Texas Reliability Entity
Event Analysis

Event:
July 10, 2012 DCS Event
Category 1g Event

Texas Reliability Entity
September 21, 2012

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Executive Summary

On July 10, 2012, the malfunction of a control system communications switch caused the simultaneous trip of two large, base-load units in the ERCOT region. Reliability Coordinator (RC) and Balancing Authority (BA) personnel and systems operated effectively to restore system frequency by deploying reserves, and then afterwards restored those reserves. 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

At 20:46:24 on July 10, 2012, two large base-load units, loaded at 1200 MW gross and 1130 MW net, tripped in the ERCOT region due to the malfunction of a control system communications switch.

System frequency measured at the RC's control center dropped from 60.011 Hz to 59.716 Hz, based on 4-second scans, as a consequence of the loss of generation. High-speed frequency recorders indicated that frequency dropped to 59.707 Hz. The drop was arrested by governor action of ERCOT region generators, aided by automatic deployment of 1108 MW of generation responsive reserve, 599 MW of regulation, as well as automatic deployment of 195 MW of Load Resources (LR) by underfrequency relay action. These actions led to system frequency recovery within 7 minutes and 44 seconds to the pre-disturbance value of 60 Hz (at 20:54:04).

The RC responded to the first event as a NERC Disturbance Control Standard (DCS) event in the ERCOT region. The event also met the definition of a Category 1g event under NERC's Event Analysis Working Group (EAWG) procedure.

II. Initial System Conditions Prior to Event

07/10/2012 at 20:46:

Actual Demand:	46,275 MW
System Frequency:	60.011 Hz
Area Control Error (Total):	~ 60 MW
Physical Responsive Capability:	~3621 MW
Wind Generation:	1470 MW

III. Sequence of Events on 07/10/2012

- 20:46:20 ERCOT region frequency prior to disturbance was 60.011 Hz.
- 20:46:24 Units trip causing the loss of 1130 MW of net generation.
- 20:46:40 ERCOT region frequency drops to approximately 59.716 Hz (59.707 Hz High-Speed Frequency Recorder Data) immediately after the trip.
- 20:46:40 195 MW of Load Resources (LR) tripped offline on Under Frequency Relay (UFR) action.
- 20:54:02 ERCOT region frequency recovers to 60 Hz.

IV. Analysis of Initial Unit Trips

A. Generation Unit Trip

The Generator Operator reported that at 20:46 CDT on July 10, 2012, two of its units tripped due to the malfunction of a control system communications switch. The switch was common to the control system for both units.

Subsequent investigation revealed that the cause of the event was a partial failure of one of the redundant core switches on the plant control system network. The core switches serve as a communications hub for both units. The partial failure of the primary core switch allowed it to keep its ports open for traffic. The secondary switch detected the problem that the primary switch had and opened its ports for communication. This simultaneous operation of both switches caused the network to loop and generate a data storm. The data storm blocked the communication between boiler controls and burner management control processors on both units. When communication between these two processors was interrupted, a unit trip occurred. “Loss of fault tolerant BCS CP” was flagged as the first hit on each burner management system (BMS) and was the immediate cause of the unit trips. Consequently, the turbine control systems on each unit listed its associated BMS as its trip signal source. The first indication of a problem to the operator was all operator screens experienced a loss of communications with the rest of the control system, which resulted in loss of visibility into the controls on both units.

The switch alarming is monitored internal to the network and is intended to notify the operator in the event of a switch fail-over, or switch port failure.

After this event, the switch supplier issued a customer advisory on August 15, 2012.

