NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ERGIS TRC Conference Call #1

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Agenda

- Status
  - Wind data review
  - Balancing area/load area exploratory comparison
  - Solar data development
- Statistical Analysis Study Approach
- Assumptions for Statistical Analysis
- Next Steps

ERGIS Task Structure

- Task 1. Study scenario development
  - Identify renewable penetration levels & other study assumptions (e.g., policy, generation expansion) with stakeholders
  - Develop independent databases for Tasks 2 and 3
- Task 2. Reserve strategy analysis
  - Data review
  - Statistical analysis of wind and load (and possibly solar) variability
  - Calculate ramps over various time frames (e.g., 10 minutes or 2 hours)
  - Explore reserve strategies to accommodate such ramps
- Task 3. Production simulation analysis
  - Apply reserve strategies to study scenarios
  - Test system robustness (e.g., to assumptions or mitigation schemes)

Reserve Strategy Analysis - Approach

- Bounds
  - 1 benchmark, 2 study scenarios
  - 3 years of data available (2004, 2005, 2006)
    - Select 1 year for primary analysis
    - Use other 2 years in sensitivity analysis as desired
- Wind, Solar, and Load Data
  - 10 min wind data from EWITS (by plant, 100 to 1,500 MW)
  - 10 min load data to be synthesized from hourly EWITS data (by load zone)
  - 10 min solar data to be synthesized by NREL
- Aggregate Profiles
  - To meet specified penetration levels in specified areas
  - By balancing area or load zone
  - Selection criteria
    - High to low by capacity factor (e.g., 3-year average)

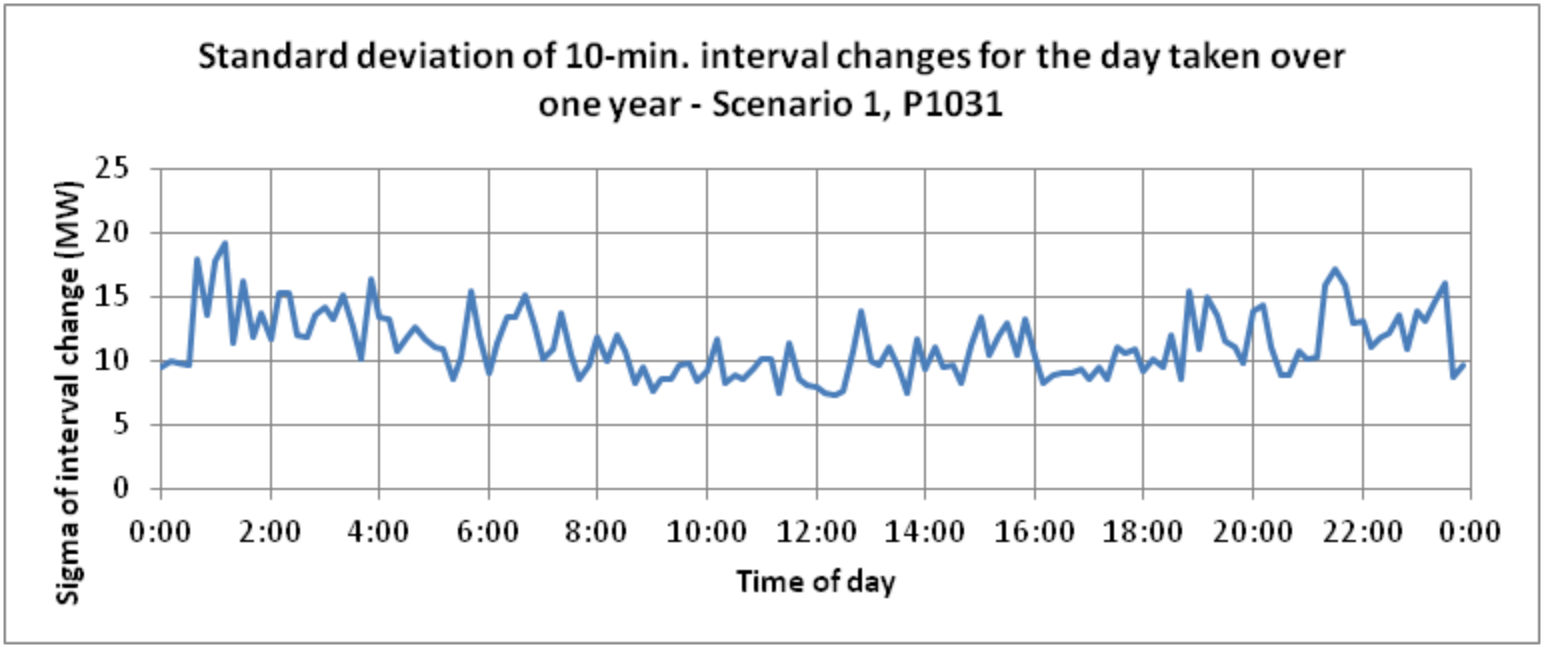
Approach continued…..

