

NERC

NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Assessment of Previous Severe Winter Weather Reports 1983-2011

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RELIABILITY | ACCOUNTABILITY



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Executive Summary

The Southwest region of the United States experienced unusually cold and windy weather during the first week of February 2011. Low temperatures during the period were in the teens for five consecutive mornings and there were many sustained hours of below freezing temperatures throughout Texas and New Mexico.

The February 2011 Cold Weather Event, however, was not without precedent. The assessment prepared jointly by FERC and NERC staff, *Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011*, (February 2011 Cold Weather Event), cited six prior severe cold weather events in the Southwest that occurred in 1983, 1989, 2003, 2006, 2008, and 2010. In addition, five additional cold weather experiences which presented operational challenges were identified and summarized in this review:

- February 1989 (WECC);
- January 1994 (RFC);
- January 2004 (NPCC/RFC);
- February 2006 (WECC); and
- January 2007 (WECC)

This report provides a review and comparison of the previous events above with the 2011 Texas event. In reviewing these events, the Event Analysis Subcommittee Trends Working Group (TWG) determined that only three were comparable, in terms of load loss or generation loss resulting in capacity shortages, to the February 2011 event

- December 1983 (FRCC);
- December 1989 (TRE/FRCC); and
- January 1994 Mid-Atlantic states (currently RFC Region)

The comparable cold weather events are discussed in the body of this report, and the remaining eight lesser cold weather experiences are listed in the appendices.

Two common themes observed in the reports of both the severe and lesser cold weather incidents were:

- Constraints on natural gas fuel supplies to generating plants; and
- Generating unit trips, derates, or failure to start due to weather related causes (e.g. frozen sensing lines, etc.)

Note: All temperatures referred to in this report are in degrees Fahrenheit

Note: For the purpose of this report the NERC Regional Entities are referred to by their current names.

February 2-6, 2011 Cold Weather Event Summary

Event Description (February 2 – 6, 2011)

Click here for: [Southwest Cold Weather Event Final report](#)

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 to -7 degrees over the period, compared to the normal average high of 51 degrees and a low of 26 degrees. Dallas temperatures ranged from 14 degrees to 19 degrees, compared to average hightemperatures 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 miles per hour (mph) produced severe wind chill factors.

As a result, 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 4,000 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 (six of seven units) over the four days beginning on February 1., requiring the need to implement rotating load shedding on each of the days from February 2 through February 4, totaling over 1,000 MW and affecting 253,000 customers. The Salt River Project Agricultural Improvement and Power District (SRP), located in Arizona, lost 1,050 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.

Background

Assignment from the NERC Operating Committee

Since the *Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011* mentioned six previous similar events, the Chair of the NERC Operating Committee (OC) requested NERC staff to make these event reports available to the NERC Event Analysis Subcommittee (EAS) and the subordinate Trends Working Group (TWG) tasking the TWG to conduct a comprehensive review and provide comparisons and contrasts for these events. This analysis should provide the basis to inform not just the reliability guideline (drafting team), but also any potential decision to propose the development of a standard as a result of the cold weather events in question.

The following actions were taken and served as the EAS's draft plan for completing the assignment:

- The TWG consolidated references pertaining to previous weather events; where available, obtained the actual reports for the years cited. All incidents reviewed by date: December 1983 (FRCC), February 1989 (WECC), December 1989 (TRE/FRCC), January 1994 (RFC), February 2003 (TRE), January 2004 (NPCC), February 2006 (MRO), December 2006 (Various), January 2007 (WECC), January-February 2008 (Various), January 2010 (Various)
- Reviewed the content of reports obtained to determine whether the events were utility specific or regional in nature.
- Completed an Excel spreadsheet so a comparison could be completed and documented.
- Determined whether the circumstances of the events were similar in size, geographic location and effect on the bulk power system as the February 2011 Cold Weather Event.
- Documented any recommendations or follow-up activities performed.
- Prepared the report, "Assessment of Previous Severe Winter Weather Reports 1983-2011," which documents the resulting analysis for the EAS and NERC OC.

Of the previous severe cold weather event reports cited in the *Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011*, the TWG's review and comparison determined only two of the six events were comparable in size and scope to the February 2011 Cold Weather Event. Those events occurred in December 1983 and in December 1989. The December 1989 event was a multi-regional event affecting entities in both ERCOT and FRCC, while the 1983 event only affected entities in the FRCC Region. The TWG did identify another similar cold weather event which was not cited in the February 2011 report. This event occurred in 1994 and affected entities in the Mid-Atlantic states (RFC). All other cold weather incidents reviewed, including four not mentioned in the Report, were determined by the TWG to be minor in nature and not comparable to the February 2011 Cold Weather Event. The next section provides details on the three comparable events.