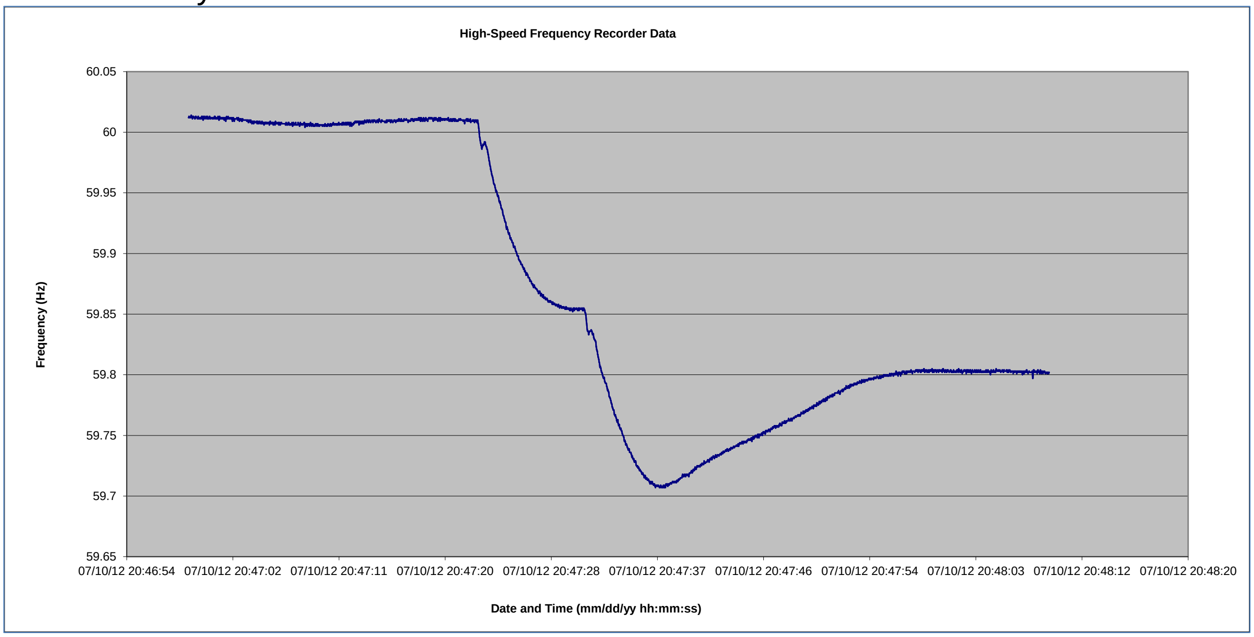
The breakers and protection system operated properly as designed. There were no personnel injuries.

V. Response Analysis

A. Initial Response

The loss of generation in the ERCOT Region during the morning of July 10, 2012 constituted a significant disturbance to grid. The Balancing Authority used the Region’s resources and reserves to balance resources and demand and return system frequency to pre-disturbance frequency well within the 15 minute target set by NERC Standards.

ERCOT region frequency was at 60.011 Hz immediately prior to the disturbance. Immediately after the disturbance, system frequency dropped to 59.716 Hz, based on 4-second scans. High-speed frequency recorders indicated that frequency dropped to 59.07 Hz. The following are among the actions that registered entities initially took to stabilize the system:



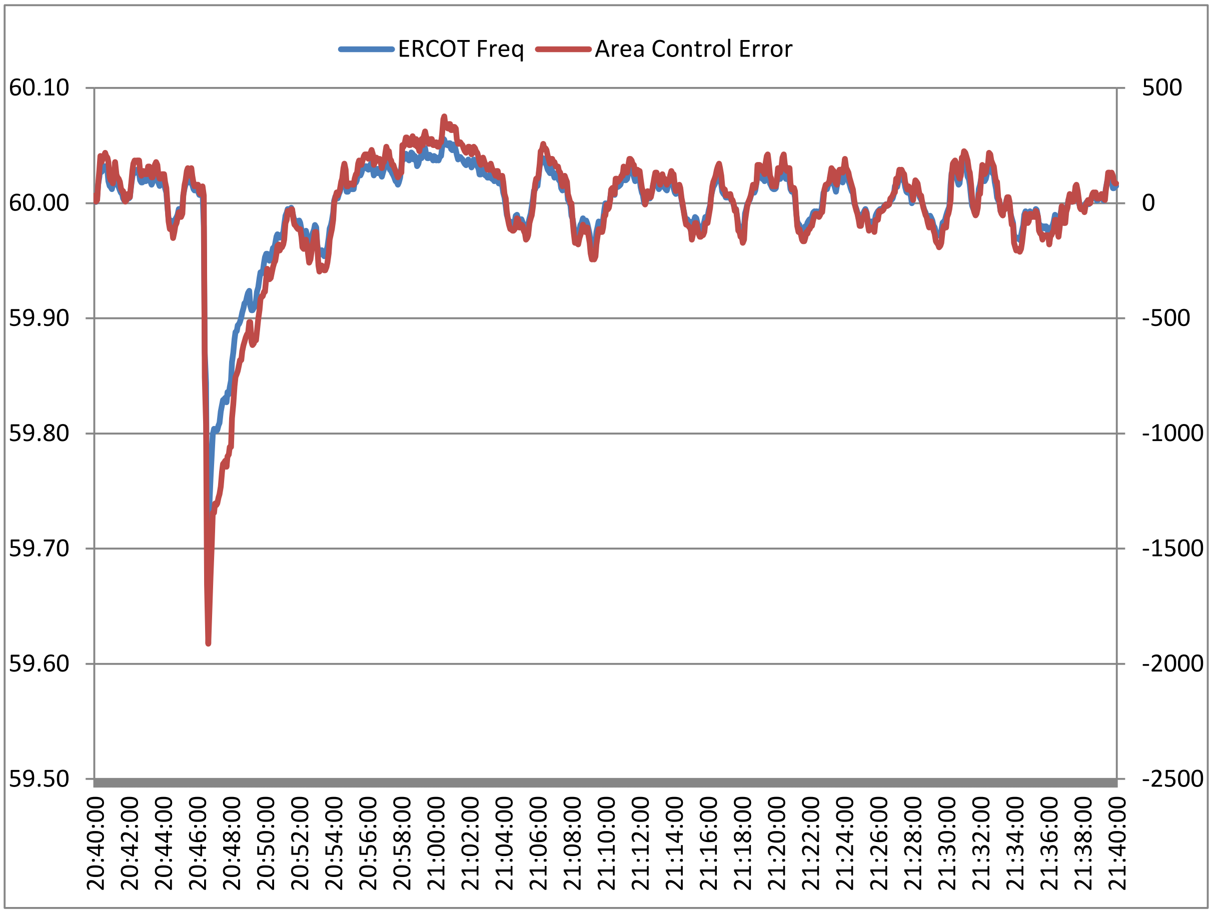
High-Speed Frequency Recorder Data on July 10, 2012.

