural Disaster	80	21000	Natural Disaster
September	2020-09-07	7:05 PM	09/08/2020	10:00 PM	Oregon: Multnomah County, Washington County, Clackamas County, Marion County, Yamhill County, Polk County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	2859	103000	Weather
September	2020-09-08	9:50 AM	09/08/2020	10:56 AM	Michigan: Ingham County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	265	0	Operations
September	2020-09-09	10:16 PM	09/11/2020	8:17 AM	Minnesota: Sherburne County;	MRO	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
September	2020-09-09	11:22 AM	09/09/2020	1:04 PM	Idaho:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Natural Disaster	0	0	Natural Disaster
September	2020-09-15	10:00 PM	09/20/2020	3:00 PM	Alabama: Florida: Georgia: Mississippi:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Transmission Interruption	236	34096	Weather
September	2020-09-15	3:04 PM	09/15/2020	3:37 PM	North Dakota: South Dakota: Montana:	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2020-09-16	7:00 AM	09/18/2020	6:00 AM	Florida: Escambia County;	FRCC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
September	2020-09-16	3:00 AM	09/21/2020	8:00 AM	Alabama: Baldwin County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	0	77600	Weather

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September	2020-09-16	2:09 AM	09/16/2020	2:20 AM	Maine: Oxford County;	NPCC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
September	2020-09-20	8:01 PM	09/21/2020	3:44 PM	Oklahoma: Canadian County;	SPP RE	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Actual Physical Attack	0	Unknown	Physical Attack
September	2020-09-22	10:02 AM	09/22/2020	12:58 PM	California:	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	System Operations	8	4350	Operations
September	2020-09-23	12:00 PM	09/23/2020	1:00 PM	New Jersey:	RF	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
September	2020-09-26	5:17 AM	09/26/2020	5:41 AM	Nevada: Clark County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Actual Physical Attack	26	13000	Physical Attack
September	2020-09-27	6:27 PM	09/28/2020	3:17 PM	California:	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Natural Disaster	337	102267	Natural Disaster
September	2020-09-30	5:55 AM	09/30/2020	11:30 PM	Connecticut: Maine: Rhode Island: Massachusetts: New Hampshire: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	155000	Weather
October	2020-10-02	7:30 PM	10/04/2020	6:30 AM	Virginia: Hanover County;	SERC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
October	2020-10-07	1:45 PM	10/07/2020	1:59 PM	Louisiana: Orleans Parish;	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	183	39089	Transmission Interruption
October	2020-10-07	4:00 PM	Unknown	Unknown	New York: Onondaga County;	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	7500	Weather
October	2020-10-07	6:50 PM	10/09/2020	3:00 PM	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	186600	Weather
October	2020-10-09	10:44 AM	10/09/2020	10:25 PM	Colorado:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2020-10-09	8:00 PM	10/15/2020	7:00 AM	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	200	50000	Weather

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October	2020-10-09	7:50 PM	10/11/2020	3:09 PM	Louisiana: Acadia Parish, Beauregard Parish, Calcasieu Parish, Evangeline Parish, Iberia Parish, Rapides Parish, Vernon Parish, Avoyelles Parish, Grant Parish, Natchitoches Parish, St. Landry Parish, St. Mary Parish, St. Tammany Parish;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	132200	Weather
October	2020-10-09	5:30 PM	10/10/2020	6:00 PM	Louisiana: Texas: Arkansas: Mississippi:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	477966	Weather
October	2020-10-09	8:00 PM	10/10/2020	6:00 AM	Louisiana: Lafayette Parish;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	50000	Weather
October	2020-10-10	11:10 PM	10/10/2020	11:15 PM	Washington: Oregon:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2020-10-10	8:05 AM	10/10/2020	12:00 PM	Oregon: Clackamas County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2020-10-10	2:22 AM	10/10/2020	5:00 AM	Louisiana: Lafayette Parish;	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	Severe Weather	Unknown	Unknown	Weather
