Wind Integration in the West: Western Wind and Solar Integration Study

JOINT CCPG-SWAT-SIERRA Meeting

Michael Milligan
NREL
Aug 20, 2008

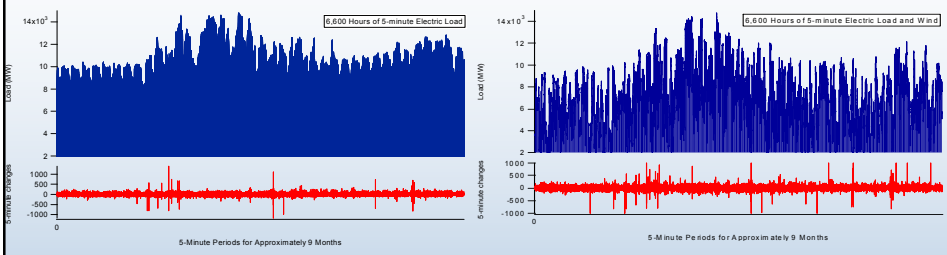
Overview of Presentation

- Challenges (and some potential solutions) to large-scale wind integration
- Western Wind and Solar Integration Study status

Key Challenges for Wind Integration at High Penetration

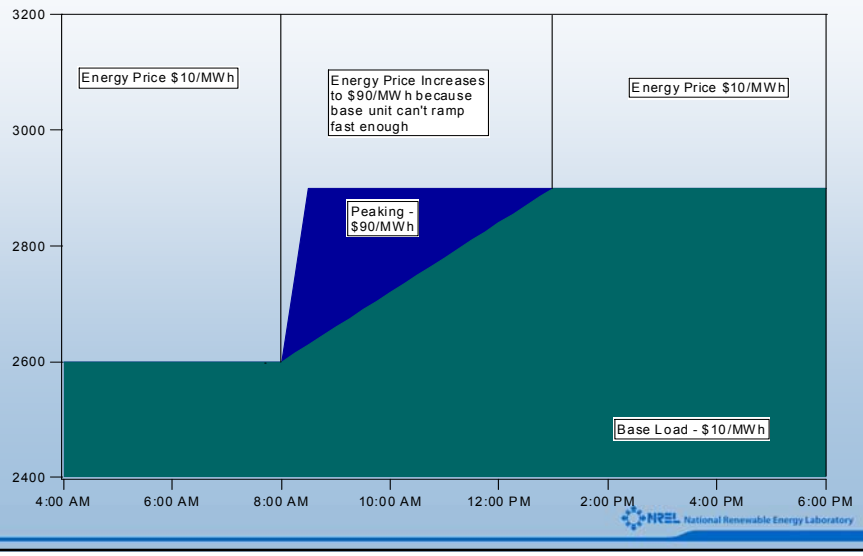
- Can the increased variability be accommodated?
- Can the increased uncertainty be accommodated?
- Is there sufficient turn-down capacity?
- Is there sufficient transmission to ensure deliverability?

Impact of 25% Wind Energy Penetration: 5-minute data



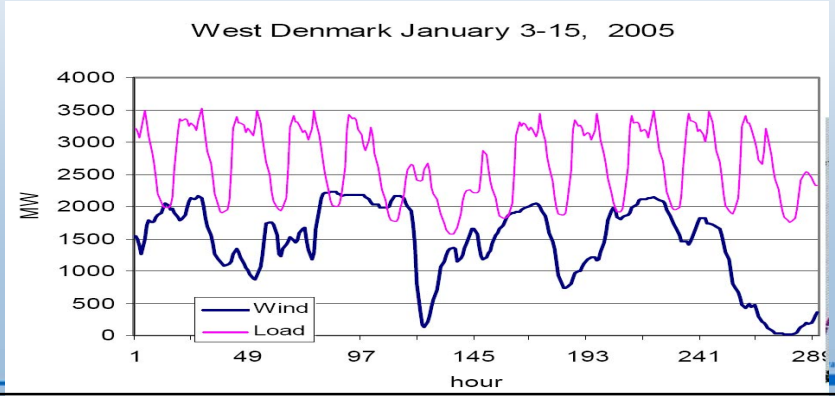
- Ramp requirements increase with 25% wind energy penetration. The upper panel also shows the importance of being able to achieve lower minimum loads by the conventional generation fleet.