Previous Severe Cold Weather Events

December 21-24, 1989 – TRE and FRCC Cold Weather Event

TRE: During December 21-24, 1989, Texas experienced the coldest temperatures recorded in over 100 years. It was the first time in history that ERCOT (which serves 85 percent of load in Texas) implemented region-wide load shedding due to heavy demands on the electric grid. ERCOT shed 1,710 MW of firm customer load. Natural gas supplies were also curtailed to most utilities (generators) during the cold weather event. The peak that occurred on December 22, 1989 was 12.4 percent above forecast and 10.8 percent over the 1988/1989 actual peak.

FRCC: During December 23-25, 1989 Florida experienced extremely cold weather throughout the state. Natural gas supplies to Florida's utilities were curtailed beginning December 22 through December 26. Record low temperatures were experienced. Record load (34,776 MW) from extreme cold temps combined with numerous units offline due to maintenance resulted in rotating blackouts (five to eight hours maximum). On December 24, 4,744 MWs of firm load was not being served.

In both TRE and FRCC, the circumstances, size, geographic area, and impact on the bulk power system (BPS) of this event were deemed to be very similar to the February 2011 Cold Weather Event.

Issues Identified:

- Inadequate cold weather preparations
- Frozen ancillary plant equipment
- Fuel oil problems
- Natural gas supplies were curtailed

Recommendations:

There were numerous recommendations for utilities in both the FRCC and ERCOT footprints. For ERCOT, according to the PUCT Report dated November 1990, certain corrective actions were implemented by the utilities.

December 24-27, 1983 – FRCC Cold Weather Event

During the period December 24 through December 27, 1983 an arctic cold front brought in record low temperatures throughout the state of Florida. On the morning of December 25, 1983, following revised temperature forecast for December 26, system operators became concerned about a potential capacity shortage for the 26th. All available units were called into service to be ready for the morning load on the 26th. Further compounding the problem was a gas curtailment which prevented a number of units from achieving stated capability. The 777 MW Manatee #1 unit tripped causing interchange from the Southern Company to exceed its 1,700 MW limit. The flow from Southern Company reached 2270 MW causing operators to place 1000 feeders of firm load into rolling blackouts. The extremely cold temperatures caused frozen controls and fuel related problems resulting in significant amounts of unavailable capacity.

The circumstances, size, and effects on the BPS of this event also are similar to the February 2011 event in ERCOT and FRCC.

Issues Identified:

- Cold weather produced frozen controls
- Interruptible natural gas supplies were interrupted
- Large Generating Unit trip due to issues with cold weather
- Generator unit derates due to gas curtailments.

Recommendations:

The report providing the details of this event did not cover any Recommendations.

Week of January 16, 1994 – RFC Cold Weather Event

Click here for: [Report on Electric Utilities' Response to the Cold Wave of January 1994](#)

A major cold wave with record-setting low temperatures swept across the mid-Atlantic and Midwest. Utilities faced unusual high demands and generator problems, began importing large amounts of energy. Faced with unusually high demands for electricity, ECAR (East Central Area Reliability Coordination) hit a new all time peak demand of 78,931 MW; about 7300 MW (10.2 percent) above the previous all-time winter peak. The generation capacity margins were at critical levels throughout the entire eastern interconnection. The extraordinary prolonged icy conditions that began in the Midwest and mid-Atlantic area on January 6, the extreme sub-zero temperatures, and the disruptions to fuel supplies to generating plants were the major contributors to generator availability problems. As available reserves dwindled, utilities turned to their established capacity emergency procedures. Both utilities implemented voltage reductions, public appeals, and voluntary curtailments (interruptible loads) in efforts to return frequency to 60 Hz. However, it required PJM and Virginia Power to resort to rotating blackouts to maintain reliability.

The circumstances, size, and effects on the BPS of this event were also very similar to the February 2011 event. The lowest frequency was 59.91 and the amounts of firm load shedding were: PJM = 1,500 MWs and Virginia Power = 800 MWs. Additionally, PJM lost a total of 13,733 MWs of net generation capacity during this event.

Issues Identified:

- Frozen coal and coal handling equipment
- Fuel oil delivery problems
- Interruptible natural gas supplies were interrupted
- Air Blast and SF₆ breakers (especially those without heaters) were particularly susceptible to problems of low pressure inhibiting their operation

Recommendations:

As a result of this event five recommendations for utilities were put forth dealing with communications, backup fuel inventory, improving gas-electricity interdependency, improve transfer capability in realtime, and communications among utilities. All of the recommended improvements were completed.

