Electric Reliability Council of Texas

Final Report: October 8 2014 Transmission Emergency Event

Prepared by: Operations Analysis
Event Date: October 8, 2014
Report Date: December 12, 2014
Event Category: Transmission - Loss of Load

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Incident Classifications

Date and time of incident	8 October 2014 15:50
Region of incident	Valley
Affected regions	Valley
Event type	Transmission Emergency
Primary cause	Unit Trip

Abbreviations and Symbols

Abbreviation	Term
AS	Ancillary Services
DRUC	Day-Ahead Reliability Unit Commitment
EEA	Energy Emergency Alert
ERCOT	Electric Reliability Council of Texas
ERS	Emergency Reserve Service
HE	Hour Ending
HRUC	Hour-Ahead Reliability Unit Commitment
HSL	High Sustainable Limit
kV	Kilovolt
LF	Load Forecast
MAPE	Mean Absolute Percent Error
MIS	Market Information System
MW	Megawatt
PRC	Physical Responsive Capability
QSE	Qualified Scheduling Entity
QSGR	Quick Start Generation Resource
RGV	Rio Grande Valley
RRS	Responsive Reserve Service
RUC	Reliability Unit Commitment
SARA	Seasonal Assessment of Resource Adequacy
SCED	Security Constrained Economic Dispatch

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2. Event Summary

On October 8, 2014, at 15:50, the loss of the entire combined cycle train at North Edinburg (NEDIN) power station (651 MW) occurred, which ultimately resulted in post-contingent thermal overloads on Rio Grande Valley (Valley) area 138 kV transmission lines. A significant flow increase on the Rio Grande Valley Generic Transmission Constraint (GTC) into the Valley region was observed, as was a decrease in voltage within the Valley. ERCOT System Operators, in coordination with the local Transmission Operators (TOs) in the Valley, immediately took actions to raise voltages and increase reactive support through use of static reactive resources in the Valley. These actions repositioned the ERCOT system in the Valley to provide additional reliability margin for the Rio Grande Valley GTC voltage stability limit. ERCOT System Operators also re-dispatched all available generation in the Valley to reduce the observed thermal overloads for the next contingency in the event one should occur. ERCOT System Operators declared a Transmission Emergency at 16:09.

After taking all actions to bring on all available generation in the region in addition to requesting emergency energy through the Railroad DC Tie, ERCOT System Operators directed actions at 16:47 for the Transmission Operators in the Valley to shed 200 MW of firm load per a pre-coordinated Mitigation Plan. The actions were necessary to address one base-case overload (over the normal (continuous) rating but under the emergency (2hr/15min) rating), several post-contingency overloads on the 138 kV system, as well as improve the reliability margin[1] on the Rio Grande Valley GTC. This firm load shed remained in effect until ERCOT instructed load restoration beginning at 18:00, after generation increased/returned to service, and the evening peak demand reduced in the Valley region. ERCOT received confirmation of all load being restored by 18:29. The Transmission Emergency ended at 19:15.

3. Pre-Event Conditions

Prior to the event ERCOT Load was at 54,346 MW, with a Valley load of 2,020 MW. Valley Net Generation was approximately 1245 MW with all Generators in the Valley on-line with the exception of the Duke combined cycle train, which was on maintenance outage. The Railroad DC Tie was on outage at the onset of the event as well. It was unseasonably warm in the Valley for October 8 with temperatures approaching 90 degrees, which contributed to the high load observed.

Notable transmission outages in the area included 345 kV bus outage at North Edinburg and a La Palma to Rio Hondo 138 kV line outage. The line outage was resulting in an active constraint on the Rio Hondo to East Rio Hondo 138 kV line.

4. Incident Event Log

[1] Reliability margin is calculated by subtracting the MW flow into the Rio Grande Valley from the Rio Grande Valley GTC.

The sequence of events comprising the incident is itemized in Table 1 Event Log. The event began with the loss of the NEDIN units at 15:50 on October 8, 2014, and ended when ERCOT ended the Transmission Emergency at 19:15 on October 8, 2014.

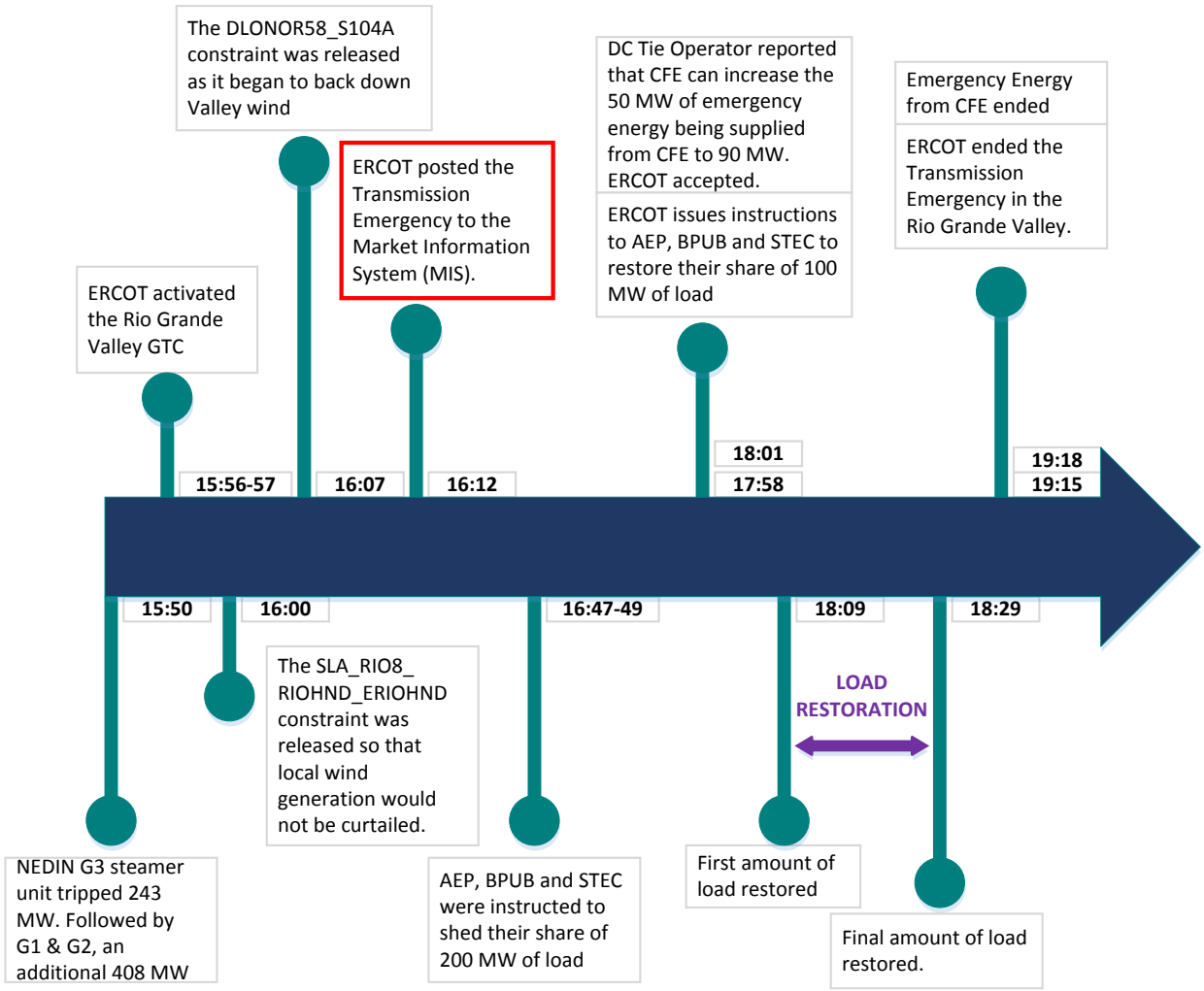

Table 1Event Log

Date/Time	Event
Oct 7	
15:00	ERCOT activated the constraint for the loss of the La Palma – Rio Hondo 138 kV (SLA_RIO8) overloading the Rio Hondo – East Rio Hondo 138 kV line (RIOHND_ERIOHND).
23:57	Duke plant (DUKE) offline for Maintenance Level 2 outage.
Oct 8	
00:15	The SLA_RIO8_ RIOHND_ERIOHND constraint was released. This is the

