State Estimation
Performance Monitoring

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Theme: Confidence in Tools (a System Operators View)
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Presentation Outline

• ERCOT Introduction

• Tools to help SE Performance
  - SE Statistics
  - ERCOT ANA State Estimator Assessment Tool (ESAT)
  - Topology Consistency Analyzer

• Summary
ERCOT - Introduction

ERCOT Capacity and Demand

• **One of the largest single control areas in US**
  – >43,000 miles of high-voltage transmission (345kV & 138kV)
  – About 90% of Texas load

• **Capacity**
  – More than 74,000 MW capacity for peak demand
  – Wind capacity: 12,000 MW – most in nation
  – Wind Generation record: 11,154 MW (Feb 19, 2015) (34% of the load at the time)
  – Wind Penetration record: 40.58 % (March 29, 2015)

• **All-time Peak Demand**
  – 69,783 MW peak load (August 10, 2015)

• **Market Size**
  – 24 Million Consumers
  – 6.8 million premises with right to choose

• **Operating as Nodal Market since Dec 2010**

Role of State Estimator

Real Time Network Security Analysis
Estimation of the system state

Security Analysis: Procedure of
- Monitoring the system
- Identifying its operating state through security assessment
- Determining necessary corrective actions to make its secure

Monitoring the current state of the system
- Use of RTUs to measure and telemeter various quantities
- State Estimator which processes these quantities and 
  computes the system state (voltage magnitude and angles).

Key inputs to State Estimator:
- System Model (configuration/connectivity, network parameters like, impedances, etc.)
- Measurements (telemetry of Analog values, status of Circuit breakers, disconnects, Tap positions, etc.)
Real-Time Network Security Analysis
State Estimation Related Standards

- Telemetry Standards, Technical Advisory Committee (TAC) Approved
- State Estimator Standards, TAC Approved
- Protocols
- Operating Guides

Ref 1: Telemetry Standards, TAC Approved http://www.ercot.com/mktrules/obd/obdlist
State Estimation Standards

State Estimation Standards Revision Process

- Revisions to the State Estimator Standards shall be made according to the approval process as prescribed in Protocol Section 3.10.9, State Estimator Standards.

State Estimation data

- ERCOT uses a State Estimator to produce load flow base cases which are used to analyze the reliability of the transmission grid.
- Accurate and redundant telemetry and an accurate transmission power system model are required by State Estimator in order to produce an optimal estimation of the transmission power system state.
- The State Estimator results are used in contingency analysis, congestion management, and other network analysis real-time sequence functions.
State Estimation Standards (contd.)

Telemetry Status and Analog Measurements Data

- Acquisition of good telemetry status and analog measurements data (Telemetry) for the transmission power system (System) together with an accurate model of the System are processed by a State Estimator to provide an optimal estimate of the System state at a given point in time while filtering measurement noise (error) and detecting gross errors.
- The quality and availability of telemetry provided to ERCOT are important to the performance of the ERCOT State Estimator.
- Telemetry is not needed at every node of the System to arrive at a good estimate of the System’s state. There are general telemetry performance criterion such that sufficient numbers and placement of measurements and accuracy of measurements that are available to achieve System observability and an overall good State Estimator performance.
- Beyond general telemetry performance criterion there are more stringent criterion needed at locations where state estimates are “critically important” (e.g., locations where reliability, security, and Market impact are of more focused concern).
State Estimation Standards (contd.)

SE Performance Requirements

• State Estimator to converge 97% of runs during a one month period.

• On transmission elements identified as causing 80% of congestion cost in the latest year for which data is available, the residual difference between State Estimator results and Power Flow results for critically monitored transmission element MW flows shall be less than 3% of the associated element emergency rating on at least 95% of samples measured in a one month period.

• On transmission elements identified as causing 80% of congestion cost in the latest year for which data is available, the difference between the MW telemetry value and the MW State Estimator value shall be less than 3% of the associated element emergency rating on at least 95% of samples measured in a one month period.
State Estimation Standards (contd.)

SE Performance Requirements (contd.)

• On 20 most important station voltages designated by ERCOT and approved by ROS; the telemetered voltage minus State Estimator voltage shall be within 2% of the telemetered voltage measurement involved for at least 95% of samples measured during a one month period.