October	2020-10-12	4:06 AM	10/12/2020	4:07 AM	Florida: Polk County;	FRCC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2020-10-13	1:14 PM	10/14/2020	2:00 PM	Washington: Whatcom County, King County, Pierce County, Thurston County, Kittitas County, Kitsap County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	76000	Weather
October	2020-10-14	6:26 PM	10/15/2020	1:11 PM	Texas: Pecos County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	18	Unknown	Transmission Interruption
October	2020-10-15	11:43 PM	Unknown	Unknown	Washington: Walla Walla County;	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
October	2020-10-15	4:50 PM	Unknown	Unknown	Michigan:	RF	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2020-10-16	2:00 PM	10/16/2020	4:00 PM	Kentucky;	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	62	0	Physical Attack
October	2020-10-20	6:48 PM	10/20/2020	6:49 PM	Illinois: Massac County;	SERC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
October	2020-10-22	8:00 AM	10/22/2020	8:01 AM	Idaho;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
October	2020-10-22	10:48 PM	10/22/2020	11:34 PM	Florida: Pinellas County;	FRCC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2020-10-23	3:42 PM	10/23/2020	11:11 PM	Ohio;	RF	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	Unknown	Transmission Interruption
October	2020-10-23	3:46 PM	10/23/2020	11:03 PM	Texas: Harris County;	TRE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	55506	Weather
October	2020-10-24	8:13 PM	10/24/2020	10:52 PM	Minnesota: Hennepin County;	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	1	4	Transmission Interruption
October	2020-10-25	2:32 PM	10/27/2020	6:00 PM	California;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	1218	370000	Weather
October	2020-10-25	3:25 AM	10/25/2020	3:45 AM	Wisconsin: Milwaukee County; Michigan;	MRO	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Suspicious Activity	0	0	Physical Attack
October	2020-10-26	1:00 PM	11/07/2020	7:00 PM	Oklahoma: Oklahoma County, Canadian County, Logan County, Cleveland County, Pottawatomie County;	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	447000	Weather
October	2020-10-26	11:24 AM	10/27/2020	4:43 PM	California: Los Angeles County, Riverside County, San Bernardino County, Orange County, Kern County, Ventura County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	136833	Weather
October	2020-10-26	9:28 AM	10/26/2020	12:20 PM	Colorado;	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	75	13000	Transmission Interruption

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
October	2020-10-26	10:00 AM	10/26/2020	10:15 AM	Kentucky:	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	64	0	Physical Attack
October	2020-10-27	5:50 PM	Unknown	Unknown	Oklahoma:	SPP RE	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	235000	Weather
October	2020-10-28	9:37 PM	11/02/2020	7:30 PM	Alabama: Florida: Mississippi: Georgia:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	253	35478	Weather
October	2020-10-28	6:00 PM	10/29/2020	1:15 AM	Louisiana:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	481268	Weather
October	2020-10-28	11:53 AM	10/28/2020	3:26 PM	Texas:	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	Unknown	Transmission Interruption
October	2020-10-28	10:28 AM	10/28/2020	10:29 AM	Texas:	TRE	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	Severe Weather	Unknown	Unknown	Weather
October	2020-10-28	5:12 PM	10/29/2020	4:30 PM	Louisiana: St. Tammany Parish, St. Mary Parish;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	72707	Weather
October	2020-10-29	8:15 AM	10/31/2020	6:45 PM	North Carolina: South Carolina:	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	461580	Weather
October	2020-10-29	11:58 AM	10/29/2020	1:10 PM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
October	2020-10-29	2:00 AM	10/31/2020	9:00 AM	Alabama: Baldwin County, Butler County, Clarke County, Conecuh County, Escambia County, Lee County, Lowndes County, Macon County, Montgomery County, Pike County, Russell County, Tallapoosa County, Talladega County, Washington County, Monroe County; Florida: Escambia County, Okaloosa County, Walton County, Santa Rosa County;	SERC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	0	90000	Weather