	constraint from the loss of the La Palma – Rio Hondo 138 kV line overloading Rio Hondo – East Rio Hondo 138 kV line. Released because it was no longer binding; loading had been reduced. Normal operation managing Cross Valley flows.
11:45	The SLA_RIO8_ RIOHND_ERIOHND constraint was activated when it showed up as binding.
15:50	NEDIN G3 (steamer) tripped while loaded at 243 MW. ERCOT frequency declined from 60.016 Hz to 59.951 Hz.
15:51	NEDIN G1 and G2 both tripped. G1 was loaded at 204 MW and G2 was loaded at 204 MW. ERCOT frequency declined from 59.957 Hz to 59.863 Hz. ERCOT deployed 599 MW of RRS following the plant trip. Total loss of generation at the NEDIN plant was 651 MW.
15:54	STEC called inquiring about losing something in the Valley. ERCOT reported all North Edinburg generation tripped. STEC reports they are seeing low voltages 131kV~132kV on the west end of the Valley.
15:55	American Electric Power (AEP) Transmission Operator reported that voltages are increasing in the Valley.
15:56	ERCOT activated the Rio Grande Valley GTC at 76% of its 1487 MW limit.
15:57	ERCOT activated DLONOR58_S104A. This is the constraint from the double-circuit loss of the Lon Hill – Orange Grove 138 kV / North Edinburgh 345 kV line (DLONOR58) overloading the Rio Hondo – Burns MVEC 138 kV line (S104A). The ERCOT Real-Time Contingency Analysis (RTCA) application indicated post-contingency loading up to 165.8% of its 174MVA Emergency (2-Hour) Rating. Activating this constraint backed down Valley wind units.
15:58	Following a request for voltage support from entities in the Valley, Sharyland reported they do not own equipment that can increase voltage.
16:00	The SLA_RIO8_ RIOHND_ERIOHND constraint was released so that local wind generation would not be curtailed. This allowed Wind Generation in the Valley to be maximized, providing a large amount of voltage stability margin/reactive support while only marginally increasing flows on the post-contingency overloaded lines.
16:01	QSE A was directed to increase bus voltage at a resource to 143.5 kV
16:04	QSE B was directed to increase bus voltage at a resource from 143 kV to 143.5 kV.
16:07	The DLONOR58_S104A constraint was released as it began to back down Valley wind and thus would be working against any efforts to produce additional voltage stability margin/reactive support.
16:07	ERCOT notified QSE C to take all units off of “ONTEST” and to take all units to HSL. ERCOT also notified QSE C to provide maximum voltage support.
16:09	ERCOT conducted a hotline call to all Transmission Operators issuing a Transmission Emergency for the Valley. The Transmission Operators were informed this may result in the deployment of Load Resources, curtailment of

	DC-Tie exports to Mexico (CFE), requests for emergency energy and Valley area load shed.
16:12	ERCOT posted the Transmission Emergency to the Market Information System (MIS).
16:14	ERCOT reviewed mitigation plan with the South Texas Electric Cooperative (STEC) Transmission Operator.
16:19	ERCOT observed a real-time overload on the Rio Hondo – Burns Magic Valley 138 kV line (S104A). This is attributed to increased output from Valley wind farms and the SILASRAY units as a result from ERCOT instructions and the release of the SLA_RIO8_ RIOHND_ERIOHND constraint. The base case constraint for this real-time overload was not activated due to the observed low reliability margin on the Rio Grande Valley GTC.
16:23	ERCOT reviewed mitigation plan with the AEP Transmission Operator.
16:39	ERCOT was notified by DC Tie Operator that the Railroad DC Tie, which was on planned outage, can be put back in service. DC Tie Operator had already spoken to CFE about emergency energy from CFE. DC Tie Operator began to prepare the DC Tie for service.
16:40	ERCOT reviewed mitigation plan with the Brownsville Public Utilities Board (BPUB) Transmission Operator.
16:44	QSE D was instructed not to take unit off-line unless they call ERCOT first.
16:47	STEC was instructed to shed their share of 200 MW of firm load.
16:48	AEP was instructed to shed their share of 200 MW of firm load.
16:49	BPUB was instructed to shed their share of 200 MW of firm load.
17:02	The DLONOR58_S104A constraint was activated to manage post-contingency overloading on the Rio Hondo – Burns MVEC 138 kV line (S104A).
17:04	QSE E reported unit started and would be fully loaded in 18-20 minutes.
17:05	AEP shed total firm load of 680 MW
17:15	AEP restored 370 MW of overcommitted firm load it that was shed
17:18	The Railroad DC Tie began providing emergency energy from CFE
17:21	QSE E reported unit breaker had been closed.
17:27	ERCOT issued manual Low Dispatch Limit (LDL) overrides for units to QSE so that the units will remain at their High Sustainable Limits (HSL).
17:37	QSE E reported the initial cause of plant trip. QSE E reported an expected outage of at least two weeks.
17:55	ERCOT instructed AEP to open the 138 kV breakers 2070 and 2075 at Weslaco Sub Station (WESLACO) to prevent overloads on the Rio Hondo to Burns Magic Valley 138 kV line during load restoration.
17:58	ERCOT instructed AEP to restore their share of 100 MW of firm load.
17:59	ERCOT instructed STEC to restore their share of 100 MW of firm load.
18:00	ERCOT instructed BPUB to restore their share of 100 MW of firm load.
18:01	DC Tie Operator reported that CFE can increase the 50 MW of emergency energy being supplied from CFE to 90 MW. ERCOT accepted.

18:07	AEP restored the Azteca – Southeast Edinburg 138 kV line which was on planned outage.
18:09	BPUB reported their share of the first 100 MW block of load (14.5 MW) had been restored.
18:10	The DLONOR58_S104A constraint was released as loading had been sufficiently reduced.
18:15	The SLA_RIO8_ RIOHND_ERIOHND constraint was activated to prevent post-contingency overloading on the Rio Hondo - East Rio Hondo 138 kV line; active through end of the day.
18:15	ERCOT instructed AEP to restore their share of the second 100 MW block of firm load.
18:15	ERCOT instructed BPUB to restore their share of the second 100 MW block of firm load.
18:16	STEC reported their share of the first 100 MW block of load (18.7 MW) had been restored. ERCOT instructed STEC to restore their share of the second 100 MW block of firm load.
18:21	BPUB reported their share of the second 100 MW block of load (13 MW) had been restored.
18:23	AEP reported their share of the 200 MW block of load (134 MW) had been restored.
18:29	STEC reported their share of the second 100 MW block of load (43.1 MW) had been restored.
18:52	ERCOT released the LDL overrides on the units. QSE C was notified.
19:12	ERCOT made a hotline call to notify Transmission Operators the Transmission Emergency would be ended effective 19:15. Notice Builder was updated.
19:15	ERCOT ended the Transmission Emergency in the Rio Grande Valley.
19:18	Emergency Energy from CFE ended.
19:58	ERCOT deactivated the Rio Grande Valley GTC.

5. Notable Facts

- Duke Combined-Cycle Plant on Maintenance Level 2 outage started at 23:57 on October 7.
- North Edinburgh Combined-Cycle Plant tripped at 15:50, resulting in the loss of 651 MW of generation. G3 (steamer) tripped off first with G1 and G2 one minute after. Frequency dropped to 59.86 Hz and recovered in less than 7 minutes. Voltage levels decreased but stayed within normal limits (+/- 5%).
- At 15:56 ERCOT activated the Rio Grande Valley GTC
- At 15:57, ERCOT began constraining on the Rio Hondo – Burns Magic Valley 138 kV (S104A) line, as it was showing post-contingency loading at 163% of its 174 MVA Emergency (2-Hour) Rating.
- At 16:00, ERCOT stopped constraining on the constraint of loss of La Palma – Rio Hondo 138 kV line overloading Rio Hondo – East Rio Hondo (RIOHND_ERIOHND) 138 kV line.
- At 16:19, the Rio Hondo – Burns Magic Valley 138 kV (S104A) line became overloaded.