Common Issues found in Cold Weather Events

Natural Gas Supply and Interdependence

- The previous cold weather events reviewed for this report highlight 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 and is expected to increase by over 90 GW over the next ten years.¹ 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. Additionally, all compression stations require electricity to power the controls for the compressors.
- In this report, one of the dominant contributing factors for generation capacity being lost and derated is inadequate gas supply during the cold winter season. Most generator owners purchase “Non Firm” capacity. As result, it is during those coldest and most critical times when natural gas customers are curtailed due to limited supply, typically due to the competing usage of natural gas provided for heating needs.
- A number of natural gas generating units that attempted to switch fuels were unable to do so, and some of those units that did switch fuels experienced operational derates. Therefore, during a severe cold weather event when generation is most needed, this additional decline in generator output due to fuel switching has the potential to exacerbate the deficiency in generation capacity.
- NERC published two special assessments on the interdependency on natural gas and electric power. The Phase I report is a primer on the issues and challenges.² The Phase II report offers specific recommendations to the electric power industry from a bulk system planning and operational perspective.³

Equipment Freezing

- One of the common problems experienced by many generators involved in the severe cold weather events were units that tripped, suffered derates, or failed to start during the event due to weather-related causes, including frozen sensing lines, frozen equipment, frozen water lines, frozen valves, blade icing, low temperature cutoff limits, and the like.

¹ NERC 2012 Long-Term Reliability Assessment:

http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2012_LTRA_FINAL.pdf

² http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/Gas_Electric_Interdependencies_Phase_I.pdf

³ http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_PhaseII_FINAL.pdf

Conclusion

Of the 11 cold weather incidents documented in the last 30 years (1983-2013), the TWG determined that there were a total of three cold weather events comparable in size and scope to the February 2011 event. In each of these three events:

- Firm Load was lost,
- The event impacted more than one utility, and
- The loss of generation caused capacity issues and immediate action was required by system operators.

A spreadsheet analysis of each incident can be found in Appendix A. A brief summary of the minor incidents can be found in Appendix B.

Reference Documents

- NERC OC directed a cold weather reliability guideline be drafted;
Click here for: [Reliability Guideline: Generating Unit Winter Weather Readiness – Current Industry Practices](#)
- An industry sponsored Standards Authorization Request (SAR) team was established.
Click here for: [Project 2013-01 Cold Weather](#) information

Appendix A – Incidents Reviewed As Compared to the February 2011 Cold Weather Event

Referenced In 2011 Report	Date		Region(s)	Loss of Firm Load (MW)	Duration of Load Loss	Loss of Generation	Problem with Natural Gas Supplies	Peak Above Forecast	New Record Peak
	Month(s)	Year							
	February	2011	TRE	4900	7 hrs 24 min	26,491 MW			
Y	January	2010	Various	--			Marginal		
Y	January-February	2008	Various	--			Marginal		
	January	2007	WECC (SRP)	--		1,043 MW			
Y	December	2006	Various	--		--	Marginal		
	February	2006	MRO (PSCo)	428	90 min	3,200 MW	Y		
	January	2004	NPCC (ISO-NE)	--		8,972 MW			
Y	February	2003	TRE	--		745 MW*	Y	11%	
	January	1994	RFC	2300	6 hrs 2 min	13,733 MW	Y		10.20%
Y	December	1989	TRE/FRCC	6454	2 hrs 10 min	11,809 MW	Y	12.40%	
	February	1989	WECC (NWPP)	--	5 hrs 47 min	5,376 MW			
Y	December	1983	FRCC	**	3 hours 45mins	96 MW Derate	Y		
*	Generation loss due to gas curtailment issues at one station. 5500 MW lost due to gas curtailment; Regained 3200 with a net loss of 2300MW								
**	Approximately 1000 Feeders were in a rolling blackout rotation. Firm Load Loss (MW) is unknown.								

Appendix B – Summary of Minor Incidents

February 21, 2003 – ERCOT Cold Weather 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.

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. The EECP Step 1 succeeded in rebalancing the system within 30 minutes. 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.

The circumstances, size, and effects on the BPS of this event are not similar to the February 2011 Cold Weather event other than it originated with extreme cold weather and gas curtailments reduced generation capacity. No Firm Load was lost.

Issues Identified:

- Natural Gas curtailments and procurement problems
- Fuel oil operating problems
- Generator unit derates due to gas curtailments.

Recommendations:

The single report providing the following recommendations:

- 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.

January 15, 2007 – Salt River Project Cold Weather Event

On Monday, January 15, 2007; Salt River Project (SRP) experienced the coldest morning in 16 years. SRP set an all time winter load peak 4229 MW (previous record, 3932 MW). The extreme cold weather, loads greater than forecasted, and the loss of eight critical generating resources forced SRP and adjacent control areas into a capacity limited condition. Backup generation failed to start which exasperated the event. Over a three hour period, SRP lost 1,043 MWs of generating capacity. There was no firm load shedding.

