Texas Reliability Entity
Event Analysis

Event:
August 20, 2010 DCS Event
Category 3 Event

Texas Reliability Entity
July 2011

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Executive Summary

On August 20, 2010, an inadvertent trip signal during testing tripped Unit B at the Generating Station A, removing 1319 MW of generation from the ERCOT Region near peak load. Other unit trips over the next six minutes removed an additional 212 MW of generation. 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 approximately 15:25:48 on August 20th, 2010, Unit B at Generating Station A tripped. This appeared as the loss of approximately 1319 MW of generation in the ERCOT Region. Generating Station A Unit B was taken out of service due to an inadvertent turbine trip signal caused by human error during planned testing of the unit.

Approximately eight seconds later (~15:25:56), Generation Station C Unit D tripped offline removing 75 MW from the system. Within the first minute, 1394 MW had been taken out of service.

System frequency dropped from 60.015 Hz to 59.749 Hz as a consequence of the loss of generation. The drop was arrested by governor action of ERCOT Region generators, aided by automatic deployment of generation responsive reserve of 1150 MW as well as manual deployment of 1150 MW of Load Acting as Resources (LaaR). BA operators responded to this event and procured additional generation to assist frequency recovery within 15 minutes. These actions led to system frequency recovery within 4 minutes and 42 seconds to the pre-disturbance value of 60 Hz (at 15:30:30).

Approaching six minutes later (at 15:31:56), Generation Station C Unit E tripped 66 MW out of service, and (at 15:32:36) Generation Station C Unit F tripped taking an additional 71 MW off line. The combined loss of generation from this second event of Generation Station C units E and F was approximately 137 MW.

After the frequency recovery, the BA had to contend with depletion of its reserves, particularly the available Adjusted Responsive Reserve (ARR) which forms the basis for emergency notifications and actions. The recovery from the initial disturbance (using manual LaaR deployment and automatic deployment of Responsive Reserve Service (RRS)) took ARR below 3000 MW. Between 15:31:56 and 15:32:36 (6 minutes 48 seconds after the initial disturbance), the loss of the Generation Station C Unit E and

Unit F removed an additional 137 MW of generation from the ERCOT Region. A "Watch" was issued at 15:33 for ARR below 2500 MW. The ARR continued to drop and fell below the BA's target minimum level of 2300 MW at 15:35, or 9 minutes 47 seconds after the initial disturbance. BA operators made Hotline calls and issued Verbal Dispatch Instructions (VDIs) to restore LaaRs and lower fleet generation due to high frequency caused by the LaaR deployment. The BA issued instruction to Generation Entity A to lower fleet generation by 400 MW at 15:44. Also between 15:38 and 15:59, requests for assistance were made for emergency power across DC ties with adjacent Reliability Coordinators. An Emergency Energy Alert (EEA) Level 1 was declared at 15:48, or 13 minutes after ARR fell below 2300 MW. Non-Spin Reserve Service (NSRS) was deployed in the ERCOT Region for the interval ending (IE) 16:15 and for the South, North, and West zones for the IE 16:30. The EEA Level 1 was cancelled at 16:35 after available NSRS was brought on-line between 16:00 and 16:15. The "Watch" issued for ARR below 2500 MW was cancelled at 18:19.

The RC responded to the first event as a NERC Disturbance Control Standard (DCS) event due to the loss of generation above 1000 MW in the ERCOT region. The event also met the definition of a Category 3a event (loss of load or generation of 1,000 MW or more in the ERCOT Region) under NERC's Event Analysis Working Group (EAWG) procedure and exceeded the most severe single contingency event for the ERCOT region. The second event with Generation Station C Unit E and F did not approach 80% of the single largest contingency and is thus not being treated as a DCS event. The second event did impact the recovery and for this reason, it is discussed in the response.