• On all transmission elements greater than 100kV; the difference between State Estimator MW solution and the SCADA measurement will be less than 10 MW or 10% of the associated emergency rating (whichever is greater) on 99.5% of all samples during a one month period. All equipment failing this test will be reported to the associated TSP for repair within 10 days of detection.
To meet these objectives ERCOT will do the following:

- ERCOT will work with TSP to resolve problem in accordance with Telemetry Standards prior to directing additional equipment.

- ERCOT may direct additional telemetry be installed on elements contributing most to 80% of congestion costs for the latest year for which data is available. If the TSP disputes the request for additional telemetry the TSP shall have the appeals process available under the Telemetry Standard section titled “ERCOT Requests for Telemetry”.

- ERCOT will enforce the requirements of paragraph (5) of Protocol 3.10.7.5.2, Continuous Telemetry of the Real-Time Measurements of Bus Load, Voltages, Tap Position, and Flows, by alarming any sum of flow around a bus the greater of 5% of the largest line rating connected to the bus or 5MW, and requesting that the applicable TSP or QSE correct the failure.

- ERCOT will post monthly results for compliance with the all requirements.

- ERCOT shall consider the quality codes sent by the data provider in assigning confidence factors for the data to be used in the State Estimator. Valid and manual quality codes shall be considered as good quality. Quality codes sent as not good quality shall be considered at a lower confidence. The confidence shall continue to decrease over time.
Telemetry Standards

Required telemetry

• Each TSP shall provide telemetered measurements on modeled Transmission Elements to ensure State Estimator observability of any monitored voltage and power flow between their associated transmission breakers to the extent such can be shown to be needed in achieving the State Estimator Standards.

• On monitored non-Load substations, each TSP shall install, at the direction of ERCOT, sufficient telemetry such that there is an “N-1 Redundancy.” An N-1 Redundancy exists if the flow remains observable on the loss of any single measurement pair (MW, MVAR) excluding station RTU communication path failures.

• In making the determination to request additional telemetry, ERCOT shall consider the economic implications of inaccurate representation of Load Models in LMP results versus the cost to remedy.
Required telemetry (contd.)

• QSEs, Resources and TDSPs are required to provide power operation data to ERCOT including, but not limited to:
  – Real time generation data from QSEs;
  – Planned Outage information from Resources
  – Network data used by any TDSP’s control center, including:
    ➢ Breaker and line switch status of all ERCOT Transmission Grid devices;
    ➢ Line flow MW and MVAR;
    ➢ Breaker, switches connected to all Resources;
    ➢ Transmission Facility Voltages; and
    ➢ Transformer MW, MVAR and TAP
  – Real time generation and Load acting as a Resource meter data from QSEs;
  – Real time Generation meter splitting signal from QSEs;
  – Planned Transmission Outage information from TDSP;
  – Network transmission data (model and constraints) from TDSP; and
  – Dynamic Schedules from QSEs;

• Real Time data will be provided to ERCOT at the same scan rate as the TDSP or QSE obtains the data from telemetry
Continuous Telemetry of the Status of breakers and Switches

• Each TSP and QSE shall provide telemetry on the status of all breakers and switches used to switch any Transmission Element or load modeled by ERCOT.

• Not required to install telemetry on individual breakers and switches, where the telemetered status shown to ERCOT is current and free from ambiguous changes in state caused by the TSP or QSE switching operations and TSP or QSE personnel.

• Shall update of the status of any breaker or switch through manual entries, if necessary, to communicate the actual current state of the device to ERCOT, except if the change in state is expected to return to the prior state within one minute.

• If in the sole opinion of ERCOT, the manual updates of the TSP or QSE have been unsuccessful in maintaining the accuracy required to support State Estimator performance to the State Estimator Standards, ERCOT may request that the TSP or QSE install complete telemetry from the breaker or switch to the TSP or QSE, and then to ERCOT.

• If the TSP disputes the request for additional telemetry the TSP shall have the appeals process available under the section titled “ERCOT Requests for Telemetry”. In making the determination to request installation of additional telemetry from a breaker or switch, ERCOT shall consider the economic implications of inaccurate representation of Model Loads in LMP results versus the cost to remedy.
The TSP shall maintain the sum of flows into any telemetered bus less than the greater of 5 MW or 5% of the largest line rating at each bus.