- Calculate Variability
  - Load, wind, solar, and net load
  - Maximum & minimum (coincident), average, standard deviation
  - Penetration (on maximum & minimum MW, by energy)
  - 10-minute deltas as function of MW output (persistence forecast)
  - 1-hour deltas as function of MW output (persistence forecast)
  - By initial area definition (e.g., BAs)
- Calculate Ramps
  - Size (MW, MW/min)
  - Duration (10 min, 30 min, 1 hour, 2 hours, 4 hours, 8 hours)
  - Direction (positive, negative)
  - Determine maximum daily ramps, average maximum daily ramps
  - Determine various expectation levels (e.g., 90%, 95%, 99.7%, 100%)
  - Track time of day or season of ramps?
- Sensitivities
  - Larger area definitions
  - Different years

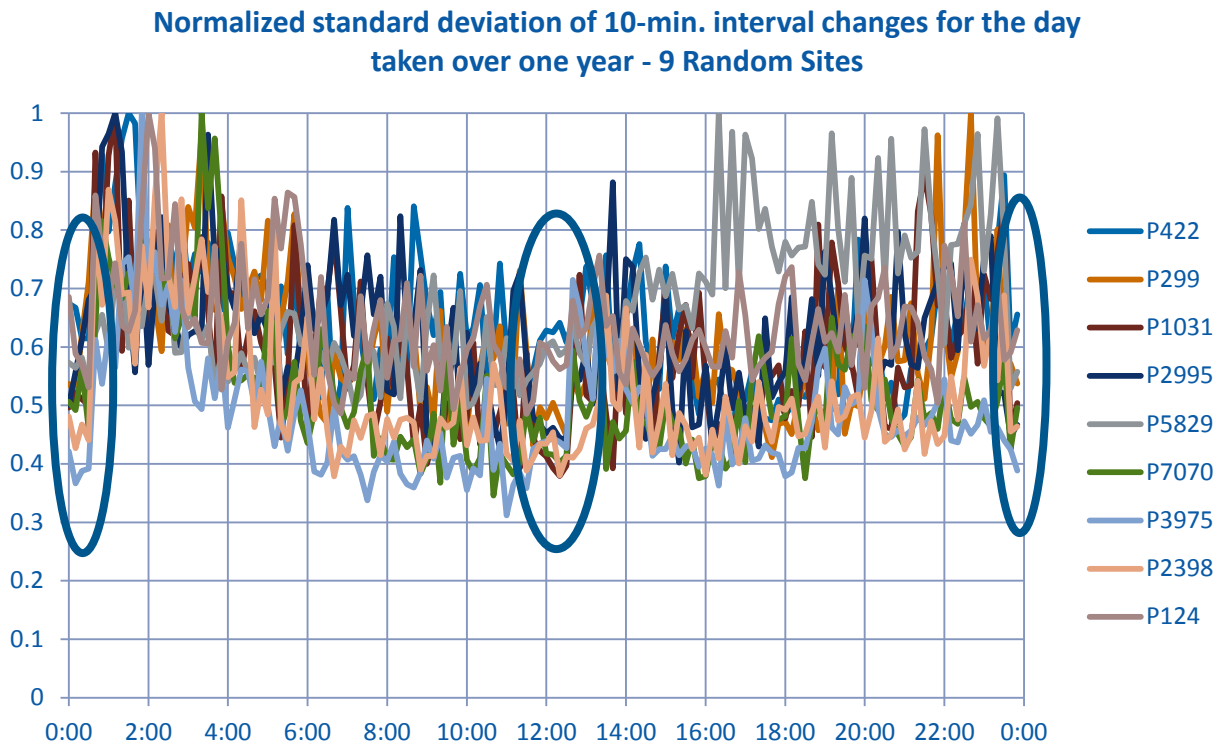
Wind Data Review

- Previous data review
  - Data was examined for modeling artifacts at individual plant level
  - Few artifacts were seen at that level after corrections applied by AWST for 12 hour data assimilation
- Additional review for artifacts of data synthesis
  - 15/16 day model restart
  - Observation data assimilated every 12 hours to align model
  - Checked data for big steps at these points
  - Looked for effects in aggregated data
  - Results show need for a fix to the 12 hour feed-in anomaly