- At 16:47, ERCOT directed the shedding of 200 MW of load in the Rio Grande Valley at 16:54 due to the base-case thermal overload (over the 121 MVA normal (continuous) rating but under the 174 MVA emergency (2hr/15min) rating) on the Rio Hondo – Burns Magic Valley 138 kV line and post contingency overload of the same line. This shedding of load also improved conditions on the Rio Grande Valley GTC as well as several post-contingency overloads on or near the Rio Hondo – East Rio Hondo 138 kV line.
- AEP shed 685 MW of load vs the 134 MW requested due to a selection error in their load-shed program. Although 370 MW were quickly restored, 180 MW of the over-shed amount was unable to be restored until ERCOT released all load to be restored.
- At 17:21, NEDIN G1 was back on-line.
- At 17:58, ERCOT issued instructions to restore firm load. At 18:29, all load was restored.

6. Detailed Discussion

6.1 Dynamic Performance (Frequency and stability)

ERCOT has a standard practice to review every significant frequency event caused by sudden loss of Generator or load. ERCOT performed post event analysis for the low frequency event caused by loss of NEDIN train as well as high frequency caused by firm load-shed. The section below provides overview of each of these events.

After NEDIN loss Event

After the loss of the entire NEDIN Combined Cycle train (651 MW) at 15:50, frequency dropped to 59.864 Hz. Immediately after, 360 MW of Regulation-Up (REGUP) and 599 MWs of Responsive Reserve Service (RRS) were deployed to recover frequency, as seen in the Figure 3 below. During this event 625 MW/0.1 Hz of generation response was observed within 16 seconds after the second trip, which is much better than minimum response of 420 MW/0.1 Hz. Phasor Measurement Unit (PMU) analysis showed strongly damped responses. There were two oscillatory modes identified; 0.647 Hz damped at 16% after the loss of the steamer and 0.673 Hz damped at 12% following the loss of the two CTs (see Figure 2). A damping higher than 3% is considered to be acceptable. The PMU data can be observed in Figure 1 and Figure 2 below. Frequency was fully recovered to 60 Hz within ~6 minutes.

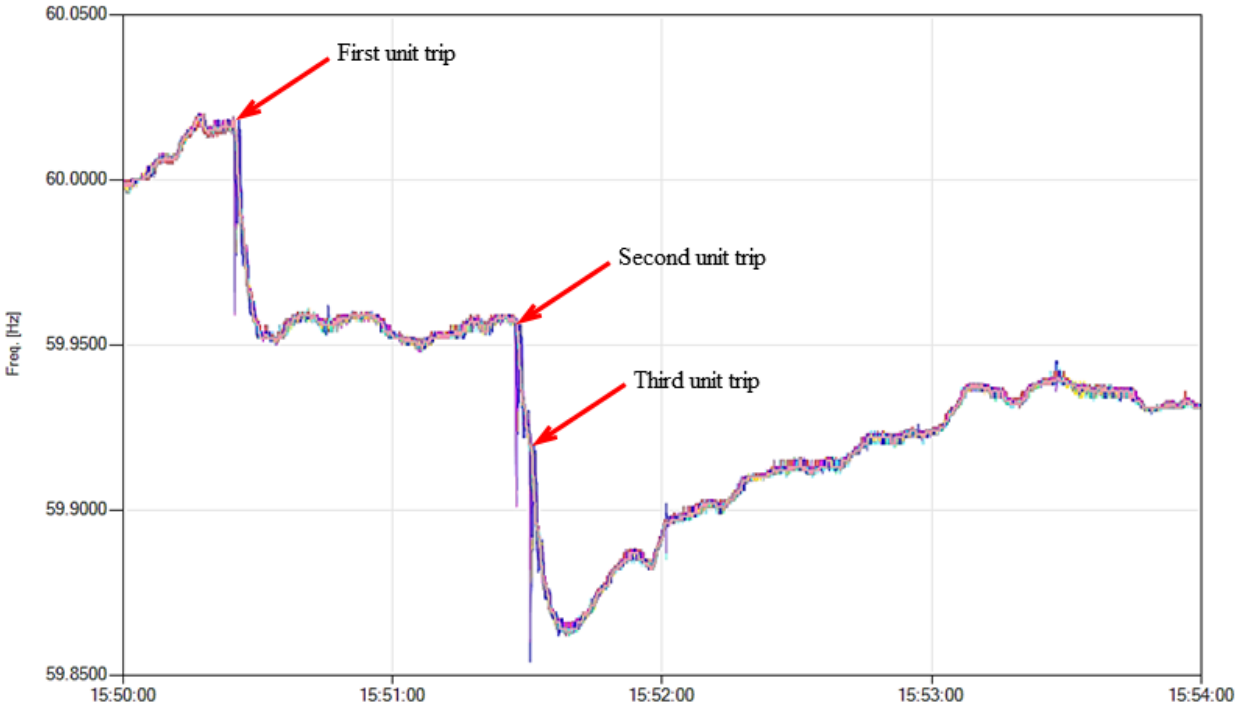

Figure 1 Frequency plots with high resolution PMU data

Figure 2 Voltage Phase Angle at Oleander (relative to Killeen Switch)

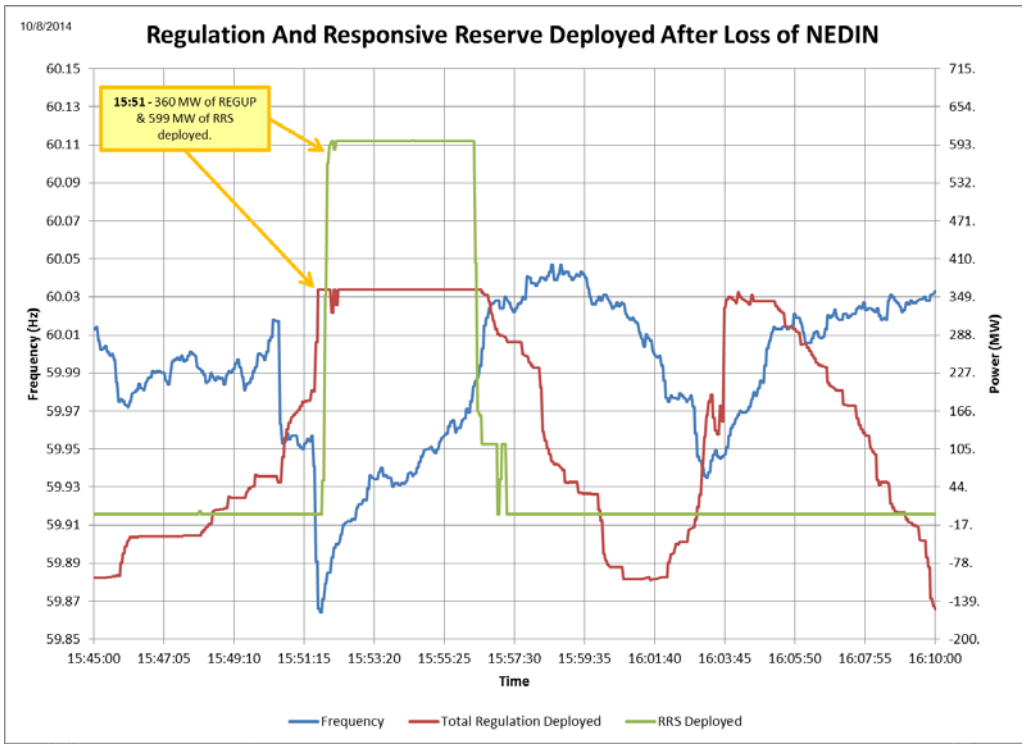

Figure 3 Regulation and RRS deployed after loss of NEDIN

After Valley Load-shed Event

After ERCOT directed 200 MW of load shed in the Valley beginning 16:47, it was observed that more than 736 MW of load was actually shed by the Transmission Operators in the Valley. This led to a high-frequency response as high as 60.123 Hz after which 390 MW of Regulation-Down (REGDN) were deployed to restore frequency. This event is illustrated in Figure 4 below. In terms of total generation response in the minutes following the load-shed event: 138 MW of generation response (reduction in output) was observed within 20 seconds of the event; 437 MW within 50 seconds of the event; and restoration of frequency to 60 Hz within 4 minutes of the event. During this event, wind generation provided just over 160 MW of governor type response (see Figure 5). Further analysis of high frequency event using PMU data showed no oscillatory modes.