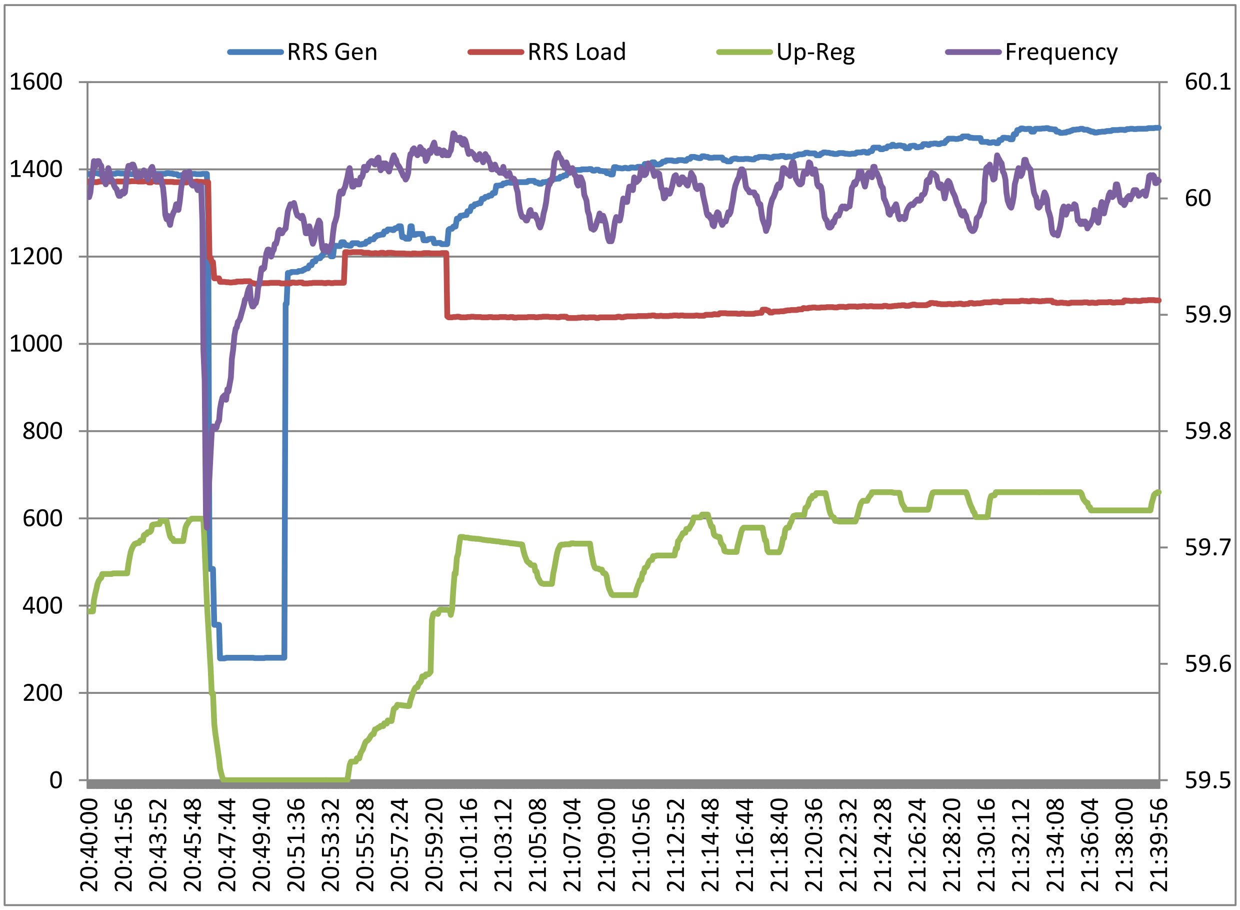
- Generator governor response arrested the frequency decline, as analyzed by the Performance, Disturbance, Compliance Working Group (PDCWG) in its draft report. The initial calculated system frequency response, termed the "B" point, was 304.78 MW/0.1 Hz, which failed to meet the target of 420 MW/0.1 Hz established in Regional Protocols 5.9.2. The second calculated response point, termed "B+30" to denote that it measures how well response is sustained 30 seconds after the event, was 288.78 MW/0.1 Hz, which also failed to meet the minimum response level. The response was due to a combination of governor action from the on-line generation resources as well as the response from Load Resources which tripped automatically due to the low frequency condition. The PDCWG noted that 105 out of 150 units (units running that were not excluded) (70.0%) sustained governor response for this event. The PDCWG also noted the following:
  - Responsive reserve was carried on nonresponsive power augmentation
  - Power Augmentation which did deploy showed delays in deployment