II. Forecasts and Initial System Conditions Prior to Event

8/20/2010 PUCT Current Day Report forecast reflecting 16:00 Peak (Pk):

Forecasted Pk HR Demand:	62533MW @ 1500 HR
Generation for Pk HR Demand	66533 MW @ 1500 HR
Schedule Gen for Pk HR Demand	57309 MW @ 1500 HR
Pk Hour load served by Balancing Energy	5494 MW @ 1500 HR
Potential for Capacity Emergency (EEA1)	Low @ 1500 HR
Potential for Deploying LaaR (EEA2A)	Low @ 1500 HR
Potential for Deploying IEL (EEA2B)	Low @ 1500 HR
Potential for Firm Load Shed (EEA3)	Low @ 1500 HR

Initial system conditions just before the event of August 20, 2010 were:

System Load:	61815 MW
Capacity on Line:	61467 MW
Net Scheduled Generation:	63070 MW
Balancing Energy:	2066 MW
System Frequency:	60.015 Hz
Schedule Control Error (Total):	-32 MW
Net Spinning Reserves:	5325 MW
Responsive Reserves:	3820 MW

III. Sequence of Events on 8/20/2010

- 15:25:40 ERCOT Region frequency prior to disturbance was 60.015 Hz.
- 15:25:48 Generation Station A Unit B operating at 1319 MW, tripped to zero.
- 15:25:48 ERCOT Region frequency dropped to approximately 59.749 Hz immediately after the trip.
- 15:25:48 1150 MW of Generation Responsive Reserve was deployed automatically in response to the frequency spike.
- 15:25:56 Generation Station C Unit D operating at 75 MW, tripped to zero.
- 15:28:56 Hotline call made to all Qualified Schedule Entities (QSE) to deploy all Load acting as Resources (LaaRs) and Hydro supplying Responsive Reserve.
- 15:30:30 ERCOT Region frequency recovered to 60 Hz.
- 15:31:56 Generation Station C Unit E operating at 66 MW, tripped to zero.
- 15:32:36 Generation Station C Unit F operating at 71 MW, tripped to zero.
- 15:33 Watch issued for ARR below 2500 MW.
- 15:35:34 ARR dropped below 2300 MW.
- 15:38 RC made request for emergency energy across the DC-Ties.
- 15:41 Hotline call made to all QSEs to restore LaaRs and Hydro supplying Responsive Reserve.
- 15:44 BA directed Generator Entity A to lower fleet generation by 400 MW due to high frequency caused by LaaR deployment.
- 15:44 BA requested Non-Spinning Reserve Service (NSRS) in the Houston zone for IE 16:15.
- 15:45 BA requested NSRS in the South, North and West zones for IE 16:30.
- 15:48 Hotline call made to all QSEs to notify them that RC declared EEA Level 1 for Adjusted Responsive Reserve below 2300 MW.

- 15:53 RC contacted the adjacent Reliability Coordinator to inquire about available transmission service across the DC-Ties. RC was informed that there was 76 MW of transmission service available across one of the DC Ties.

- 15:59 RC contacted Transmission Operator A to confirm the available capacity on the DC Ties.

- 16:00:06 183 MW of NSRS came on-line in the Houston zone.

- 16:13:38 ARR level returns above 2300 MW.

- 16:15:06 Additional 777 MW of NSRS came on-line in the remaining zones, for a total of 960 MW.

- 16:29 BA released Generation Entity A of the instruction to lower fleet generation by 400 MW.

- 16:35 EEA Level 1 was cancelled.

- 18:19 Watch issued for Adjusted Responsive Reserve below 2500 MW was cancelled.

IV. Analysis of Initial Unit Trips

A. Generation Station A Unit B

The root cause of the trip of Generation Station A Unit B was human error. At 15:25 on 08/20/10, Generation Station A Unit B experienced an automatic reactor trip while the plant was stable at approximately 100% power. The reactor trip was caused by an inadvertent turbine trip signal initiated during planned testing. The Generator Operator is required to perform this test every three months. As part of this required quarterly testing, trip signals from various protective devices are simulated to verify correct operation. Bypass mechanisms are in place to prevent an inadvertent trip of the unit. In this event, the Generator Operator technician failed to initiate the bypass for one of the protective devices, hence, the unit tripped when the device output was operated.

The Generation Station A Unit B main generator output breaker operated as per design. There was no equipment damage due to the trip of Generation Station A Unit B.

Since the quarterly surveillance testing is a routine test, the Generator Operator did not notify the RC prior to the test.

B. Generation Station C Unit D

The Generation Operator identified several issues for the trip of the Generation Station C Unit D (steam turbine). The combined cycle train was operating at 212 MW output, versus nameplate capacity of 270 MW (79% of nameplate rating). When the disturbance occurred, the steam turbine unit auto-peaked, exceeding the maximum 4th stage pressure limit, which in-turn, tripped the steam turbine unit. Causal factors for the unit trip include the following:

(1) The high ambient temperature that day reduced gas turbine efficiency and caused the Generator Operator to maximize the steam turbine output with the use of supplemental firing.
(2) The unit back pressure was higher than normal due to a vacuum leak on the steam turbine condenser. This higher back pressure caused the 4th stage pressure to run higher than normal.

