



Fast Acting Energy Storage Solutions for ERCOT











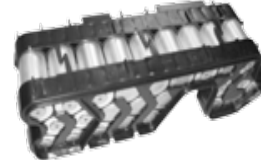

ERCOT Power Storage Working Group
October 1, 2010

Presentation Outline: Fast Acting Energy Storage

- A123 Systems background info
- Framing the opportunity
- Comparison of fast acting and long duration storage
- Comparisons of fast storage and thermal generation
- Applications
- ERCOT need for short duration product
- Barriers to adoption
- ERCOT's storage friendly attributes

A123 Designs and Manufacturers Advanced Energy Storage Systems

Sharing innovation across three market segments

Transportation	Electric Grid	Consumer & Industrial
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Hybrids, Plug-In Hybrids and Electric Vehicles</p>  <p>▼</p>  </div> <div style="text-align: center;"> <p>Heavy-Duty Hybrids</p>  <p>▼</p>  </div> </div>	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Power Plant Hybridization & Frequency Regulation</p>  <p>▼</p>  </div> <div style="text-align: center;"> <p>Network Energy Storage</p>  <p>▼</p>  </div> </div>	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Portable Power</p>  <p>▼</p>  </div> <div style="text-align: center;"> <p>Industrial</p>  <p>▼</p>  </div> </div>
<ul style="list-style-type: none"> + Fuel economy + Reduced emissions + Energy independence + Lighter-weight components + Fuel efficiency 	<ul style="list-style-type: none"> + Increase grid reliability + Enable Wind and Solar Integration + Increase plant efficiency/utilization 	<ul style="list-style-type: none"> + Improve performance + Reduce emissions + Reduce toxic battery chemicals
<p>Drivers</p>		

Global Operations

Corporate Headquarters and R&D: Watertown, Massachusetts

- + 1700+ employees in multiple locations worldwide
- + >400,000 square feet of manufacturing facilities in Massachusetts, China, and Korea

Corporate Headquarters, Research and Development

- Watertown, Massachusetts: Automotive and Grid systems assembly

Systems Design and Manufacturing

- Hopkinton, Massachusetts: Automotive and Grid systems assembly
- Novi, Michigan: Automotive system design and assembly

Controls System Software

- Chesterfield (St. Louis) Missouri: Energy Solutions Group

Materials Research

- Ann Arbor, Michigan
- ### Powder, Coating, and Cell Plants

- Incheon, Korea
- Changzhou, China
- Changchun, China
- Zhenjiang, China

Supplier Quality

- Shanghai, China



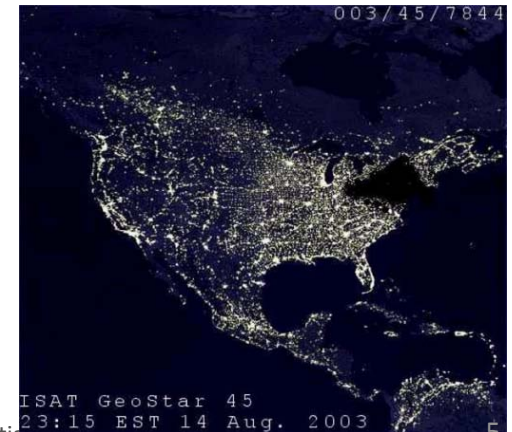
The Grid Challenge

- Reduce green house gas emissions
 - + Clean Air Act
 - + Meet Renewable Portfolio Standards (RPS)
 - + Improve efficiency of existing plants



- Increase the proportion of variable renewable energy resources
 - + Intermittent renewable generation challenges the ability to balance supply and demand on the grid
 - + Traditional solutions (Gas Turbine Generators) offset advantage of renewables

- Maintain and improve grid reliability
 - + Prevent threat of blackouts
 - + While improving asset utilization



A123 Systems Grid Storage Applications



**A123 Systems SGSSs™ installed on the grid, Chile
12MW performing grid stabilization services**



Photo courtesy of

ERCOT PSWG

- Direction from last meeting
 - + Address fast acting storage separate from long duration
 - + Comparison to thermal generator delivers power quality
- Our solution must live within the new ERCOT environment
 - + The nodal market is effectively here today.
 - + Impact of increased renewables with CREZ.
- We can learn from others
CAISO, ISO NE, PJM, NYISO
- Take a step back
 - + Open exploration – How is storage uniquely suited to serve ERCOT
 - + This is Texas – We can do it our way.