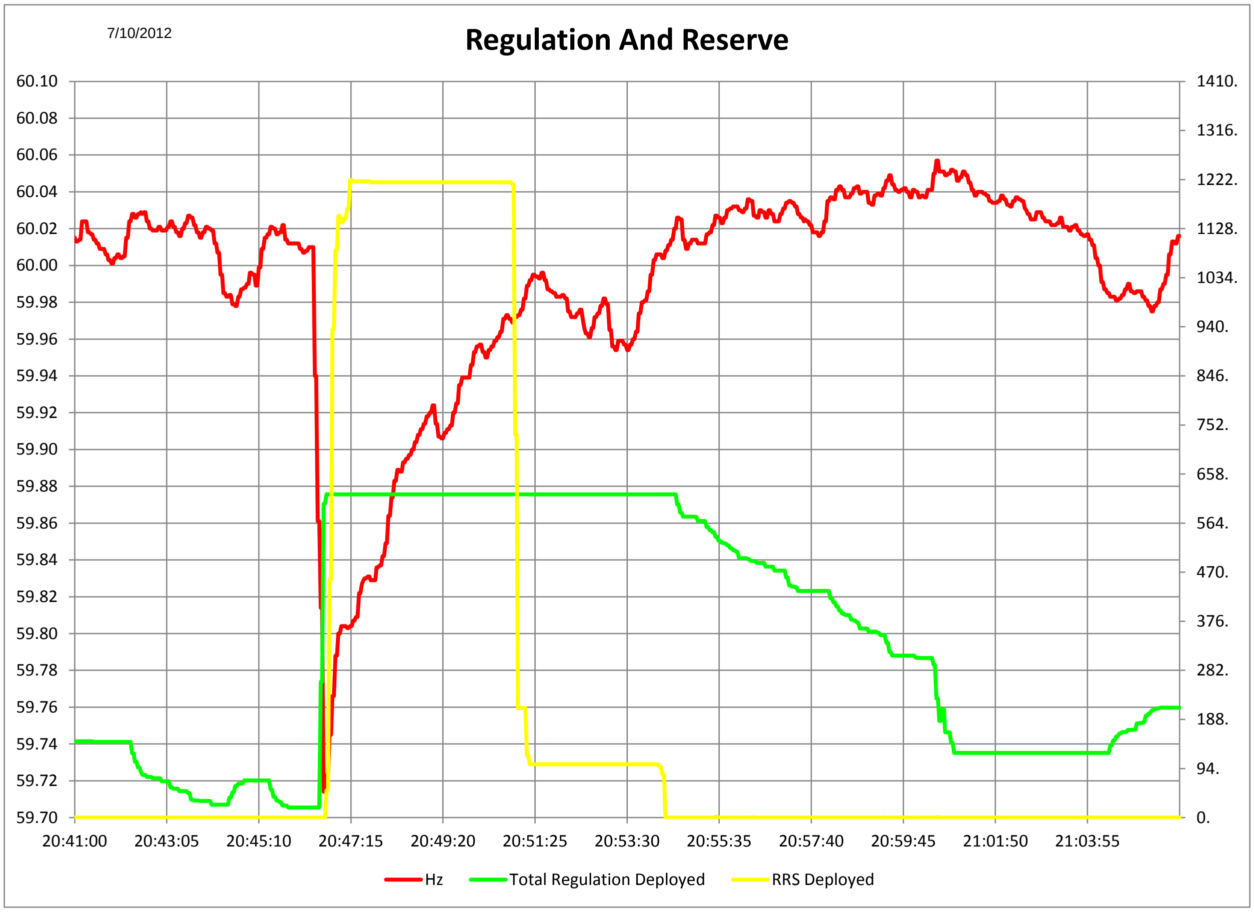
- The Area Control Error (ACE) reached a minimum value of -1913 MW during the event. The BA's control center computer made a step deployment of 599 MW of generation regulation, within 10 seconds of the frequency bottom, modifying the setpoint sent to QSEs to accomplish this deployment. Texas RE did not identify any problems with this automatic deployment or the response from QSEs to ramp their generators output up within 10 minutes as required. Similarly, 1108 MW of Responsive Reserve Service (RRS) from generators was deployed after the event.