Individual Wind Plant Data Review



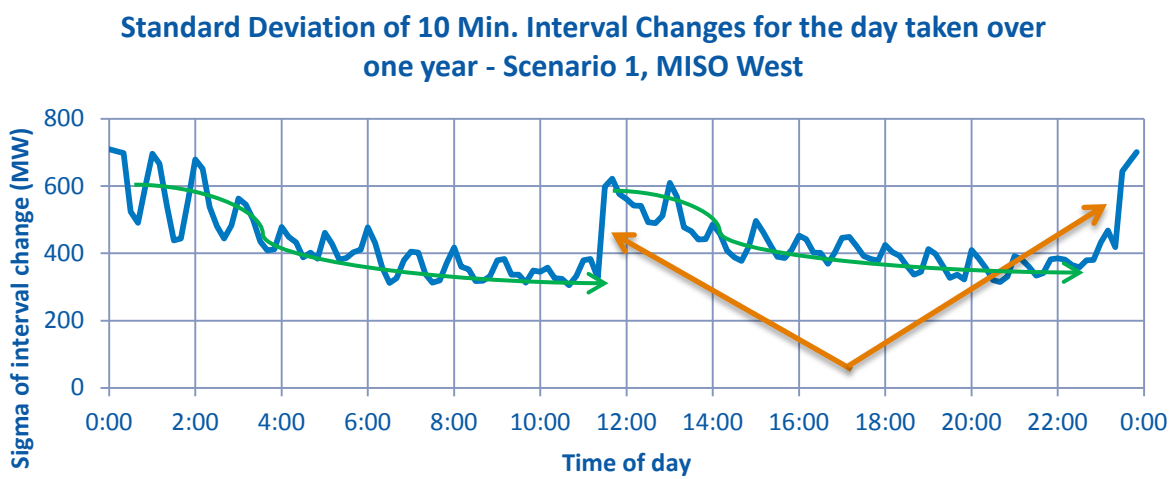
Individual Wind Plant Data Review



Aggregate Wind Data Review

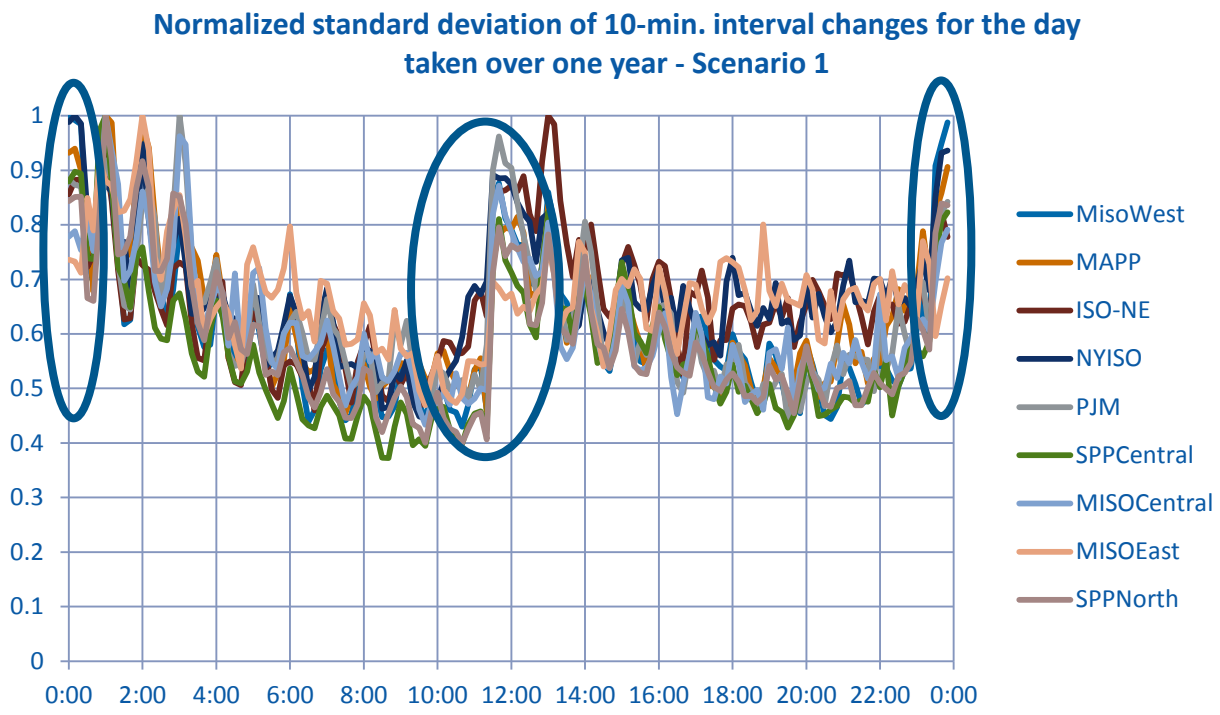
EWITS scenario 1 regional wind capacities

Region Name	Capacity (MW)
ISO-NE	4291
MAPP	13809
MISO Central	12193
Miso East	9091
MISO West	59260
NYISO	7742
PJM ISO	22669
SERC	1009
SPP Central	44055
SPP North	48243
TVA	1247

