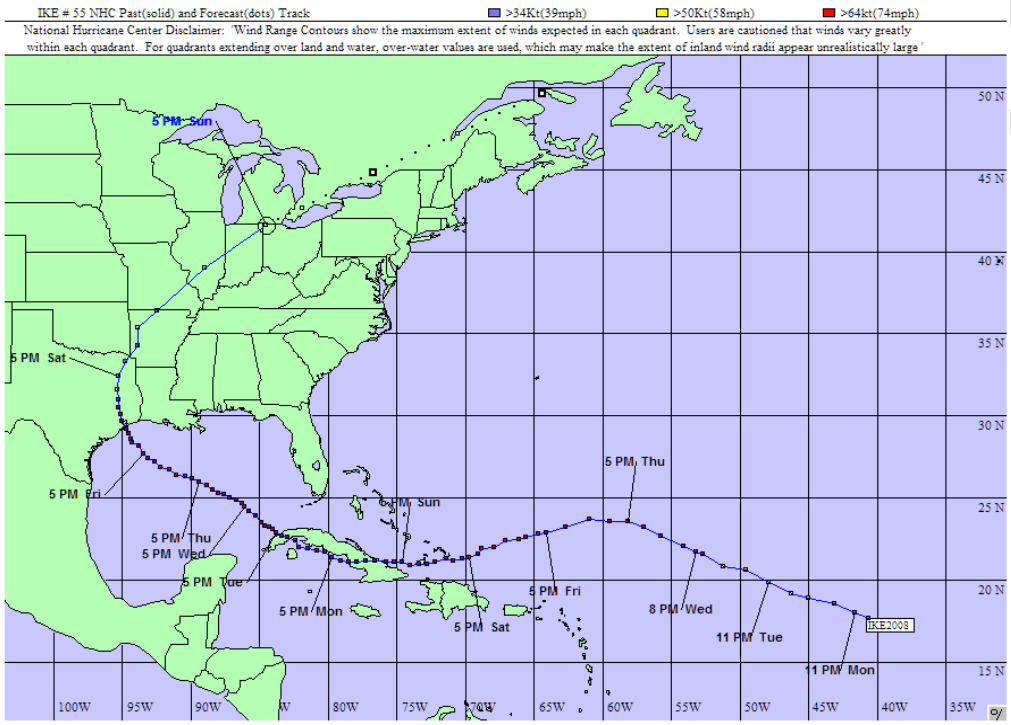
REPORT FOR
RELIABILITY AND OPERATIONS SUBCOMMITTEE

ERCOT HURRICANE IKE SUMMARY

SEPTEMBER 12 2008

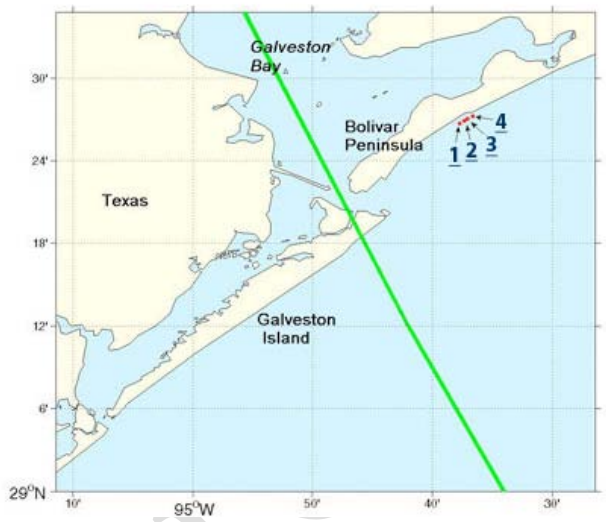


On Behalf of the ERCOT Reliability and Operations Subcommittee

PREPARED BY

Stan Morris
MANAGER, OPERATIONS-TNMP
Paul Rocha
DIRECTOR, TRANSMISSION PLANNING-CENTERPOINT ENERGY
Ken Donohoo
DIRECTOR, SYSTEM PLANNING DISTRIBUTION AND TRANSMISSION-ONCOR
Bill Blevins
MANAGER, OPERATIONS SUPPORT-ERCOT
Ken McIntyre
SUPERVISOR, ADVANCED NETWORK APPLICATIONS-ERCOT

FOREWARD



Hurricane Ike was very similar to Hurricane Alicia, of 1983. Alicia struck Galveston and Houston, Texas directly, causing $2.6 billion in damage and killing 21 people; this made it the worst Texas Hurricane since Hurricane Carla in 1961. Hurricane Alicia was a category 3 Hurricane with 115 mph winds at landfall. Hurricane Ike was a category 2 storm with winds of 110 mph as it made landfall. Hurricane Alicia's path after landfall was similar to that of Ike. Alicia's eye traveled up the I-45 evacuation route from Galveston to Houston. Ike traveled up Galveston Bay slightly north of Alicia's path inland toward Houston. Important differences between Ike and Alicia were (1) Ike had a much larger wind field and (2) Ike had a much greater storm surge than Alicia. Because of these factors, Ike caused more damage and was more disruptive than Alicia and effectively replaced Alicia as the worst Texas Hurricane since Hurricane Carla in 1961.

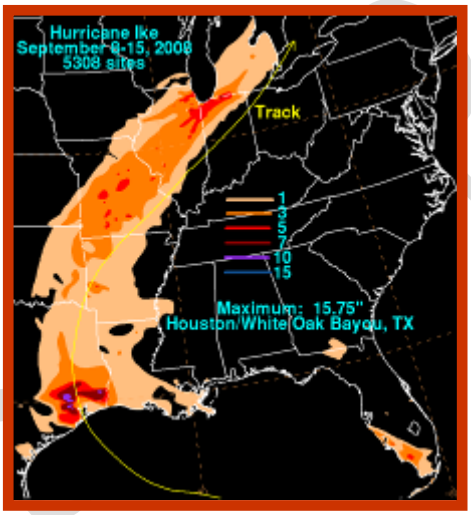
As one would expect for a storm of the magnitude of Hurricane Ike, the ERCOT system experienced significant transmission line and generator outages, and loss of load. Under these extreme conditions, the ERCOT network performed well. Voltages and transmission line loadings remained within acceptable limits and the system remained stable. Not withstanding loss of multiple SCADA readings during the storm, system observability remained within acceptable parameters and the ERCOT state estimator was able to solve.

Since the ERCOT network performed well under these adverse conditions, no protocol or operating guide revisions are proposed in this report. The remainder of this report contains details concerning ERCOT operations and network applications during the storm.

STORM SUMMARY

At 2:10 am CDT Hurricane Ike made landfall over Galveston Texas.

The Hurricane eye passed over Houston around 5:20 am September 13 2008. Ike maintained winds of Hurricane force till it passed through the Lufkin area.



Satellite images show that Ike covered most of the Gulf of Mexico on Friday before making landfall. The winds from this storm were felt prior to landfall. Ike was a storm of significant size which delivered a path of damage of 200 miles wide by 1600 miles long. Winds during the Hurricane affected the gulf coast from Freeport to Lake Charles La. Winds were still in the Tropical storm force range up into the northern United States.

TRANSMISSION COMPANY SUMMARY

TEXAS-NEW MEXICO POWER COMPANY

Texas-New Mexico Power Company (TNMP) serves approximately 113,000 customers in Galveston and Brazoria counties. TNMP has 92 distribution circuits in the two counties. Due to the Hurricane, power was lost to all but one circuit and practically all customers were without power.

TNMP's System Operations Center is located in League City and is in a potential mandatory evacuation zone. TNMP also has a back-up operations center located in Lewisville. Due to the projected path of the storm TNMP implemented its Emergency Operations Plan and activated the back-up site. The back-up site took over primary control of the system on Thursday before the storm made landfall and the League City site became a satellite of the Lewisville site. Since no mandatory evacuation was ordered, a core group remained at the League City site, monitored the storm activity and managed the service restoration afterward. The Lewisville site managed operations for the rest of TNMP's service areas.

The first outage occurred at 6:41 PM on Friday, September 12 at the Old Ocean Substation in Brazoria County. The last outage occurred at 8:03 AM on Saturday, September 13. Damage assessment was started around 10:00 AM when the weather permitted. The transmission system received very little damage. A total of six 69 KV transmission poles were destroyed and the static was damaged on two 138 KV structures. Re-energizing the transmission system was started almost immediately and the majority of the transmission system was back in service on Monday.

TNMP serves five refineries in Texas City and one refinery in Sweeney. Service was restored to all refineries by Tuesday, September 16. The docks in Texas City did flood and required extensive repair to the distribution system but they were operational on Thursday.

Outages on the distribution system were mainly caused by trees. Extensive tree trimming had to be performed before repairs to the distribution could be done. All distribution outages were repaired in two weeks with service being restored to the remaining customers on September 27.

After the majority of the transmission system was back in service TNMP experienced high voltage due to the lack of load. Five transmission lines were removed from service to control voltage.

TNMP has a total of 155 employees in the Gulf Coast Region. More than 700 workers, including employees from other areas, contractors, and other utility companies were brought in to assist in service restoration. This number includes: linemen, tree trimming crews, engineers and other support personnel. A staging site was set up at Gulf Greyhound Park in LaMarque.

TEXAS-NEW MEXICO POWER LESSONS LEARNED

- Lessons learned from Hurricane Rita was that voltage on the transmission system would be high prior to the storm making landfall due to reductions in load as industries and commercial customers shut down and people evacuated the area.
- TNMP removed 80 MVAR of capacitors from service on the distribution system on Thursday and Friday morning before the storm hit. As a result no high voltage was experienced prior to the storm.

CENTERPOINT SUMMARY

CenterPoint Energy delivers electricity to over 2 million customers in a 5,000-square-mile area around Houston. The company's electric system suffered widespread damage as a result of 100-mile-per-hour winds and trees and wind-blown debris on power lines. Highlights of the first day included:

- Restoration of the Coastal Water Authority Lynchburg water pumping station, a major source of water for the City of Houston and other smaller communities in the area
- Service restoration for one water treatment facility and one wastewater treatment plant in the City of Houston
- Restoration of service to hospitals such as the Veteran's Administration Hospital in the Texas Medical Center; Memorial Herman Hospital, Memorial City; and the Heart Institute in Clear Lake City
- Inspections by company personnel of electric substations on Galveston island, with a goal of restoring service to the University of Texas Medical Branch as soon as possible
- Company damage assessment experts flew over the area conducting aerial surveys and documenting damage.

CenterPoint Energy crews were working around the clock and were ready to integrate the more than 7,000 skilled workers who are came to Houston beginning on starting Sunday September 13 2008.

Damage to the CenterPoint system from Hurricane Ike was varied. At the Island the storm surge was severe. Load was lost due to the flooding of customers. The storm's impact affected the entire CenterPoint Energy system, causing power outages to almost all CenterPoint Energy's customers, and extended well beyond CenterPoint Energy's service area into east Texas.

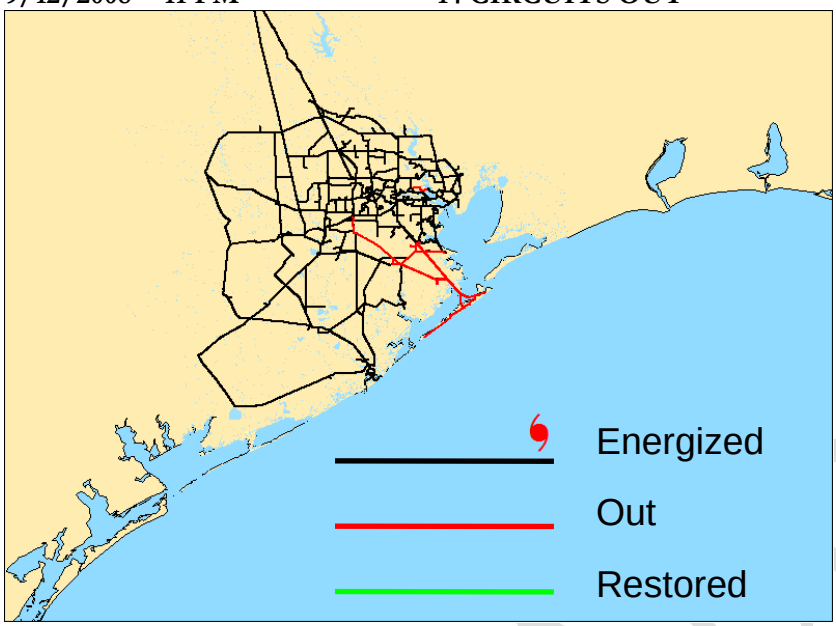
Getting crews in to access the damage was a challenge as large amounts of debris and flooding prevented access.

Highway 45 into Galveston was littered with boats and debris. Note the vehicle in the picture on the right is blocked due to high water.