Each QSE or TDSP shall provide data to ERCOT that meets the following availability:

- Ninety eight (92%) percent of all telemetry provided to ERCOT must achieve a quarterly availability of eighty (80%) percent. Availability will be measured based on end-to-end connectivity of the communications path and the passing of Real-Time data with a Valid, Manual, or Calculated quality code at the scheduled periodicity.

- TDSP’s shall make reasonable efforts to obtain this data from retail customers associated with new customer-owned substations to meet this standard or obtain agreement from ERCOT that these retail customers have entered into arrangements with ERCOT to provide this data to ERCOT. If the data cannot be obtained under either of these methods, ERCOT shall report such case to the Independent Market Monitor.
Telemetry Standards (contd.)

General Telemetry Performance Criteria (contd.)

• The following criterion will apply in general to Telemetry provided to ERCOT (Contd):
  – Exceptions to the General Telemetry Performance Criterion shall be made for data points not significant in the solution of the State Estimator or required for the reliable operation on the ERCOT Transmission System. Some examples of these are:
    ➢ Substation with no more than two transmission lines and less than 10 MW of load;
    ➢ Connection of Loads along a continuous, non-branching circuit that may be combined for telemetry purposes;
    ➢ Substations connected radially to the bulk transmission system.
    ➢ Under ERCOT declared emergencies, the metrics will be suspended until normal operations have resumed.
Supplemental Telemetry Performance Criterion

• ERCOT will identify MW/MVAR Telemetry pairs, not exceeding 10% of the Transmission Elements in ERCOT, and 20 voltage points that are important to reliability, system observability, support of State Estimator performance, or are of a commercial Market concern.

• This important telemetry must meet more stringent criterion for accuracy and availability where specifically addressed. ERCOT will review and publish this list annually.

• ERCOT will use the following criterion to identify this specific telemetry:

  ➢ Loss of a telemetry point that results in the inability of ERCOT to monitor loading on a transmission line operated at 345 kV or above.
  ➢ Loss of a telemetry point that results in the inability of ERCOT to monitor loading on a 345/138 kV autotransformer.
  ➢ Loss of a telemetry point that results in the inability of ERCOT to monitor the loading on transmission facilities designated as important to transmission reliability by ERCOT. A list of specific facilities will be published annually.
  ➢ Telemetry necessary to monitor transmission elements identified as causing 80% of congestion cost in the year for which the most recent data is available.
  ➢ Telemetry necessary to monitor the voltages on the 20 most important station voltages.
  ➢ Each QSE or TDSP shall provide data to ERCOT that meets the following availability:

  ❖ Ninety two (92%) percent of the important telemetry defined by ERCOT must achieve a quarterly availability of ninety (90%) percent. Availability will be measured based on end-to-end connectivity of the communications path and the passing of Real-Time data with valid, manual, or calculated quality codes at the scheduled periodicity.
Telemetered data shall be provided continuously.

Lost data or signals, whether failed or in error, must be restored promptly by the provider of the telemetered data.

It is recognized that some data may be more essential to the state estimator solution. ERCOT will inform the TDSP or QSE if a data item is essential and needs to be repaired as quickly as possible.

QSE and TDSP repair procedures and records shall be made available to ERCOT upon request.

When ERCOT notifies a data provider of a data element which is providing telemetry data inconsistent with surrounding measurements, the provider shall, within 30 days, either:

a) Calibrate/repair the mis-behaving equipment
b) Request an outage to schedule calibration/repair of the mis-behaving equipment
c) Provide ERCOT with a plan to re-calibrate or repair the equipment in a reasonable time frame or
d) Provide ERCOT with engineering analysis proving the data element is providing accuracy within its specifications. Before ERCOT requests review/re-calibration of a problem piece of equipment it shall discuss the problem with the provider to attempt to arrive at a consensus decision on the most appropriate action.
Telemetry Standards (contd.)

Calibration, Quality Checking and Testing

- It is the responsibility of the owner to insure that calibration, testing and other routine maintenance of equipment is done on a timely basis, and that accuracy meets or exceeds that which is specified in this Appendix, for both the overall system and for individual equipment where detailed herein.

- Coordination of outages required for these activities with ERCOT is also the responsibility of the owner.

- Each TSP/QSE shall have a plan on file with ERCOT to assure accurate telemetry of data.