Fast Acting vs. Long Duration Storage Solutions

High Power

High Energy



- | | |
|---|---|
| <ul style="list-style-type: none"> • Applications: <ul style="list-style-type: none"> + Area Regulation + Reserve + Renewable Ramping, Enabling Access to Full Energy Value + Back Up Power • Very high Charge/Discharge Rates • Short Duration (<1hr) • Many cycles (100s per day) • Continuous use | <ul style="list-style-type: none"> • Applications: <ul style="list-style-type: none"> + Peak Shifting + Renewable time shifting, Adding Incremental Energy Value + Renewable Curtailment Recovery + Arbitrage + T&D Asset Deferral • Low Charge/Discharge Rates • Long Duration (2-8 hrs) • 1-2 cycles per day • Less frequent use |
|---|---|

Comparison to Thermal Generation

Fast Storage

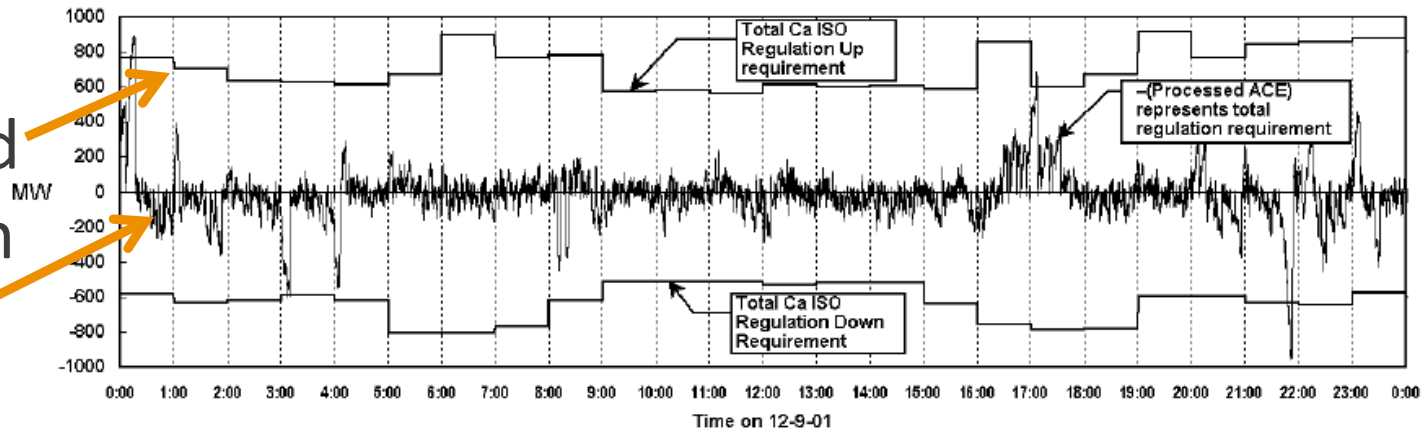
- Limited duration
- Sub cycle response
- Portable, scalable
- Power factor correction DVARs
- Black start/Islanding
- High cycle capabilities

Thermal Generation

- Unlimited duration
- 15 minute response
- Large scale fixed location
- Governor response
- Low cost for continuous operation
- High startup and cycling costs