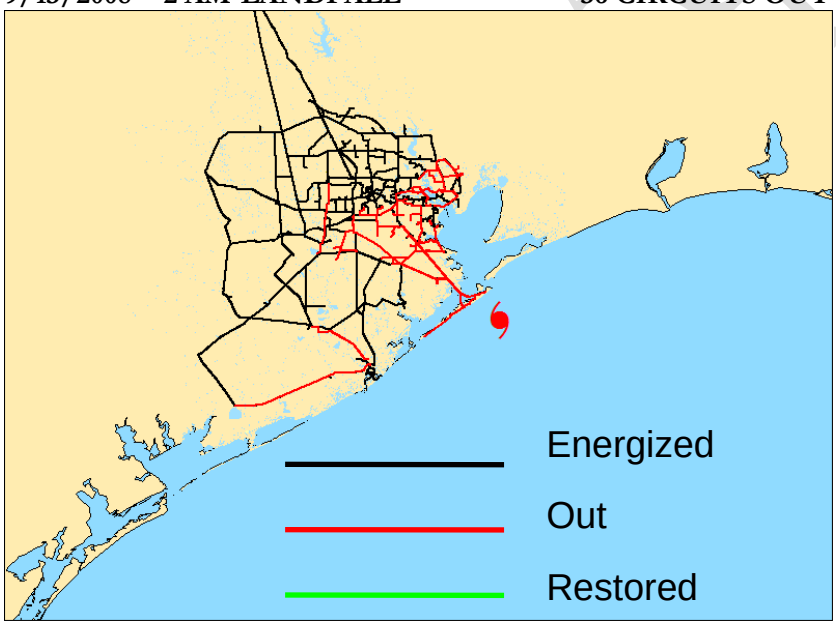
CenterPoint Energy damage assessment teams and government officials used helicopter crews to survey the damage. This is typical for damage assessments after major storms. The same method was used for Hurricane Dolly which made landfall near Brownsville earlier in the 2008 Hurricane season.

At the peak of the storm CenterPoint had about 100 Transmission Circuits affected. The following is a chronological summary of the outages and the restoration in the CenterPoint area.

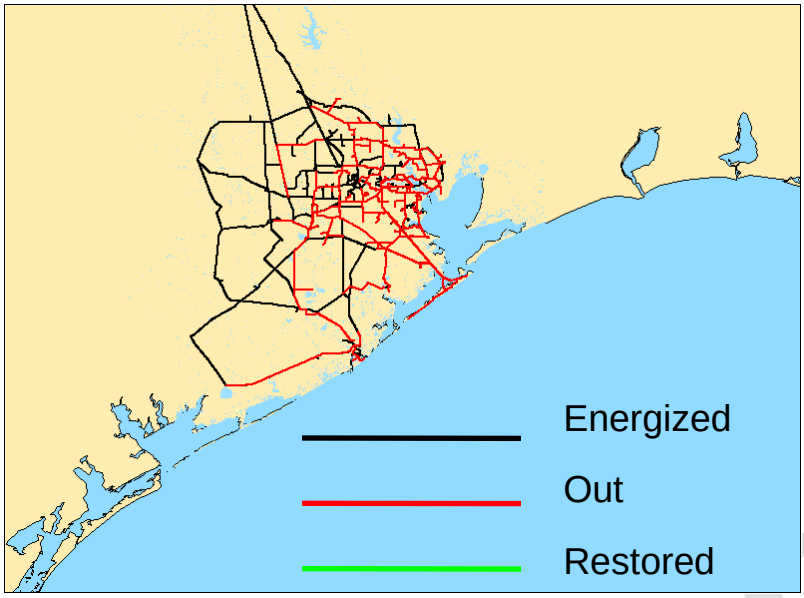
HURRICANE IKE
9/12/2008 11 PM **14 CIRCUITS OUT**



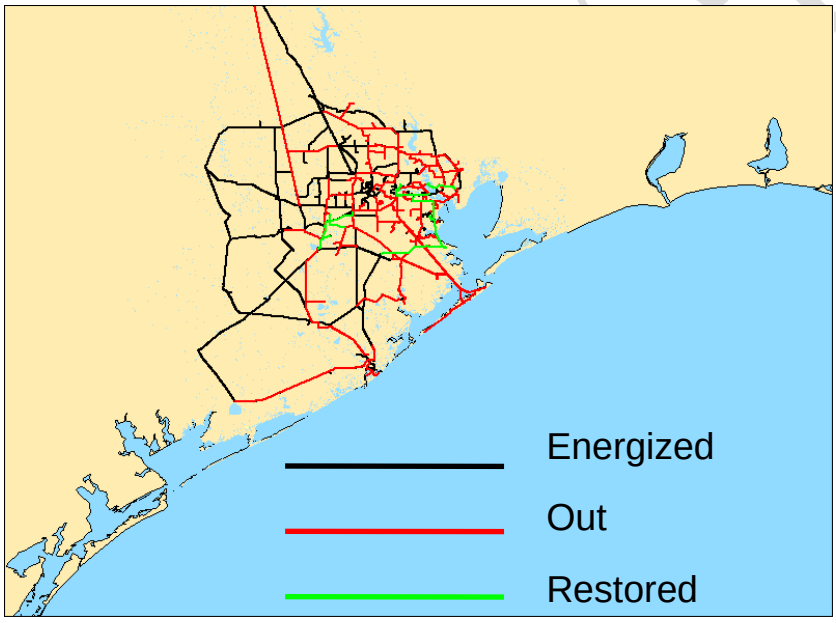
HURRICANE IKE
9/13/2008 2 AM-LANDFALL **36 CIRCUITS OUT**



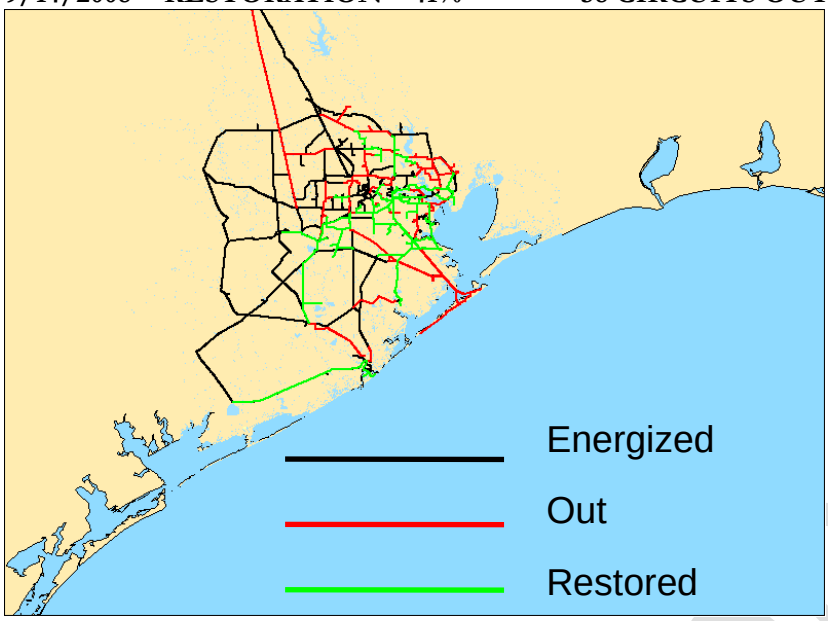
HURRICANE IKE
9/13/2008 3 PM 97 CIRCUITS OUT



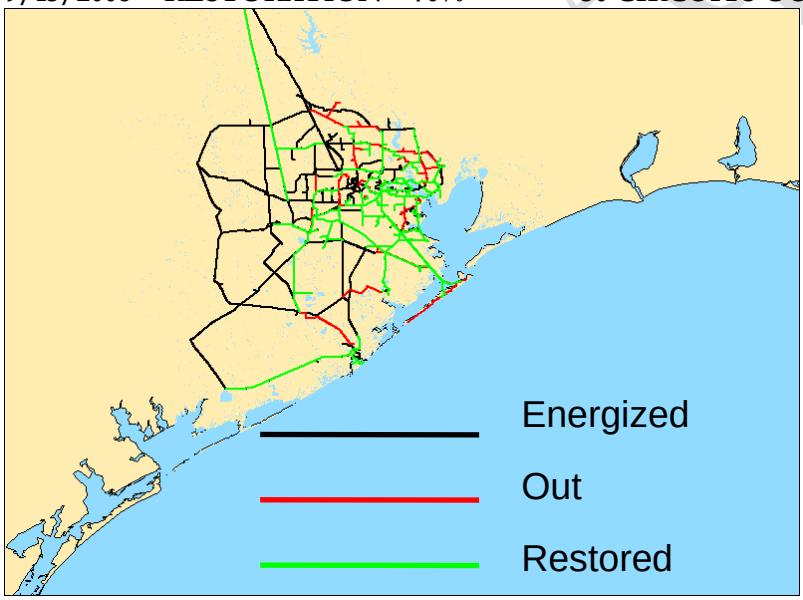
HURRICANE IKE
9/13/2008 EVENING 90 CIRCUITS OUT & 7 CIRCUITS RESTORED



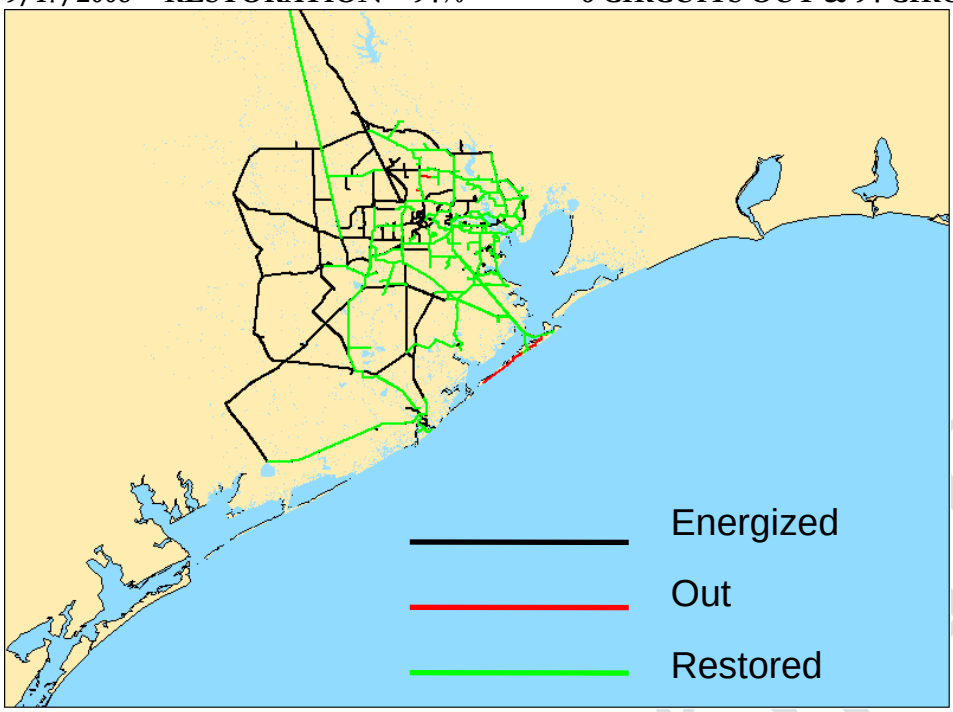
HURRICANE IKE
9/14/2008 RESTORATION – 41% 58 CIRCUITS OUT & 40 CIRCUITS RESTORED



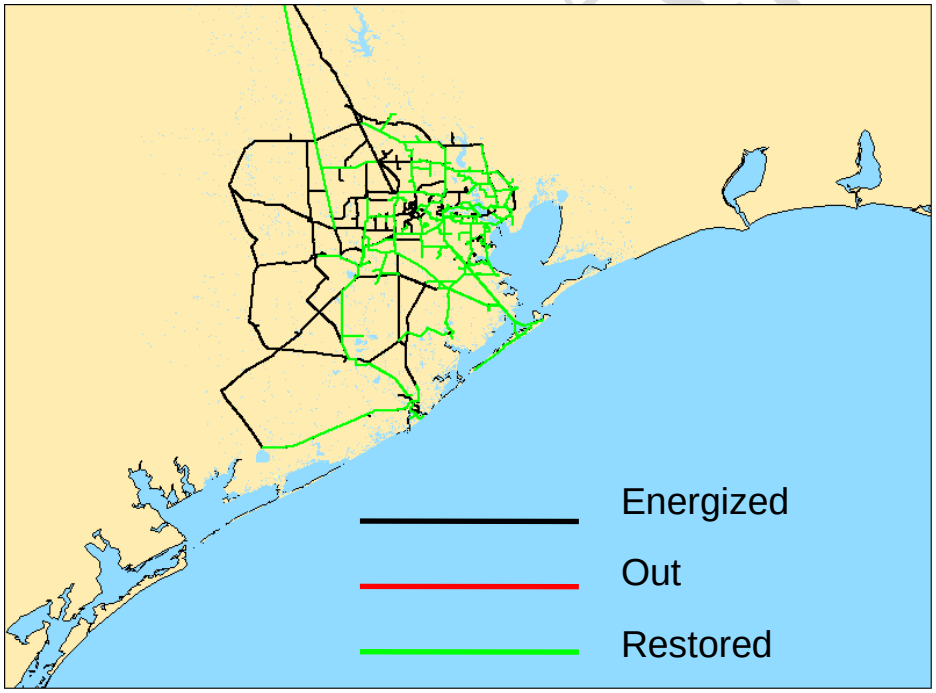
HURRICANE IKE
9/15/2008 RESTORATION – 70% 30 CIRCUITS OUT & 70 CIRCUITS RESTORED



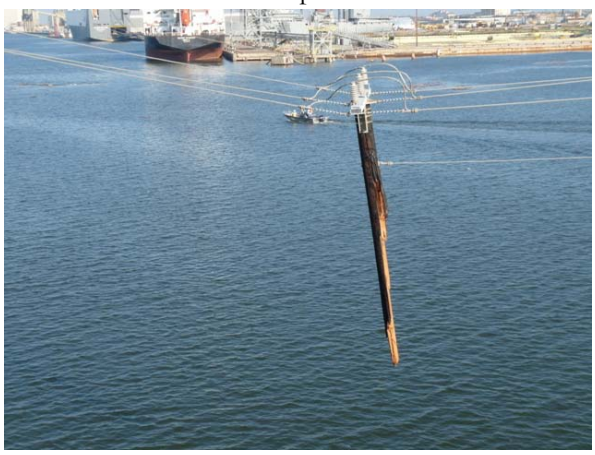
HURRICANE IKE
9/17/2008 RESTORATION – 94% 6 CIRCUITS OUT & 94 CIRCUITS RESTORED

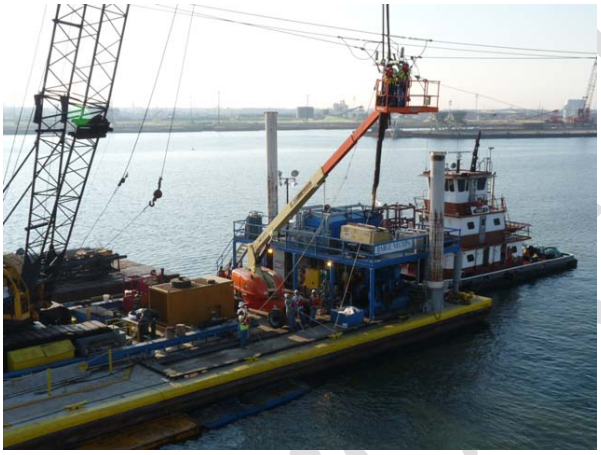


HURRICANE IKE
9/23/2008 RESTORATION – 100% 100 CIRCUITS RESTORED



Not all lines in the CenterPoint area could be reached with normal crew support. Barges were required and on standby for areas like the Houston ship channel.