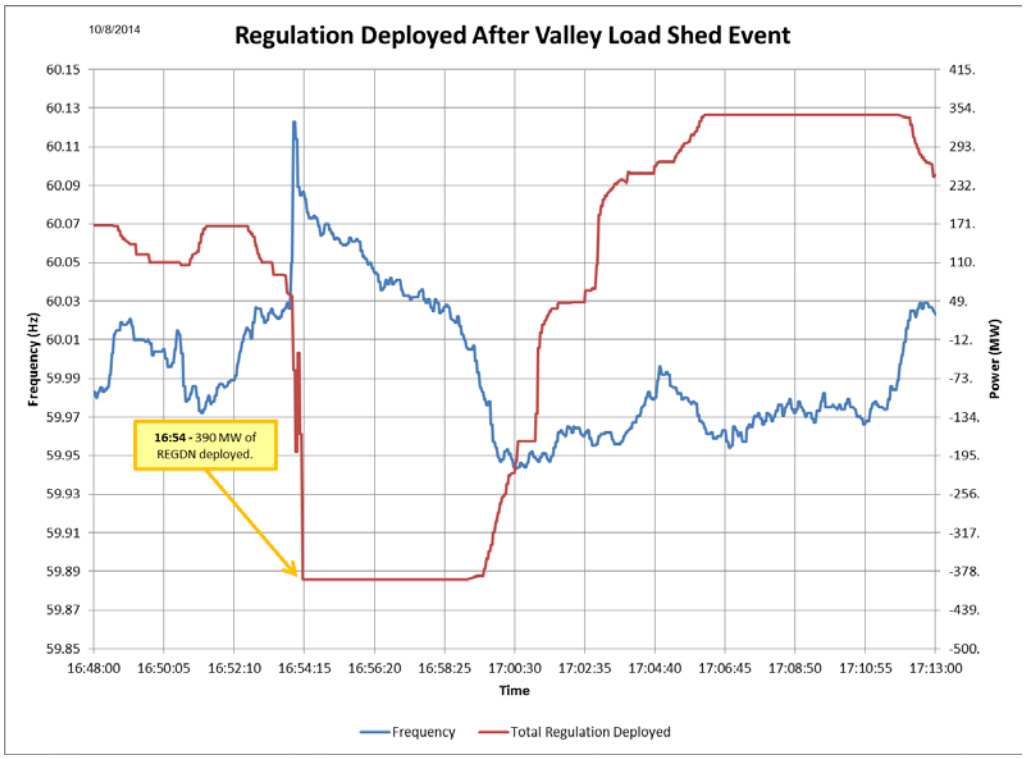

Figure 4 Regulation Deployment after the Valley Load Shed

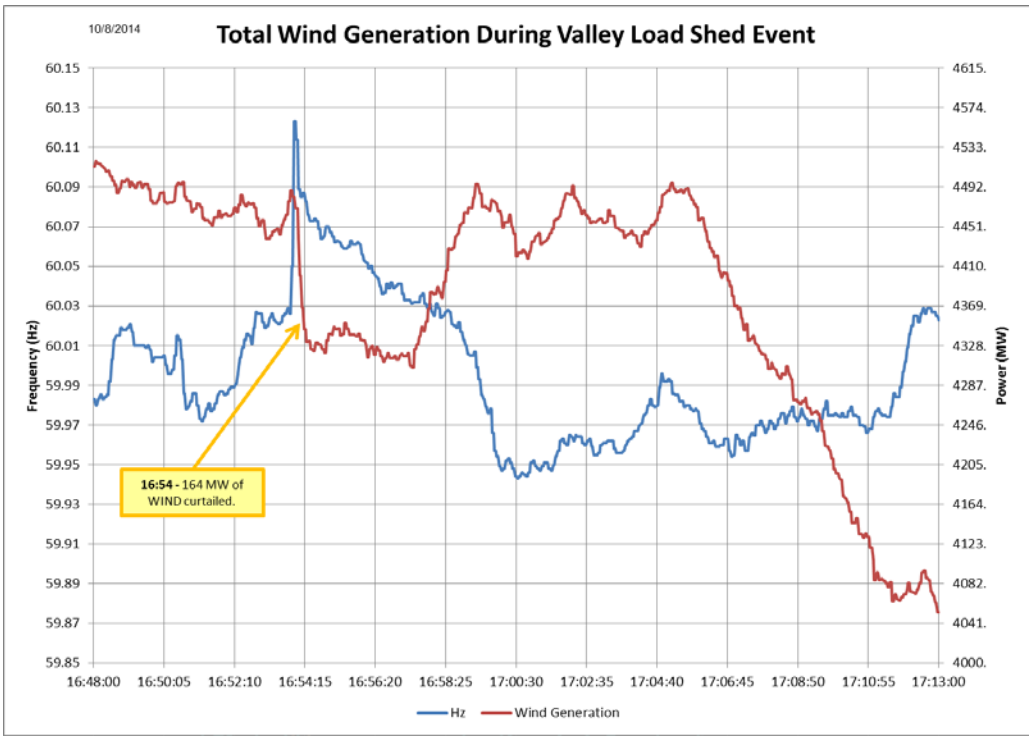

Figure 5 Wind Generation Responding to high frequency caused by Valley Load shed

6.2 Load and Wind Forecast performance

The Day-Ahead 14:00 load forecast snapshot on October 7 predicted Southern weather zone load levels very close to what was experienced in real-time. The forecast was within 70 MW on average for HE 16:00 compared to real-time, this equates to 1.5% MAPE, which is well below an acceptable MAPE of 4%. The October 8, 12:00 and 14:00 load forecast snapshot also provided in Figure 6 illustrates a very accurate load forecast as the day progressed. The load forecast error increases for HE 18:00 and HE 19:00 and those errors were primarily driven by the manual load shed during this event.