C. Generation Station C Unit E and F

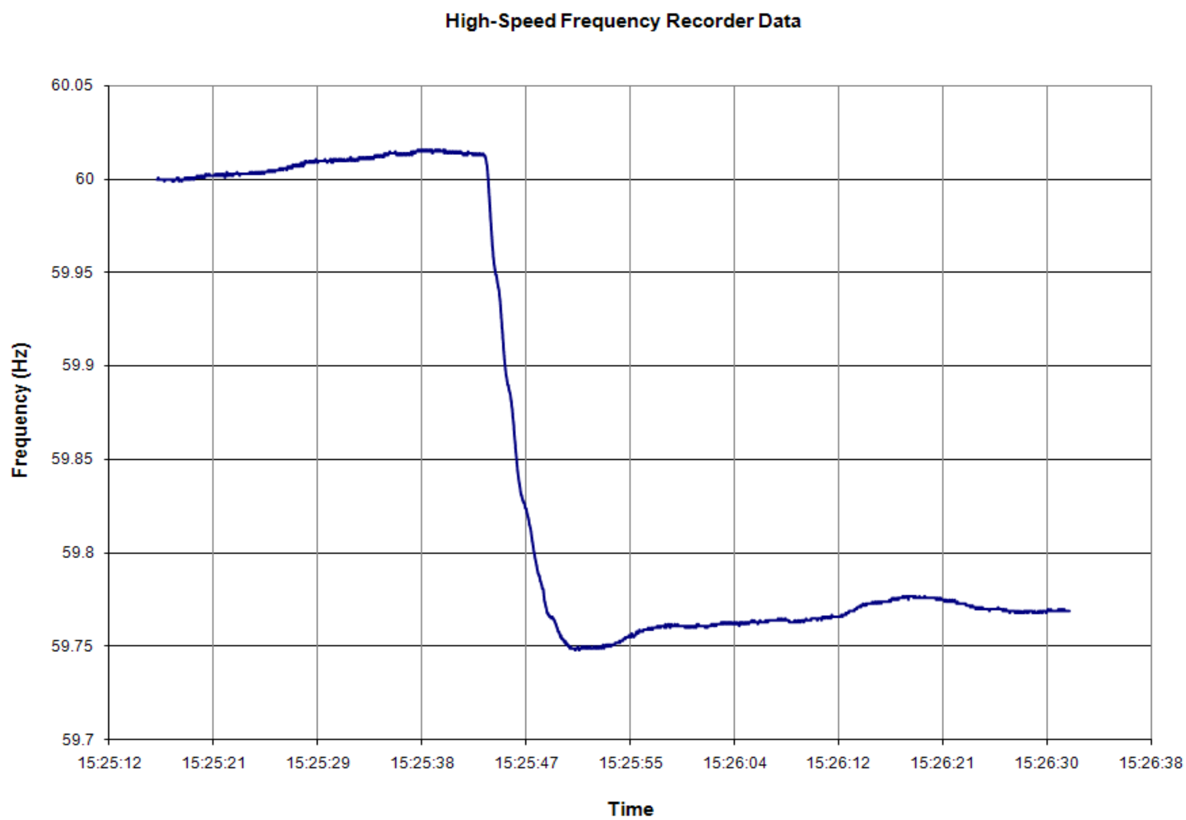
Approximately 6 minutes and 48 seconds after the initial disturbance, the Generation Station C Unit E and F (both gas turbines) tripped due to high steam flow. This was caused by an inrush of steam from the steam turbine tripping and the plant control valves not responding quickly enough to control the flow. The Generator Operator identified the issue to be sticking control valves.

V. Response Analysis

A. Initial Response

The loss of 1394 MW of generation in the ERCOT Region during the afternoon of August 20, 2010 constituted a significant disturbance to grid operations (generation loss represented 2.2% of ERCOT Region load). The BA 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 requirement set by NERC Standards.