Some lessons learned from previous storms were that building up the elevation in certain areas would help protect subs from flooding. The following pictures are provided as comparison between older and newer substation construction. The Moody and Galveston stations are older and West Bay and Seawall are newer.

MOODY SUBSTATION

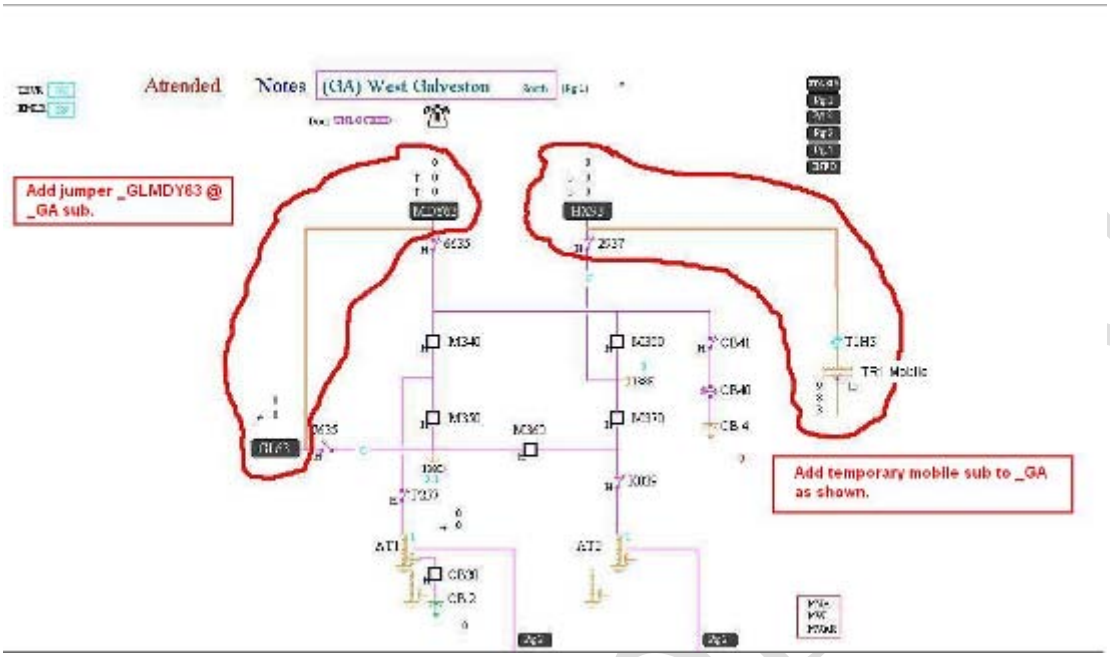
GALVESTON SUBSTATION

Older lower elevation substation designs were more susceptible to storm surge.

WEST BAY SUBSTATION **SEAWALL SUBSTATION**

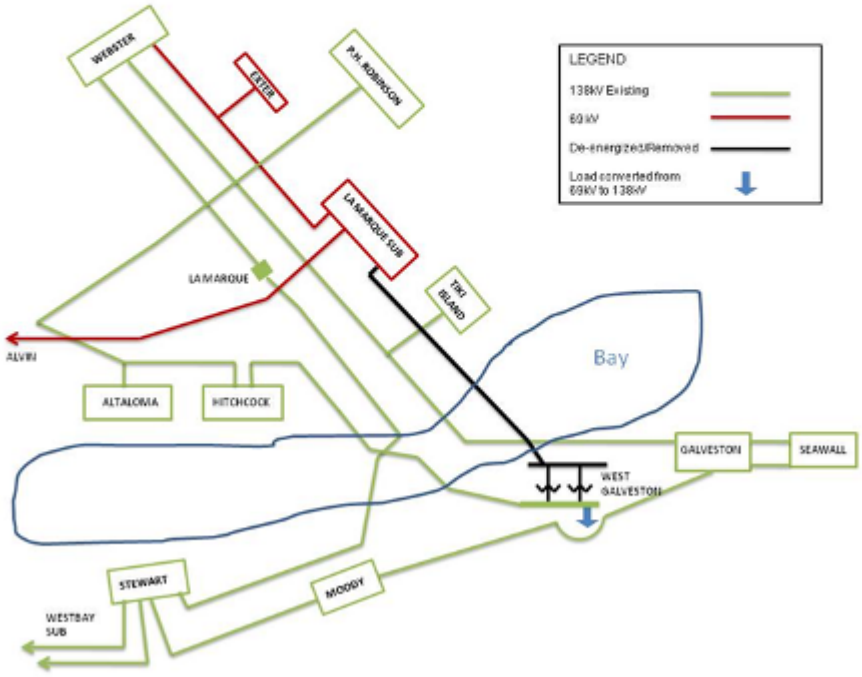
Newer higher elevation substation designs were helpful in protecting against storm surge.

STORM SURGE IN GALVESTON WAS SIGNIFICANT AND DAMAGE TO THE WEST GALVESTON SUBSTATION WAS PRIMARILY DUE TO ITS PROXIMITY TO THE COAST.



CenterPoint installed a Mobile Substation in order to restore circuits in the Galveston area. This could supply approximately 45 MW of load.

Galveston Island Network Changes - Temporary



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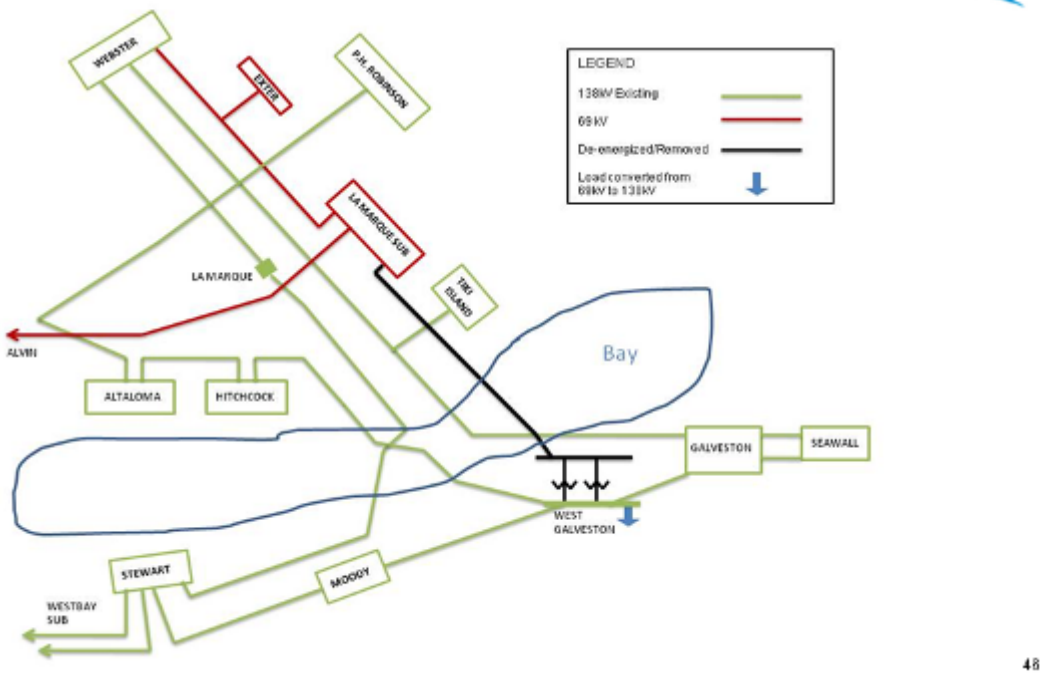
- **A**fter reviewing damage assessments and analyzing power flow study results, CenterPoint Energy decided not to restore the 69 KV portion of damaged West Galveston substation and 69 KV Ckt. 13, Lamarque – West Galveston
- Removal of damaged 69 KV connections to Galveston Island could cause some increased loading on remaining three 138 KV connections to Galveston Island (Timing depends on rate of load restoration and growth on Galveston Island)

Galveston Island Network Changes - Permanent



- CenterPoint Energy believes upgrades of remaining 138 KV facilities would be more practical, cost-effective, and timely than restoration of damaged 69 KV facilities
- CenterPoint Energy will evaluate upgrades to remaining 138 KV connections to Galveston

CENTERPOINT LESSONS LEARNED

- Storm surge affected Galveston Island, including CenterPoint substations
- ERCOT actions to adjust for increased probability of line outages was effective
- The Generators in the CenterPoint area performed well
- The 2007 completion of STP– Hillje– WAP tie-line helped
- Availability of mobile substations aided restoration effort
- The new Entergy 138 KV line expedited water plant restoration
- Relay and Control infrastructure performed well
- Hurricane training and drills were effective in preparing personnel

ONCOR SUMMARY

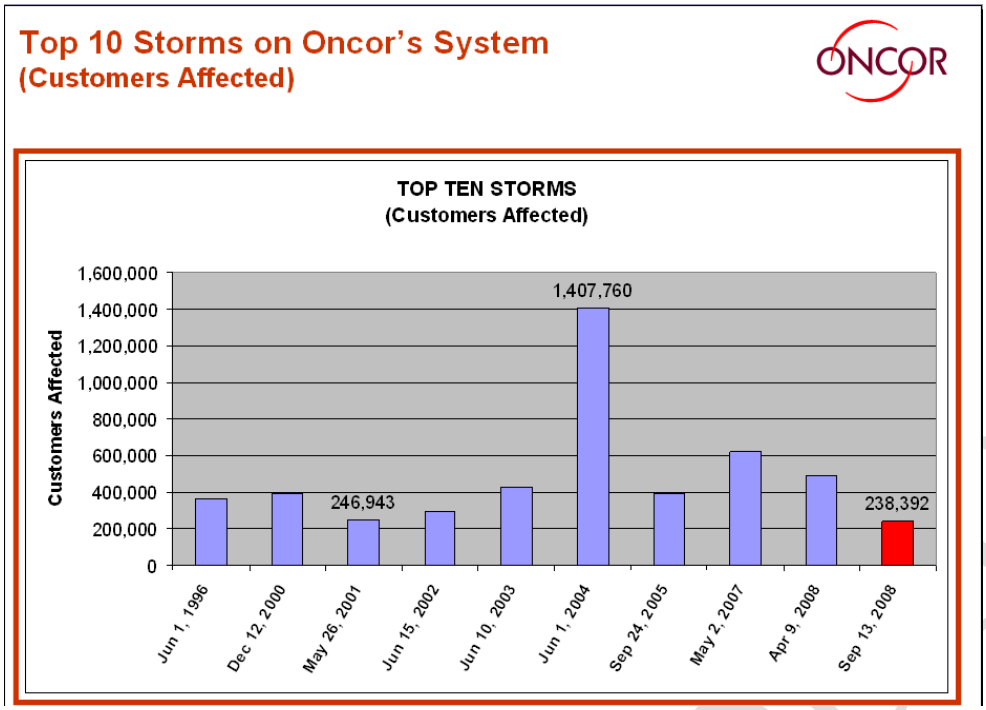
ONCOR is a regulated electric distribution and transmission business that provides reliable electricity delivery to consumers. ONCOR operates the largest distribution and transmission system in Texas, providing power to 3 million electric delivery points over more than 102,000 miles of distribution and 14,000 miles of transmission lines. Hurricane Ike passed through ONCOR's service area, primarily in its Eastern Region, with winds up to 90 mph causing power outages throughout the area. Throughout ONCOR's south east service area there were more than 100,000 homes and businesses without power. This area affected by Hurricane Ike was Angelina, Nacogdoches, Cherokee, Anderson, Henderson, Van Zandt, Smith, Rusk and Gregg Counties. At the peak of Hurricane Ike's impact on Sept. 13, 108,000 homes and businesses were without power.