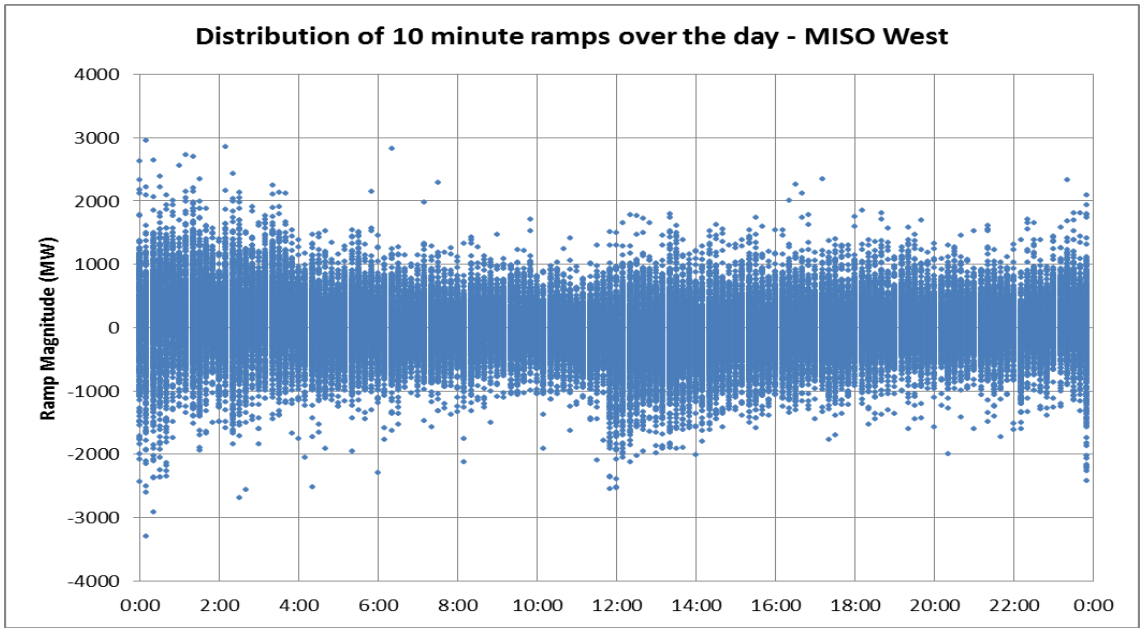


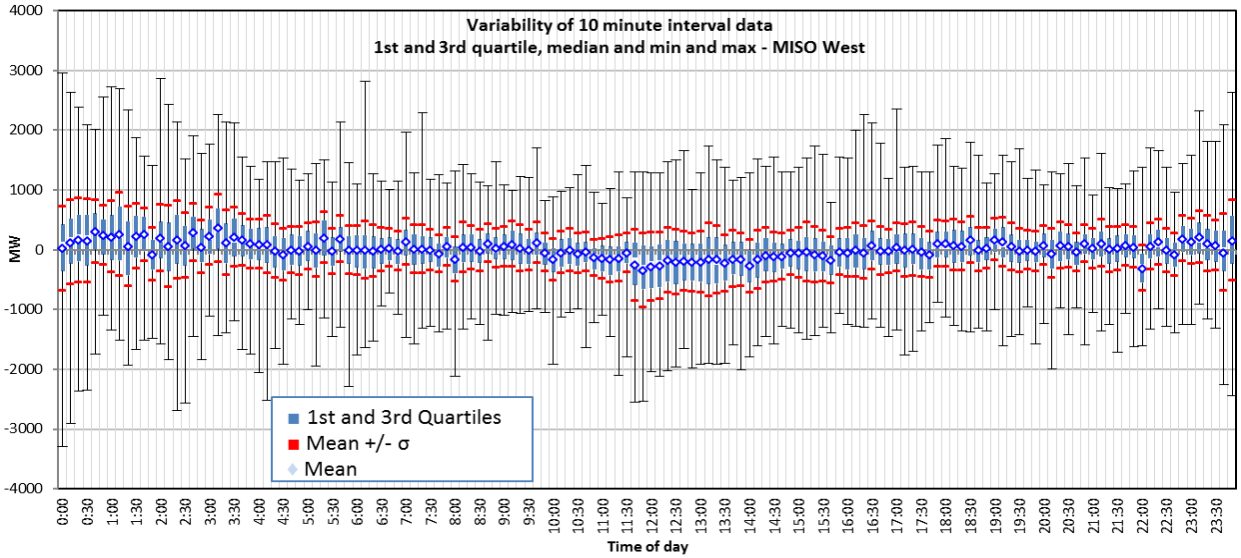
- The noon and midnight artifact is again prominent but advanced in time by 30 minutes (red arrows). The 30 minutes corresponds to the beginning of the AWST correction window.
- The rawinsonde data assimilation seems to induce a transient with exponential decay (green lines). This transient is only obvious when aggregating a significant number of sites.