Rapid Cycling Fits Frequency Regulation

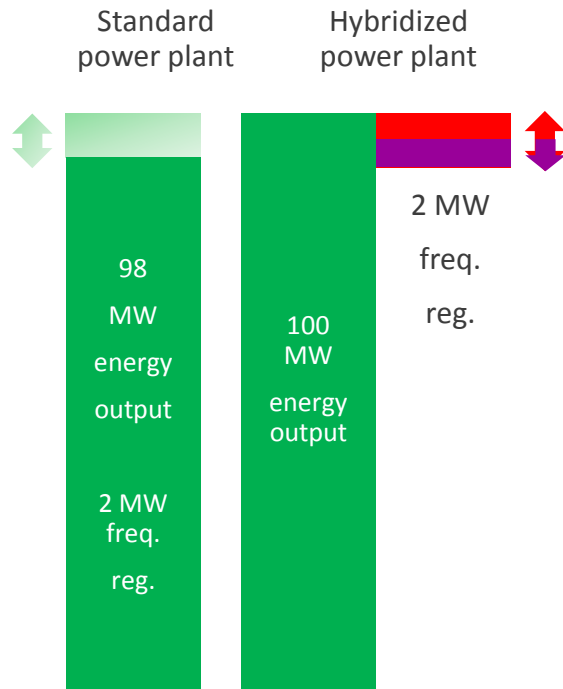
Capacity sold
is larger than
AGC/actual
utilization



Market Based Regulation

The Problem:

- Thermal plants providing regulation operate less efficiently, have increased O&M costs and worse emissions

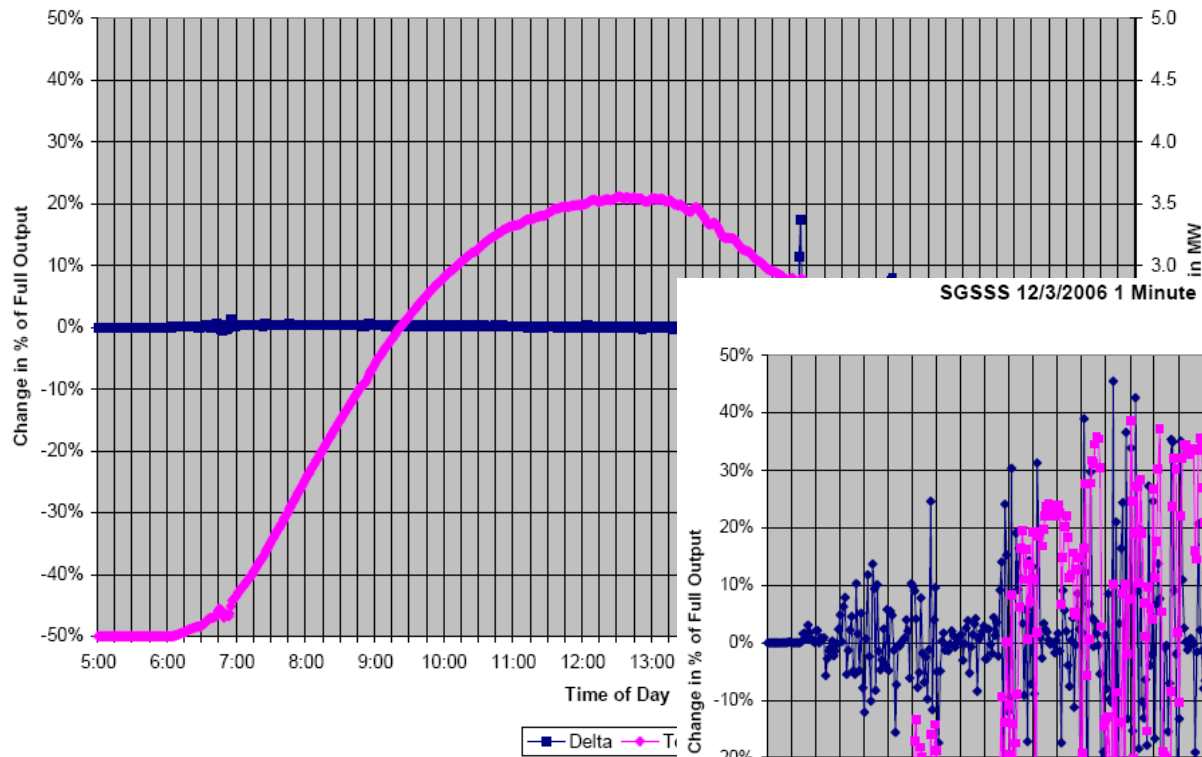


The Solution:

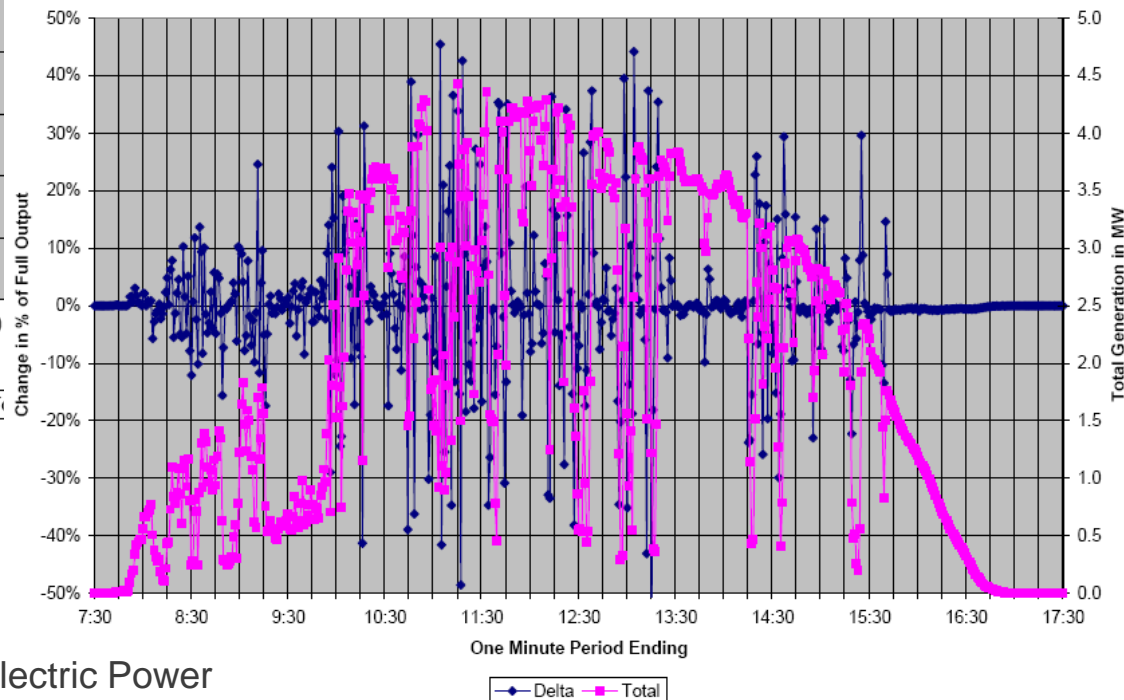
- Free up assets for additional generation
- Reduce natural gas consumption
- Reduce maintenance cost
- Improve emissions by >50%

PV Challenge and Opportunity: Periodic Intermittency, Smoothing and Extra Services