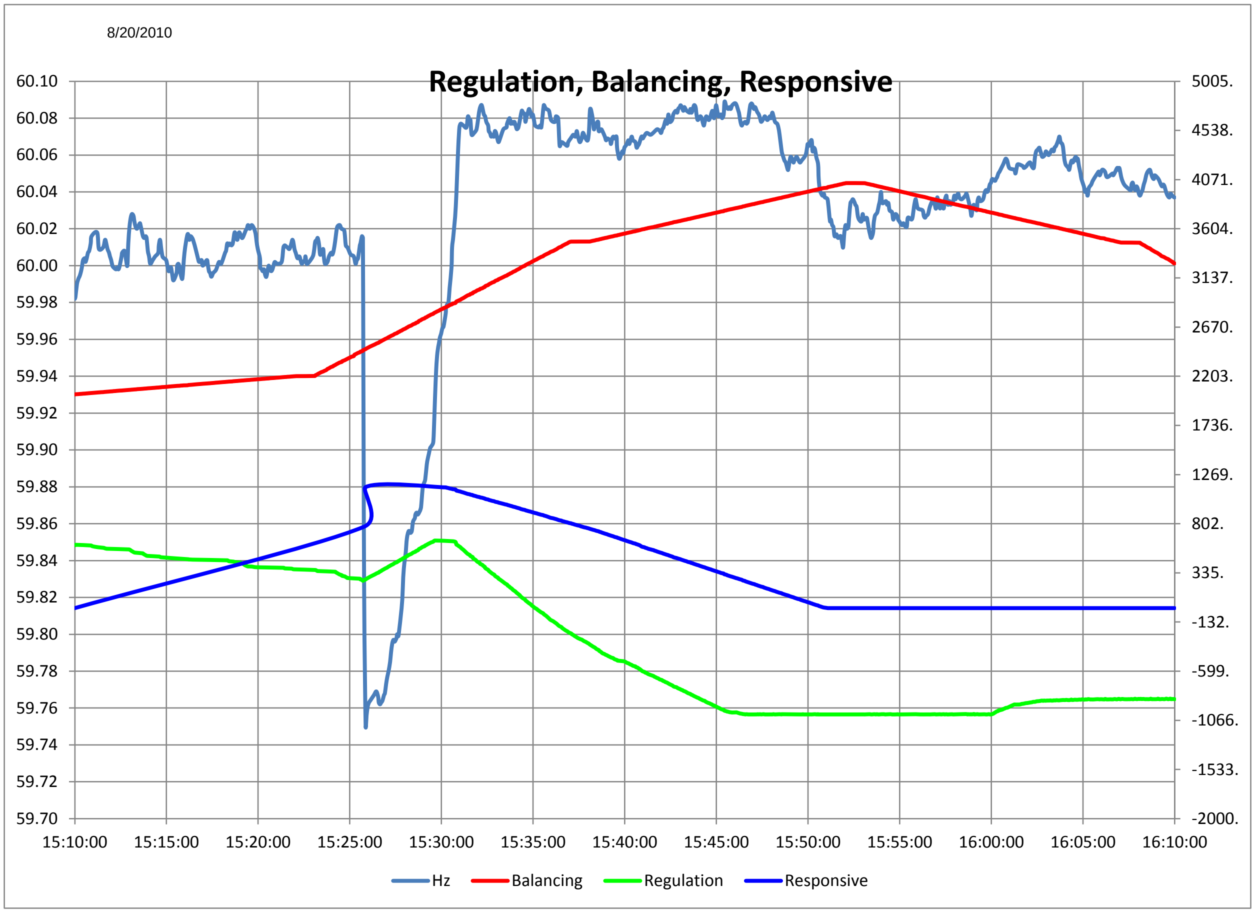
ERCOT Region frequency (measured at the RC control center) was at 60.015 Hz immediately prior to the disturbance. Immediately after the disturbance, system frequency dropped to 59.749 Hz. The following are among the actions that registered entities initially took to stabilize the system:



High-Speed Frequency Recorder Data on August 20, 2010.