Can the non-wind fleet ramp quickly enough?

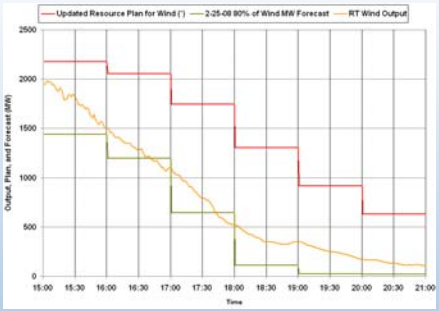


Integrating "large" wind penetrations: what does it take?

- Better use of existing flexibility
- Acquire additional flexibility across BAs
- Acquire additional physical flexibility

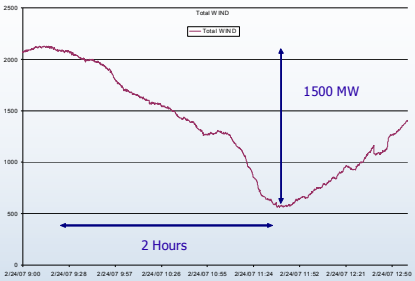


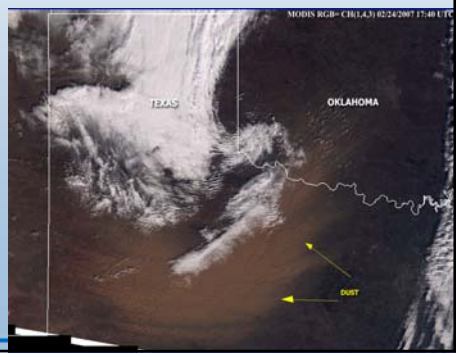
Large Ramps Pose Operational Challenges



http://www.ercot.com/meetings/ros/keydocs/2008/0313/07._ERCOT_OPERATIONS_REPORT_EECP022608_public.doc

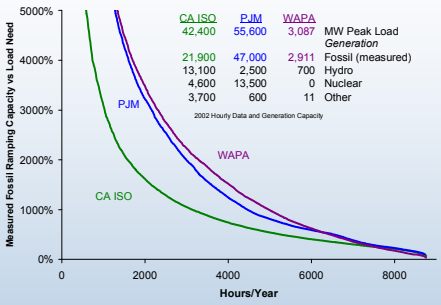
Aggregation Changes Event Characteristics From a Contingency to a Large Ramp





Better use of existing flexibility

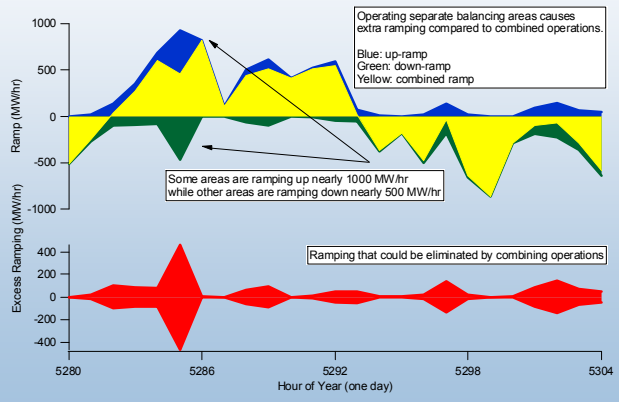
- Tap into maneuverable generation that may be "behind the wall"[1]
- Provide a mechanism (market, contract, other) that benefits system operator and generator
- Fast energy markets help provide needed flexibility[2] and can often supply load following flexibility at no cost[3]



[1]Kirby & Milligan, 2005 Methodology for Examining Control Area Ramping Capabilities with Implications for Wind http://www.nrel.gov/docs/fy05osti/38153.pdf
[2]Kirby & Milligan, 2008 Facilitating Wind Development: The Importance of Electric Industry Structure. http://www.nrel.gov/docs/fy08osti/43251.pdf
[3]Milligan & Kirby 2007, Impact of Balancing Areas Size, Obligation Sharing, and Ramping Capability on Wind Integration . http://www.nrel.gov/docs/fy07osti/41809.pdf

Acquire additional flexibility across BAs

- Reduce the need for ramping by combined BAs (real or virtual)
  - Ramping *capability* adds linearly
  - Ramping *need* adds less than linearly



