

Texas Reliability Entity Event Analysis

Event:
**May 8, 2011 Loss of Multiple Elements
Category 1a Event**

Texas Reliability Entity
July 2011

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Executive Summary

On May 8, 2011 at 15:53, the ERCOT Region experienced the simultaneous loss of the 345 kV Bus B at Substation A and the Substation A 345/138 kV autotransformer. Substation A 345 kV Bus B includes the Substation A to Substation C 345 kV line, Substation A to Substation D Switch 345 kV line, Substation A to Substation E 345 kV line, Substation A to Substation F 345 kV line, Substation A to Substation G 345 kV line, and Substation A to Generating Station H 345 kV line. Generating Station H Unit J and K tripped with approximately 425 MW being disconnected from the grid. 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 May 8, 2011 at 15:53, a vacuum bottle interrupter on a Capacitor Bank Switch located inside a customer-owned facility at Generating Station H failed. This failed interrupter placed a sustained “C” phase to ground fault on the radial 138 kV line fed by Substation A CB XXX-1. As a result of this fault, Substation A CB XXX-1 tripped and then reclosed one second later. The reclosure of CB XXX-1 reenergized the faulted circuit. Relaying for CB XXX-1 once again detected the fault and issued a trip signal to the CB. CB XXX-1 tripped a second time, but less than one cycle later, the “C” phase pole of the circuit breaker failed. The failure of the circuit breaker pole allowed for fault current to continue to be fed to the failed customer interrupter.

As designed, the breaker failure circuitry for CB XXX-1 energized the Transformer Differential lockouts for the 345/138 kV Autotransformer at Substation A (Note: the 345/138 kV Autotransformer is the only source for CB XXX-1). This lockout relay operated at approximately 15:53:08; tripping all circuit breakers on the 345 kV Bus B and blocking a reclose signal for each until high side Air Switch #XXX-8 on the 345/138 kV Autotransformer opened (isolating the Autotransformer from the 345 kV Bus).

All circuit breakers on 345 kV Bus B were then allowed to reclose. For this event, all circuit breakers on the bus reclosed except CB XXX-2 (connected to the Generating Station H). The reason this circuit breaker did not reclose is that its “Recloser Cutoff” Switch was in the “Off” position.

The fault condition caused the Generating Station H Unit J to trip with a net output of 213 MW and the Generating Station H Unit K to trip with a net output of 212 MW.

425 MW tripped within the first minute of the event.

The failed CB XXX-1 was replaced and returned to service on May 11, 2011 at 18:50.

System frequency dropped from 60.037 Hz to 59.901 Hz as a consequence of the loss of generation. The drop was arrested by governor action of ERCOT Region generators. Balancing Authority (BA) Physical Responsive Capability (PRC) remained above 4000 MW for the duration of the event.

This event did not meet the criteria as a NERC Disturbance Control Standard (DCS) event since the loss of generation was below the 1100 MW threshold for the ERCOT Region. The event met the definition of a Category 1a 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 May 8, 2011 were:

System Load: 47,795 MW
 System Frequency: 60.005 Hz
 Physical Responsive Capability: ~4150 MW

ERCOT Region load was 47,795 MW and total wind generation was approximately 5,215 MW.