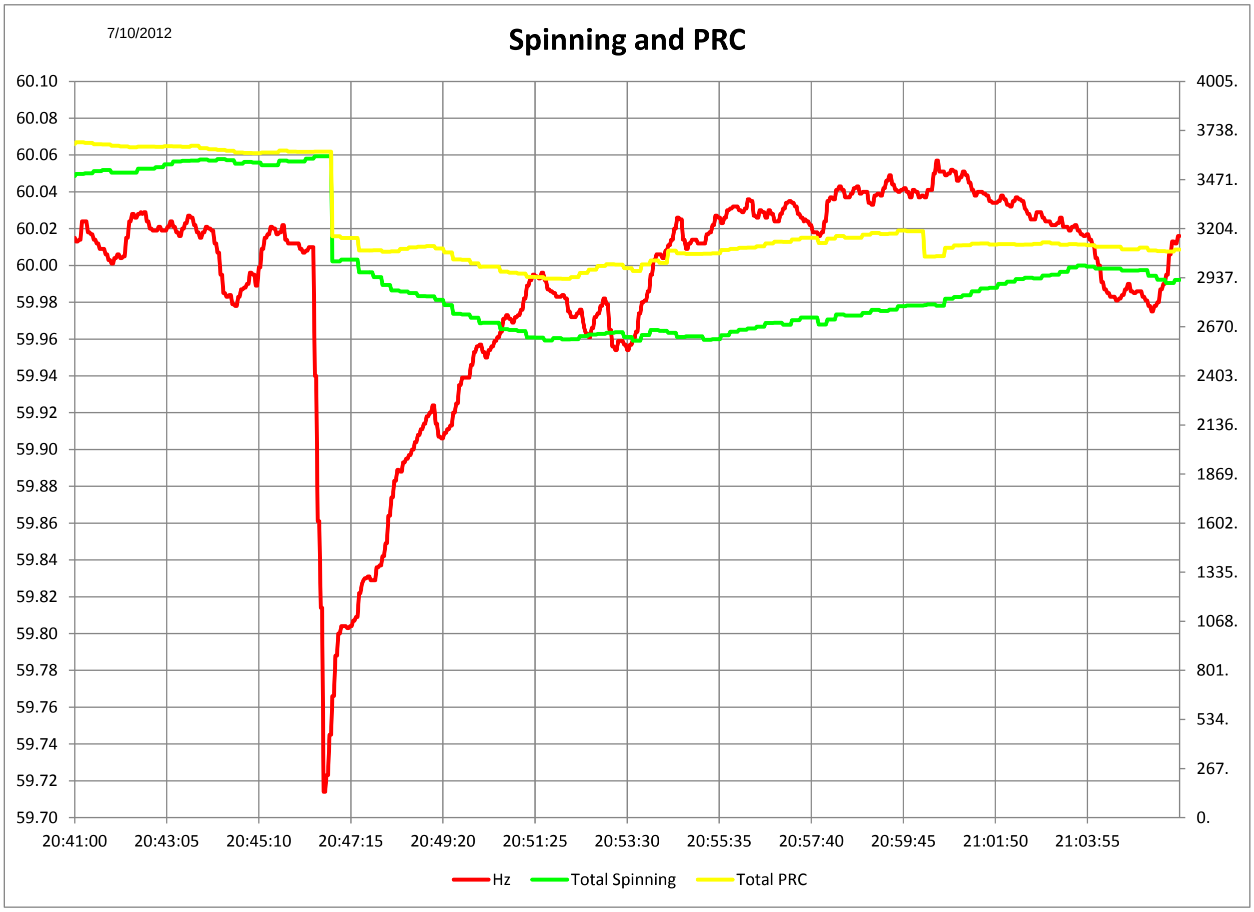
- Automatic deployment of 195 MW of LR by underfrequency relay action aided the frequency recovery.

The result of these actions was that system frequency returned to its pre-disturbance value of 60 Hz within 7 minutes and 44 seconds.




