



Event Investigation – October 3, 2006 System Outage (Bryan/College Station) Area ERCOT Compliance Report

Executive Summary:

At 17:27 on October 3, 2006, multiple equipment failures led to loss of the entire Gibbons Creek substation, a major facility with three 345/138kV autotransformers. The resulting topology left the Bryan / College Station area weakly linked to the rest of ERCOT, and the ensuing voltage excursions caused local transmission companies to shed customer load to prevent complete loss of service. Additional generation outside this load pocket tripped, and ERCOT instructed Load as a Resource (LaaR) to disconnect in order to maintain frequency and meet recovery requirements. Despite issues with communications, ERCOT and the TDSPs coordinated their actions to manage the grid from their respective wide-area and local views, through restoration. Five QSEs with LaaR did not meet Protocol 10-minute deployment criteria, but it appears that other applicable Protocol and NERC Standards were met.

This report by ERCOT Compliance examines whether applicable Protocols, Operating Guides and NERC standards were met during this event. A timeline of the event is attached. Information was provided by ERCOT Operations and transmission companies, QSEs and generators. Additional reports from these entities detail the events more fully.

Transmission Equipment Failure Issues

On October 3 2006 at 17:27, multiple equipment failures occurred at the Texas Municipal Power Agency (TMPA) Gibbons Creek Substation. The initial problem, an internal fault in the “A” phase of a 138 kV coupling capacitor voltage transformer (CCVT) on the line to Roan’s Prairie Substation, was initially cleared by protection. During this fault, the current-sensing components of the backup protective relay failed. The series arrangement of these components in the primary and backup protective relays on this line effectively disabled both of them. An automatic attempt to restore service re-established the fault, which did not clear this time per design. This second fault lasted long enough to cause the CCVT to explode, flashing over to the “B” phase CCVT. At this point, relays meant to protect other substation equipment sensed the fault conditions contributed through their sensing elements, sent trip signals to other circuit breakers and effectively removed the station, three autotransformers and a generator step-up transformer from service.

Equipment failure in NERC and ERCOT requirements requires misoperations analysis; TMPA completed that task. The series-connection of protective relays is contrary to ERCOT Operating Guides for new equipment, but this station was installed prior to those requirements and is “grandfathered”. Similarly, no clear issues with coordination studies, equipment review or maintenance on TMPA or Brazos Electric Power Cooperative equipment can be found from examining the information obtained or the requirements. While TMPA reported past alarm indications suggesting CCVT problems, they were intermittent, did not appear compelling

enough to demand immediate action – and neither ERCOT or NERC requirements mandate specific actions based on these signs.

TMPA addressed equipment issues identified in their review of the event.

- The failed CCVT along with its other two phase units in the set were tested and replacements made. TMPA is reviewing its other CCVT installations and has shared model information with other ERCOT TDSPs.
- Similarly, the failed relay was replaced by Brazos and adjustments to the CT ratio made to reduce the current sensed during faults, thereby reducing the possibility of damage. Other relays for transformer protection were also replaced by TMPA.
- Two additional sets of current transformers (CTs) have been ordered for line protection at Gibbons Creek to eliminate series current connections shared by primary and secondary relaying. These will bring these schemes closer to arrangements called for in the Operating Guides for new equipment.

Of longer term significance, three transmission projects were previously planned to address known risks identified through studies to meet NERC planning criteria. The new Keith Switching substation went into service earlier in 2006; Jack Creek substations and the Gibbons Creek Autotransformer project should be in service by summer of 2008. While other proposals may have merit (such as under voltage load shedding), these planned projects - once completed - will provide a more robust grid into the area, and improve the ability to isolate faulted equipment in the Gibbons Creek substation.