Milligan & Kirby 2007, Impact of Balancing Areas Size, Obligation Sharing, and Ramping Capability on Wind Integration . http://www.nrel.gov/docs/fy07osti/41809.pdf

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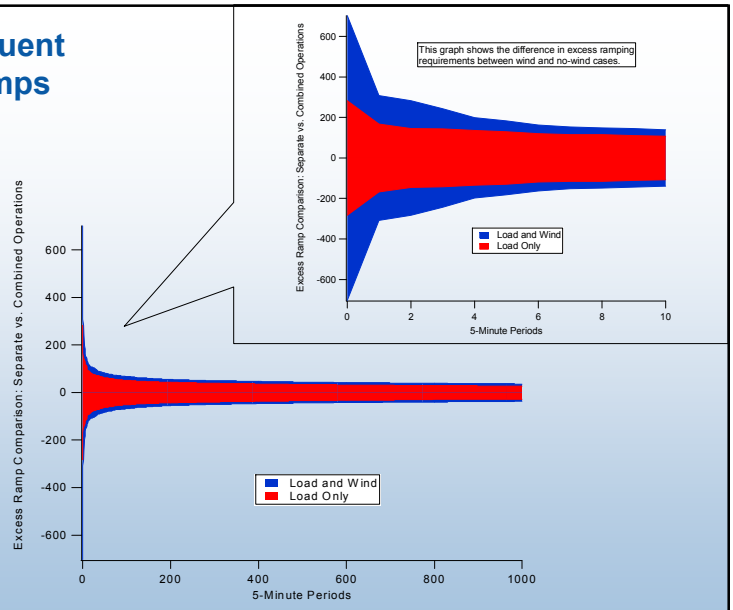
Large, infrequent 5-Minute Ramps can be significantly reduced



Milligan & Kirby 2008, An Analysis of Sub-Hourly Ramping Impacts of Wind Energy and Balancing Area Size . To appear

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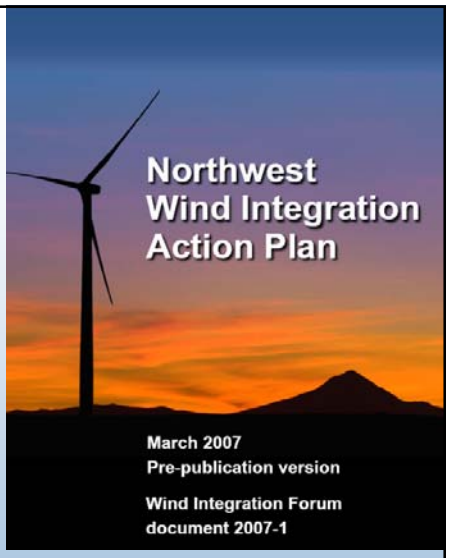
How can lower turn-down be acquired?

- Less base-load/more flexible generation
- Economic curtailment
- How to get there?
  - Transparent market signals that value turn-down (negative prices during low-load/high-wind periods)
  - In regulated markets may need some form of targeted resource planning

Recognized Importance of Fast Energy Markets

- Fast markets
  - Will improve overall system performance and economics
  - Will correctly separate load following from regulation, increasing flexibility and reducing costs

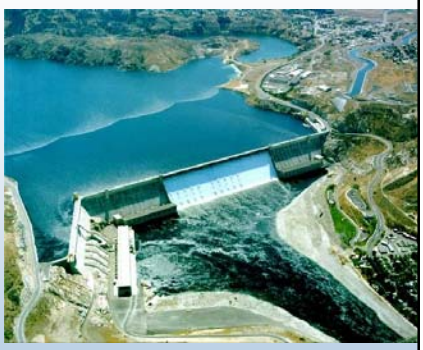


Balancing Area Consolidation: What Other Analyses/Experiments are Underway?