RRS Gen
RRS Load
Up-Reg
Frequency
1600
1400
1200
1000
800
600
400
200
0
60.1
60
59.9
59.8
59.7
59.6
59.5
20:40:00
20:41:56
20:43:52
20:45:48
20:47:44
20:49:40
20:51:36
20:53:32
20:55:28
20:57:24
20:59:20
21:01:16
21:03:12
21:05:08
21:07:04
21:09:00
21:10:56
21:12:52
21:14:48
21:16:44
21:18:40
21:20:36
21:22:32
21:24:28
21:26:24
21:28:20
21:30:16
21:32:12
21:34:08
21:36:04
21:38:00
21:39:56


7/10/2012
Regulation And Reserve
60.10
60.08
60.06
60.04
60.02
60.00
59.98
59.96
59.94
59.92
59.90
59.88
59.86
59.84
59.82
59.80
59.78
59.76
59.74
59.72
59.70
1410.
1316.
1222.
1128.
1034.
940.
846.
752.
658.
564.
470.
376.
282.
188.
94.
0.
20:41:00
20:43:05
20:45:10
20:47:15
20:49:20
20:51:25
20:53:30
20:55:35
20:57:40
20:59:45
21:01:50
21:03:55
Hz
Total Regulation Deployed
RRS Deployed



B. Reserves

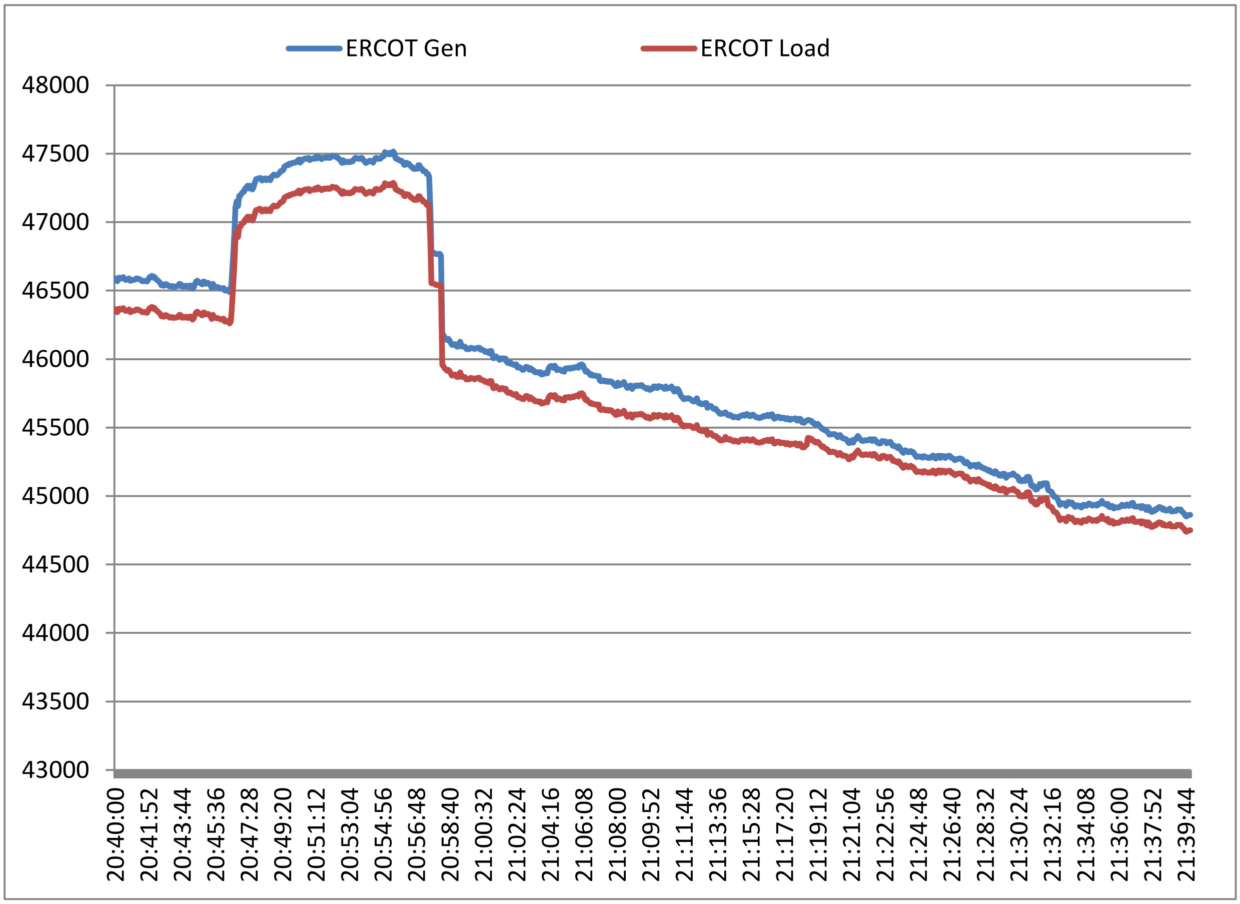
The Physical Responsive Capability remained above 2900 MW for the duration of the event.