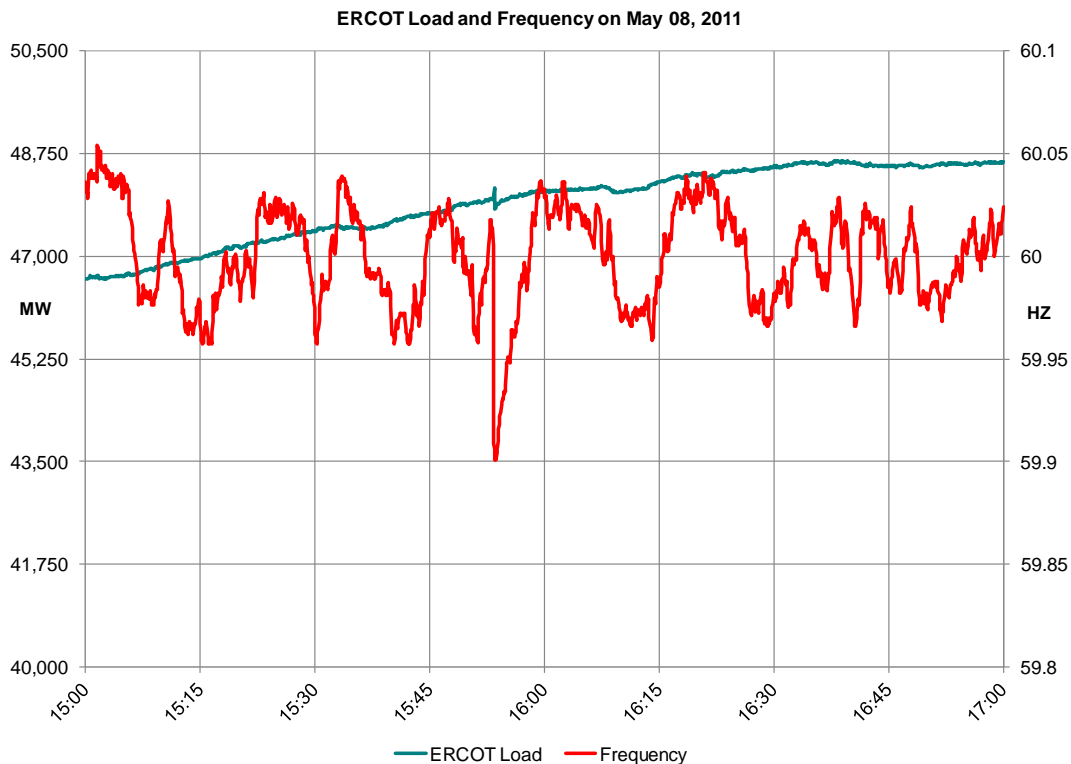


Figure 1 ERCOT Region Load and Frequency on May 08, 2011

III. Sequence of Events on 05/08/2011

May 08, 2011

- 15:53:15 ERCOT Region frequency prior to disturbance was 60.005 Hz.
- 15:53:30 Substation A 345 kV Bus V and the Substation A 345/138 kV autotransformer tripped. Bus B includes Substation A to Substation C 345 kV line, Substation A to Substation D Switch 345 kV line, Substation A to Substation

E 345 kV, Substation A to Substation F SES 345 kV, Substation A to Substation G 345 kV line and Substation A to Generating Station H 345 kV line.

- 15:53:30 Generating Station H unit J tripped causing the loss of 213 MW of generation and unit K tripped causing the loss of 212 MW from the system. 425 MW tripped within the first minute of the event.
- 15:53:30 ERCOT Region frequency dropped to approximately 59.901 Hz.
- 15:54 Restoration of the Substation A 345 kV Bus 2 was completed.
- 15:54 Restoration of the Substation A - Substation C 345 kV line was completed.
- 18:45 Restoration of the Substation A to Generating Station H 345 kV line was completed.
- 20:05 Generating Station H unit J returned back to service.
- 20:20 Generating Station H unit K returned back to service.

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- 19:00 Substation A 345/138 kV autotransformer returned back to service

IV. Analysis of Event

A. Transmission Owner A

At approximately 15:53:05 a vacuum bottle interrupter on a Capacitor Bank Switch located inside a customer-owned facility at Generating Station H failed. This failed interrupter placed a sustained “C” phase to ground fault on the radial 138KV line fed by Substation A CB XXX-1. As a result of this fault, Substation A CB XXX-1 tripped and then reclosed 1 second later. The reclosing of CB XXX-1 reenergized the faulted circuit. Relaying for CB XXX-1 once again detected the fault and issued a trip signal to the CB. CB XXX-1 tripped a second time, but less than 1 cycle later the “C” phase pole of the CB failed. The failure of the CB pole allowed for fault current to continue to be fed to the failed customer interrupter.

As part of the CB XXX-1 protection system, when a trip signal is issued to the CB and its auxiliary switches open but fault current is still present, the relaying energizes its breaker failure circuitry.

Sequence of Events

- 15:53 Customer owned vacuum bottle interrupter failure
- 15:53 Substation A 138 kV CB XXX-1 tripped and reclosed
- 15:53 Substation A 138 kV CB XXX-1 tripped, but less than 1 cycle later the “C” phase pole of the CB failed
- 15:53 Substation A-345 kV Bus B CBs XXX-2, XXX-3, XXX-4, XXX-5, XXX-6, and XXX-7 tripped via breaker failure logic
- 15:53 Substation A-345/138 kV Auto Transformer tripped. 345 kV Switch XXX-8 (high side switch) tripped
- 15:53 Substation A-345 kV Bus B CBs XXX-3, XXX-4, XXX-5, XXX-6, and XXX-7 reclosed
- 17:21 Substation A-345 kV CB XXX-2 closed

As designed, the breaker failure circuitry for CB XXX-1 energized the Transformer Differential lockouts for the 345/138 kV Autotransformer at Substation A (the 345/138 kV Autotransformer is the only source for CB XXX-1). This lockout relay operated at approximately 15:53:08; tripping all CB’s on the 345 kV Bus B and blocking a reclose signal for each until high side Air Switch #XXX-8 on the 345/138 kV Autotransformer opened (isolating the Autotransformer from the 345KV Bus).

All CB’s on the 345 kV Bus B were then allowed to reclose. For this event, all CB’s on the Bus reclosed except CB XXX-2 (CB connected to the Generating Station H Generating Station). The reason this CB did not reclose is that its “Recloser Cutoff” Switch was in the “Off” position.

There was no loss of load for this event. (The load at the customer-owned facility that is supplied by CB XXX-1 was off-line at the time of the event.)

All protective relaying circuits functioned as designed. The failed CB XXX-1 was replaced and returned to service on May 11, 2011 at 18:50.