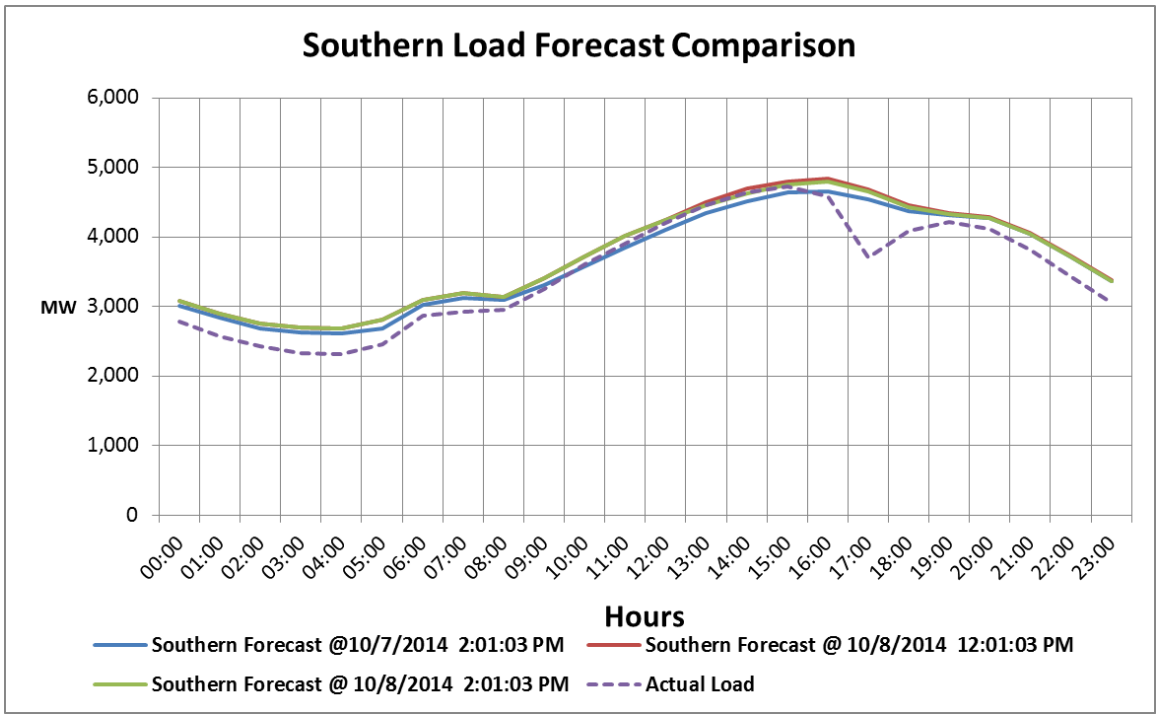

Figure 6 Southern Load Forecast and Actual Load

The Valley load in Figure 7 below is calculated as 43% of Southern Weather Zone. This is consistent with Valley load assumptions in other studies.

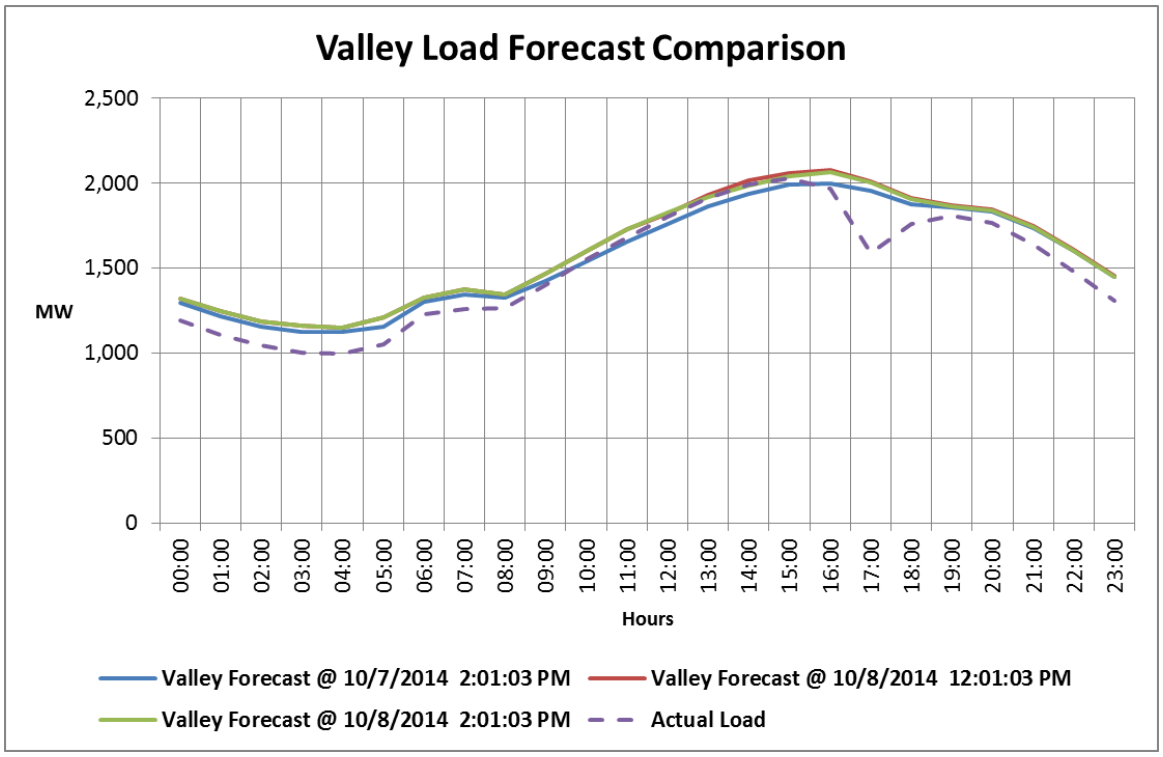

Figure 7 Valley Load Forecast and Actual Load

The Day-Ahead 14:00 Wind Forecast snapshot on October 7 predicted Valley Wind (Redfish and Los Vientos) at levels very close to the real-time output (see Figure 8). The wind forecast error increases for HE 18:00 and HE 19:00 and those errors were primarily driven by curtailments. For HE 1600, the Day-Ahead Wind Forecast error for Valley wind was 6.97% or -42 MW error, which is consistent with normal Wind Forecast accuracy.

