

Texas Reliability Entity Event Analysis

Event: April 11, 2011 Loss of Multiple Elements Category 1b Event

Texas Reliability Entity
July 2011

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Executive Summary

On April 11, 2011 at 01:32, the ERCOT Region experienced the simultaneous loss of the Substation A-Substation B 345 kV double circuit, Generating Station C Unit E and Generating Station D Unit F. Also, at 01:33, Generating Station D Unit G tripped. This report provides: (1) an overview of the event; (2) background on system conditions just prior to the event; (3) the detailed sequence of events; (4) an analysis of the causal and contributing factors for concerns that arose in this event; and (5) recommendations for follow-up action.

I. Event Overview

On April 11, 2011 from 00:35 to 02:19 on April 11, 2011, the ERCOT Region experienced a simultaneous loss of two 345 KV lines, eight 138 KV lines associated with a severe thunderstorms that moved into the north Texas area. According to the National Weather Service, "Thunderstorms erupted late Sunday night April 10, 2011 into early Monday morning April 11, 2011 across North Texas as a dry line and its trailing cold front pushed through the region. Preliminary storm survey results indicate 4 tornadoes occurred, two in Johnson County (first tornado maximum winds of 100-110 mph, second tornado estimated winds around 90 mph), one in Kaufman County (third tornado with winds of 100-105 mph), and one in Hunt County (fourth tornado with winds of 100-110 mph). Numerous reports of wind damage were received, with some of the worst in Ellis and Dallas Counties."

At 01:31:50, tornadic storms caused the loss of the 345 kV double circuit between the Substation A and Substation B substations. Transmission Operator H reported two lattice steel structures on the circuit that were twisted and bent to the ground.

The fault condition caused the Generating Station C Unit E to trip at 01:32:20, with a net output of 591 MW and the Generating Station D Unit F to trip, with a net output of 199 MW.

Generating Station D Unit G tripped at 01:33:10, with a net output of 188 MW.

978 MW tripped within the first minute of the event.

System frequency dropped from 60.037 Hz to 59.791 Hz as a consequence of the loss of generation. The drop was arrested by governor action of ERCOT Region generators. These actions led to system frequency recovery within 4 minutes to the pre-disturbance value of 60 Hz (at 01:37:10). Balancing Authority (BA) Physical Responsive Capability (PRC) remained above minimum target of 2300 MW set by ERCOT Protocols for the

duration of the event. Physical Responsive Capability dropped below 3000 MW from 01:38:45 to 01:40:05 as a result of response to the unit trips.

This event did not meet the criteria as a NERC Disturbance Control Standard (DCS) event since the loss of generation was below the 1083 MW threshold for the ERCOT Region. The event met the definition of a Category 1b event (loss of three or more bulk power system elements (i.e. generators, transmission lines, and buses)) event under NERC's Event Analysis Working Group process.

II. Initial System Conditions Prior to Event

Initial system conditions just before the event of April 11, 2011 were:

System Load: 28,781 MW
 System Frequency: 60.037 Hz
 Physical Responsive Capability: ~3200 MW