Aerial patrol near Lufkin

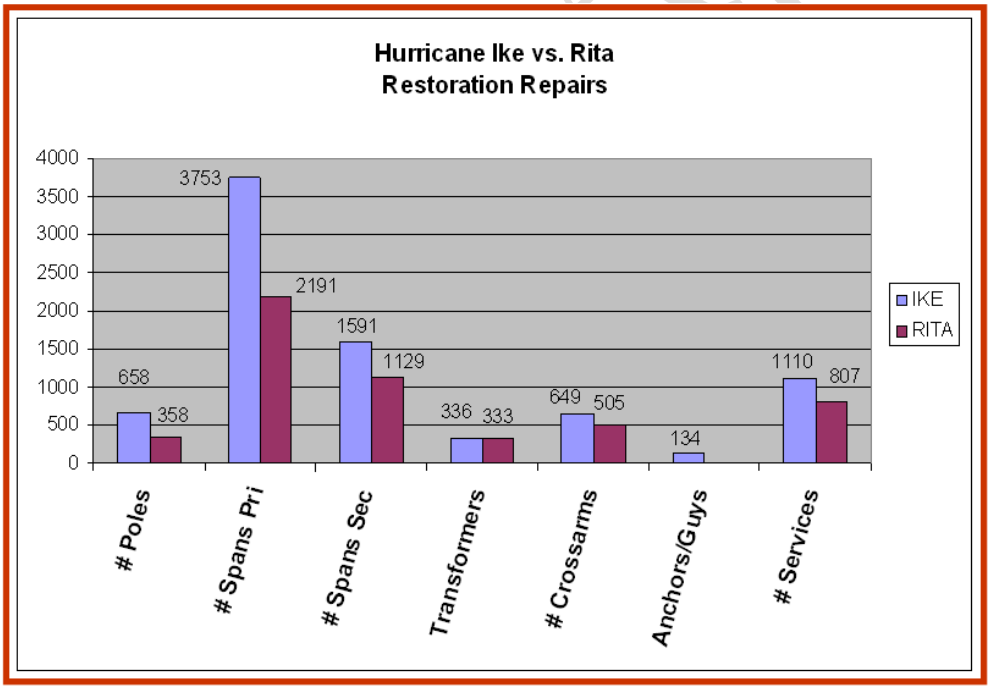
Damage Summary			
Trees in Lines	Structures Damaged	Wood Poles Replaced	Cross-arms Replaced
60	18	10	8

Assets Impacted					
69 kV # Lines	138 kV # Lines	345 kV # Lines	Substations	Feeders	Customers
7	10	1	25	52	37,361

Ike is the tenth worst storm in ONCOR's history regarding customers affected.



Hurricane Ike produced more devastating winds and more damage to ONCOR facilities than did Hurricane Rita.



Support personnel and crews were on-site in east Texas beginning on September 12th until September 26th.

The majority of damage was caused by high wind and trees falling into the lines. ONCOR replaced 658 poles in total.

Transmission Restoration

- 18 transmission lines were affected, eliminating all sources to 25 substations.
- The first outage event was recorded at 07:53 on 09/13/2008.
- The last outage event was recorded at 14:34 on 09/13/2008.
- 12 of the substations were back in service in approximately 24 hours, with an additional 11 restored within 36 hours. The last two stations were restored in approximately 39 and 54 hours, respectively

Mutual assistance:

ONCOR employees and contractors assisted CenterPoint from September 17th until October 1st.
219 ONCOR employees, 705 Contract employees. CenterPoint showed their appreciation to ONCOR by placing a half page ad in the Sunday (October 12) Dallas Morning News.

ONCOR LESSONS LEARNED

- Aerial patrol critical to quick evaluation of widespread transmission and distribution line damage
- Excellent utilization of town managers and distribution service advisors
- Excellent early preparation, prediction of potential impact, 4 staging areas prearranged in east Texas
- Mutual Assistance worked well
- Need training for Resource Tracking and damage evaluation
- Continue to refine ICS roles in the Emergency Restoration Plan

ERCOT SUMMARY

ERCOT COMMUNICATIONS

ERCOT operations posted an ALERT at midnight September 12 through 20:35 CDT, and upgraded the ALERT to an EMERGENCY NOTCE at 20:35 due to the potential landfall of Hurricane Ike along the Texas coast. ERCOT also issued a media advisory September 12, 2008 and follow up media conditional reports September 14 and 15. Additionally to these ERCOT specific communications ERCOT participated in NERC-FERC-Reliability Coordinator calls. These calls started prior to the storm and continued following the storm through September 16, 2008.

The following QSE's were identified as having operations in the area of landfall.

BP ENERGY COMPANY (QSE)	CALPINE POWER MANAGEMENT LP
DIRECT ENERGY LP	EAGLE ENERGY PARTNERS I LP (QSE)
FULCRUM POWER SERVICES LP	FORTIS ENERGY MARKETING AND TRADING GP
NRG TEXAS POWER LLC (QSE)	RELIANT ENERGY POWER SUPPLY LLC (QSE)
SHELL ENERGY NORTH AMERICA (US) LP (QSE)	SHERBINO I WIND FARM LLC (QSE)
SILVER STAR I POWER PARTNERS LLC (QSE)	SUEZ ENERGY MARKETING NA INC (QSE)
CONSTELLATION ENERGY CONTROL AND DISPATCH	TENASKA SERVICES.

September 12 2008 ERCOT called all QSE centers in the affected path to determine their staffing and confirm the Back Up locations was manned. For affected TDSP's; ERCOT established a conference bridge so an open line between operations centers could be established. Media advisories went out on Friday before the storm. This advisory included instructions on how consumers could report outages, Hurricane preparedness and how to receive updates for grid conditions during the storm.

ERCOT PRELIMINARY TRANSMISSION STUDIES

To better posture ERCOT for the storm, studies were performed the day before landfall. This was done to prepare operations for the issues likely to be encountered for the areas impacted by the storm. The most likely landfall was Houston-Galveston so ERCOT studied impacts in this area. The studies focused on the North and Northeast region (North-Houston corridor), and the South/West region (South-Houston corridor). The South/West region study results were as follows.
Assumption: 40000MW base-case with Coast Load around 5000-7000MW varying to see impacts.

North and Northeast region (North-Houston corridor) study:
Below are the summary notes taken from the studies.
Scenario 1: Initially 100MW import into Houston, North to Houston=-112, SH=+8 Scenario,

Study 1: Looked at potential outages in the Northeast corner of the Houston area. All transmission was out at Chambers and Cedar Bayou.

Result: One 69KV line indicated it may be loaded beyond emergency load shed rating. This line was expected to have cleared; studies showed no cascading beyond that. Of note there were no shift factors effective to resolve this 69 KV overload.

Study 2: Potential outages in the Northeast corner of the Houston area. All transmission was out at Chambers and Cedar Bayou and all King 345KV lines were outage.

Result: No additional issues identified from -800 to +500 Houston export levels.

Study 3: Potential outages in the Northeast corner of the Houston area. All transmission was out at Chambers and Cedar Bayou, all King 345KV lines were outage, all THW 345KV lines outage and the THW bus was outage with 500 import total into Houston.
Result: This showed Result of post contingency overloads as follows:
Overload indicated at Dansby upon a loss of the double circuit Twin Oak Switch-Gibbons Creek & Twin Oak Switch-Jack Creek 345 KV line.
Overload indicated at Blessing upon a loss of the STP-Elm Creek 345 KV Line.
Overload indicated at Lake Whitney upon a loss of Bosque SW-Whitney 138 KV line.

Scenario 2:
Study: All 4 North to Houston 345KV lines are out of service;

Results: For the contingency of STP-Elm Creek the situation was controllable with the remaining Houston generation. ERCOT would be required to back down at WAP and GBY
For the contingency of double circuit Gibbons Creek-Twin Oak Switch & Gibbons Creek-Jack Creek ERCOT studies showed to lowering FTR as extremely effective.
Lesson:

1. ERCOT should look to procure generation with wide capability range to assist in managing the imports during the storm.
2. Minimize North to Houston flows to keep impact of losing lines into and around the North Houston area to a minimum.
3. North Scenario (#2) demonstrated ERCOT was able to lose all 4 North to Houston 345KV lines and clear contingencies
4. NE Scenario (#1) demonstrated ERCOT able to lose Chambers 345KV, Cedar Bayou 345KV and 138KV, King 345KV and clear all post-contingency overloads by keeping North to Houston initial flows to minimum levels as stated above.

South/West region (South-Houston corridor) study

The study showed that ERCOT should minimize South to Houston flow to keep impact of losing lines into and around the South Houston area to a minimum (~500 MW).

1. The worst scenario was the loss of STP-DOW double circuit, STP-Hillje double circuit and the STP-WAP; (5 345 KV lines out at STP)
    a. No base case overloads showed up, but the next contingency of either Elm Creek-STP double circuit or STP-White Point results in an invalid solution. Backing down one of the STP unit corrected this without any thermal overloads or voltage issues.

2. Also studied were the following less severe contingencies. Studies showed that base-case conditions were manageable for all of the following outages.
    a. STP-DOW Double circuit out-of service
    b. STP-DOW and STP-Hillje Double circuits out of service
    c. STP-DOW and Hillje-WAP Double circuits out of service
    d. STP-DOW Double circuit and STP-WAP out of service
    e. STP-DOW and Hillje-WAP Double circuits and STP-WAP out of service
    f. STP-DOW Double circuit and Hillje bus out of service

The studies indicated ERCOT should attempt to limit Houston dependency upon imported power as much as possible. This implied ERCOT should look to procure generation with wide capability range to assist in managing the imports during the storm.

Note that both the North and Northeast region (North-Houston corridor), and the South/West region (South-Houston corridor) base case was from the same model were based the current Operations model and (the North-Houston corridor ended up in the worst quadrant of Ike's current path).

ERCOT STAFFING DURING EVENT

At ERCOT additional staff was present from 8 pm on Friday September 12 2008 through the evening shift September 13, 2008. Operations Engineering, Outage Coordination, Advance Network Applications, Operations Planning and Energy Management support staff were manned for 24 hour coverage during the storm. Additional management staff was on site from Friday through Sunday September 14, 2008 to assist in NERC-FERC communications and to provide additional support for the event.

ERCOT RELIABILITY CRITERIA

ERCOT normally maintains a list of contingencies for Normal Operations to meet NERC and regional reliability criteria. This list contains normal single circuit outages along with selected double circuit outages. ERCOT realized that during the Hurricane the risk of double circuit outages would increase and that it would be beneficial to maintain the Houston-Galveston area transmission in a more reliable manner. To do so ERCOT identified N-2 scenarios just prior to the Hurricanes landfall so that the area would be as prepared for the impact of landfall. These studies were used to limit import and export in the Houston area to withstand double outages. The limit ERCOT established was 1000 MW import and export. ERCOT moved back to N-1 criteria as the storm passed in the early morning.

The following Chart shows the flow as approximately 100 MW net export from Houston at midnight. During the storm Houston became a net exporter as load dropped due to distribution outages. At 8 am ERCOT observed a maximum export of approximately 1500 MW. By this time the storm had passed over the Houston area and was located between Cleveland and Conroe Texas. The storm was moving slowly at about 15 mph North and East. The Entergy and ONCOR systems were starting to encounter outages due to Hurricane force winds in their service area.

Chart-ERCOT Transfers Houston Area
9/12/2008 6:00:00PM to 9/15/2008 6:00:00PM

ERCOT OUTAGES

The highest concentration of the transmission outages were in the Houston area. This was expected and planned for beforehand. The total transmission outages were 141 with the following breakdown.

- TNMP-23 transmission outages.
- CenterPoint - 100 transmission outages.
- ONCOR -18 transmission outages.

A total of 61 generators were affected by the storm and were forced out at some time during the event. Several sites were shut down prior to the storm making landfall. Some sites in low lying areas were shut down and evacuated. Others were staffed but due the loss of transmission to the facility the units to become unavailable. Others were forced off due to local issues at the site as a result of the storm. The estimated total capacity forced out for this storm was 6000 MW. This outaged capacity was a gradual reduction in capability and it should be noted that capacity in Houston area did not become an issue since most of the load in the Houston area had been lost. Houston was an exporter shortly after the storm passed over the Houston area.

September 13 2008 at 16:00 there was approximately 123 transmission outages: 5 – 345KV lines 92 – 138 KV lines and 26 – 69KV lines. The number of customer outages were: CenterPoint - 2,016,423; ONCOR – 113,405; Texas New Mexico – 113,000; LCRA (Co-Op load) – 7,780; AEP – 2,000; for an ERCOT total of 2,252,608.
The maximum customer outage in the ERCOT region was approximately 2.5 million customers. From NERC-FERC reports the North America outages from this storm were over 7 million total customer outages. This is the largest outage since the Northeast Blackout in August 2003. This estimate includes areas outside the ERCOT region but demonstrates the magnitude of the storm even after it left the ERCOT region.

ERCOT LOAD AFFECTED

The following chart shows the load before during and after the hurricane. The Blue trend is the ERCOT LOAD and the Green trend is the COAST LOAD. At 4 pm on Friday Sept 12th the load in the Coast region was approximately 10,000 MW. The next morning on the 13th of September the load fell below 2,000 MW. Along with this load drop due to the Hurricane the following day a front hit the Houston area which reduced temperatures into the 80s.