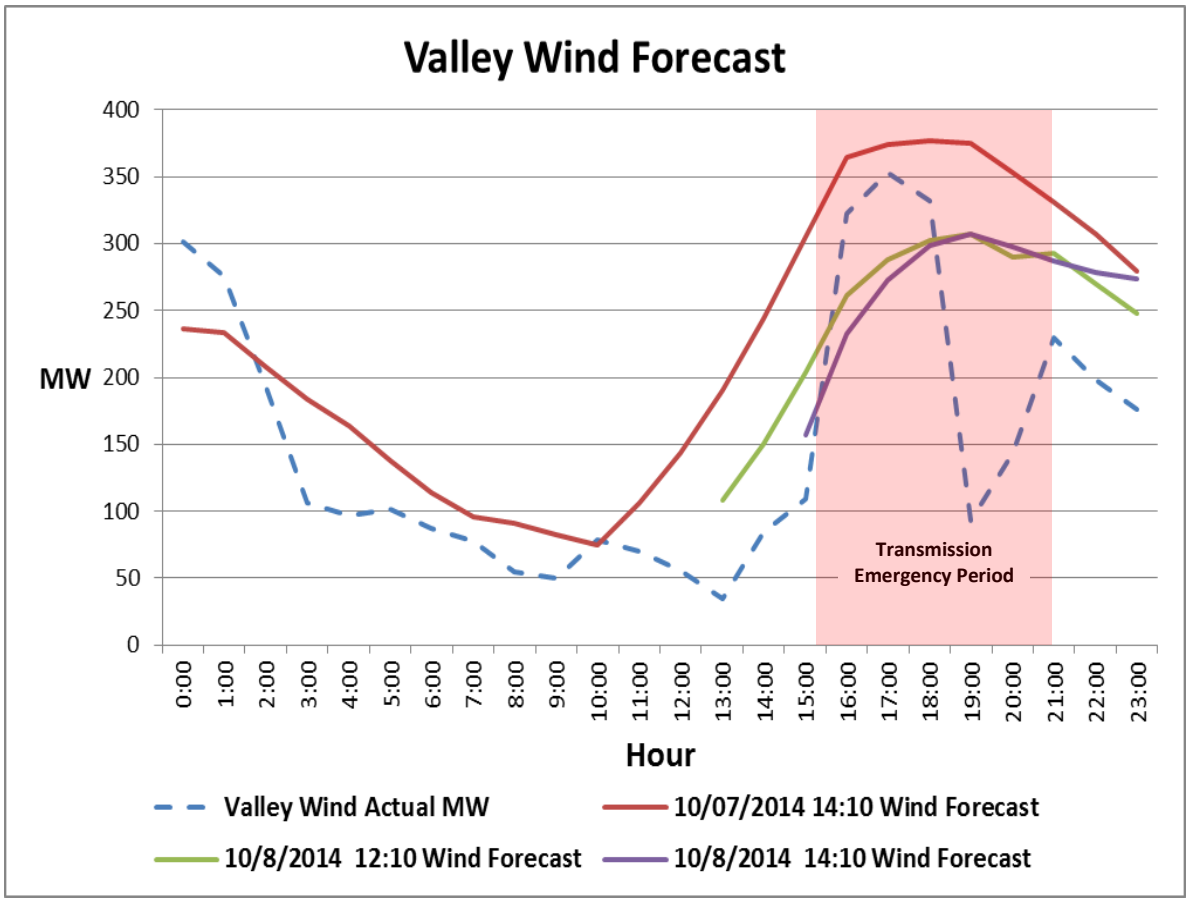

Figure 8 Valley Wind Forecast and Actual

6.3 Outage Coordination

BEFORE

Prior to the trip of the North Edinburg Combined Cycle train, there were several outages ongoing in the Valley area. The substations in the Valley region with the ongoing outages are identified in Figure 9 below. Outage Coordination (STNET) studies showed that for the outages on La Palma – Rio Hondo 345 kV line and on Laureles - Port Isabel 138 kV line, if full generation at Silas Ray Plant was unavailable, an Outage Coordination Transmission Outage Action Plan (OCTOAP) was necessary. This OCTOAP was created and made available to allow for post-contingency actions for any real-time overloads.

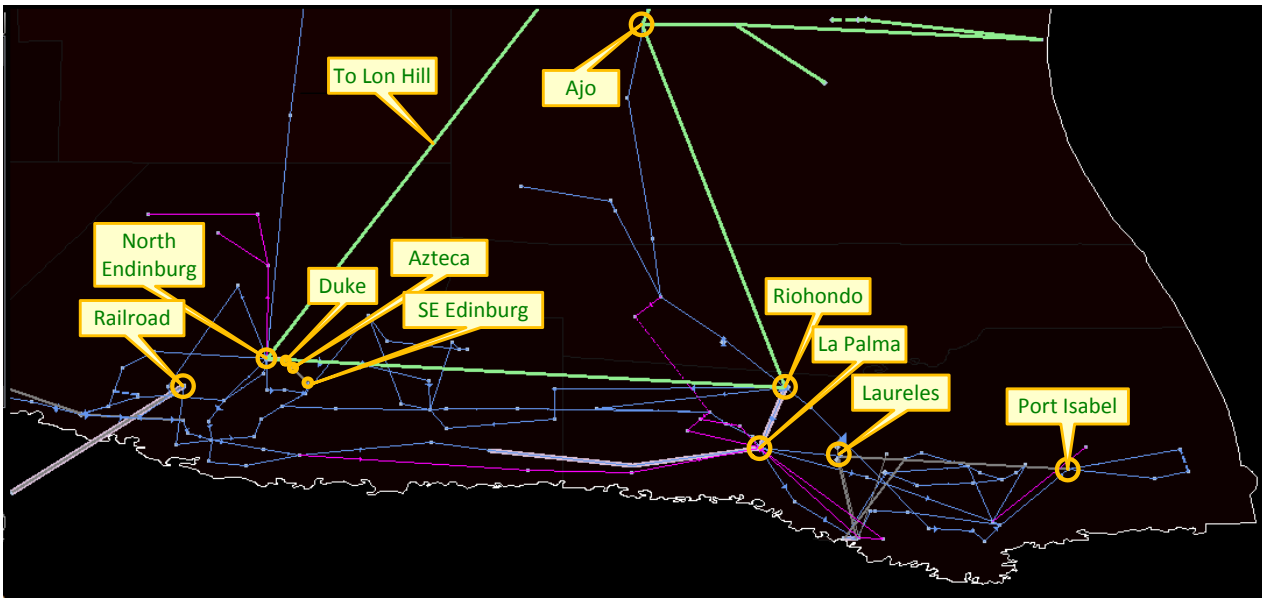

Figure 9 Substations in the Valley region with ongoing outages

Table 2 below provides an overview of the various substations in the Valley region with ongoing transmission outages for October 8.

The notable 345 kV transmission ongoing outages in the Valley region included:

- 345 kV bus (labeled 342 in the ERCOT model) at North Edinburg
  - This planned outage began on September 2, 2014.
- La Palma to Riohondo (LA_PAL_RIOHON01) 345 kV line
  - This planned outage began on September 24, 2014, to string in new conductor, reroute line, upgrade relay panel, and upgrade line terminal.

Table 2 Transmission outages

Equipment Station Name	Equipment Station Name	Outage Type	Actual Start Date	Planned End Date	Actual End Date	Nature Of Work	Notes
AZTECA	SE_EDINB	Planned	10/6 10:15	10/10 16:00	10/8 18:07	Replace Equipment	Replace Poles with Steel and install Davit arms with new HP Insulators.
LA_PALMA	RIOHONDO	Unavoidable Extension	9/24 6:31	10/19 22:00		Other	String in new conductor, reroute line, upgrade relay panel, and upgrade line terminal
LAURELES	P_ISABEL	Planned	10/6 8:18	10/10 16:00	10/08 19:40	Line Maintenance	2014 Line Rehab/Reinsulate Project
RAILROAD		Planned	10/3 17:03	10/17 17:00	10/8 16:45	Other	#2 Converter at HVDC Tie unavailable

Resource outages are indicated in Table 3 below.

Table 3 Resource outages

Equipment Station Name	Outage Type	Nature Of Work
DUKE	Maintenance Level 2 (St Dt 10/7/2014)	Boroscope (18 kV)
DUKE	Maintenance Level 2 (St Dt 10/7/2014)	Steam Turbine Limited/Unavailable Due to CT/GT Work
RAYMND2(LR)	Maintenance Level 1 (St Dt 10/23/2010)	Other
RAYMND2(LR)	Maintenance Level 1 (St Dt 12/5/2010)	Unknown
SILASRAY 5	Forced (St Dt 7/1/2014)	Mothballed

AFTER

After the trip of the NEDIN Combined Cycle Train, and issuance of a transmission emergency in the Valley, the Railroad DC Tie outage was marked as ended at October 8, 2014, 16:45 PM and the DC Tie was put back into service for transporting emergency power from CFE. ERCOT started seeing flow on this DC Tie at 17:19 PM; the DC Tie import increased to 50 MW at 17:23 PM. Also on October 8, 2014, AEP ended outages on the Azteca to SE Edinburg 138 kV line and Laureles to Port Isabel 138 kV line at 18:07 PM and 19:40 PM respectively. At 20:41, QSE E changed the Resource Status on DUKE Combined Cycle from OUT to STARTUP and at 23:07 DUKE train was released to SCED for dispatch.

6.4 Transmission Security Performance

Real-Time Contingency Analysis

After the NEDIN trip event, the next RTCA run at 15:54 started indicating severe post-contingency overloading for the double-circuit loss of the Lon Hill – Orange Grove 138 kV / North Edinburgh 345 kV (DLONOR58) on the Rio Hondo – Burns MVEC 138 kV line (S104A). At 15:57 ERCOT activated the constraint DLONOR58 to prevent post-contingency overloading on the Rio Hondo - Burns MVEC 138 kV line (S104A). This constraint was then released at 16:07 as activating it backed down Valley wind units, in turn working against any efforts to produce additional voltage stability margin/reactive support. At 16:19 ERCOT observed a real-time base-case overload on the Rio Hondo – Burns Magic Valley 138 kV line (S104A). Following the load-shed instruction at 16:51 the real time loading on this line reduced to below this line's normal rating of 121 MVA. Figure 10 below provides an overview of the real time flow on this line along with post-contingency overloading during the event.