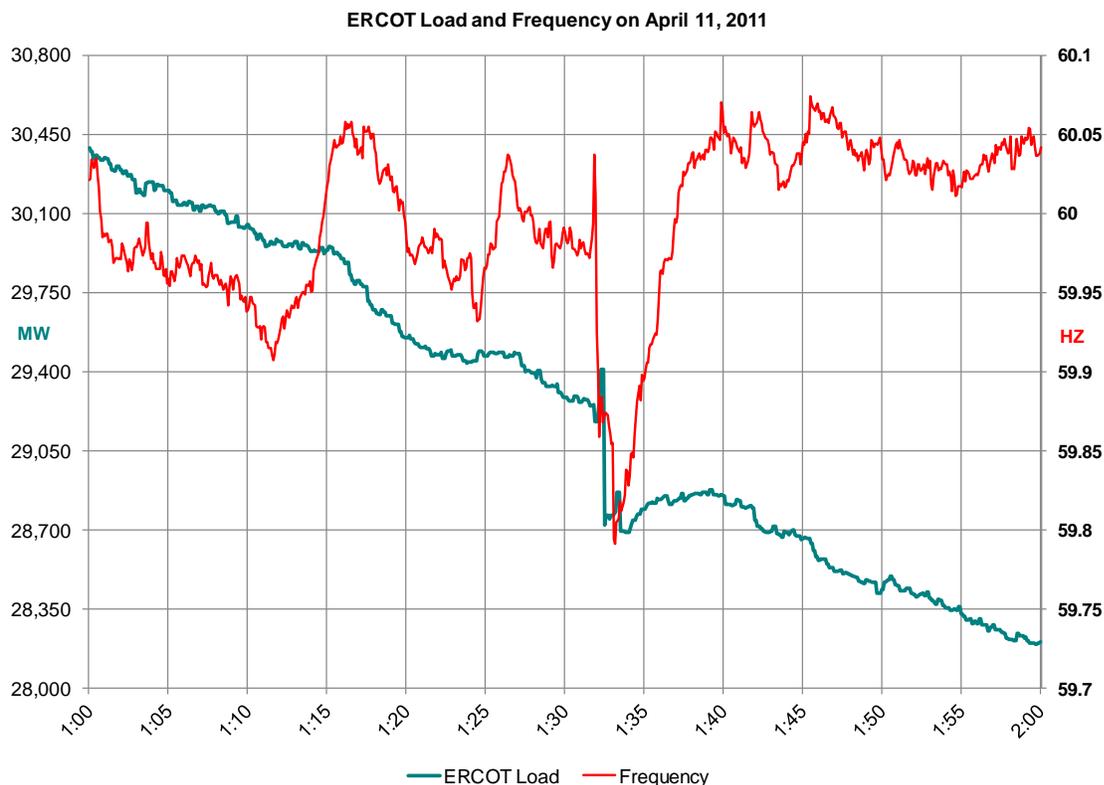


Figure 1 ERCOT Region Load and Frequency on April 11, 2011

III. Sequence of Events on 04/11/2011

- 01:31:50 ERCOT Region frequency prior to disturbance was 60.037 Hz.
- 01:31:50 Substation A to Substation B 345 kV double circuit tripped.
 Substation A CB XXX-1 tripped, reclose and tripped
 Substation A CB XXX-2 tripped, reclose and tripped
 Substation B CB YYY-1 tripped, reclose and tripped
 Substation B CB YYY-2 tripped, reclose and tripped

- 01:32:20 Generating Station C unit E operating at 591 MW and Generating Station D unit F operating at 199 MW tripped to zero.
- 01:33:10 ERCOT Region frequency dropped to approximately 59.791 Hz.
- 01:33:20 Generating Station D unit G operating at 188 MW tripped to zero.
- 01:37:10 ERCOT Region frequency recovered to 60 Hz.

IV. Analysis of Event

A. Transmission Operator H

Tornadic storms moved through the north and central Texas early Monday morning on April 11, 2011. Following those storms, field personnel found two lattice steel structures on the circuit that were twisted and bent to the ground.

Sequence of Events on 4/11/2011

01:31:37 Substation A CB XXX-1 tripped, reclose and tripped
01:31:37 Substation A CB XXX-2 tripped, reclose and tripped
01:31:37 Substation B CB YYY-1 tripped
01:31:37 Substation B CB YYY-2 tripped
01:31:47 Substation B CB YYY-1 reclose and tripped
01:31:47 Substation B CB YYY-2 tripped and tripped

Transmission Operator H's System Protection confirmed that the operations at Substation B (CBs YYY-2 and YYY-1) were in fact a trip, reclose (recloses 10 seconds after initial trip), and trip (TRT) on both breakers as designed. Transmission Operator H's System Protection confirmed that the breakers at Substation A operated as designed as a TRT.

Field personnel were dispatched to the general area of the fault. They discovered two lattice steel structures on the double circuit line were twisted and bent to the ground. Transmission Operator H developed a plan to reconstruct the two structures including one of the structure's foundation that was damaged in the event.

Transmission Operator H replaced two lattice towers. The towers were discovered twisted and bent to the ground due to a likely tornado. The foundation of one structure was damaged severely enough that the tower foundation had to be reconstructed. Transmission Operator H completed repairs on April 14th at 17:58 hours.

All other breakers involved operated as per design during this event. No personnel injuries or other equipment damage were identified. No protective system misoperations were reported.

B. Generating Station D Unit 1 and Unit 5

The Generating Station D plant experienced a line voltage event that resulted in a drop in voltage to less than 70% expected. This initiated protective action within the plant systems. The protective actions resulted in automatic shut off of essential equipment as

designed. Both units experienced the same event and the subsequent protective actions resulted in the units tripping offline.

For both events, data and event lists were examined. No issues or malfunctions were discovered, all protection features operated as designed. The units were released for a restart. The initial review and release for restart was completed at 04:05 for Unit F and 03:12 on for Unit G.

Unit F was restarted at 06:10 the unit was online generating electricity at 06:31 and released for commercial operation on Automatic Generation Control (AGC) at 07:34. Unit G was restarted at 03:12 the unit was online generating electricity at 03:30 and released for commercial operation on AGC at 04:40.

All breakers involved operated as per design during this event. No personnel injuries or equipment damage were identified. No protective system misoperations were reported.

C. Generating Station C Unit E

Generating Station C Unit E was disconnected from the ERCOT Region grid by automatic opening of the generator breaker at 01:32:08. The unit was operating near full load, approximately 600 Net MW, when the Substation A to Substation B 345 KV double circuit transmission line experienced a fault. This was the initiating event leading to the trip of the unit. Due to the transmission disturbance, Generating Station C Unit E initially experienced turbine overspeed. The unit overspeed protection controls properly attempted to correct for the sudden loss of load to the generator but the unit ultimately tripped on main boiler high superheat outlet pressure to keep from exceeding operational limitations.

After confirming the cause of the trip, the condition of the unit, and the condition of the protective systems, plant operations personnel immediately initiated startup procedures to return the unit to service.