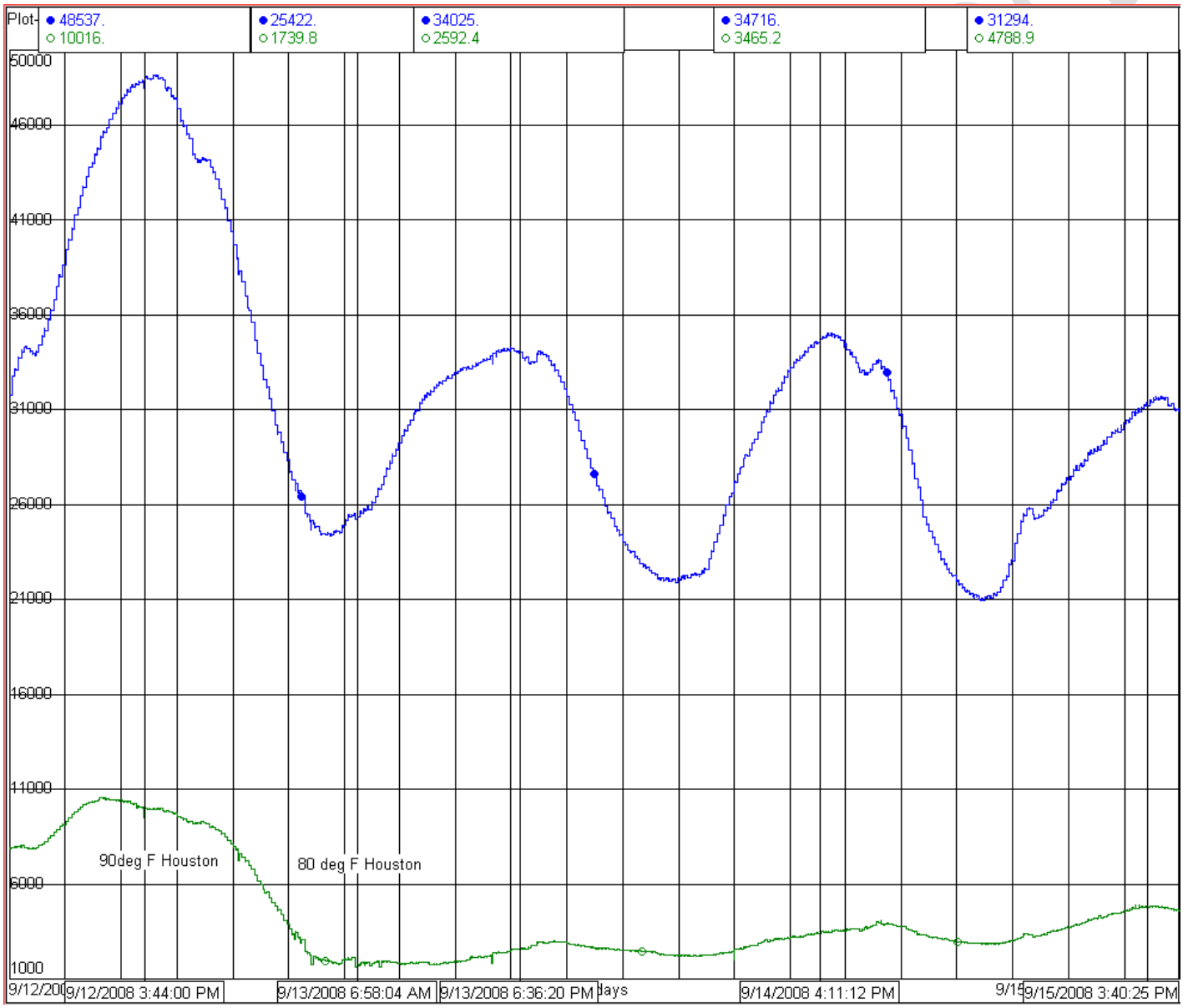


Chart-ERCOT Total Load shown with the Coastal zone included
9/12/2008 6:00:00PM to 9/15/2008 6:00:00PM

Houston load is typically 10,000 MW in September but after the Hurricane struck the load fell as low as 1,600 MW. Many Co-Gen facilities and industrial processes along the Gulf Coast were shut down prior to the storm. It took up to a week for some of these facilities to return to normal operations. Some industrial facilities in the Texas City area were damaged as a result of the tidal surge from the storm. Two distribution poles and all metering were replaced at these facilities. Normal operations was restored on Thursday, September 18, to those facilities. As can be seen by the following day peaks about 1300 MW were added the first day and 1000 MW were added the second day and 1000 MW were added the third day. The Load pick up was slow in the affected area due to the extensive distribution network damage received to the CenterPoint and TNP service areas. CenterPoint reported approximately 1200 distribution circuits of their 1500 total circuits were out of service immediately after the Hurricane passed over the Houston area. Commercial and industrial shut downs, utility crew access limitations and evacuations of residents were significant factors in how the load picked up.

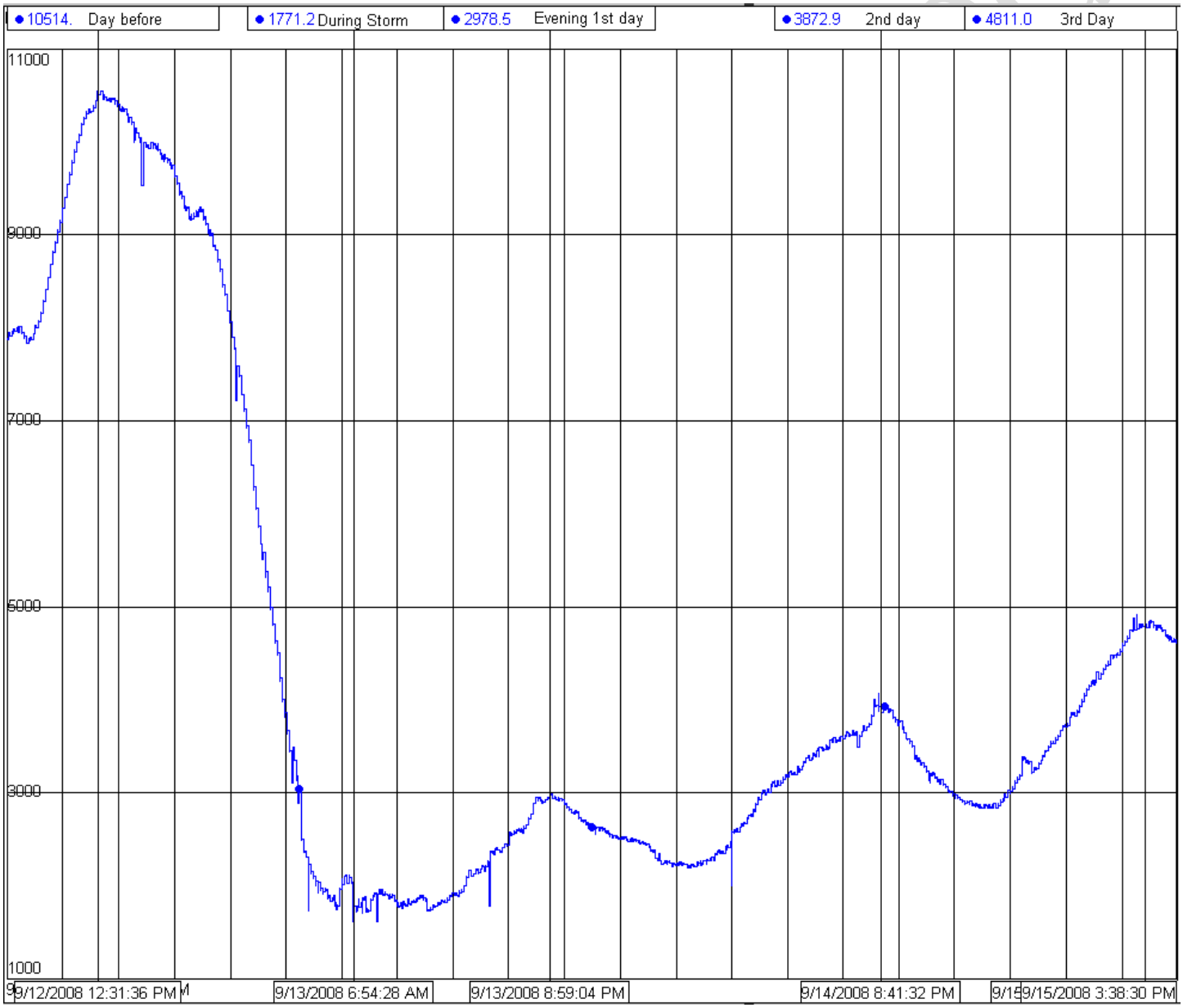
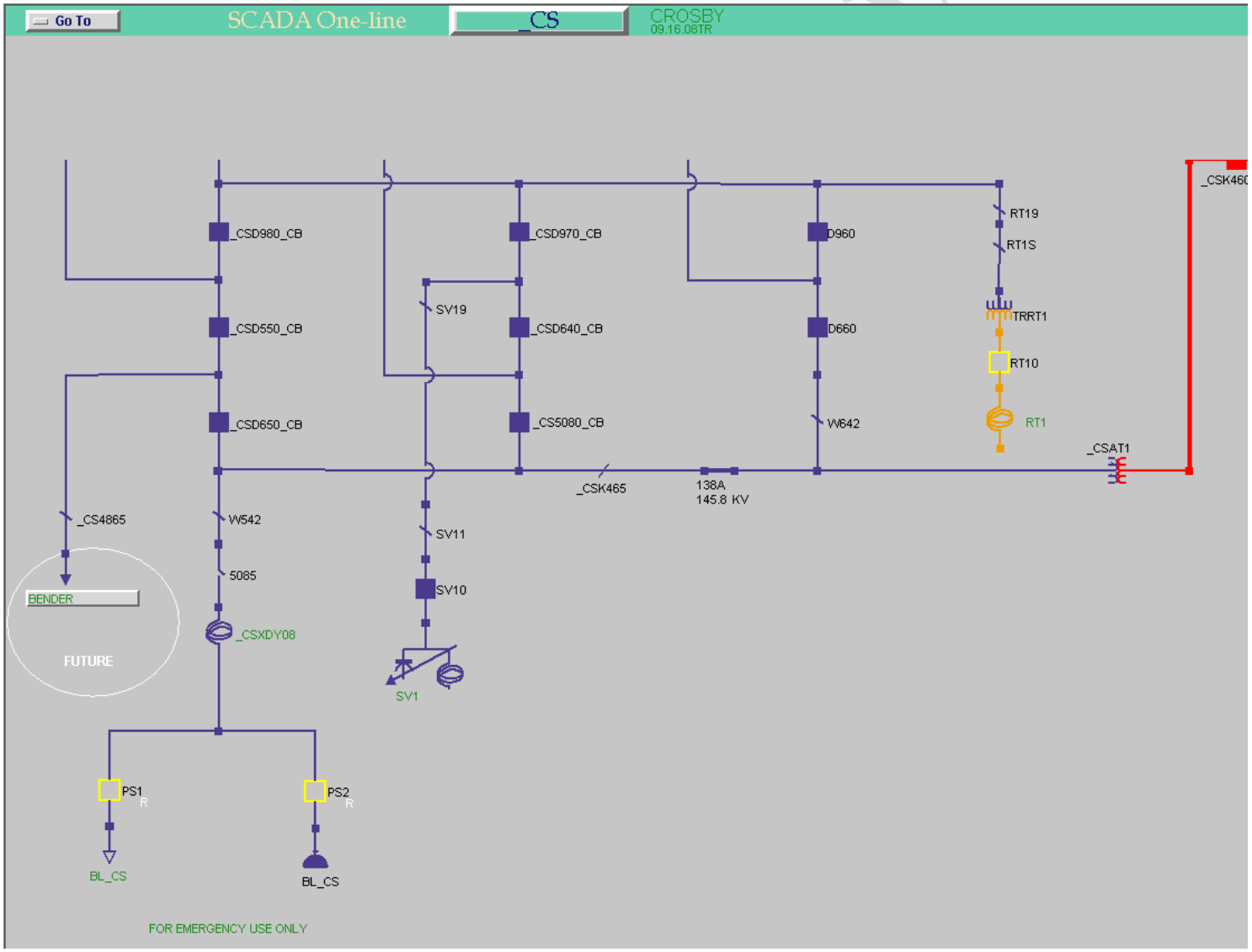