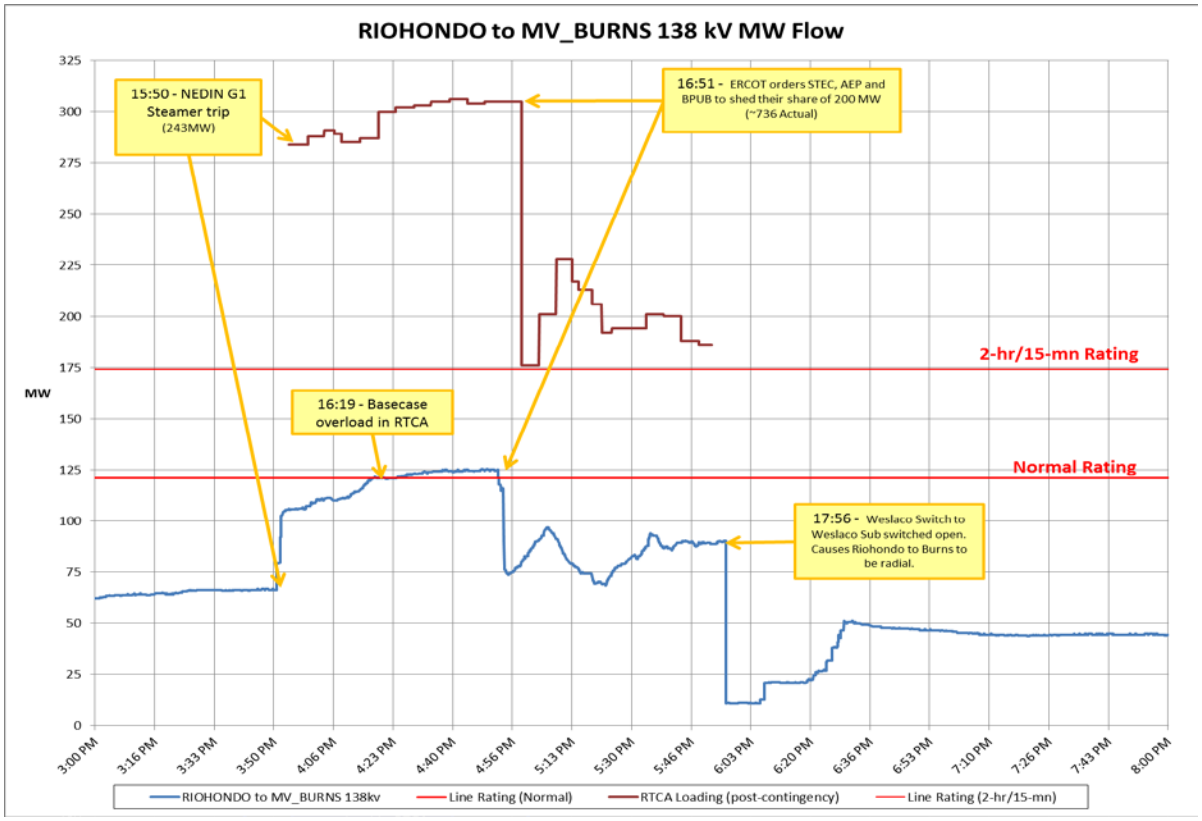

Figure 10 Flow and Limits on Rio Hondo – Burns MVEC 138 kV line

Real-Time Study Analysis: Cascading Studies for Lon Hill – North Edinburgh 345 kV / Orange Grove 138 kV Double-Circuit Contingency

After the initial disturbance where the North Edinburgh units tripped, ERCOT EMS triggered RTCA and a new N-1 overload was identified for the loss of the Lon Hill – North Edinburgh 345 kV / Lon Hill – Orange Grove 138 kV Double-Circuit contingency overloading the Rio Hondo – Burns Magic Valley 138 kV line. Post-contingency loading on this line, as indicated in the real-time contingency analysis, ranged from 101% to 176% of its 174 MVA Emergency Rating. Cascading studies were performed by both the shift engineer and the operations support engineer. The operations support engineer study case used a snapshot from real-time where the post-contingency loading was 122%. After manually initiating the contingency in the study case and opening the Rio Hondo – Burns Magic Valley 138 kV line, no additional overloads or voltage issues remained, nor was any additional load lost. This study provided a basis for identifying a manageable post-contingency loading level of 122% that allowed time for post-contingency actions.

The shift engineer study case used a snapshot from real time where the post-contingency loading was 161.4% of its Emergency Rating. The shift engineer study indicated cascading outages within the Rio Grande Valley up to 1850 MW of load (this does not take into account automatic UVLS) were possible with an ERCOT system load level of 46829 MW. After manually initiating the contingency in the study case and opening those elements loaded above 125% of their Emergency Rating (All line segments on

the Rio Hondo to Weslaco 138 kV line, including Rio Hondo – Burns Magic Valley), several thermal overloads remained. After opening those elements loaded at more than 125% of their Emergency Ratings (La Palma – Haine Drive 138 kV, La Palma – Rio Hondo 138 kV, La Palma – Rangerville Magic Valley 138 kV # 2), the study case did not solve. Further assessment indicated that, at this point, there would be a voltage collapse in the Rio Grande Valley amounting to the 1850 MW indicated earlier. Studies showed that shedding 200 MW of load pre-contingency at several stations in the area as indicated in Table 4 below would reduce the post-contingency loading to 121% and eliminate the base-case overload of Rio Hondo - Burns MVEC 138 kV line (S104A). By obtaining 50 MW of emergency energy across the Railroad DC Tie, studies indicated that the post-contingency loading could be further reduced to 114%. By the time this study could be concluded, ERCOT system operators had already directed the 200 MW of load shed, and as such no further assessments on this study were conducted.

Table 4 Loads Shed Details from Real-Time studies

Shift Engineer Study Case Load Shed Details	
Substation	Load-shed Amount
MV_BURNS	11
MV_HBRG4	11
SE_EDINB	42
PHARR	40
ELGATO	30
MV_DOEDN	40
N_ALAMO	15
MERETT	22

An important observation was made during the analysis of this event. There was a planned 345 kV bus outage at North Edinburgh. Due to the breakers connected to this bus being open to facilitate this outage, the loss of the Lon Hill – North Edinburgh 345 kV line would also open up the North Edinburgh – Rio Hondo 345 kV line. This made the effect of the contingency more severe in studies than what would normally be seen. This outage started on 09/02/2014 06:41:00 and ended on 10/24/2014 16:00:00.

Post Event Analysis: UVLS Assessment

The UVLS assessment was conducted using the VSAT tool and a real-time snapshot case taken after the NEDIN plant trips at 15:52:28 on October 8, 2014. There are three levels of voltage at which load may be shed under the UVLS program in the Valley – in per unit, 0.9, 0.85 and 0.75; these levels are available in DWG Stability Book.

Examining the post-contingency results from VSAT, the simulation, without modeling any UVLS showed several stations which were equipped with UVLS relays had voltages that were below the 0.9 per unit level. At these stations (see Table 6 below), the corresponding fractions of load available for automatic load shedding were tripped and the VSAT analysis performed again. Precise load and load-shedding levels are also shown on Table 6 below.

Table 6 UVLS Loads with post-contingency voltages below 0.9 per unit

EMS NAME	TSP/TO	LOAD MW	LOAD SHED MW
W_MCALLN	AEP	61	19.5
N_MCALLN	AEP	77	77
PHARR	AEP	41	41
POLK_AVE	AEP	63	29
NEDIN	AEP	20	20
HALL_ACR	AEP	56	39
MCOLL_RD	AEP	47	16
HIDALGO	AEP	15	7.5
MV_DOEDN	MVEC/STEC	40	40
ADERHOLD	MVEC/STEC	15	15
L_MILPAS	MVEC/STEC	24	24
PHARMVEC	MVEC/STEC	30	30
MV_HBRG4	MVEC/STEC	11	11
MV_WEDN4	MVEC/STEC	15	15
MV_PALM4	MVEC/STEC	9	9
TOTALS (MW)		524	393

In summary, results indicate that 393 MW of UVLS load would have been shed as a result of the most severe single contingency in the Rio Grande Valley region and would likely have prevented voltage collapse in the Rio Grande Valley. The results were as follows:

1. Pre-UVLS study was insecure in the base case and had a negative stability margin (~-200 MW). There were several locations in the Valley, with post-contingency voltages below 0.9 per unit at the base case load level.
2. Post-UVLS study was secure in the base case and had a positive stability margin of ~300 MW. There were no voltages below 0.9 per unit at the base case load level.
3. Post-UVLS branch overloading was also within 115% of the Emergency rating.