- The midnight feed-in seems to induce a more severe shock compared to noon.
- The oscillation in the standard deviation has *exactly* a one hour period.

Aggregate Wind Data Review



Impact on Ramps





Impact on Ramps

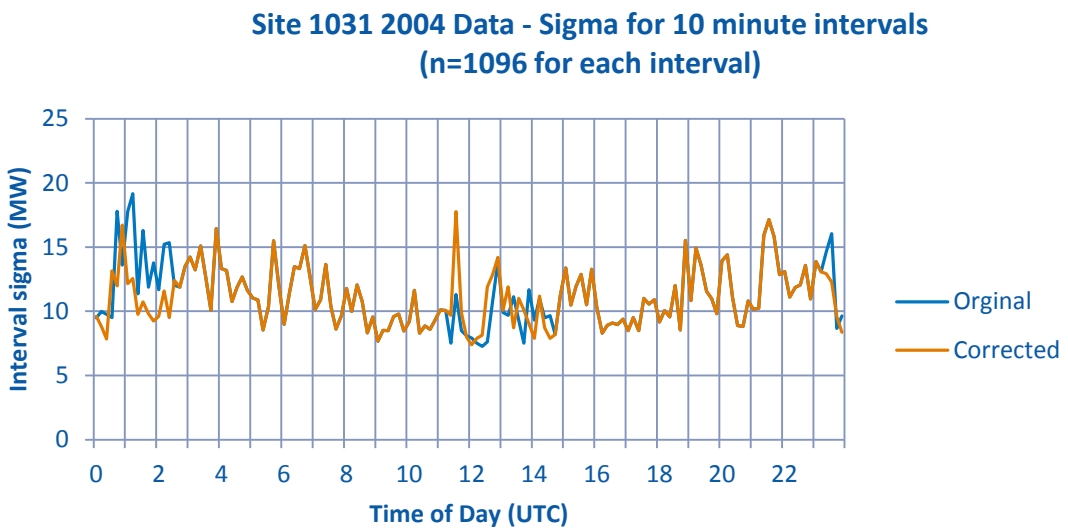
Top 50 10-minute up and down ramps in the AWST correction windows

