Wind Integration: ERCOT Experience

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ERCOT System Planning

8th CARNEGIE MELLON CONFERENCE ON THE ELECTRICITY INDUSTRY, March 13-14
Outlines

• ERCOT Quick Facts

• Competitive Renewable Energy Zone (CREZ) project

• Wind Generation Resource (WGR) Protocol Requirement:
  – Voltage, Frequency

• Tools
  – Wind Day-Ahead Forecast and Ramp Forecast Tool
  – ERCOT Reliability Assessment Tool
  – Market Analysis Interface Tool
  – Inertial Frequency Response Estimator Tool

• Challenges
  – Weak Grid
  – Sub-synchronous Control Interaction
Quick Facts

- **Electric Reliability Council of Texas – the ERCOT grid:**
  - Covers 75% of Texas land
  - Serves 85% of Texas load
  - >40,000 miles of transmission lines
  - >550 generation units

- **Wind Integration**
  - Wind capacity: ~9,800 MW
  - Most in the nation and fifth highest in the world
  - Includes about 2,000 MW in coastal area
  - Wind generation record: 7,400 MW (Oct. 7, 2011), 15.2 percent of load at the time

ERCOT connections to other grids are limited to direct current (DC) ties, which allow control over flow of electricity.
Wind Capacity Installed by Year and Locations

The data presented here is based upon the latest registration data provided to ERCOT by the resource owners and can change without notice. Any capacity changes will be reflected in current and subsequent years’ totals. Scheduling delays will also be reflected in the planned projects as that information is received.

This chart now reflects planned units in calendar year of installation rather than installation by peak of year shown.
CREZ System Characteristics

- To accommodate additional 10GW wind generation in the near future.
- Deliver wind power from remote region to the load centers through long extra high voltage transmission lines.
- Located at remote region, far away from synchronized generators and load.
- Significant power electronic devices to provide system support.
- Weak Grid
  - Low short circuit ratio (SCR)
  - Voltage will not be stiff, challenge for voltage control (steady state and dynamic)
  - System performance is dominated by high wind/low wind, not summer peak/winter off-peak
Voltage and Frequency Requirement

- Wind Generation Resources (WGRs) are required to provide +/- 0.95 pf reactive support to the system at Point of Interconnection (POI).

- Voltage control at weak grid (areas without conventional units) can result in unstable response.

- Multiple WGRs connected to the same POI may also result in unstable response (hunting).

- Increasing WGRs can replace the conventional units and results in less frequency support (governor and inertia support).

- WGRs are required to provide primary frequency response.
WGR Primary Frequency Response: actual measurement

12/19/2011

PU at B  2.00  RRSC
PU at B +30  2.00  MAV Spinning Available  0.00

Low Load

HSL  145.49

Poor/No Frequency Response

Hz  Total Generation  Expected Generation  UDBP
WGR Primary Frequency Response: actual measurement

Good Frequency Response
Wind Forecast

Web-based application available to System Operators to visualize, on a system-wide or an individual resource basis, the Short Term Wind Power Forecast (STWPF; 50% probability of exceedance) and the Wind Generation Resource Power Potential (WGRPP; 80% probability of exceedance)
Wind Ramp Forecast

Probabilities of system-wide 180-min ramp events. Example, there is a 30% chance of a 2000-MW Up ramp occurring over 180-minutes and starting at 17:45.
Inertia response decline and tool to estimate real time inertia response

Data set I: event before 2008 (less wind installed capacity)
Date set II: events after 2008 (more wind installed capacity)
• ERAT is intended to show Operators when there is potentially high risk of a loss-of-load event (both on a Hour-Ahead and Day-Ahead basis)

• The risk is assessed considering Wind and Load forecast errors and potential forced outages of planned online generation
## Market Analysis Interface:

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Challenges: Weak Grid Condition

- **Low Wind Output**
- **High Wind Output**

![Diagram showing bus connections and voltage levels](image)

- **WGR**
- **Point Of Interconnection**
- **ERCOT**

**Voltage Levels**:
- 0.69kV
- 34.5kV
- 34.5kV
- 69kV
- 69kV

PMU (Phasor Measurement Unit)
Sub-synchronous Control Interaction: October 2009 SSCI Event

1. Single Line to ground fault
2. Open the line breaker to clear the fault in 2.5 cycles
3. Wind farms are radial connected to series cap 345 kV line
4. SSCI occurs
5. After 200ms (12 cycles), system voltage exceeded 1.5pu (520 kV) and wind turbines damage occurred.
6. Voltage continued to raise to ~2pu and series cap damage occurred.
7. Series cap was bypassed and oscillation was finally damped out after 1.5 seconds.

Figure 2: Oscillography Recorded at Wind System A during the Event.
Thanks for your time!

Questions?

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