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 H Unit J and K

On May 08, 2011, approximately 218.5 MW from the Generating Station H unit J and approximately 217.6 MW unit K tripped respectively.

Sequence of Events: The sequence of events is broken down by Unit below.

Unit J Events

15:53 Direct Transfer Trip from 87L-2 Line Current Differential Relay
15:53 Breaker ZZZZ Opened after breaker XXX-2 tripped in Substation A
15:53 Gen Breaker Open Unit Trip
17:23 Breaker ZZZZ Closed and Unit available for restart
20:05 Gen Breaker Closed
21:40 Unit on AGC – Event End

Unit K Events

15:53 Direct Transfer Trip from 87L-2 Line Current Differential Relay
15:53 Breaker ZZZZ Opened after breaker XXX-2 tripped in Substation A
15:53 Unit online in island mode
18:15 Gen Breaker Open Unit offline
17:23 Breaker ZZZZ Closed and Unit available for restart
20:20 Gen Breaker Closed
21:40 Unit on AGC – Event End

The plant has experienced similar events in the past and restored from the events without understanding the cause and or potential for secondary events. This has potential to and has resulted in significant financial impact to the plant.

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 425 MW of generation and multiple BES elements in the ERCOT Region on May 8, 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 60.005 Hz immediately prior to the disturbance. Immediately after the disturbance, system frequency dropped to 59.901 Hz. Generator governor response arrested the frequency decline.

B. Reserves

BA Physical Responsive Capability (PRC) remained above 4000 MW for the duration of the event.

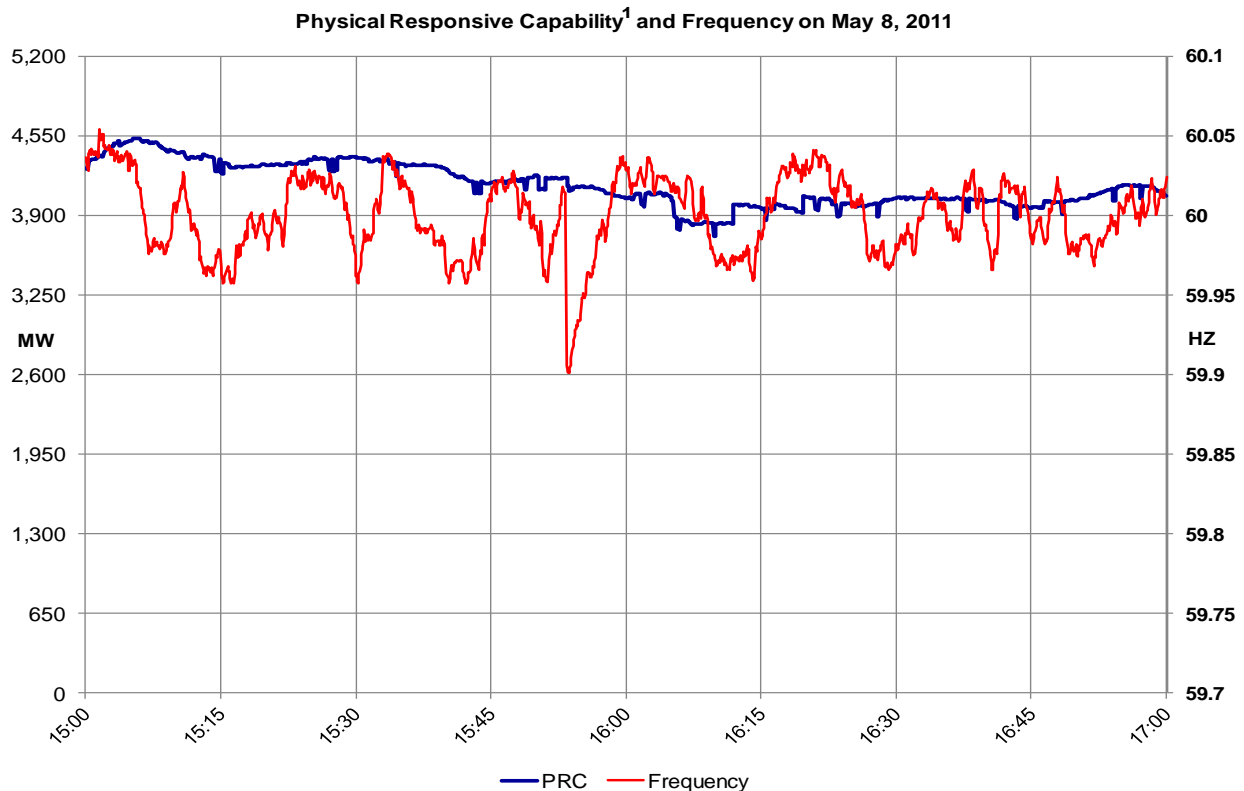


Figure 2: Physical Responsive Capability and Frequency on May 8, 2011

C. Registered Entity Corrective Actions

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

- Transmission Owner A replaced the failed CB XXX-1 was replaced and returned it to service on May 11, 2011 at 18:50.

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.