- 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 208.63 MW/0.1 Hz, which failed to meet the target of 420 established in ERCOT 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, declined to 159.30 MW/0.1 Hz, which also failed to meet the minimum response target.
- Similar issues occurred with other combined cycle units as during previous DCS events. Those combined cycle units which were operating at or near their peak rating produced little or no frequency response. The PDCWG also noted the following concerns with this event:
    - Six QSEs did not deliver Responsive Reserve Service (RRS) within 10 minutes.
        - Two of these QSEs did not appear to attempt to deliver RRS.
    - Four QSEs with RRS obligations did not meet minimum Primary Frequency Response performance.
    - 510 out of 766 units (units running that were not excluded) (66.6%) sustained governor response for this event.
- The BA control center computer made a step deployment of the entire amount of generation RRS, 1150 MW, within eight 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 by the BA or the response from QSEs to ramp their generators output up within 10 minutes as required.
- Manual deployment of LaaR reduced load by 1329 MW (vs. target of 1150 MW required under ERCOT Protocols) within 10 minutes after the BA issued Verbal Dispatch Instruction (VDI) at 15:28:56, approximately three minutes after the initial disturbance. Only 20 MW LaaR tripped automatically. Since the RC's control center frequency measurement indicated a minimum frequency of 59.749 Hz, above the target of 59.7 (this limited response is expected due to minor variations in frequency across the system coupled with LaaR underfrequency relay sensitivities). One LaaR provider with approximately 22 MW of load experienced a telemetry failure but still deployed.

The result of these actions was that system frequency returned to its pre-disturbance value of 60 Hz within 4 minutes and 42 seconds.


8/20/2010
Regulation, Balancing, Responsive
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60.08
60.06
60.04
60.02
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59.94
59.92
59.90
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Hz
Balancing
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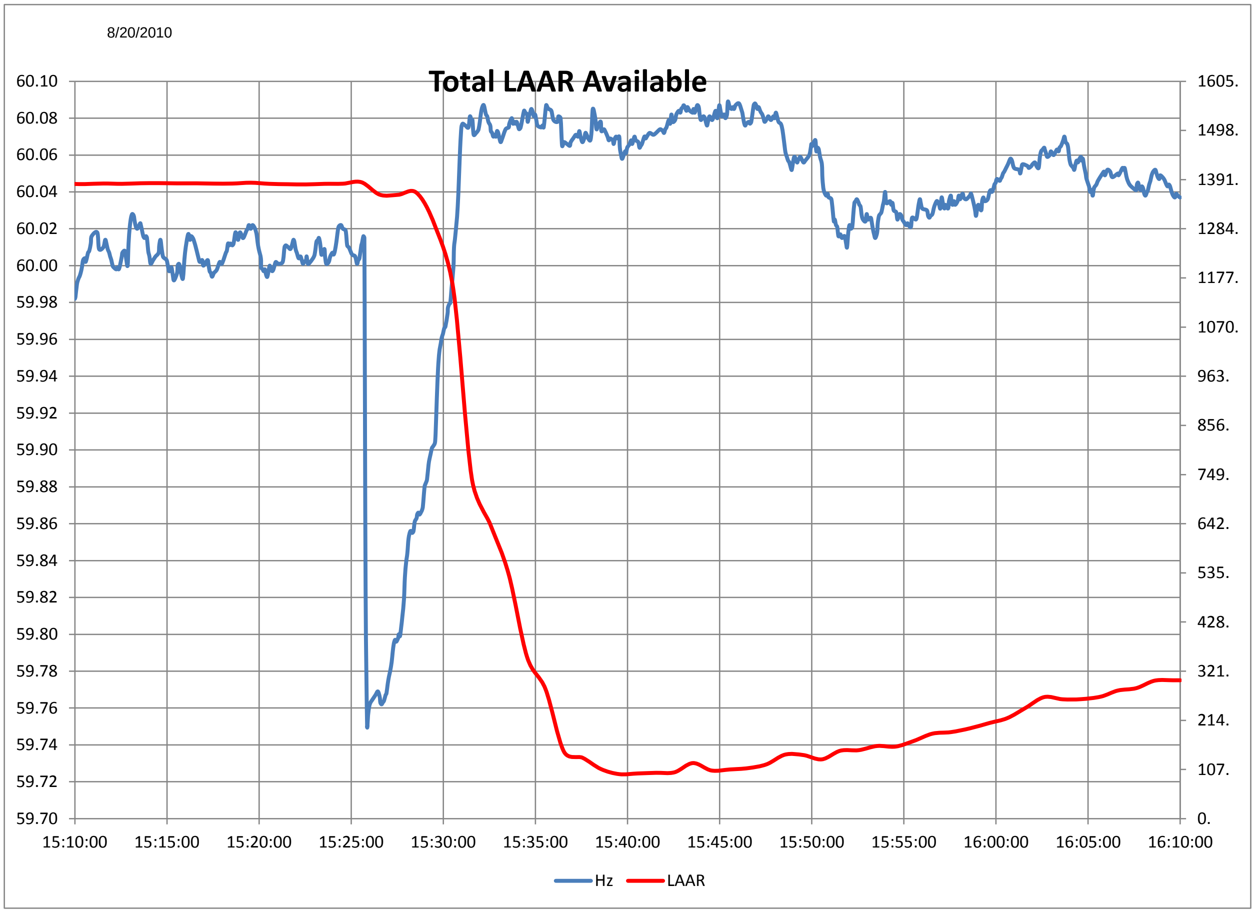