Actions for Grid Support

The multiple-contingency event created local voltage issues in the Bryan/College Station area affecting several TDSPs. From review of logs and reports, it appears that both TDSP and ERCOT operators maintained situational awareness and communicated with each other, although there were difficulties caused by lack of working communications equipment at Gibbons Creek and the sheer number of companies and personnel involved. Decisions to shed load (approaching 340 MW), including rolling blackouts, were executed by the local companies to maintain their portion of the grid. ERCOT Operations issued Transmission Alerts and revised limits twice on the North-Houston CSC after the forced outages and stayed in communication with local TDSPs, allowing them to carry out local actions but providing input on transmission loading. ERCOT Operations and Planning conducted a study after the event that reinforces the idea that the voltage oscillations were localized to this area, and not likely to produce a significantly wider collapse upon further contingency. Review of North-Houston transmission flows and topology does not identify any cascading outages following single contingency, in compliance with NERC's standards on Interconnected Reliability Operating Limit (IROL) violations. Restoration of the grid had some delays but all were worked through without subjecting the grid to wider disturbances. One restoration situation involved apparent misunderstanding of the impact of lock-out relays on breaker operations, which set back recovery efforts. No clear issues with expected actions to manage grid conditions per ERCOT or NERC criteria were found. Additional training on relaying facilities is recommended for operations staff with the delegated responsibility for switching.

Loss of Generation

Generators at four locations tripped during the first minute of the Gibbons Creek events. Three of these locations had system conditions that explain the loss of units. However, at one location, it was not immediately clear why the facility's units tripped. XXXX Generator 1 breaker tripped with no flag indicated at the time of the Gibbons Creek fault and the other units at the site tripped a few seconds later. Plant staff indicated a possible issue with neutral-overcurrent relaying, and they reviewed the operations with their TDSP. This appears to be another instance of misoperation, and the plant owner conducted the required review, even if the review's finding is inconclusive. The plant manager indicated further follow-up planned during upcoming outages; their personnel should also confirm coordination of protective relaying during nearby transmission faults per Operating Guide 3.1.4.6.

Frequency Recovery

Loss of generation reached 1214 MW, which qualifies as a NERC Disturbance Control Standard (DCS) event. This standard measures the ability of a control area to recover within fifteen minutes from a significant frequency disturbance. Qualifying DCS events are initiated by loss of generation totaling between 80% and 100% of the largest single contingency (1250 MW in ERCOT). ERCOT's system automatically deploys generation that provides RRS; in this event, 539 MW was deployed. Generation QSEs appear to have performed within the recently approved criteria; some validation is still in progress. To assure meeting DCS recovery time, ERCOT issued a VDI eight minutes into the event (17:35 pm) to deploy any un-deployed LaaRs to supply Responsive Reserve. Five out of the ten QSEs with LaaR RRS awards did not respond with 95% of their award within the 10 minute criteria in Protocols 6.5.4. In aggregate, 642 MW of LaaR was shed within ten minutes per ERCOT data, and it took over twenty minutes to achieve 95% of the 1150 MW obligation. Despite these delays, ERCOT frequency returned to 60 Hz in just over 10 minutes. The DCS recovery criteria was achieved well before that time, as it is only necessary to return to frequency at the start of the event, which was below 60 Hz – but the ERCOT system operator would not know this in real time. ERCOT kept LaaR out of service until 19:17. There were minor issues with LaaR telemetry and communications, and restoration, but QSEs with LaaR maintained their load shed MW above minimum criteria throughout the deployment, once the threshold was reached.

Corrective actions plans were requested, reviewed and will be tracked to completion for the five QSEs above. Telemetry at one LaaR is also under review to assure that the QSEs design could continuously provide the data quantities they are responsible for. Additionally, ERCOT is developing more stringent testing requirements for a Protocol revision. Clarification about length of LaaR deployments and use of substitution is recommended based on this event.

Data and Communication Equipment Issues

One of the QSEs transmitted an erroneous signal related to plant output. The problem resulted from loss of AC input to ERCOT-pollled settlement meters, which quit updating MW values to the battery-backed RTU when the substation de-energized. An alternative signal not dependent

on these meters was put in service 8 minutes after the event by QSE staff; a permanent solution has been put in place.

Fault recordings on the Gibbons Creek substation 345kV bus were disabled due to technician error. Sufficient information was available from other sources to reconstruct the event.

Personnel at Gibbons Creek apparently lost power to their telephone system and were dependent on a single cell phone connection during part of the event. While this was utilized effectively, it added difficulty and it is recommended that the facility owners examine the communication capability between this plant and local control centers.

Recommendations and Conclusion:

Events such as this one, with multiple equipment failures, can produce wide ranging effects; they also highlight the degree of cooperation and communication among system operators to manage unusual situations. Completion of the actions planned above will lead to improved readiness and reliability. With the exception noted for LaaR QSE performance, the NERC Standards and other ERCOT Protocols examined here appear to have been met. These criteria typically provide minimum requirements and may omit meaningful details. It is hoped that the companies in ERCOT will try to exceed these minimums and use this opportunity to learn and better prepare for future events.