- Virtual consolidation
  - NTTG's ADI
- NREL's Large-scale studies
  - Western Wind and Solar Integration Study (WWSIS)
  - Eastern Wind and Transmission Study (EWITS) with JCSP
  - Activity in the NW includes BPA's 'feed-forward' AGC concept

Other Flexibility Options

- Fast-ramping generation with good heat rates, low turn-down, low start-up cost
- Bi-lateral pooling agreements (similar to ADI but longer time frames)
- Innovation in hydro scheduling
- Economic wind curtailment, ramp limitations during critical periods
  - Morning load pickup
  - Evening load drop off
- Storage has value, but not cost-effective

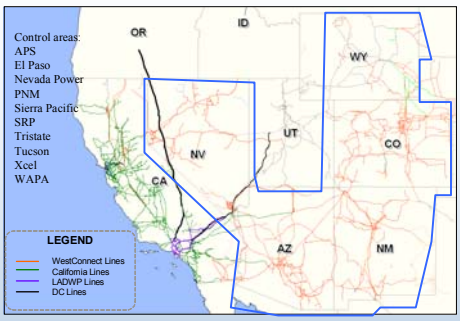


What about wind forecasts?

- Forecasts must be tuned to the needs of the system operator and ***integrated in control room***
- Forecasts of potentially large ramp events?
- High-wind warning systems?
- Aggregate wind forecast error is reduced with large geographic aggregation
- Geographic dispersion can reduce forecast errors by 30-50% (WindLogics, UWIG Forecasting Workshop, Feb 2008)

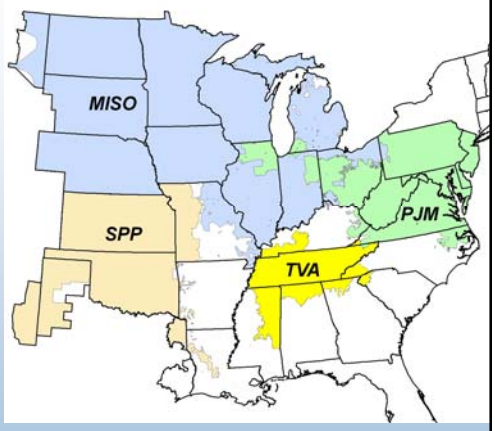
	Mean Absolute Error (Percent)
Next day hourly wind power forecast	10-14% of rated capacity
Next day total energy forecast	20% of energy delivered
Next 2-3 hour power schedule	5-7% of rated capacity

NREL's Large-scale integration studies



Western Wind and Solar Integration Study, Debbie Lew, project manager

Penetrations % Energy:
30% Wind
3.5% CSP
1.5% PV



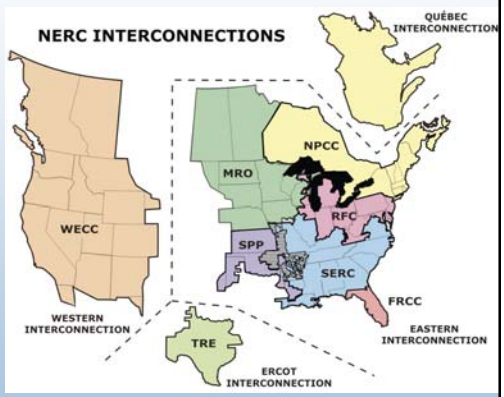
Eastern Wind and Transmission Study (30% Wind penetration (energy): Dave Corbus, project manager

Why undertake a regional integration study?

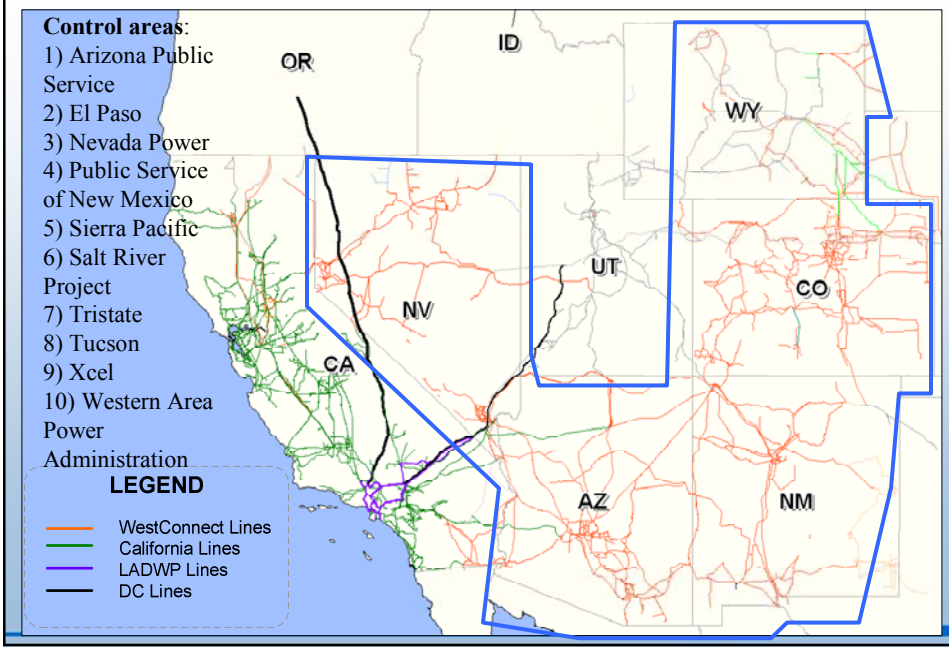
- DOE/NREL/AWEA's 20% Wind by 2030 Scenario (http://www.20percentwind.org)
  - 20% scenario needs 25% wind in WECC
- Western Governor's Association Clean and Diversified Energy Initiative
- WestConnect's Virtual Control Area Study (now part of WWSIS)
- RPS targets in most of WestConnect states and rapid growth in wind/solar expected in this region