Chart-ERCOT Coastal Zone.
9/12/2008 6:00:00PM to 9/15/2008 6:00:00PM

EMERGENCY BLOCK LOAD TRANSFER

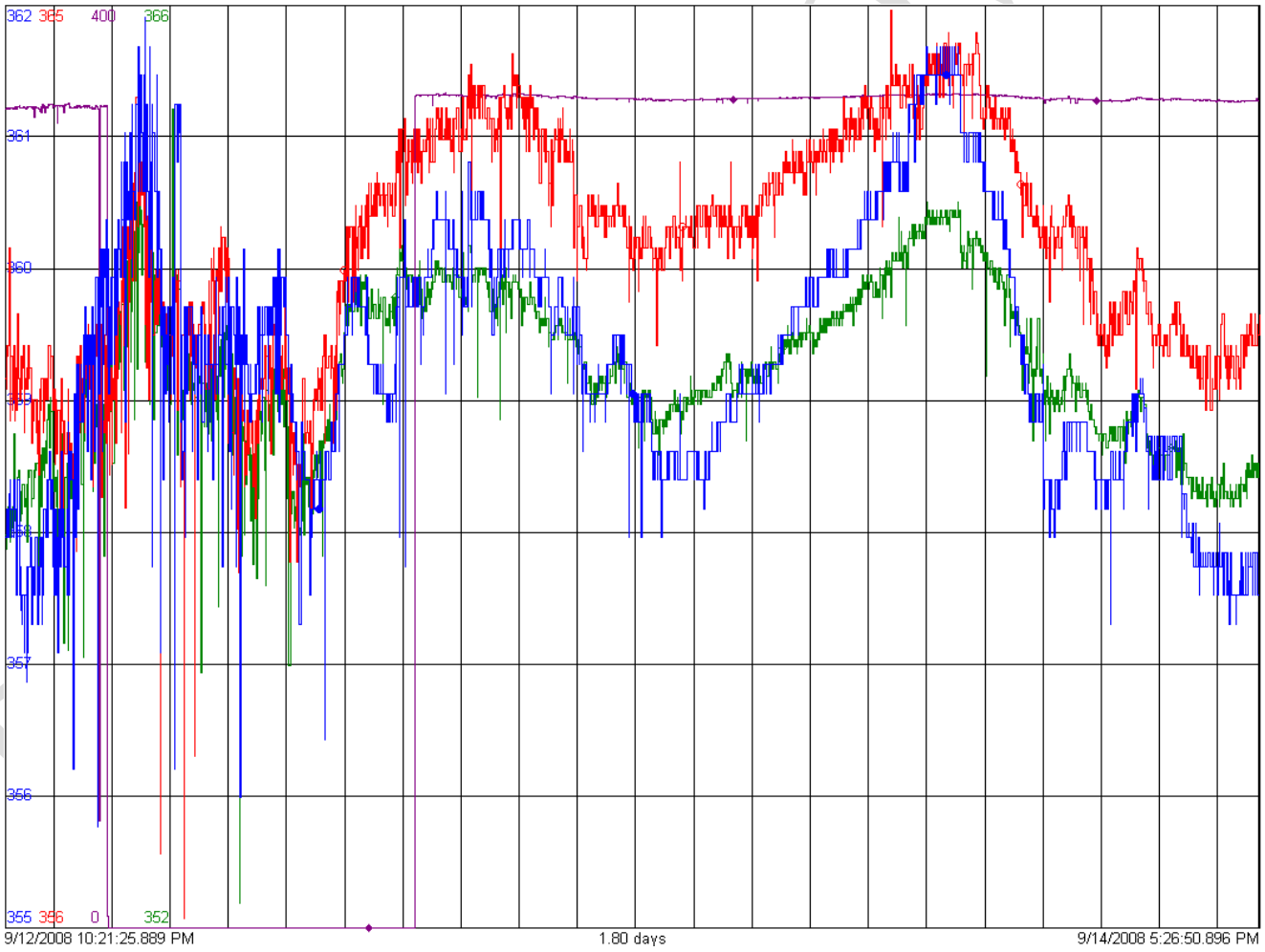
- Implemented emergency interconnection from CenterPoint's Crosby substation to Entergy's Dayton substation 9/15/2008
- From Dayton substation, CenterPoint used new transmission line built by Entergy after Hurricane Rita to restore power to water plant on the Trinity River normally served by Entergy.
- Disconnected Entergy emergency connection 9/19/2008.
- ERCOT facilitated a BLT to Entergy in the College Station area 9/16 to 9/18 from Brazos Electric Co-Op through the distribution system.
- ERCOT also facilitated a BLT to Entergy in the College Station area 9/24 to 9/25 through the distribution system.

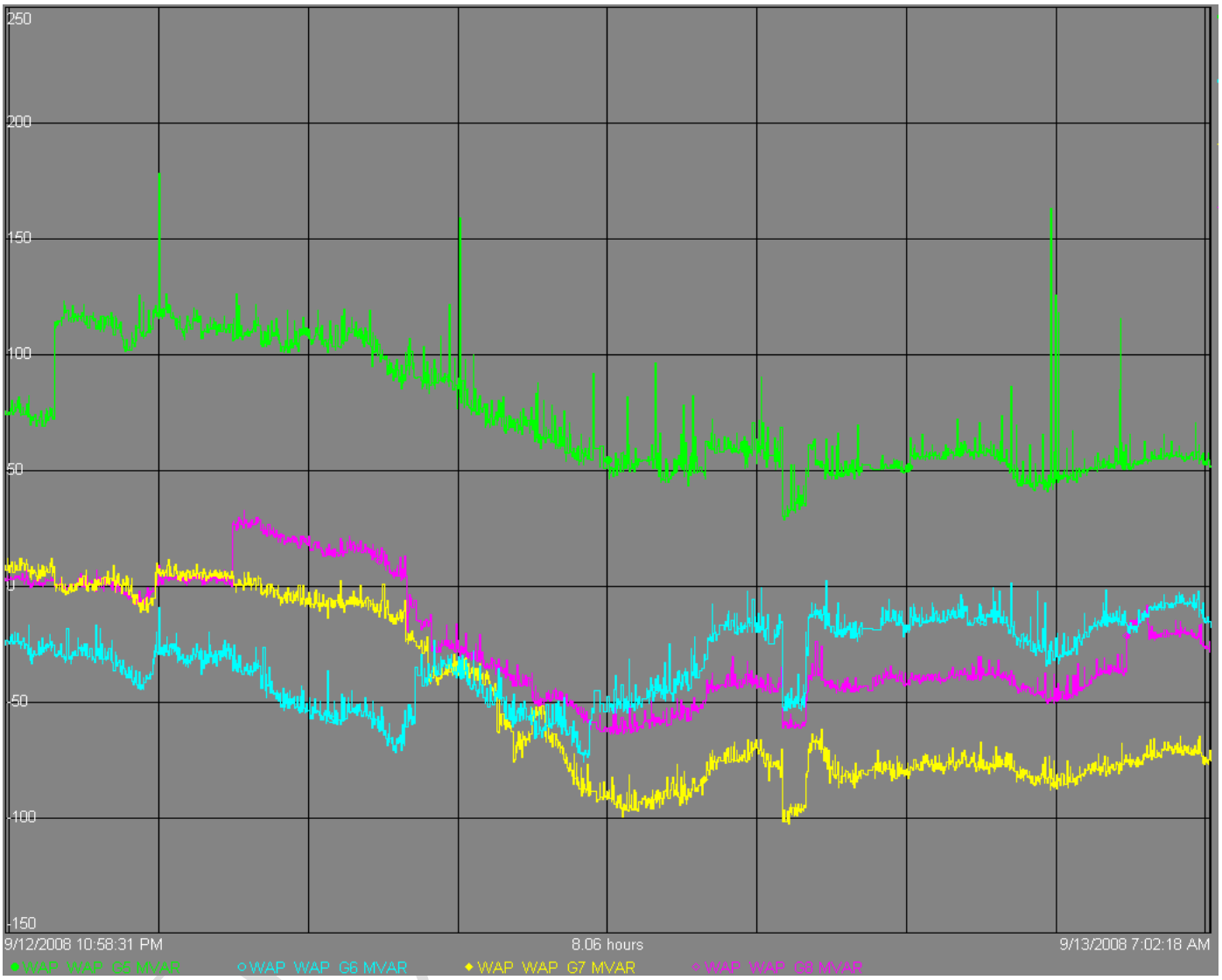


ERCOT VOLTAGE PERFORMANCE

During the storm higher than normal voltages were seen across the CenterPoint system. This was due to low loads in the Houston area and minimal transfers out from the Houston area. The result was that the 345, 138 and 69 KV systems had higher voltages during the storm event than during normal operation.

This chart shows Voltages on the 345 KV system were as high as 363 KV at THW and 361 KV at WAP 345 KV busses, within 5% of nominal voltage. As indicated on the following chart, NRG's generators on the 345 KV system (WAP units 6, 7, and 8) operated in the lead to reduce voltages, while the 138 KV unit (WAP-5) operated slightly in the lag, close to unity when generator transformer losses are considered. This indicates good performance by the generating units in controlling high 345 KV voltages. Less generator support was required on the 138 KV system because the 138 KV system voltage is largely managed by automatic tap changing 345/138 KV autotransformers.