B. Reserves and Declaration of Emergency Energy Alert

After the frequency recovery, the BA had to contend with depletion of its reserves, particularly the ARR that forms the basis for emergency notifications and actions. The recovery from the initial disturbance (manual LaaR deployment and automatic RRS deployment) dropped ARR below 3000 MW, the point at which an "Advisory" is called for under ERCOT Protocols 5.6.4. The RC did not issue an Advisory. Between 15:31:56 and 15:32:36 (6 minutes 48 seconds after the initial disturbance), the loss of the Generation Station C Unit E and F removed an additional 137 MW of generation from the ERCOT Region. A "Watch" was issued at 15:33 for ARR below 2500 MW. The ARR continued to drop below the BA minimum level of 2300 MW at 15:35, or 9 minutes 47 seconds after the initial disturbance. BA operators made Hotline calls and issued VDIs to restore LaaRs and lower fleet generation due to high frequency caused by the LaaR deployment, having the effect of increasing the ARR. Between 15:38 and 15:59, requests for assistance were also made to obtain assistance across DC ties the neighboring Reliability Coordinator and DC Tie operator. An EEA Level 1 was declared at 15:48, or 13 minutes after ARR fell below the BA's target minimum level of 2300 MW. NSRS was deployed in the Houston zone for the interval ending (IE) 16:15 and for the

South, North, and West zones for the IE 16:30. The EEA Level 1 was cancelled at 16:35 after available NSRS was brought on-line between 16:00 and 16:15. The "Watch" issued for ARR below 2500 MW was cancelled at 18:19.

The result of these actions was that the ARR remained below the BA target minimum level of 2300 MW for 38 minutes. At no time did the ARR drop below the BA's Contingency Reserve level of 1354 MW. Contingency Reserve is defined by the RC as the most severe single contingency unit loss evaluated on a quarterly basis.

VI. Conclusions

In general, the steps taken in the recovery from this event achieved the desired results. Given the large number (four) of unit trips during the event, and the high volume of incoming communications, RC and BA operators handled the situation effectively.

- The adjacent Reliability Coordinator was contacted early in the EEA and responded with facilitating interchange schedules for 76 MW of emergency energy across the DC tie.

Equipment owners have taken actions to address problems as noted:

- The Generator Operator for Unit B identified corrective actions to prevent recurrence of the human error deemed the root cause of this event, in accordance with the Generator Operator corrective action program.

- The Generator Operator identified the following corrective actions for the generators at Generation Station C. For Unit D's trip:
  (1) The Generator Operator is working with a welding contractor to complete condenser leak repairs.
  (2) The alarm point has been adjusted to alert the operator earlier of a potential 4th stage pressure issue.
  (3) On higher than normal ambient temperature days, the gas turbine outputs are being increased to control 4th stage pressure.
  (4) The Generator Operator completed inlet pressure control valve tuning to improve performance in similar situations.

  For the Generation Station C Unit E and F trips, the Generator Operator identified the issue with the valve positioner that controls the inlet steam pressures going to the gas turbine. This positioner was replaced on September 12, 2010. Additionally, a replacement valve was purchased to replace the sticking control valves.

Lastly, while frequency response from generators and LaaR performed to effectively address the initial frequency response, the ERCOT Region was short on the "B" and

“B+30” calculation of system frequency response as a consequence of high loading on units in general and the limited response obtained from combined-cycle plants. Some 510 out of 766 units (running that were not excluded) provided the “sustained” governor response for this event. A third of the units did not contribute or actually reduced output instead of increasing it.