Wind Challenges & Integration Actions

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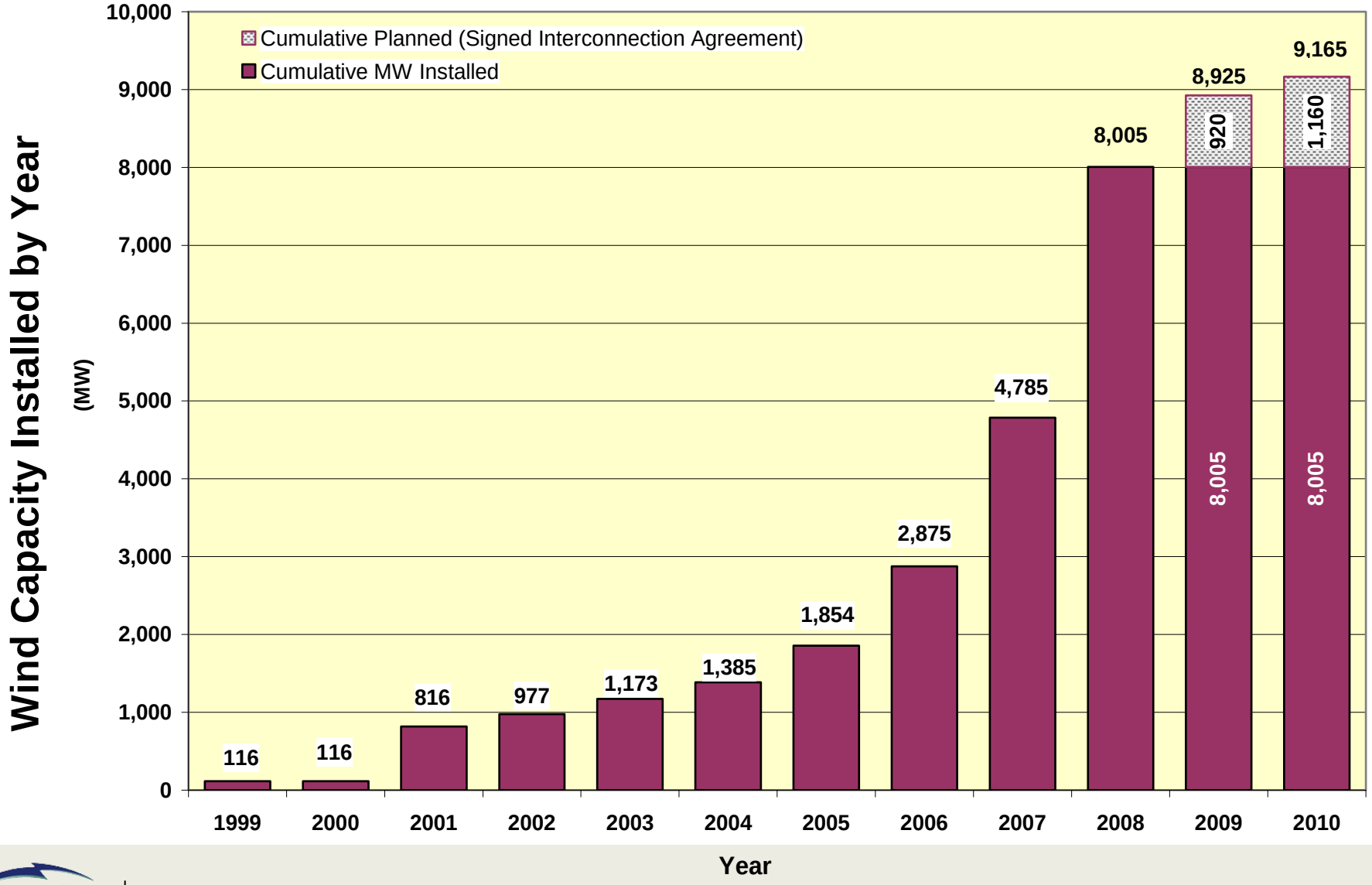
ERCOT Wind Capacity



(as of December 31, 2008)

Increased Challenges presented by Wind

- **Scheduling sufficient generation resources to meet demand.**
- **Maintaining adequate dynamic reactive power capability to respond to voltage events.**
- **Frequency control.**
  - Depletion of Regulation Reserves
  - Ramp rates
  - System inertia
  - CPS1 compliance
- **Low Voltage Ride-through.**

How Wind Resources Increase Challenges

- **Scheduling sufficient generation resources to meet demand.**
  - Wind resources can neither store, nor schedule their primary energy source.
  - Any energy schedule for a wind resource is a forecast; with associated uncertainty much, much higher than the uncertainty associated with a scheduled thermal generation unit.
  - This uncertainty must be covered by reserves from controllable units or loads

How Wind Resources Increase Challenges

- **Maintaining adequate dynamic reactive power capability to control voltage.**
  - Conventional synchronous generating units utilize a fairly standardized Automatic Voltage Regulator technology to provide voltage control automatically
  - Older (Inductive) wind units have to provide reactive with external switching devices while new (asynchronous) wind units can provide reactive capability through internal power electronics.