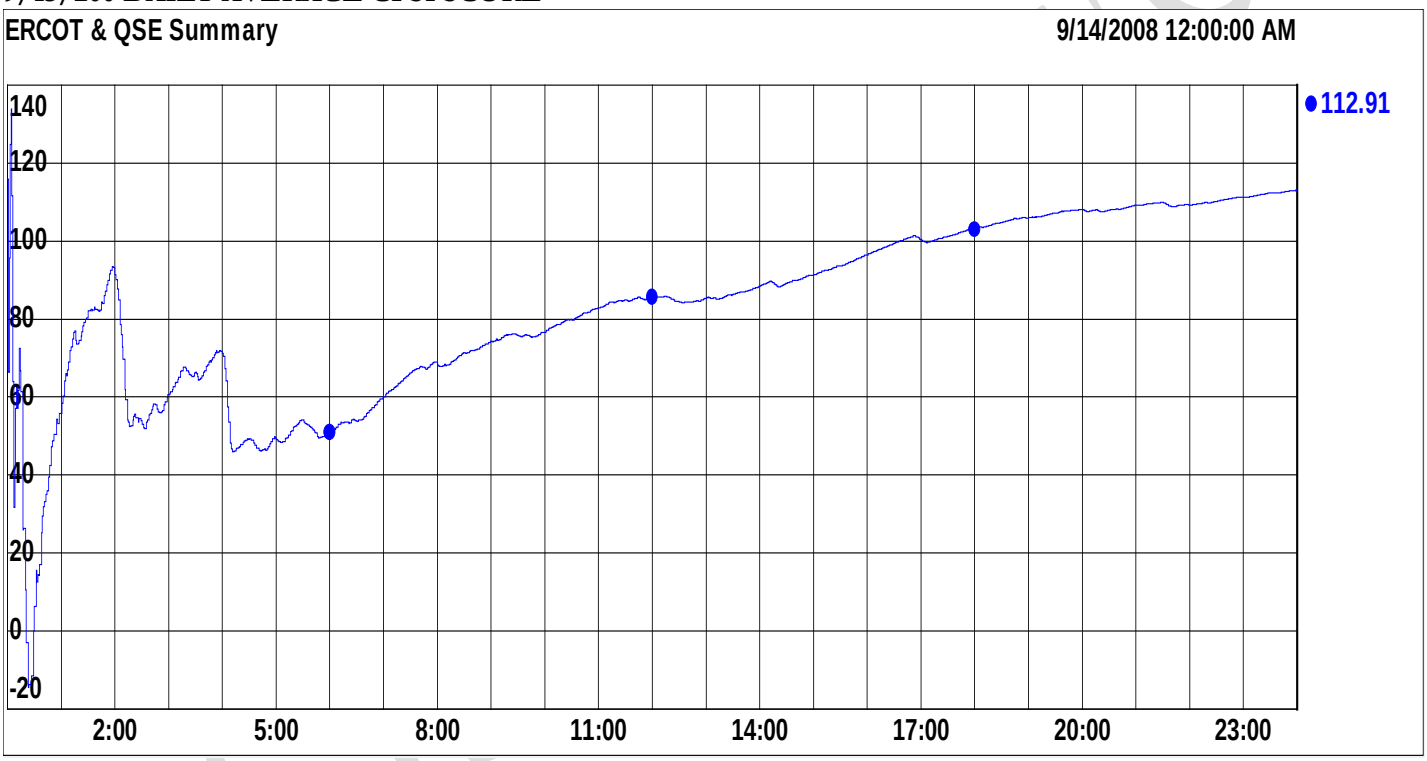




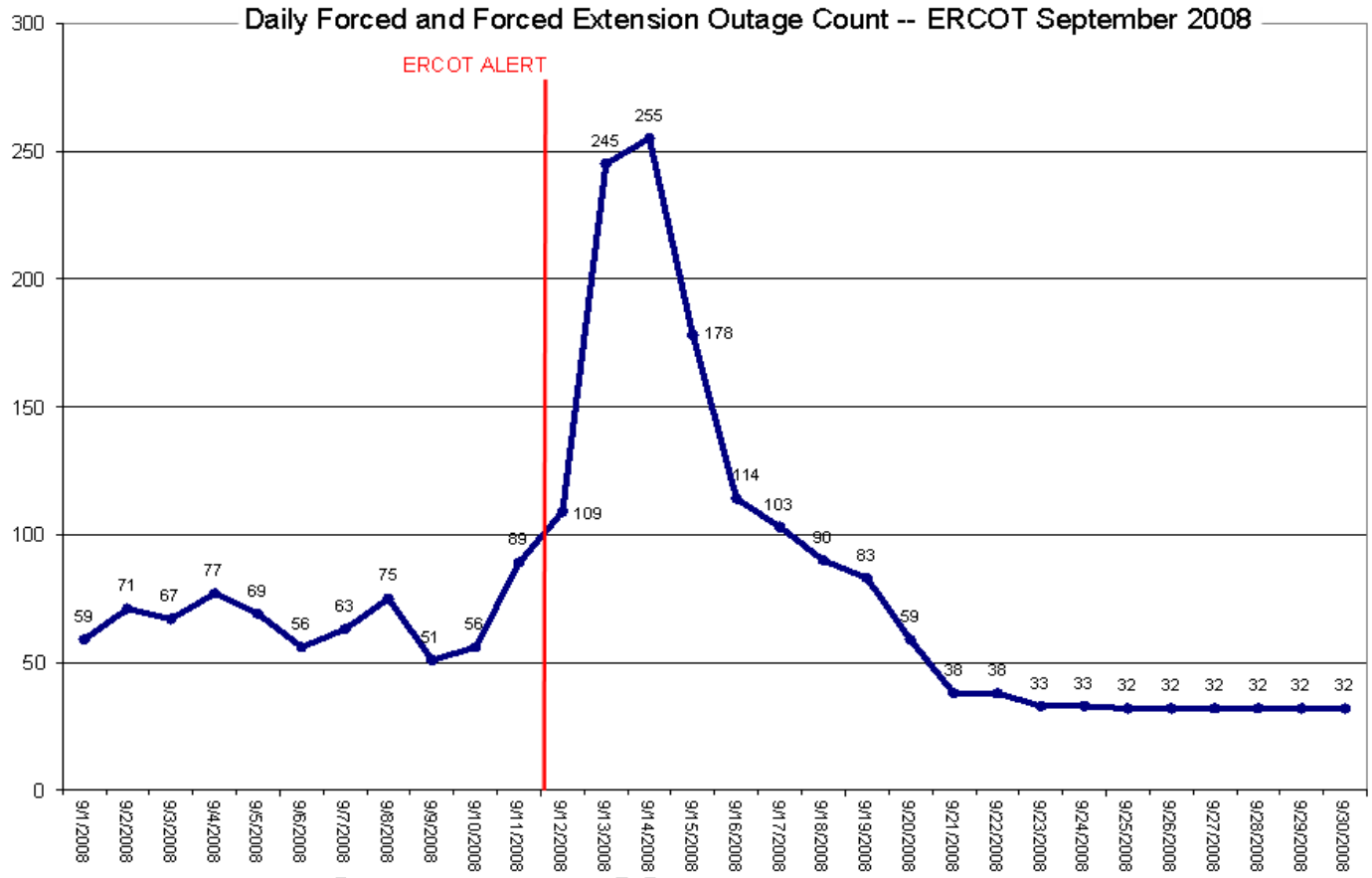
WAP5-8 VAR shows WAP was a net 20 MVAR consumer with WAP 5 supplying 80 MVAR and WAP6-8 in the lead a total of 100 MVAR.

During and aftermath of Hurricane Ike over ERCOT Balancing Authority, CPS1 Scores were significantly affected due to rapidly dropping load and intermittent loss of generation in the Houston and Galveston areas. Balancing load during Hurricane condition was a significant challenge primarily due to inaccuracy from the look-ahead tools and the significant variations in load and generation. The Monthly CPS1 Score before Ike's Landfall stood around 129 %, since then daily CPS1 score has been decreasing and we have either failed or passed with low scores. The monthly CPS1 score currently stands at 120.4 %.

9/13/200 DAILY AVERAGE CPS1 SCORE



ERCOT OUTAGE AND EXTENTSION RATE DURING THE MONTH



Developed by Advanced Network Applications

OVERVIEW

The State Estimator is a critical application for maintaining reliability and security of the ERCOT system. During large impacting events such as Hurricane Ike, the State Estimator requires extra attention and continued real time support by operations personnel to ensure its ability to provide valid solutions.

Hurricane Ike was predicted to make landfall on the Texas coast between the hours of 1am to 6am on the morning Saturday 13th September. For this reason, ERCOT operations staff was required to be available on site for the Control Room operations starting 11pm Friday night. Hurricane Ike reached the Texas coast at approximately 2:10am, moving north and then north-east through the morning reaching Houston at 5:20am. The Hurricane then continued north and threatened to reach the Dallas/Fort Worth area around 5pm. By 7pm, Hurricane Ike had moved away from the Dallas area and moved north-east and reduced to a tropical storm category. At this time ERCOT operations staff were no-longer required to be onsite for Control Room support and could continue normal on-call support.

SE CONVERGENCE

The State Estimator runs at least every five minutes and reports a State Estimator solution status. The type of solutions can be:

- **'Valid Solution'** which means the solution converged and all buses met the 30MW/30MVar mismatch criteria,
- **'Solved with Mismatch'** which means the solution converged however at least one bus did not meet the 30MW/30MVar mismatch criteria.
- **'Invalid Solution'** which means the solution was not able to converge within the set number of iterations

Only Valid Solutions from the State Estimator are included as a successful convergence for convergence performance monitoring. The State Estimator Convergence Performance for the hours of September 13th is provided in Figure 1.

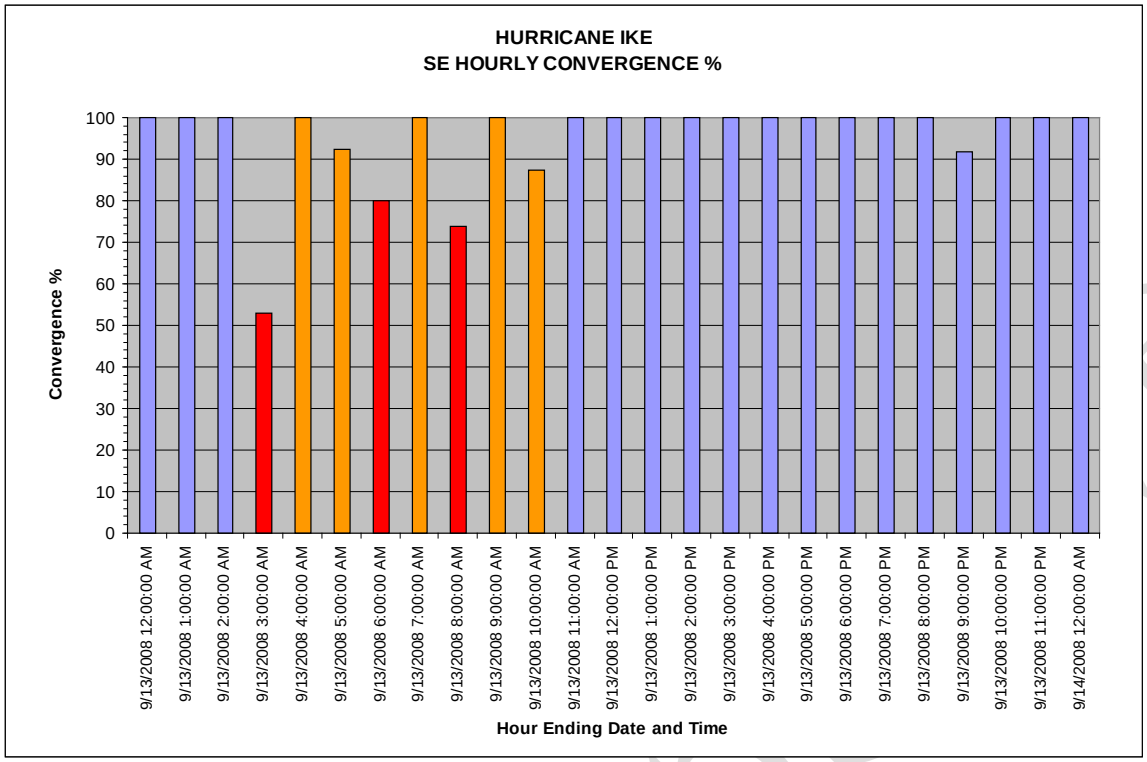


Figure 1 State Estimator Convergence Performance

It can be seen for hour ending 3am, the convergence performance reduced to approx 52%. This is due to the time when Hurricane Ike made land fall at approximately 2:10am on the Texas coast resulting in the loss of transmission elements and large numbers of topology changes in the State Estimator. During multiple changes on network, the State Estimator was receiving momentarily incorrect status of switches on the network due to loss of telemetry caused by the Hurricane. Discrepancies between out of service elements, telemetered MW generation, transmission flows and switching device status caused a number of the State Estimator 'Invalid Solution'. This lowered the convergence performance for hour ending 3am. The same effect can be seen for hour ending 6am, when Hurricane Ike reached the Houston area at approximately 5:20am. State Estimator again produced a number of 'Invalid Solutions' due to discrepancies between telemetered values and out of service elements. The reduced convergence performance for hour ending 8am was the result of the ERCOT EMS Tap Estimation application estimating incorrect tap position for a Phase Shifter transformer. This was identified by ERCOT support personnel and required manual replacement. The issue's surrounding Tap Estimation is further discussed later.

ERCOT Engineering Support Personnel were able to utilize the State Estimator Statistical application to quickly identify MW/MVar mismatches and topology coherency issues from which ERCOT could validate the system status with QSE's and TSP's. Then ERCOT would manually replace the SCADA value or status on the ERCOT EMS with the correct value. Therefore the hourly convergence performance would oscillate as a result of this physical action of loss of transmission elements and incorrect telemetry and ERCOT's reaction of validating the actual status and values and manually replacing the values in the ERCOT EMS.

SE MW AND MVAR MISMATCH AND SOLUTION STATUS

As mentioned earlier, to be included in the convergence performance, the State Estimator solution must be a 'Valid Solution', and meet the 30MW/MVar mismatch criteria. Figure 2 below shows the maximum MW and MVar mismatch for each State Estimator run. Also provided (in yellow) is the State Estimator solution results which are represented as Valid Solution = 0, Solved with MW/MVar mismatch = -50, and Invalid Solution = -100. This shows the number of Invalid Solutions and Solved with Mismatch around the 2:10amd and 5:20am times, corresponding to Hurricane Ike reaching the Texas coast line and also reaching Houston.

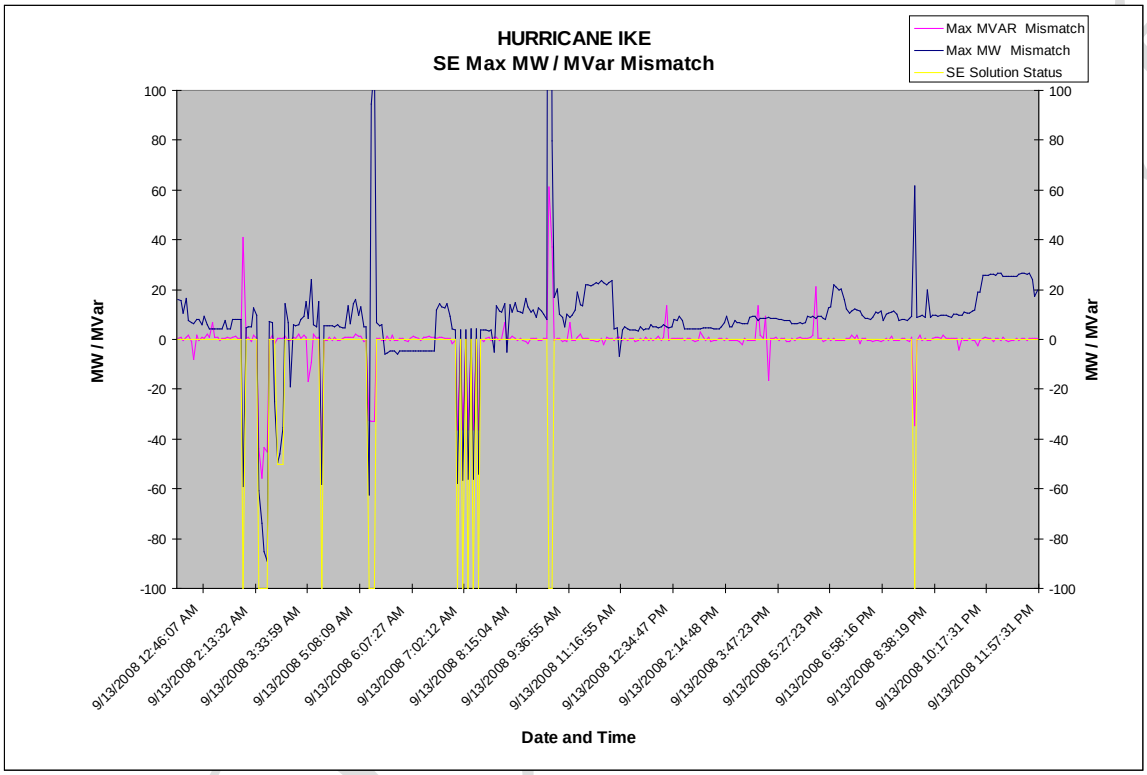


Figure 2 State Estimator MW/MVar Mismatch and Solution Status

SE OBSERVABILITY AND MEASUREMENT REDUNDANCY INDEX

The State Estimator Observability was not impacted during the Hurricane event. This can be seen in the Measurement Observability statistics in Figure 3 below. Those sites that were no longer observable because of telemetry failure were already out of service and therefore did not adversely affect observability or the state estimation. On occasions when ERCOT lost telemetry before the site was physically out of service, the situations were identified quickly and resolved by manually replacing the SCADA on the ERCOT State Estimator after the situation was verified by the QSE or TSP.