- If a TSP/QSE repeatedly fails other telemetry metrics defined in these guides, ERCOT may require a revision of this plan.
ICCP Links

• Data Quality Codes
  ➢ Market Participant’s shall provide documentation to ERCOT describing their native system quality codes and defining the conversion of their quality codes into the ERCOT defined quality codes.
  ➢ Status & analogs telemetered to ERCOT will be identified with the following quality codes:
    ➢ Valid – represents analog or status the TSP or QSE considers valid
    ➢ Manual – represents a analog or status entered manually at the market participant (not received from the field electronically)
    ➢ Calculated – represents an analog point that the TSP or QSE calculates.
    ➢ Suspect - Represents a analog or status in which the TSP or QSE is unsure of the validity
    ➢ Invalid – Represents a analog or status which the market participant has identified as out of reasonability limits.
    ➢ Com_fail – informs ERCOT that due to communications failure, the analog or status provided ERCOT is not current
ICCP Links (Contd)

- Reliability of ICCP associations

- Each participant using ICCP associations must achieve a monthly availability of ninety-eight (98%) percent, excluding approved planned outages.
- Availability will be measured based on end-to-end connectivity of the communications path and the passing of configured data at the scheduled periodicity. This will include establishing a process to coordinate downtime for ICCP associations and database maintenance.
- High availability configuration as allowed by the ERCOT Nodal ICCP Communications Handbook should be treated as a single association to achieve this availability measure.
- Each TSP and QSE shall use fully redundant data communications between its control center systems and ERCOT systems such that any single element of the communication system can fail and:
  - For server failures, complete information must be re-established within five minutes by automatic failover to alternate server(s).
ERCOT Request for telemetry

• ERCOT is required to protect transmission assets operated at 60 kV or above from damage. To do this, ERCOT may request that additional MW, MVAR, and voltage telemetry be installed, while attempting to minimize adding equipment to as few locations as practicable.

• ERCOT may request additional telemetry when it determines that network observability or the measurement redundancy is not adequate to produce acceptable state estimator results.

• Prior to making a request for additional telemetry, ERCOT will provide evidence supporting a congestion or reliability problem requiring additional observability and, define expected improvements in system observability needed. If the request is for telemetry additions at more than one location, ERCOT will prioritize the requested additions.
ERCOT Request for telemetry (contd)

• Upon receipt of a request for additional telemetry, the TDSP or QSE will have sixty (60) days to either:

  ➢ Accept ERCOT’s request for additional telemetry, provide the telemetry within 18 months and notify ERCOT of the implementation schedule;
  ➢ Provide an alternative proposal to ERCOT, for implementation within the next 18 months, which meets the requirements described by ERCOT;
  ➢ Propose a normal topology change (change normal status of switch(es)) in the area which would eliminate the security violations which are ERCOT’s concern. (i.e. eliminates the possibility of flow through a networked element and turns the security problem into a planning problem which is un-affected by unit dispatch);
  ➢ If ERCOT rejects the alternate solution, the TSP or QSE may appeal the original request to TAC within 30 days. If, after receiving an appeal, TAC does not resolve the appeal within 65 days, the TSP or QSE may present its appeal to the ERCOT Board. Indicate that the requested telemetry point is at a location where the TDSP or QSE does not have the authority to install the requested telemetry. For points on privately owned facilities connected to the ERCOT Transmission Grid, an attempt will be made to facilitate ERCOT's telemetry request; or
  ➢ File a request with the PUCT requesting expedited action for an Order directing that the responsibility for reliability and protection of this specific element or elements of the transmission system be withdrawn from ERCOT and assigned to the requesting TDSP. ERCOT will then immediately remove the elements from its Real Time Congestion Management system as monitored elements pending the PUCT decision.
ERCOT Request for telemetry (contd)

- If ERCOT has not received acknowledgement that a request has been received within thirty (30) days of its sending, ERCOT will contact the TDSP or QSE for verification of receipt.
ERCOT Request for redundant telemetry