SGSSS 08/11/2004 1 Minute Power Changes for the Full System



SGSSS 12/3/2006 1 Minute Power Changes for the Full System

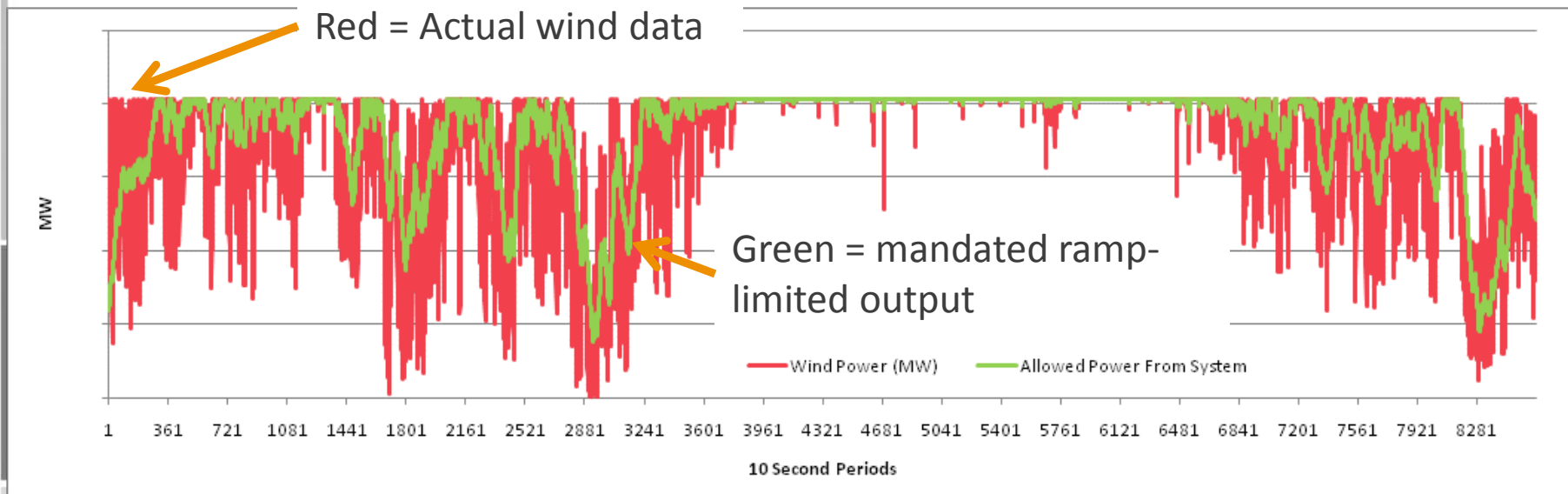


Source: Tucson Electric Power

Case Study 3: Wind Ramp Management for Interconnection

The Problem:

- Wind and PV plants intermittent output challenges utility's ability to balance supply and demand. Interconnection approval requires ramp mgmt.

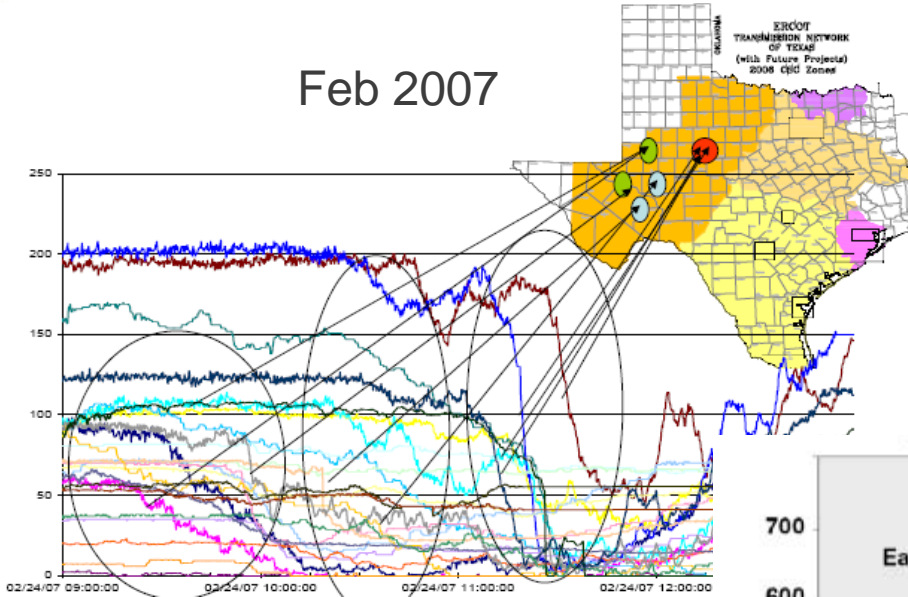


The Solution:

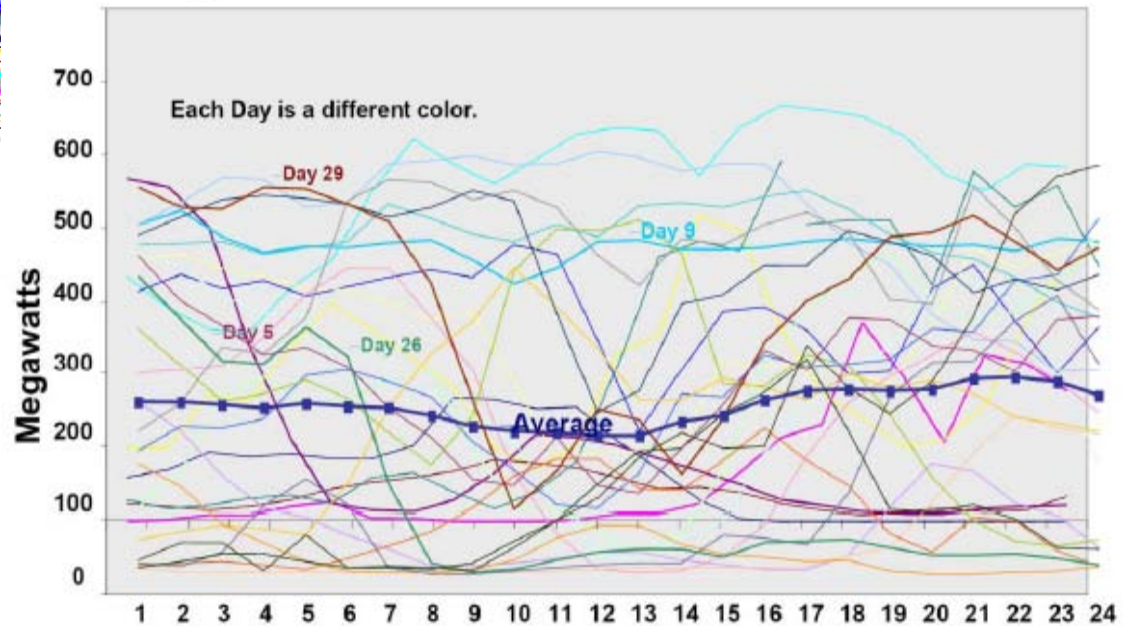
- Adding a right-sized “power battery” enables wind plant to cost effectively conform to utility ramp rate requirements. Interconnection approval is a critical path precursor to delivering wind developer's energy into a very high-value market

Wind Challenge and Opportunity: Persistent Intermittency Needs Smoothing And Shifting

Feb 2007



CAISO Wind Production (Tehachapi)