C. Generation Unit Response

The Generator Operator for the unit that tripped has completed the following items to return the units to service:

- The switch that partially failed and its redundant twin were replaced. The recommended firmware upgrades were completed.

When the event occurred, all communications, both internal and external to the plant were interrupted and/or not updating. This fed information to the Generator Operator and the Balancing Authority that the units were still generating at 1130 MW, when in fact they had tripped off line at 20:46:24. (See chart below)



No telemetry updates from the affected units occurred until the communication switch was reestablished at 22:24:52. In the interim, the Generator Operator manually overrode the generation output signal the two units at 20:57:32 and at 20:58:08. The Generator Operator overrode the telemetry points with manual data input to provide an accurate input signal and improve the accuracy of automated analysis programs.

During the loss of accurate incoming telemetry data the risk was that the State Estimator (SE), Real Time Contingency Analysis (RTCA), and Security Constrained Economic Dispatch (SCED) did not see acknowledge that the generation was off line and thus the correct amount of generation available to the system. In the event that the telemetry points could not have been overridden by the operator to provide accurate input signal for the RC's automated analysis programs, the RC may have had to update SE for the down range systems to see the proper configuration.

The Generator Operator changed their generation telemetry to send it directly from the Remote Terminal Unit (RTU), bypassing the control system that failed. In the event this occurred again, the BA and RC would be telemetered the proper Generator MW values.

D. Demand Side Resource Response

Approximately 195 MW of demand side resources tripped automatically due to the action of underfrequency relays. The BA may base up to 1400 MW of its 2800 MW of RRS on such demand side resources, termed Load Resources (LRs) at the time of this event. LR's providing RRS are expected to have this capability set to 59.7 Hz within 20 cycles. Data collected data from the high resolution frequency recorders in the Region show that frequency went to 59.707 HZ. Based on this data there were no misoperations noted with the Load Resource performance. Thus the partial automatic activation of underfrequency relays can be attributed to the close proximity of the dip in frequency to the relay set-point at which these resources should be activated and slight variations in the frequency sensed at different locations.

VI. Conclusions

In general, the steps taken in the recovery from this event achieved the desired results. System Operators handled the situation effectively.

Last, frequency response from generators and LR performed to effectively address the initial frequency response and met the minimum levels on the "B" and "B+30" calculation of system frequency response. 105 out of 150 units evaluated during this event (i.e. units running that were capable of providing governor response) provided the 'sustained' governor response for this event.

Demand side resources contributed to the recovery from this event. Subtle differences in relay setting sensitivity and the frequency at different points of the grid resulted in a partial deployment that was effective.