The circumstances, size, and effects on the BPS of this event are not similar to the February 2011 event other than it originated with extreme cold weather and gas curtailments reduced generation capacity. No Firm Load was lost.

Issues Identified:

- Inadequate cold weather preparations, did not have valley plants prepared for the 20 year freeze
- Freezing of ancillary equipment - Instrument sensing lines froze.
- Icing on cooling towers derated units
- Inadequate situational awareness (not understanding what was tripping)
- Dispatching was unaware of CISO emergency assistance procedure and assumed market was providing. Therefore load shedding did not occur.

February 17, 2006 – Public Service of Colorado Disturbance

Starting at approximately 1245 on Friday, February 17, 2006 Public Service began to experience electric generation plant failures due to the combination of cold weather, high humidity, and other mechanical issues. On February 18th, PSCO conducted rotating controlled outages of 100K customers for approximately 90 minutes (30 minute outage intervals for each block of 100k customers) for a net reduction of 428 MWs. There was no transmission loss or system islanding; There were no frequency or voltage excursions; System was returned to normal at 1609 on February 18th. During the event 18 generators tripped off line or was capacity limited for a capacity reduction of 3,200 MWs.

This event was not similar in size or effect on the BPS compared to the February 2011 cold weather event. The amount of load lost was minimal (428MW). The one similarity to the more severe events discussed in this report was the extreme cold weather and the lack of gas supplies.

Issues Identified:

- Inadequate cold weather preparations
- lack of available gas supplies
- inability to import energy

Recommendations:

There were 22 related recommendations from the analysis of this event. Some of these include:

- Improve weather forecasting

- Review normal and emergency communication procedures
- Improve ability to calculate contingency reserves
- Revise Public Appeals procedures
- Improve scheduling and tagging of emergency import power.
- Identify and correct equipment problems.
- WECC members review and update plans for gas curtailments

January 14 – 16, 2004 – ISO New England Cold Weather Event

In January 2004, New England experienced unusually severe weather and electricity demand conditions. In particular, extremely low temperatures and very high demand for electricity combined with tight conditions in the natural gas markets to stress-test the electricity system in New England during January 14 - 16, 2004. This Cold Snap pushed the electricity system in New England close to its limits. Despite record winter peak electricity demand, many unexpected generator outages, and projected capacity deficiencies, the ISO was able to avoid interruptions of electrical supply. However, there was a loss of 8,972 MWs of generation during this event but did not produce any losses of Firm Load. The availability of gas transportation for non-firm customers within New England was a limiting factor and a root cause of both high gas prices and gas unit unavailability.

This event was not similar in size or effect on the BPS compared to the February 2011 cold weather event. Additionally, there was no Firm Load lost. The one similarity to the more severe events discussed in this report was extreme cold weather and the lack of gas supplies.

Issues Identified:

- Unexpected generator outages
- lack of available gas supplies

Recommendations:

- Improve ISO-NE understanding of and coordination with the gas industry.
- Better coordinate gas and electric market timing to maximize gas usage.
- Provide market incentives to ensure unit availability during critical periods.
- Discuss with regulators and stakeholders about the barriers to dual-fuel capability.

A ISO-NE / NEPOOL task force was established to review and take corrective actions in response to the recommendations made. Additionally, The ISO identified several other key actions that will provide significant benefit to New England relative to the Cold Snap issues identified.

February 1-8, 1989 – Northwest Power Pool Event

During the first week in February 1989, an arctic air mass caused abnormally cold temperatures and record loads throughout the Northwest Power Pool area. On February 3, 1989 at 0900 PST a new all-time Pool coincident peak of 49,789 MW was recorded. Colstrip #3 and WNP2 were forced outages

until the evening of February 2nd. Hunter #1 was off line until early on the 4th. Several more units like Hunter #2 and Naughton #1 were forced off during the period February 1-8th. The total net generation capacity lost was 5,376MW. However, there were no reports of Firm Load loss. Transmission system experienced heavy transfers. The cold weather resulted in air leaks on compressor systems and circuit breaker problems. SF6 pressure in power circuit breakers fell below normal operating levels and some gases became liquified.

This event was not similar in size or effect on the BPS compared to the February 2011 cold weather event. Additionally, there was no Firm Load lost. The one similarity to the more severe events discussed in this report was cold weather and the lack of gas supplies.

Issues Identified:

- inadequate cold weather preparations
- lack of available gas supplies
- unexpected generator forced outages

Recommendations: None were reported

Other Incidents

The following events did not experience large generation capacity losses and did not experience any loss of Firm Load. Additionally, the TWG could not find any published reports on them other than the mention of them in the February 2011 NERC FERC Inquiry Task Force Final Report. The following information came from that report.

- **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 billion cubic feet per day (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.
- **January-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 Opal processing plant in Wyoming fell due to 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.
- **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 Bcfd 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.