November	2020-11-01	6:00 PM	11/01/2020	6:09 PM	Ohio:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	85677	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
November	2020-11-01	12:31 PM	11/01/2020	12:35 PM	California: Placer County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
November	2020-11-02	11:12 AM	11/02/2020	11:21 AM	Florida:	FRCC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
November	2020-11-07	5:40 PM	11/07/2020	10:10 PM	Colorado:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
November	2020-11-09	12:00 PM	11/10/2020	9:45 AM	New Hampshire: Coos County;	NPCC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
November	2020-11-10	10:42 AM	11/10/2020	12:45 PM	Arizona: Maricopa County;	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2020-11-13	12:20 AM	11/13/2020	8:00 AM	Washington: Snohomish County;	WECC	Cyber event that could potentially impact electric power system adequacy or reliability.	System Operations	0	0	Operations
November	2020-11-14	7:40 AM	Unknown	Unknown	California: San Bernardino County;	WECC	Fuel supply emergencies that could impact electric power system adequacy or reliability.	Fuel Supply Deficiency	0	0	Fuel Supply Deficiency
November	2020-11-15	3:08 PM	11/15/2020	10:30 PM	Ohio:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	123361	Weather
November	2020-11-15	2:52 PM	11/16/2020	5:59 AM	Ohio:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	96809	Weather
November	2020-11-15	12:30 PM	11/18/2020	9:44 AM	Michigan: Huron County, Livingston County, Macomb County, Monroe County, Wayne County, Washtenaw County, Tuscola County, St. Clair County, Lapeer County, Oakland County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	150000	Weather
November	2020-11-15	3:37 PM	11/17/2020	12:15 PM	Michigan: Iosco County, Oscoda County, Ogemaw County, Livingston County, Ionia County, Barry County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	57327	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
November	2020-11-15	11:05 PM	11/16/2020	5:00 AM	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	62408	Weather
November	2020-11-15	11:30 AM	11/16/2020	3:25 AM	Ohio: West Virginia: Virginia: Indiana:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	75000	Weather
November	2020-11-18	8:30 AM	11/18/2020	10:50 AM	Missouri: Jackson County;	SERC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2020-11-18	10:20 AM	11/18/2020	11:18 AM	Maine:	NPCC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2020-11-20	9:10 AM	11/20/2020	9:22 AM	Texas: Kentucky: Arizona: New Mexico: Oregon: Washington:	TRE	Cyber event that causes interruptions of electrical system operations.	System Operations	0	Unknown	Cyber Attack
November	2020-11-21	11:59 AM	11/21/2020	12:59 PM	Nevada: Clark County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Actual Physical Attack	21	577	Physical Attack
November	2020-11-23	5:50 AM	11/23/2020	7:27 AM	Wisconsin: Dane County;	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
November	2020-11-30	2:33 PM	11/30/2020	5:20 PM	Texas: El Paso County;	TRE	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	0	0	Transmission Interruption
November	2020-11-30	4:24 PM	12/01/2020	2:25 PM	Massachusetts: Maine: Connecticut: Rhode Island: Vermont: New Hampshire:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	116000	Weather
December	2020-12-01	12:32 PM	12/01/2020	10:50 PM	Ohio:	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	170190	Weather
December	2020-12-03	9:01 AM	12/03/2020	9:03 AM	Colorado:	WECC	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	89	0	Transmission Interruption
December	2020-12-03	12:44 AM	12/05/2020	11:03 AM	California: San Diego County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	93	73000	Weather

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2020-12-03	10:57 AM	12/04/2020	3:02 PM	California: Kern County, Los Angeles County, Orange County, Riverside County, San Bernardino County, San Diego County, Tulare County, Ventura County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	132	51686	Weather
December	2020-12-05	4:40 PM	Unknown	Unknown	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	271231	Weather