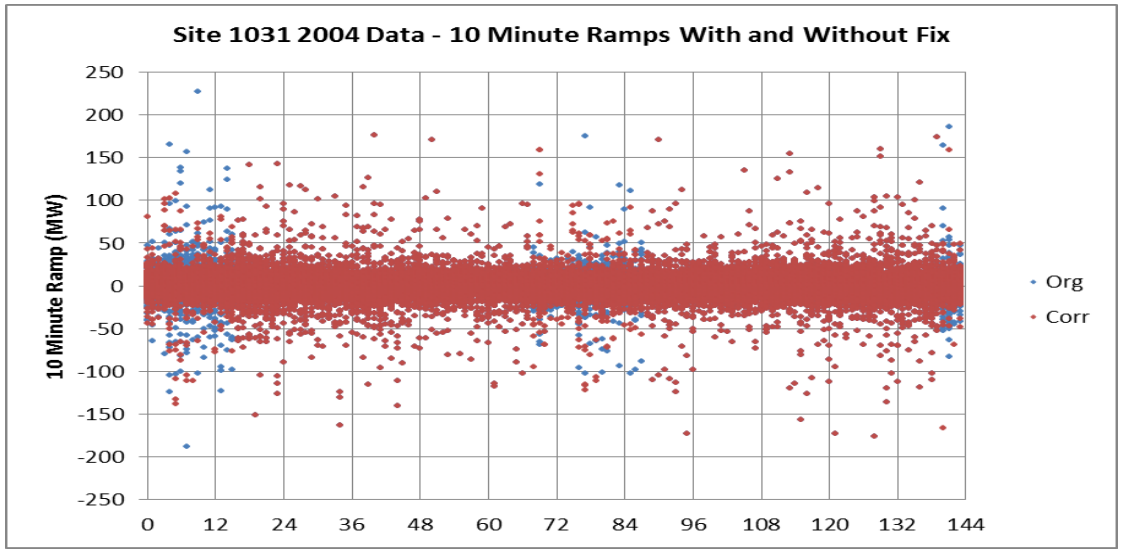
	Top 50 Up Ramps		Top 50 Down Ramps	
	Count	%	Count	%
MISOWest	13	26%	35	70%
MAPP	4	8%	17	34%
ISO-NE	16	32%	6	12%
NYISO	7	14%	13	26%
PJM	12	24%	29	58%
SPPCentral	10	20%	25	50%
MISOCentral	8	16%	4	8%
MISOEast	7	14%	6	12%
SPPNorth	9	18%	18	36%
All	12	24%	36	72%

Proposed Data Fix

- Objectives
  - Manipulate as little of the data as possible
  - Maintain characteristic variability at the site and aggregated levels
  - Approximate the spatial correlation between sites
  - Minimize large ramps in the correction window
- Procedure
  - Substitute “good” data for “bad” data from within the same wind plant’s profile (i.e., don’t use data from plant X for plant Y)
  - Randomly select a day out of the dataset
  - Select the time period immediately before the “bad” time period (e.g., use 10-11am as substitute for 11-noon)
  - Remove trend from the “good” data, retain variability
  - Add “good” data’s variability to trend of “bad” data
  - Use same day & time for substitution at all plants to retain spatial correlation