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Timeline of Events: October 3, 2006

- 17:27:49 Gibbons Creek to Roan Prairie A Phase CCVT had an internal fault.
4 cycles later Fault was cleared but caused a current sensor for the protective relay to burn open, during that time the recloser tested the circuit.
22 cycles later Because of the backup relay current sensor had failed the CCVT exploded and flashed into the other line (B Phase) which saw the fault and tripped out the Roans Prairie to Gibbons Creek substation. The fault caused T1 and T3 Autotransformers to trip off line at the same time with T2 to follow, blacking the Gibbon Creek station, At the same time UUUU, VVVV, WWWW and XXXX (nearby generation units) tripped off line causing a 1214 MW loss of Generation, frequency dropped to 59.788 Hz.
- 17:28 ERCOT Transmission Security noted that an Alarm Summary indicated that the Gibbons Creek 345 kV buss tripped. ERCOT Frequency Control reported a possible DCS Event for the loss of four Generation Plants.
- 17:31 ERCOT deployed 593 MWs of RRS.
- 17:31 Two of the Roans Prairie substation breakers were manually tripped for high voltage on their open-ended 345kV line.
- 17:35 ERCOT Frequency Control issues a VDI (F-100306-01) issued to all QSEs to deploy any unused LaaRs and Hydro supply.
- 17:37 The third breaker at Roans Prairie was manually trip by SCADA.
- 17:38 ERCOT Transmission Security noted that BTU was reporting voltage issues in the area.
- 17:39 ERCOT Transmission Security noted from TXU that the Jewett – Robinson 138kV line was swing from 137 MVA to 214 MVA.
- 17:46 BTU Operators began removing all rural substation load beginning with Kurten Substation.
- 17:49 ERCOT Transmission Security noted that City of Bryan notified them of voltage problems and that they where shedding load to stabilize the system. ERCOT ordered further load shed at 17:55.
- 17:57 ERCOT Transmission Security noted that College Station started to shed load to stabilize the system in their area.
- 18:12 ERCOT Transmission Security issued an Alert to change the North – Houston limit to 1400 MW from the 2400 MW due to the loss of the Gibbons Creek – O’Brien and Roans Prairie – Kykendahl 345 kV lines.
- 18:34 Gibbons Creek 354 kV North bus was manually energized.
- 18:36 Gibbons Creek 354 kV South bus was manually energized
- 18:37 Gibbons Creek 138 kV South breaker was energized.
- 18:53 ERCOT Transmission Security issues an Alert to change the North – Houston limit to 1000 MW from the 1400 MW due to the loss of the Gibbons Creek – O’Brien and Roans Prairie – Kykendahl 354 kV lines.
- 18:54 Keith Switch breaker was manually closed but tripped out twice.
- 18:55 GPL operator tried to close a Gibbons Creek via SCADA but it did not allow him to close it. The breaker was closed manually. This energized the second Twin Oak 345 kV line.

19:03 TMPA repeated its try to close a Gibbons Creek breaker via SCADA but had to close it manually. This energized the 345 kV line to O'Brien. Because of the transformer lockout relay in the locked out position, the flow through the 345 kV breakers sent a breaker fail signal to the Twin Oak and O'Brien substation which caused the O'Brien 345 kV and both the Twin Oak 345 kV lines to trip from the remote ends. All of the previous actions deenergized both the 138 kV and 345 kV busses.

19:17 ERCOT Frequency Control requested LaaRs restoration; logged as complete at 19:54.

19:38 TXU energized the Twin Oak lines from the TXU end.

19:43 BTU reported to begin rolling blackouts.

19:53 Gibbons Creek North 345 kV bus and the 138 kV bus through Twin Oaks is energized.

20:03 Gibbons Creek South 345 kV buss and the 138 kV bus through Twin Oaks is energized.

21:58 Gibbons Creek 345 kV breaker to Roan's Prairie was manually closed.

22:16 Gibbons Creek 138 kV breaker to Bryan East was closed by SCADA.

23:02 Gibbons Creek 138 kV breaker to Greens Prairie was closed. This energized the last 138 kV line except for the Roan's Prairie 138 kV line. The T3 autotransformer remains out until the follow day.