Regional Studies

- Eastern Wind Integration and Transmission Study (EWITS)
- Western Wind and Solar Integration Study
- Scope of studies
  - Wind Mesomodeling
  - Integration Study
    - Simulate study year using load and climate patterns of 2004, 2005, 2006
    - Statistical analysis
  - EWITS includes transmission study and is coordinated with MISO/PJM/SPP et al JCSP



Study Footprint (WestConnect outside of California)



Study Overview

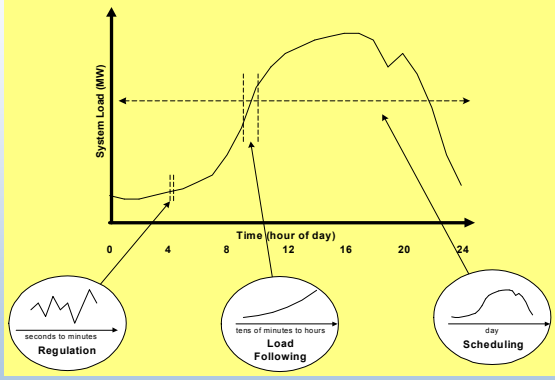
- Goal
  - To understand the costs and operating impacts due to the variability and uncertainty of wind, PV and concentrating solar power (CSP) on the grid
  - Not the cost of wind or solar generation
- Issues
  - Does geographic diversity help?
  - How do local resources compare to out-of-state resources
  - Can balancing area cooperation help manage variability?
  - What is the benefit of wind forecasting?
  - How can hydro help with wind integration?
- Scope of study
  - Operations, not transmission study
  - Study year – 2017 to line up with WECC studies
  - Simulate load and climate of 2004, 2005, 2006 forecast to 2017
  - Simulate all of WECC but all subhourly variability accommodated by WestConnect

High Renewables Basecase 2017

	Wind	Solar PV	Concentrating Solar Power	Total
Study footprint (WestConnect)	30% by energy	1.5%	3.5%	35%
	28,256 MW	2472 MW	2884 MW	33,613 MW
Rest of WECC	20%	0.9%	2.1%	23%
	36,767 MW	2895 MW	3378 MW	43,040 MW
Total	65,023 MW	5368 MW	6262 MW	76,654 MW

Integration Study - Key Tasks

- Evaluate operating impacts and associated costs
  - Regulation
  - Load Following
  - Unit Commitment
- Evaluate reliability impacts
  - Effective Load Carrying Capability/Loss of Load Probability



Tasks and Schedule

- Stakeholder Meeting (5/23/07) with 56 participants
- Data Collection (until 5/08)
  - Wind and solar mesoscale modeling (3TIER)
  - Utility load, generator, transmission data (Exeter)
- Preliminary Analysis (3-7/08) - GE
  - Extensive statistical analysis with various options for wind/solar sites and transmission
- Scenario Development (8/08) - GE
  - In-state vs out-of-state resources
  - Geographically diverse resources
  - Mega projects
  - Best correlated with load
- Stakeholder Meeting (8/14/08)
- Run Scenarios (starting 8/08) - GE
  - Examine costs due to regulation, load following, unit commitment
  - "Dives" to investigate issues such as Hoover
  - Examine mitigation strategies/options
  - Determine contributions to reliability and capacity value
- Preliminary Technical Results (end '08)
- Reporting and Stakeholder Meeting (mid '09)