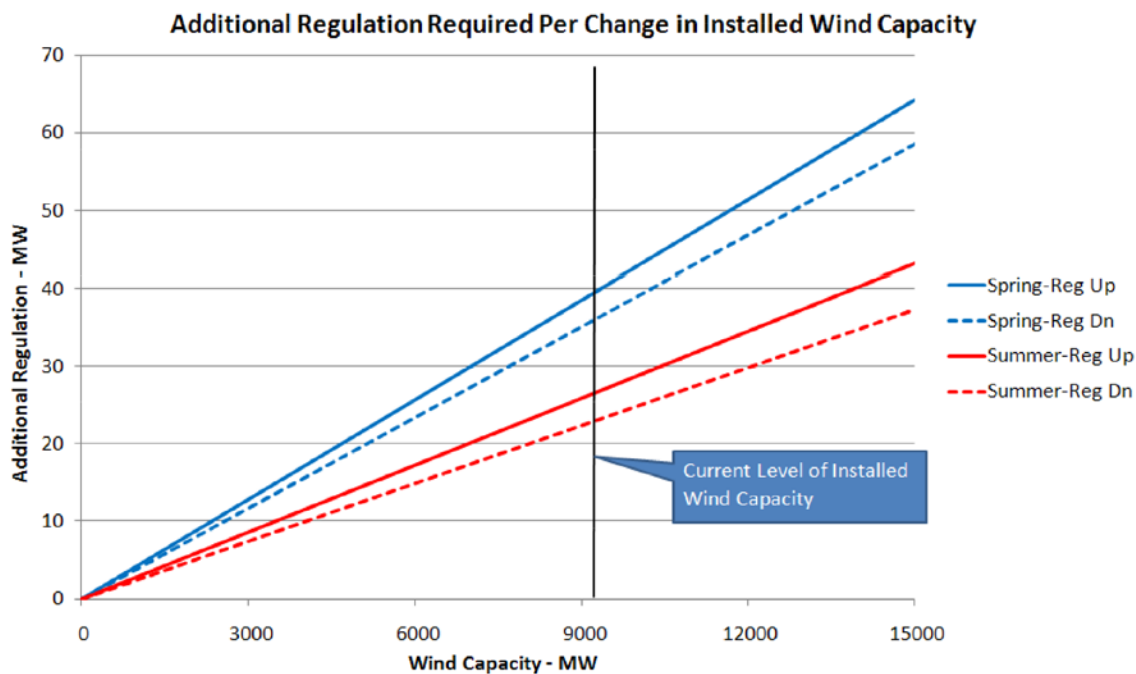


Overspeed Wind Shutdown

ERCOT Need for Fast Service

TAC Update, April 8, 2010

GE Study for Regulation Service Assuming 5-minute Nodal Dispatch



- *“Wind Generation does increase the amount of Regulation Reserve requirements.”*

Barriers to a Fast Service

- Market protocols embedded with assumptions for traditional generators
- Types of obstacles:
 - + Barriers by Omission
 - + Barriers by Married Requirement
 - + Missed Opportunity Barriers

Barriers by Omission

ERCOT Nodal Protocols 3.17.2

- *“Responsive Reserve Service (RRS) may be provided by:

 - + (a) Unloaded, On-Line **Generation Resource** capacity;
 - + (b) **Load** Resources controlled by high-set, under-frequency relays;
 - + (c) **Controllable Load** Resources;
 - + (d) **Load** Resources capable of controllably reducing or increasing consumption under dispatch control (similar to Automatic Generation Control (AGC)) and that immediately respond proportionally to frequency changes (similar to generator governor action);
 - + (e) **Hydro Responsive Reserves** as defined in the Operating Guides; and
 - + (f) **Direct Current Tie (DC Tie)** response that stops frequency decay as defined in the Operating Guides.”*
- Storage not explicitly excluded, yet no exact fit
- Solution: Define eligibility by ability instead of type

Barriers by Married Requirement

ERCOT Nodal Protocols 8.1.1.2

- *“General Capacity Testing Requirements*
 - + *Once the designated Generation Resource reaches its HSL, the QSE shall hold it at that output level for a minimum of 30 minutes.”*
- The High Sustained Limit is a factor in the quantity of ancillary services that may be offered into the market
- Implicit married requirement: resources that provide responsive reserve (order of seconds to minutes) must also provide 30 minutes of energy
- Solution: Separate fast response from energy provision

Missed Opportunity Barriers

ERCOT Nodal Protocols 8.1.1.2.1

- *“Ancillary Service Technical Requirements and Qualification Criteria and Test Methods*
 - + *Resources providing Reg-Up or Reg-Down must be capable of delivering the full amount of regulating capacity offered to ERCOT within five minutes.*
 - + *ERCOT shall maintain a duration interval, for each increasing ramp, hold, or decreasing ramp sequence, of no less than two minutes.”*
- ERCOT could obtain faster response with appropriate scaling incentives
- Storage can respond in sub-seconds but has little incentive
- Solution: reward faster performance

Storage-Friendly Attributes

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- “The minimum amount per Resource for each Ancillary Service product that may be offered is one-tenth (0.1) MW.”
- Competitive and open generation market
- No federal-state divide: less uncertainty over functionalities that cross across jurisdictional boundaries



Thank You