How Wind Resources Increase Challenges

- **Frequency Control – Regulation depletion**
  - With a variable energy source; wind units vary in output.
  - In current Zonal operation, ERCOT operators must determine the need for controllable generation (Balancing Energy) 30 minutes ahead of need.
  - With the increased amount of variable wind resources the possibility of missing the forecast need for Balancing Energy and running out of Regulation Reserves to control frequency is higher.

How Wind Resources Increase Challenges

- **Frequency Control – Ramp rates and interaction with congestion management**
  - Wind units in ERCOT are concentrated in west Texas and transmission congestion occurs due to this concentration.
  - When congestion is encountered and units are dispatched to decrease output and subsequently released from that dispatch, the units tend to move at the same time.
  - Many of these units are capable of going between full load and zero in 30 seconds; much faster than conventional units providing frequency regulation.

How Wind Resources Increase Challenges

- **Frequency Control - Increased wind penetration reduces inertia on grid**
  - Wind generators contribute less spinning mass synchronously linked to the transmission grid than conventional units.
  - With reduced grid inertia, small disturbances result in greater frequency response making frequency control more difficult.
  - Affects NERC CPS1 scores

Sensitivity of CPS1 Performance to Wind

Month	Possible Change of CPS1 Score % per 1000 MW of increase in Average Wind Generation
January	-5.25 %
February	-4.31 %
March	-5.28 %
April	-5.39 %
May	-4.00 %
June	-1.28 %
July	-1.21 %
August	-1.22 %
September	-1.20 %
October	-3.33 %
November	-5.40 %
December	-4.86 %

How Wind Resources Increase Challenges

- **Low Voltage Ride-through.**
  - Technologies in wind generators have varying capabilities for remaining online through brief dips in transmission voltage.
  - Such dips are rare, but can be wide-spread across the transmission network in the event of a severe (3 phase) transmission line fault.
  - Without low voltage ride-through, many wind generators could trip simultaneously, increasing system generation lost for a single contingency

ERCOT Strategic Initiatives

Scheduling sufficient generation resources to meet demand.	**•Substitute ERCOT wind forecast for participant estimates in operations planning (Done – PRR 763)** **•Improve Wind Forecast (In Progress, e.g. PRR 794)** **•Revise Non-spinning reserve requirements to mitigate risks. (Done – 11/1/2008)** **•Develop new scheduling metrics for wind generators (PRR 793 in progress)** **•Train Operators on Operator Training Simulator for high wind variation scenarios (In Progress)** **•Create risk assessment tool which assesses risk of varying wind/load/outages and advises operator when mitigation required (In Progress)** **•Add risk advisory to current wind forecast service (In Progress)** **•Future – Nodal RUC will incorporate ERCOT wind forecast**

ERCOT Strategic Initiatives

Maintaining adequate dynamic reactive capability to respond to control voltage.	**•Survey all wind resources to establish capacities and model in EMS and planning studies (In Progress)** **•Clarify protocol requirements for dynamic reactive control. (In Progress)** **•Perform dynamic reactive studies in wind regions. (In Startup)** **• Install measurement system and use phasor measurements to validate dynamic studies.**
Frequency Control	**•Evaluate sensitivity of CPS1 measurement to increasing wind penetration.** **•Implement ramp rate limits for wind control (In progress, PRR 771 was first step, PRR 788 is pending** **•Future** –Nodal SCED will run every 5 minutes –CREZ projects will reduce congestion management actions

ERCOT Strategic Initiatives

Low Voltage Ride-through.	**•OGRR to require low voltage ride through for all new units (Done, OGRR 208)** **•Perform studies to determine if existing units need to implement low-voltage ride-through (In progress, RFP issued)**

Other Initiatives

- **Commissioned an Ancillary Service study in conjunction with CREZ docket**
- **Supporting the Wind Operations Task Force and Renewable Technologies Work Group**
- **Exploring additional forecasting tools with AWS Truewind**
  - Develop a ramp forecast
  - Improve operator situational awareness
- **Developing a risk based reliability assessment tool**
  - Considers unit forced outages
  - Considers wind & load forecast accuracy.
- **Developing High Wind Generation Scenarios for the Operator Training Simulator**
- **Expanding Voltage Security Assessment Tool monitoring to include West Texas**
- **Gearing up to perform Low Voltage Ride-through dynamic fault analysis and steady state voltage support analysis**