- ERCOT will maintain redundancy on monitored non-Load substations to achieve an N-1 observability measure.
- ERCOT will identify and produce a list of telemetry points in the ERCOT system that are required to maintain the N-1 observability measure on monitored non-Load substations.
- This list will be published annually. ERCOT will use this list to identify telemetry points whose loss will result in:
  - Inability of ERCOT to monitor loading on a transmission line operated at 345 kV or above.
  - Inability of ERCOT to monitor loading on a 345/138 kV autotransformer.
  - Inability of ERCOT to monitor loading on transmission facilities designated as important to transmission reliability by ERCOT. A list of these facilities will be published annually.
- ERCOT will maintain redundancy on monitored non-Load substations to achieve an N-1 observability measure.
ERCOT Request for redundant telemetry (Contd)

• ERCOT may request additional MW, MVAR and voltage telemetry to make these measurements redundant.
• In this request, ERCOT will identify these points, and the contingency/overload condition and the unit dispatch which makes this a possible concern.
• If the request is for telemetry at multiple locations, ERCOT will prioritize the requested additions.
• Upon receipt of a request for additional telemetry, a TDSP or QSE has sixty (60) days to:
  ➢ Provide ERCOT with a schedule of equipment installations within the next eighteen (18) months which will provide the proposed telemetry;
  ➢ Propose an alternative solution which will serve the same purpose as the ERCOT identified telemetry additions with a proposed implementation within 18 months;
  ➢ In cases where the request is based on the availability rate of an existing telemetry point, the TDSP or QSE will provide a plan to improve the availability rate of the identified telemetry to an acceptable level, or provide documentation for why this cannot be accomplished;
  ➢ If ERCOT rejects the alternate solution, the TSP or QSE may appeal the original request to TAC within 30 days. If, after receiving an appeal, TAC does not resolve the appeal within 65 days, the TSP or QSE may present its appeal to the ERCOT Board.
  ➢ Identify and propose a schedule of equipment installations within the next 18 months which would, as a result, change the classification of the transmission element identified by ERCOT; or
  ➢ Indicate that the facility that telemetry is being requested is not owned or covered by an interconnect agreement that allows the requested party to install the additional telemetry.
ERCOT Request for redundant telemetry (Contd)

• If ERCOT does not have knowledge that a request has been received within thirty (30) days of its sending, ERCOT will contact the TDSP or QSE for verification of receipt.

Telemetry Standards Revision Process

• Revisions to the Telemetry Standards shall be made according to the approval process as prescribed in Protocol Section 3.10.7.5
## ERCOT

### State Estimator Convergence Rate

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Wednesday, March 31, 2010

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# ERCOT

## MW Residuals vs Telemetry for Major Transmission Elements

**Monthly by Market Participant**

**March, 2010**

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### ERCOT

#### Buses Not Meeting Telemetry Standards

Monthly by Market Participant

March, 2010

**TSP1**

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**TSP2**

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Tools to help SE Performance

SE Statistics

ERCOT ANA State Estimator Assessment Tool (ESAT)

Topology Coherency Analyzer
State Estimator Statistics (SE STATS)

- Tool developed in-house at ERCOT
- Monitors SE performance and metrics, aids in identifying possible topology errors.
- Measures performance on several metrics.
State Estimator Statistics (Contd.)

- **Measurement Quality**

- **Dead Equipment with Active Measurements**
  Tracks discrepancies between equipment status and analog telemetry values
State Estimator Statistics (Contd.)

• Estimates Quality
State Estimator Statistics (Contd.)

• Tracks Residuals
State Estimator Statistics (Contd.)

• Illustrations

Branch Status Error

A branch in the SE model can be a transmission line, transformer, or zero-impedance branch (ZBR)
State Estimator Statistics (Contd.)

- Injection Status Error

An injection could be a generator or load
SESTATS also detects a discrepancy between CB status and existing analog measurements assigned to the CB.
Detecting Topology Errors via SE Results

• Limitation of SESTATS
  - Requires available measurements on the elements
  - Cannot identify complicated errors

• Topology errors lead to measurement residuals
  - Topology errors, like bad telemetry values, usually cause large measurement residuals around the locations of errors in SE results.
  - Bus mismatch is also a good indicator of the existence of topology errors.
Detecting Topology Errors via SE Results

- Detecting and identifying the wrong branch status using SE results
Detecting Topology Errors via SE Results

• Detecting and identifying the bus splitting/merging issue via SE result
Detecting Topology Errors via SE Results

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Detecting Topology Errors via SE Results