Also in Figure 3 is the Redundancy Index. The Redundancy Index represents the ratio of the number of known measurements to the number of unknowns (state variables). In order to solve for "N' unknowns, ERCOT should have at least the same number of known values (N). Therefore, the redundancy should be at least equal to 1.0. However, having a Redundancy Index greater than one does not guarantee measurement observability of the system; the 'spread' of the known measurements is also a factor for observability.

The Redundancy Index during Hurricane Ike was very erratic compared to normal operating conditions. The large variations can be attributed to the loss and recovery of large amounts of telemetry from remote RTU's. The Redundancy Index is also affected by the manual replacements performed by QSE's, TSP's and ERCOT. However the number of manual replacements performed compared to the total number of telemetered points available is very small, therefore the effect on the Redundancy Index is also very small. As can be seen the Redundancy Index never went below 1.0, and on average held at approximately 1.82 for the day. During normal operating conditions the Redundancy Index ranges between 1.8 and 2.2.

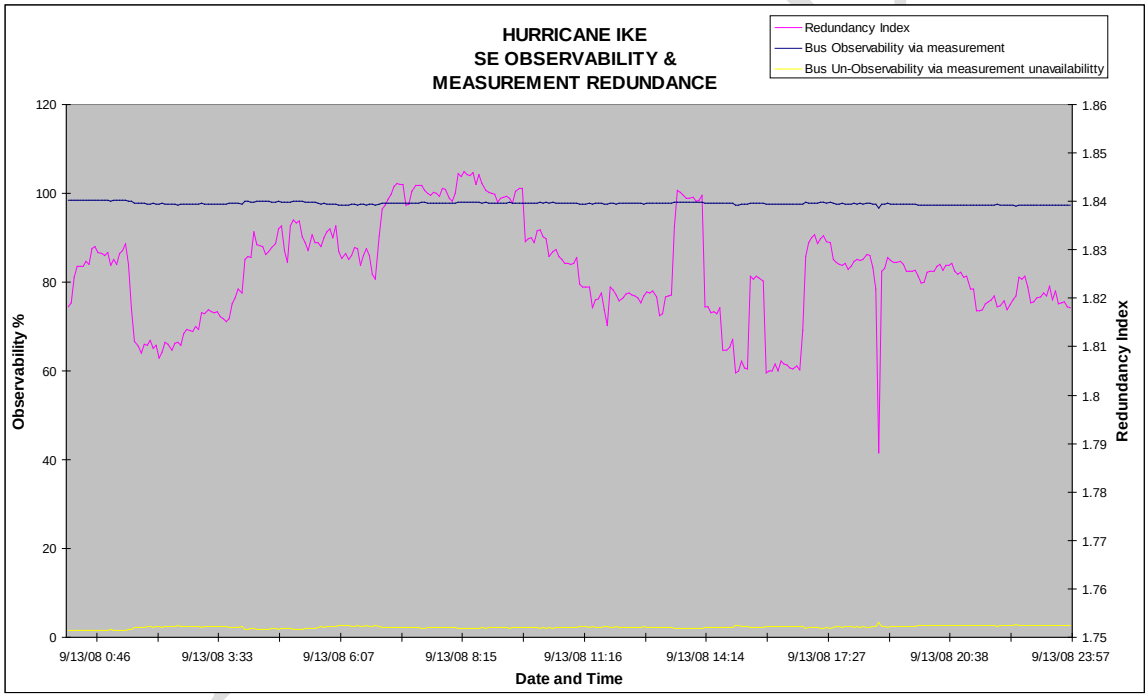


Figure 3 State Estimator observability and Redundancy Index

SE TOPOLOGY CHANGES

The amount of system topology changes handled by the State Estimator increased during the Hurricane Ike event. Figure 4 below shows the total number of Circuit Breaker changes and the Cumulative Number of Changes with each State Estimator run. The time scale has been reduced to show the amount of changes during Ike's land fall at 2:10am and as it moved through to Houston at approximately 5:20am.

It is hard to determine from Figure 4 how much the topology changes affected the performance of the State Estimator, as it not only depends on how many changes, but also depends on the what circuit breaker and its location on the ERCOT grid. What can be seen is between the hours of 12am and 6am there was a lot of activity on the grid, some of it reflected in the telemetry and circuit breaker status changes.

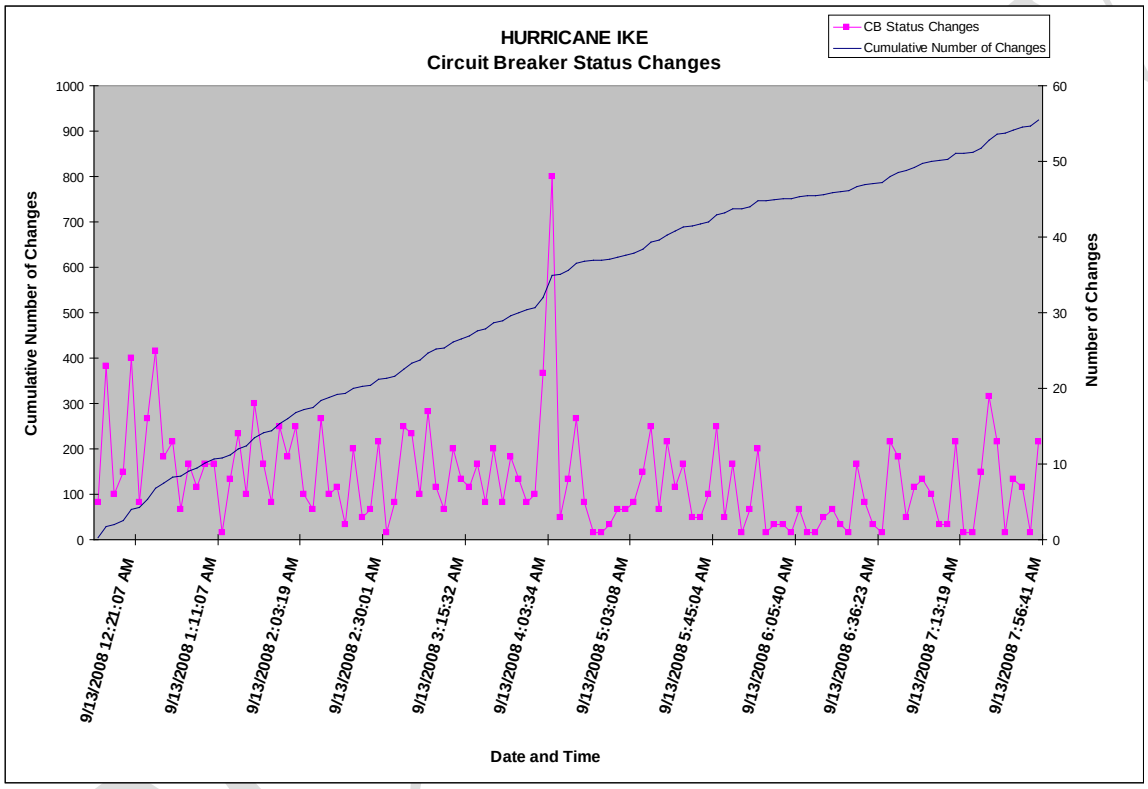


Figure 4 State Estimator Circuit Breaker Changes

RTCA

The Real Time Contingency Application successfully ran for all State Estimator Valid Solutions during the event. There were three unsolved contingencies during the event which were confirmed by ERCOT support personnel as 'not real' and instructed the Operators to disregard. The reason for being unsolved was not identified during the event, but ERCOT support personnel continued to monitor the contingencies and passed on their findings to the Operators.

Later analysis found issues with these three particular contingencies, even though their contingency definitions appeared correct, the same unsolved result was replicated. ERCOT will continue to investigate the issue and will raise an SPR if required.

TAP ESTIMATION

Tap Estimation is an application for estimating tap position for all transformers based on observable measurement for Voltage, MW and MVar, and to a lesser extent the telemetered transformer tap position. Tap Estimated positions have a high weighting in the State Estimation process and if they are incorrect the result will invariably cause a Invalid Solution. During normal operations, Tap Estimation is responsible for causing intervals of Invalid Solutions; therefore ERCOT support personnel are aware of the issues associated with the application. This was seen during the Hurricane Ike event where an incorrect estimated tap position on a Phase Transformer caused a number of Invalid Solutions. It was identified by ERCOT personnel and corrected using a manual replaced value.

OBSERVATIONS AND IMPROVEMENTS

The following are observations of what ERCOT did well and what could have done better. A list of things to consider is needed to help groups such as the Advanced Network Applications to prepare for the technical issues and also the other logistical issues such as staffing. The following observations should help develop such guidelines.

Firstly it was observed that Operations had decided to operate the system in some critical areas to N-2. Although it is hard to predict exactly where such events such as a Hurricane or any wide spread event, exactly what will be critical, it is possible to derive likely list of N-2 contingency definitions. Having a predefined list of N-2 contingency definitions available and current allows Operations to activate such contingencies for preparation studies and during the actual event. Having this list will also alleviate the workload during the event of loading study cases, setting a Base Case with the first outage (N-1), and then run the contingency analysis to get N-2 results.

Another observation was the inability for State Estimator and Telemetry Support Personnel to communicate to the relevant Market Participants Support Personnel to resolve issues. During the event all communication for validating switch status and telemetry issues was between Control Center operators. This only caused distraction and seem a deterrent for Market Participants from the 'real' problems being managed. It has been suggested that like Support Personnel from ERCOT and Market Participants should have separate contacts and lines of communication to manage State Estimator and Telemetry

issues. This would also avoid cluttering the Control Center to Control Center communications with possibly non-critical matters.

Better tools to determine telemetry issues quickly. Some enhancements to EMS displays may be required to facilitate this. The Short Term Load Forecast results were not as expected and were limited by a setting in the application itself. This highlights the need to review all settings and tuning parameters in all EMS applications in preparation for the abnormal conditions, i.e. very low system load and reverse load power (injecting into grid). Some of these settings are derived for normal operating conditions and can limit application performance.

Therefore in better preparing for such an event, guidelines should consist of the following:

- Plan and maintain a N-2 list of contingencies to be activated in RTCA upon request
- Produce a contact list of Market Participant EMS, SCADA and Telemetry Support Personnel
- Set up a dedicated conference bridge for EMS, SCADA and Telemetry issues
- List of displays and data capture for monitoring SE health and Telemetry.
- Debrief the ERCOT Control Center personnel of EMS Application issue's and possible limitations due to the event and provide temporary work around options.
- Support Personnel must review EMS applications settings and tuning parameters to minimize EMS application limitations.

SUPPORTING DATA

All of the information in this report was derived from data captured from the State Estimator Statistics application and logs from support personnel. All data has been captured and stored in Excel spreadsheets by the Advanced Network Applications group. Also captured during the event were snapshots (save cases) of the system for each valid SE solution. These save cases can be used for future analysis, review or training and are available upon request.

ERCOT SUMMARY

In summary ERCOT has reviewed the events and determined the system performed very well during the event. It is anticipated that as the storms move into the area that loads will drop off. If the storm takes a northerly track attention should be paid to the DFW area as it may be susceptible to damage as well. This Storm moved east and did not directly threaten DFW.

IT STAFF COMMENTS

- The continuous conference call worked out very well. At all times we had one person in the office and 4+ on the phone. So, IT was able to work on any issue instantly, and were able to adjust priorities and assignments among a large team on the fly.
- The handoffs between shifts on the conference call were not orchestrated and support staff may benefit in having a turn over process in the future.
- STLF issues were unforeseen.
- ERCOT will need some display changes to help find bad telemetry quickly.
- Some of the Houston QSEs have their backup control center in College Station. This is not a poor plan but points out that a widespread event could remove both control centers.
    - We need a management approval plan in place to handle non-standard, remedial activities. It can define who makes the call and/or defines the criteria to be met.
    - We need an alternate communication plan. We were discussing, but did not execute, a plan to help Brilliant QSE. The team was told that we still need written confirmation from them as to what they needed us to do. We even suggested having them find any of their employees who had a working third party email (e.g. Hotmail, Gmail, etc.) to give us approval.
    - The team is working on some tools to copy the previous day's bids/schedules/plans for a given QSE. Any other changes will have to be ad hoc.

ADVANCED NETWORK APPLICATIONS

- ERCOT should take a snap shot of the system every hour and archive them for future analysis. These cases can be helpful when we are preparing for another Hurricane in the future.

- Make available for all, the report on previous emergencies, printed out and handy. For example, we can email out the current ERCOT report to all the operations engineers and have a couple of printed copies in the control room on the day of the next emergency. Going through such a report can remind staff of items they did not expect.
- Make a list of EMS displays that have information about lost telemetry, outages, available generations etc.
- Identify any displays (EMS, Hab Excel, PI etc...) that we do not currently have which will be helpful in a future emergency and build them as soon as possible.

OPS ENGINEERING

- Advance studies are very helpful.
- Good use of Engineer console in Control Room during storm.

OUTAGE COORDINATION

- Outage coordination should staff prior to the landfall.
- Beneficial to keep outages as up to date as possible.
- Having Outage Coordination in the back of the Control Room Area assist in quick communication.

ACTIONS:

- Add turn over sheets for Support staff and perform more orchestrated turn over for support staff.
- Add telemetry quality to Load Area displays
- Establish criteria of when to run studies prior to Hurricanes.
- Establish N-2 criteria of what circuits ERCOT should be using N-2.
- Establish a guideline of when to use and when to release N-2 criteria.