Wind Data

- Previous data sets assembled from various years, measurements and assumptions
- Hired 3TIER to undertake largest wind mesomodeling to date
- Wind speed database (24TB)
  - Entire western US at 2km x 2km grid
  - 10, 20, 50, 100, and 200m hub heights
  - 10 minute intervals for 2004-6
- Wind power database (100's GB)
  - Selected 32,000 grid points
  - Each grid points holds 30 MW
  - Based on Vestas V90 3MW turbine and 3TIER's SCORE process
  - Hourly forecast for day-ahead wind output

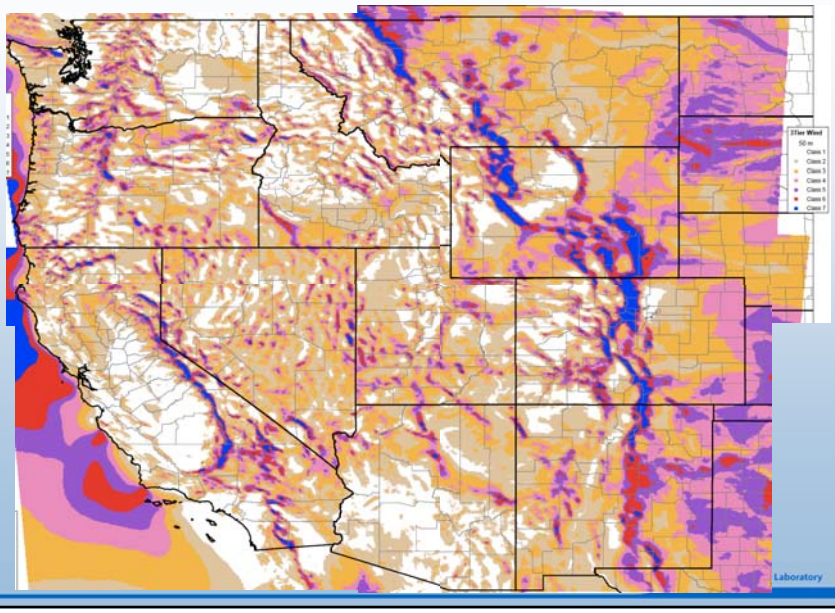
This database was designed for:

- Spatial and temporal comparisons of sites
  - Geographic diversity
  - Load correlation
- Estimates of power production from hypothetical wind plants
  - Investigating needs for storage based on wind variability
  - Examining potential transmission line loadings from hypothetical wind farms
  - Simple economic calculations comparing cost of delivered energy from in-state versus out-of-state
- Use by others, WECC

This database was not designed for:

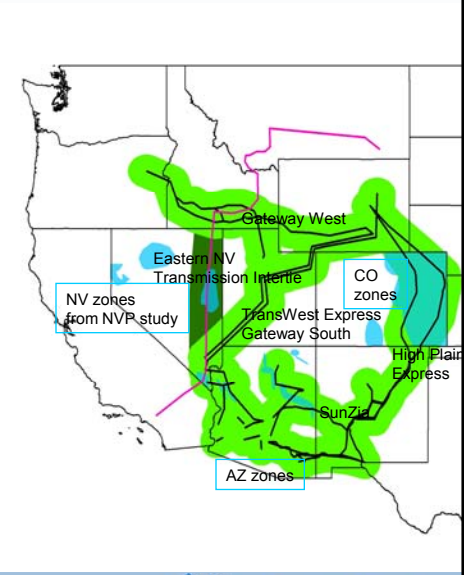
- Needs for high accuracy, absolute wind speed or power output
- Long-term average wind speed or wind power output
- This was not designed to be used as the only basis for investment. Ground-truthing modeled data with actual measurements is critical.