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Detecting Topology Errors via SE Results

- Detecting and identifying the bus splitting/merging issue via SE result
Detecting Topology Errors via SE Results

- Detecting and identifying wrong connectivity via SE result
Detecting Topology Errors via SE Results

- Detecting and identifying the bus splitting/merging issue via SE result
Detecting Topology Errors via SE Results

• Detecting and identifying the bus splitting/merging issue via SE result
Detecting Topology Errors via SE Results

- Detecting and identifying line/transformer impedance

- Detecting and identifying shunt device parameters
Tools to help SE Performance

SE Statistics

ERCOT ANA State Estimator Assessment Tool (ESAT)

Topology Coherency Analyzer
• Dashboard to monitor the SE health
  - Performance, Accuracy, Issues

• Alert System - sends emails and text messages to cell-phones

• Tool for Operations Engineers to take a proactive approach to address SE issues
ERCOT ANA State Estimator Assessment Tool - (ESAT)

SE Last Run: 26-05-2010 13:34:09 d
Current Time: 26-05-2010 13:36:18 d

SE Solution: INVALID
SE Solution: SOLVD W. MISMTCH

General
Gen: 48405.20 MW
DC Flow: -336.50 MW
Load: 48741.70 MW
Wind: 820.67 MW
Freq: 59.99 Hz

Information

SE States (TRUE = 1, FALSE = 0)

Valid SE Solution

Tolerable Mismatch (P/Q/Error Cost)

Valid Solution (Voltage Conv.)

P/Q/Error Cost Mismatch Violations

Maximum Bus Mismatch

Maximum Measurement Residuals

Total Islands: 1
Voltage Violations: 40
Branch Violations: 0
Unsolved Contingencies: 0
Dead Units: 0
Dead Lines: 6
Redundancy Index: 1.79
Total Buses: 6414
Total Dead Buses: 596
Units Obs. %: 94.6
Loads Obs. %: 96.7
Bus Obs. %: 100.0

Total Cost Index: 76450

Maximum Bus Measurement Mismatch

Load 25.1 16.3
Line -82.2 132.5
Unit 9.3 16.3
Transformer 162.2 184.8
ZBR 18.1 20.7
Bus KV Meas Residual -0.2

52
ERCOT ANA State Estimator Assessment Tool - (ESAT)

Total Islands: 1
Voltage Violations: 50
Branch Violations: 0
Unsolved Contingencies: 1
Dead Units: 0
Dead Lines: 6
Redundancy Index: 1.79
Total Buses: 6419
Total Dead Buses: 600
Units Obs. %: 94.0
Loads Obs. %: 96.9
Bus Obs. %: 100.0

SE Solution: [Image]
SE Last Run: 25-05-2010 14:56:11 d
Current time: 25-05-2010 14:58:26 d

SE States (TRUE = 1, FALSE = 0)

Valid SE Solution

Tolerable Mismatch (P/O/Error Cost Violations)

Valid Solution (Voltage Conv.)
P/O/Error Cost Mismatch Violations

Valid Solution (Weight Conv.)

SE Manual Trigger?

Total Cost Index: 69613

Maximum Bus Mismatch
6.7 MW 0.6 MVAR

Maximum Bus Measurement Mismatch
330.2 MW 163.9 MVAR

Maximum Measurement Residuals
344.4 MW 199.1 MVAR

General
Gen: 47377.11 MW DC Flow: 55.63 MW
Information
Load: 47321.48 MW Wind: 1427.65 MW Freq: 60.02 HZ

 ERCOT Total Wind Generation
Telemetered Total Gen. Erct Total Load ERCOT Total Wind Generation

Load
Real
21.9
-17.0

Line
-344.4
-169.2

Unit
11.7
-13.7

Transformer
211.1
-199.1

ZBR
-15.7
22.0

Bus KV Meas Residual
-0.2
ERCOT ANA State Estimator Assessment Tool - (ESAT)

General
- Gen: 49405.20 MW
- DC Flow: -336.50 MW

Load: 48741.70 MW
- Wind: 820.67 MW
- Freq: 59.99 Hz

SE Solution:
- SE Last Run: 26-05-2010 13:34:09
- Current time: 26-05-2010 13:36:18

SE States (TRUE = 1, FALSE = 0)
- Valid SE Solution
- Tolerable Mismatch (P/Q/Error Cost)?
- Valid Solution (Voltage Conv.)
- P/Q/Error Cost Mismatch Violations
- SE Manual Trigger?