Generating Station C unit E was connected to the grid at 09:45 on 04/11/11 and was released for full load operations at 12:45 on 04/11/11.

All breakers involved operated as per design during this event. No personnel injuries or equipment damage were identified. No protective system misoperations were reported.

V. Response Analysis

A. Initial Response

The loss of 978 MW of generation and multiple BES elements in the ERCOT Region on April 11, 2011 constituted a significant disturbance to grid operations. The BA used the Region’s resources and reserves to balance resources and demand and return system frequency to pre-disturbance frequency.

ERCOT Region frequency (measured at the RC control center) was at 60.033 Hz immediately prior to the disturbance. Immediately after the disturbance, system frequency dropped to 59.791 Hz. Generator governor response arrested the frequency decline. The system frequency returned to its pre-disturbance value of 60 Hz within four minutes.

B. Reserves

The recovery from the initial disturbance temporarily dropped Physical Responsive Reserve capability below 3000 MW, the point at which an “Advisory” is called for in ERCOT Protocols, for one minute and 20 seconds.

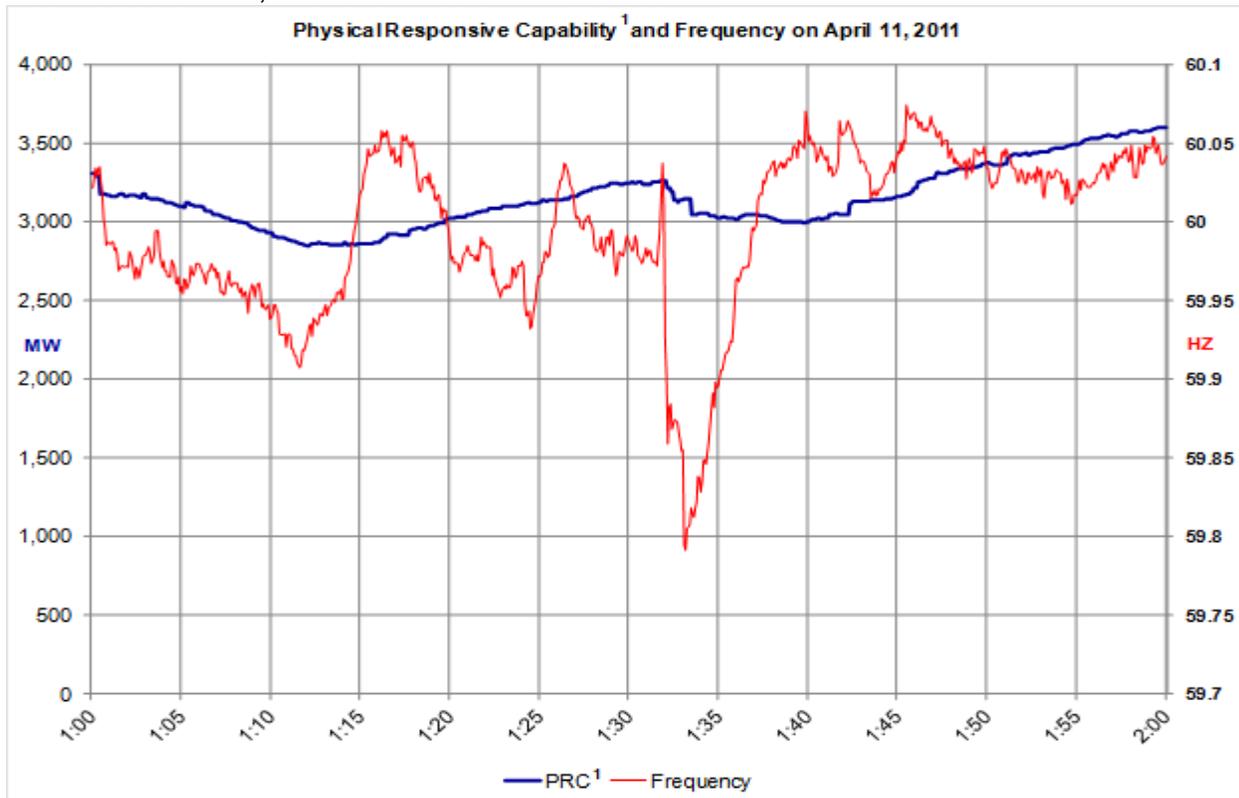


Figure 2: Physical Responsive Capability and Frequency on April 11, 2011.

C. Registered Entity Corrective Actions

Equipment owners have taken the following actions to address the problems noted:

- Transmission Operator H replaced two lattice towers damaged due to a likely tornado. The foundation of one structure was damaged severely enough that the tower foundation had to be reconstructed. Transmission Operator H completed repairs on April 14th at 17:58 hours.

VI. Conclusions

In general, the steps taken in the recovery from this event achieved the desired results. Given the number BES elements outaged during the event, and the high volume of incoming communications, RC and BA operators handled the situation effectively.

Equipment owners have taken actions to address problems as noted previously.