Western US – 2006 Wind Map



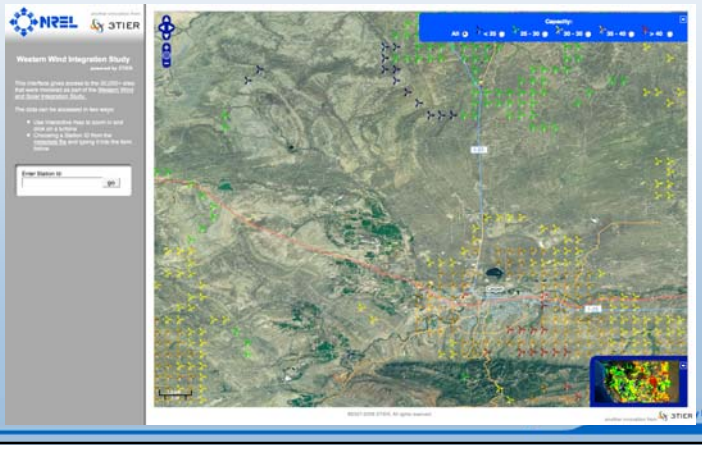
Wind Site Selection

- 3TIER downselected from 1.2M to 30,000 points. GE will select final sites.
  - Exclusions - recreation, urban, forests, slopes, high elevation, etc. (NREL)
  - Preselected sites - existing or planned wind plants (Platts database/NREL)
  - Transmission corridors or zones (200 GW) - based on proposed new transmission and initial zone information (excl new NV zones)
  - Load correlation (250 GW) - best diurnal correlation with Westconnect load
  - Best resource (450 GW) - best wind power density
  - Additional sites added in to help validate model results



Web-based interface for wind data

- Click on site and download 10 minute wind speed and wind power output data stream for selected periods
- Planned release in summer to be accompanied by webinars explaining use of database



Solar Modeling

- Perez of SUNY ran solar model for US
  - 10km x 10 km grid
  - 1 hour intervals for 2004-2006
  - Direct normal and global insolation
  - Available at http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/
- PV Modeling
  - By weather station site (150 sites for western US)
  - Template of different orientations and tracking configurations
- Concentrating Solar Power (CSP) Modeling
  - Parabolic trough plants with 6 hours thermal molten salt storage, similar to APS Abengoa plant
  - Modeled over 200 GW of CSP sites
- Fast PV variations driving need for subhourly PV analysis

Need for Subhourly PV Analysis

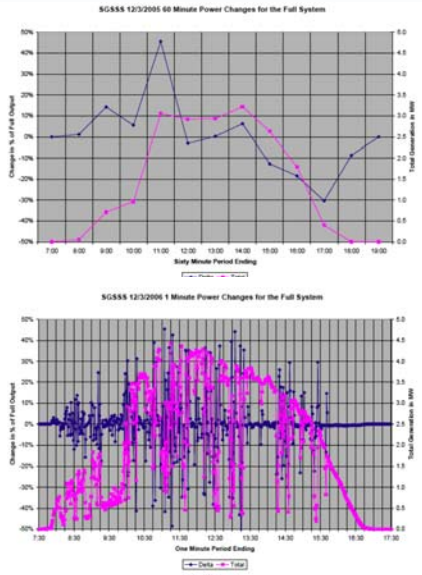


Figure 10

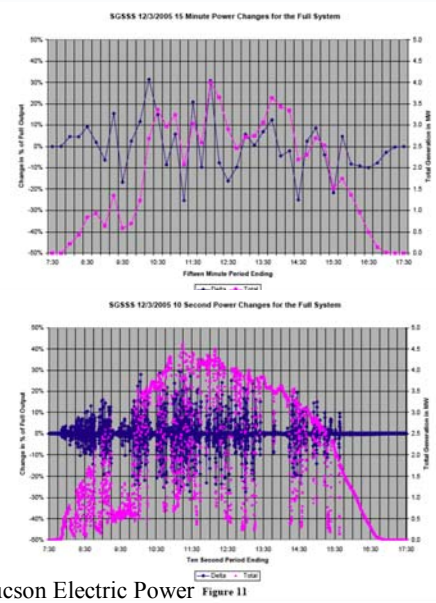


Figure 11

Source: Tom Hansen, Tucson Electric Power

Summary

- Wind mesomodel datasets are being validated and will be publicly available in mid-2008
- Stakeholder Meeting August 14, 2008 in Colorado
- Preliminary results later in 2008
- Final results in mid-2009

Information

- WWSIS web site
  - http://westconnect.com/init_wwis.php
- Utility Wind Integration Group
  - www.uwig.org
- NREL's Wind Integration Team
  - http://www.nrel.gov/wind/systemsintegration/
- Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22(3), August 2007; pp. 900-908
  - http://www.nrel.gov/docs/fy07osti/41329.pdf