SE Manual Trigger?
- Total Islands: 1
- Voltage Violations: 40
- Branch Violations: 0
- Unsolved Contingencies: 0
- Dead Units: 0
- Dead Lines: 6
- Redundancy Index: 1.79
- Total Buses: 6414
- Total Dead Buses: 596
- Units Obs. %: 94.6
- Loads Obs. %: 96.7
- Bus Obs. %: 100.0

Total Cost Index: 76450

Maximum Bus Mismatch
- -6.0 MW
- 0.7 MVAR

Maximum Measurement Residuals
- 162.2 MW
- 184.8 MVAR

Maximum Bus Measurement Mismatch
- 81.1 MW
- 114.1 MVAR

Load
- Real: 26.1
- Reactive: 16.3

Line
- Real: -82.2
- Reactive: 132.5

Unit
- Real: 9.3
- Reactive: 16.3

Transformer
- Real: 162.2
- Reactive: 184.8

ZBR
- Real: 18.1
- Reactive: 20.7

Bus KV Meas Residual
- Reactive: -0.2
ERCOT ANA State Estimator Assessment

SE Solution: 26-05-2010 13:35
SE Last Run: 26-05-2010 13:35
Current time: 26-05-2010 13:35

SE States (TRUE = 1, FALSE = 0)

SE Manual Trigger?

Valid Solution (Voltage Conv.)

Valid Solution (Weight Conv.)

P/O/Error Cost Mismatch Violations

Tolerable Mismatch (P/O/Error)

Bus Mismatch MW: +/- 30 MW
Bus Mismatch MVAR: +/- 30 MVAR
Solution Cost Index: 999990
Measurement Residual MW: +/- 300 MW
Measurement Residual MVAR: +/- 300 MVAR
Number of Islands: 1
Number of Branch Violations: 0
Number of Voltage Violations: 50
Number of Unsolved Contingencies: 0

Total Islands: 1
Voltage Violations: 40
Branch Violations: 0
Unsolved Contingencies: 0
Dead Units: 0
Dead Lines: 6
Redundancy Index: 1.79
Total Buses: 6414
Total Dead Buses: 596
Units Obs. %: 94.6
Loads Obs. %: 96.7
Bus Obs. %: 100.0

Total Cost Index: 76450

Maximum Bus Mismatch:
-6.0 MW 0.7 MVAR

Maximum Measurement Residuals:

Maximum Bus Measurement Mismatch:
81.1 MW 114.1 MVAR

Load Real:
-25.1 16.3
Line Real:
-82.2 132.5
Unit Real:
9.3 16.3
Transformer Real:
162.2 184.8
ZEB Real:
18.1 20.7
Bus KV Meas Residual Real:
-0.2

Freq: 59.99 Hz
ESAT (Contd.)

• E-mail Alert

---

Sample E-mail Alert:

From: E-Mail Hoster; ECCT-Operator Support Team
To: ECCT-Operator Support Team
Subject: ISSUED Alarm: Alarm

Original text of the incoming message:

Date: 12:00 AM

Message text:

To the ECCT Operator Support Team:

An ALARM has been issued at 12:00 AM on [Date].

The affected issue is [Issue Description].

Please take appropriate action.

Sincerely,

[Operator Name]
Tools to help SE Performance

SE Statistics

ERCOT ANA State Estimator Assessment Tool (ESAT)

Topology Coherency Analyzer
Topology Consistency Analyzer

• Helps to identify topology inconsistencies
Topology Consistency Analyzer (Contd.)

Station Tabular

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Validation of violations

- Basecase violations
  - Flow Based on State Estimation value
  - SCADA value of the flow

- Contingency violations
  - Basecase (pre-contingency) Flow Based on State Estimation value
  - SCADA value of the flow
Summary

• SE Performance Standards for ERCOT

• Telemetry Standards

• Tools to help SE Performance
  - SE Statistics
  - ERCOT ANA State Estimator Assessment Tool (ESAT)
  - Topology Consistency Analyzer
References

Questions?
Thank U !!

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(Sarma.Nuthalapati@ercot.com)