6.5 Load Shed and Restoration

At 16:47 ERCOT instructed AEP, STEC and BPUB to shed their share of 200 MW of firm load. The tables below show the amount of load shed ordered compared to the actual load shed by each ERCOT Transmission Operator.

Table 7 AEP's Share: 132 MW/200 MW

TIME	AEP Actual Load Shed	AEP Ordered
17:05	685.05	132.00

17:10	521.62	132.00
17:15	347.21	132.00
17:20	314.50	132.00
17:25	320.67	132.00

Table 8 BPUB's Share: 26 MW/200 MW

BPUB's Share : 26 MW/200 MW		
TIME	BPUB Actual Load Shed	BPUB Ordered
17:05	20.89	26.00
17:10	27.68	26.00
17:15	28.95	26.00
17:20	31.23	26.00
17:25	31.05	26.00

Table 9 STEC's Share: 40 MW/200 MW

TIME	STEC Actual Load Shed	STEC Ordered
17:05	29.81	40.00
17:10	44.20	40.00
17:15	46.11	40.00
17:20	42.96	40.00
17:25	46.30	40.00

Table 10 below identifies the total amount of affected customers by the load shed for each ERCOT Transmission Operator.

Table 10 Affected Customers by Transmission Operator

Transmission Operator	Affected customers
AEP	191,344
STEC	12,276
BPUB	12,738
Total	**216,358**

As indicated in the above totals, load shed response was 736 MW for a 200 MW load-shed instruction. ERCOT submitted RFIs to the ERCOT Transmission Operators requesting details on their load shed amounts. AEP indicated in its RFI response that the reason for the large amount of load shed, in

addition to the requested amount, was an error in selection of load-shed programs within a new automated computer feeder load-shed program, which resulted in the program attempting to try to interrupt all feeders for the Valley. As a result, AEP tripped 685 MW of firm load. AEP was able to restore 370 MW of load within 10 minutes. The program prohibited recognition of 19 feeders (180 MW) for additional load to be restored until ERCOT instructed all load to be restored.

At 18:00, ERCOT started issuing instructions to restore load and by 18:29 the entire Valley load was fully restored. Figure 11 depicts the Valley Load at key times during the event including load restoration.

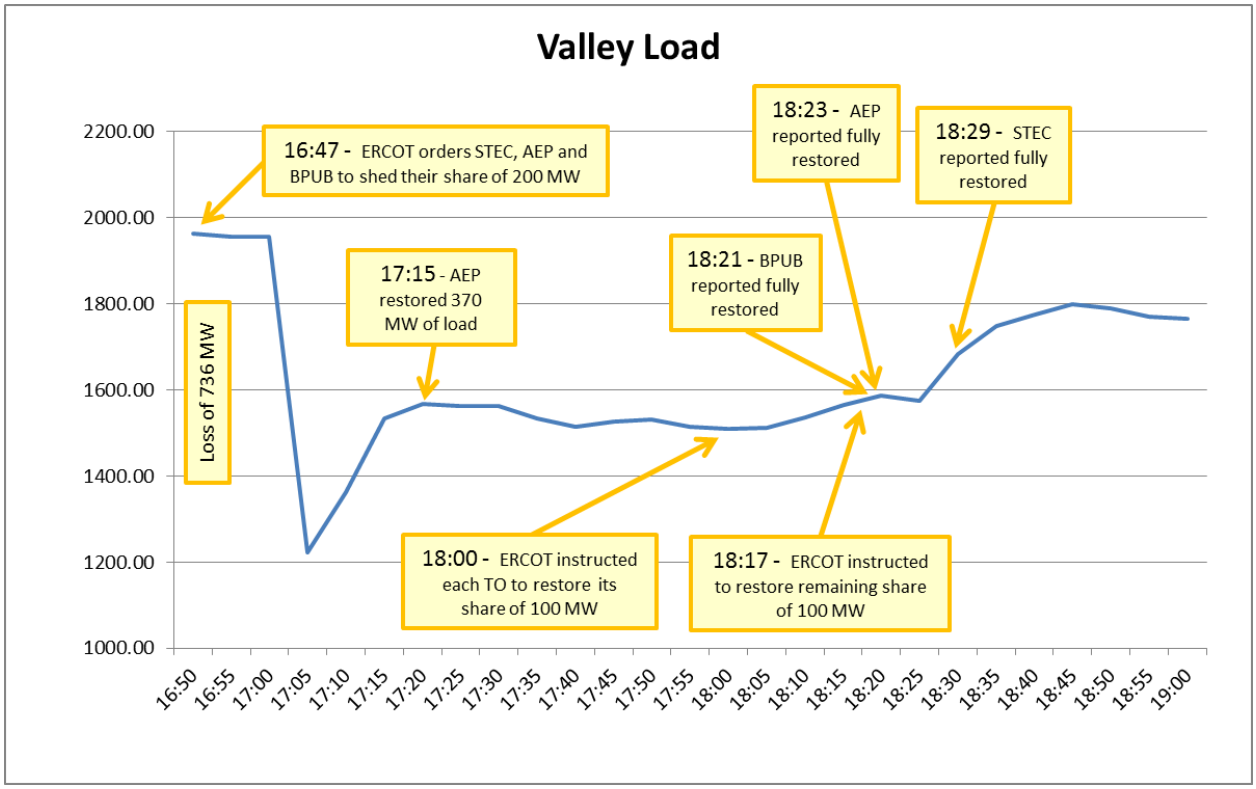

Figure 11 Valley Load during the event

6.6 Reliability Unit Commitment

There were no resources committed by Reliability Unit Commitment (RUC) processes in the Valley. All available resources were on-line at the time of the event.

7. Conclusions

On October 8, 2014, the ERCOT System Operators, in coordination with ERCOT Transmission Operators, appropriately repositioned the Valley region to prepare for the next contingency while they simultaneously worked to minimize the amount of load shed required to address actual and post-contingency overloaded transmission facilities. The system conditions following the loss of the NEDIN combined cycle train validate that studies conducted in advance would not have identified any issues.

Actual results indicated, at the time, that the Valley Import limit was not exceeded and no lines were overloaded immediately after the loss of NEDIN. Only post-contingency overloads appeared in RTCA after the unit trips. All of the actions taken by the System Operators were timely, appropriate and effective in reducing flows on the Valley interface and increasing the voltage stability limit by increasing reactive support in the Valley region.

Load and wind forecast performance did not have any negative effect on this event and were within normal ranges of performance. Resources (including Wind resources) helped support frequency and reactive support in the region.

Load-shed performance for STEC and BPUB was as expected, while AEP, due to a selection error in its load-shed program, over-shed by 550 MW immediately and averaged about 180 MW over the instructed amount for the duration of the load-shed instruction.

Frequency and Dynamic performance was as expected and stable.

Transmission Security analysis validated that the calculated amount of load shed was appropriate to address the base-case overload and reduce the post contingency overloads to a manageable level. ERCOT System Operator actions to raise voltage levels in the Valley and decisions to maximize wind generation and reactive support in the Valley area were appropriate and beneficial as it provided much additional voltage stability for a small increase in thermal flows on the overloaded lines. Cascading analysis indicated that after the NEDIN trip, if the next most severe single contingency occurred, cascading could occur that would have been limited by the Under Voltage Load Shedding (UVLS) scheme employed in the Valley area to prevent voltage collapse of the entire Valley region. This UVLS scheme remained available, if needed, due to the TOs appropriate actions of shedding load on other circuits to preserve the UVLS load.