December	2020-12-06	9:45 AM	12/06/2020	5:00 PM	Pennsylvania:	RF	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2020-12-07	6:10 PM	12/08/2020	9:09 PM	California: Kern County, Los Angeles County, Orange County, Riverside County, San Bernardino County, Ventura County, Tulare County;	WECC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	286	76234	Weather
December	2020-12-08	9:43 AM	12/08/2020	10:33 AM	Michigan: Wayne County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2020-12-09	1:20 PM	12/09/2020	2:30 PM	Missouri: Kansas:	MRO	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2020-12-10	4:30 PM	12/12/2020	5:00 AM	Washington: King County;	WECC	Unplanned evacuation from its Bulk Electric System control center facility for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2020-12-11	10:51 PM	12/11/2020	11:57 PM	Texas: Harris County;	TRE	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2020-12-13	6:47 AM	12/13/2020	7:36 AM	California:	WECC	Uncontrolled loss of 200 Megawatts or more of firm system loads for 15 minutes or more from a single incident for entities with previous year's peak demand less than or equal to 3,000 Megawatts.	System Operations	298	159239	Operations
December	2020-12-14	11:00 AM	Unknown	Unknown	Idaho: Oregon:	WECC	Cyber event that could potentially impact electric power system adequacy or reliability.	Cyber Event	0	0	Cyber Attack
December	2020-12-14	5:01 PM	12/14/2020	5:34 PM	California:	WECC	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2020-12-14	1:30 AM	Unknown	Unknown	New Jersey: Pennsylvania: Maryland: Illinois: Delaware: District of Columbia:	RF	Cyber event that could potentially impact electric power system adequacy or reliability.	Cyber Event	0	0	Cyber Attack
December	2020-12-16	11:20 PM	12/17/2020	7:20 AM	Oklahoma:	MRO	Unexpected Transmission loss within its area, contrary to design, of three or more Bulk Electric System Facilities caused by a common disturbance (excluding successful automatic reclosing).	Transmission Interruption	Unknown	Unknown	Transmission Interruption
December	2020-12-17	8:07 AM	12/17/2020	8:32 AM	California:	WECC	Electrical System Separation (Islanding) where part or parts of power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system.	Severe Weather	35	17000	Weather
December	2020-12-17	4:19 PM	12/17/2020	4:57 PM	Michigan: Wayne County;	RF	Complete loss of monitoring or control capability at its staffed Bulk Electric System control center for 30 continuous minutes or more.	System Operations	0	0	Operations
December	2020-12-18	6:34 AM	12/18/2020	9:51 AM	Oregon: Clackamas County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack
December	2020-12-20	5:06 AM	12/20/2020	5:22 AM	California: Los Angeles County;	WECC	Cyber event that could potentially impact electric power system adequacy or reliability.	Cyber Event	0	0	Cyber Attack
December	2020-12-22	2:20 AM	12/22/2020	2:21 AM	Washington: Pierce County;	WECC	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Vandalism	0	2000	Physical Attack
December	2020-12-24	11:40 PM	Unknown	Unknown	Pennsylvania: Bucks County, Chester County, Delaware County, Montgomery County, Philadelphia County, York County;	RF	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather/Distribution Interruption	Unknown	68114	Weather
December	2020-12-25	3:51 AM	12/25/2020	3:52 AM	California:	WECC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	Physical Attack
December	2020-12-25	6:51 PM	12/25/2020	7:24 PM	Ohio: Kentucky:	RF	Physical threat to its Facility excluding weather or natural disaster related threats, which has the potential to degrade the normal operation of the Facility. Or suspicious device or activity at its Facility.	Suspicious Activity	0	0	Physical Attack

Data	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Area Affected	NERC Region	Alert Criteria	Event Type	Demand Loss (MW)	Number of Customers Affected	Category
December	2020-12-25	7:55 AM	12/25/2020	4:45 PM	Connecticut: Maine: New Hampshire: Massachusetts: Rhode Island: Vermont:	NPCC	Loss of electric service to more than 50,000 customers for 1 hour or more.	Severe Weather	Unknown	19000	Weather Physical Attack
December	2020-12-28	5:31 PM	12/29/2020	1:31 PM	Virginia:	SERC	Damage or destruction of its Facility that results from actual or suspected intentional human action.	Vandalism	0	0	