Individual Wind Plant w/ and w/o Fix

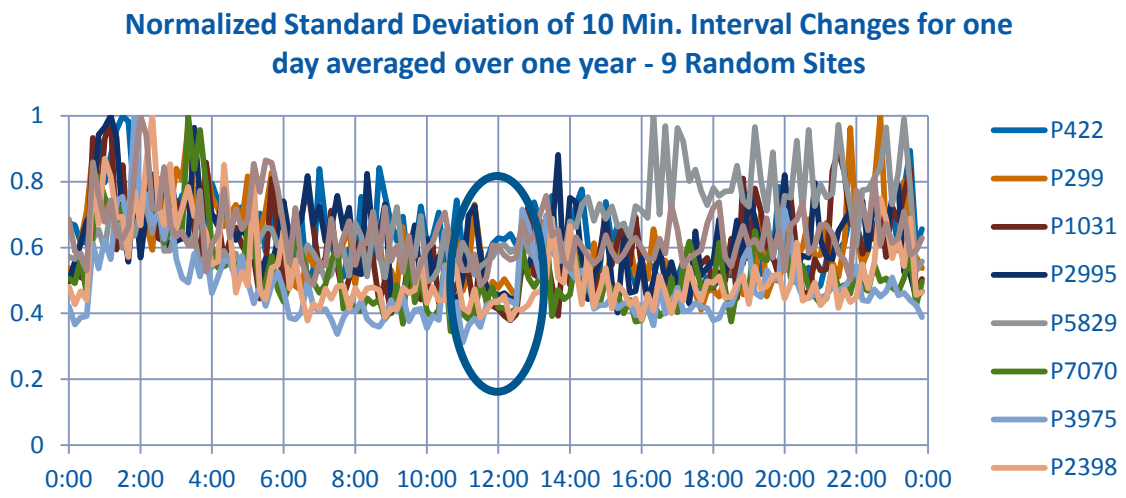


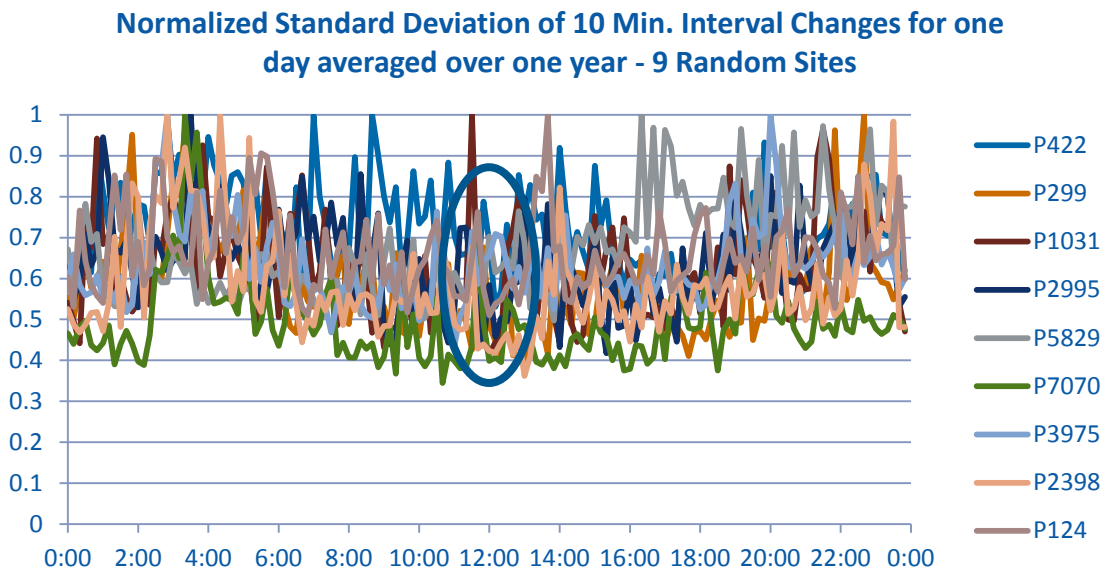


Several different time periods or windows were tested.

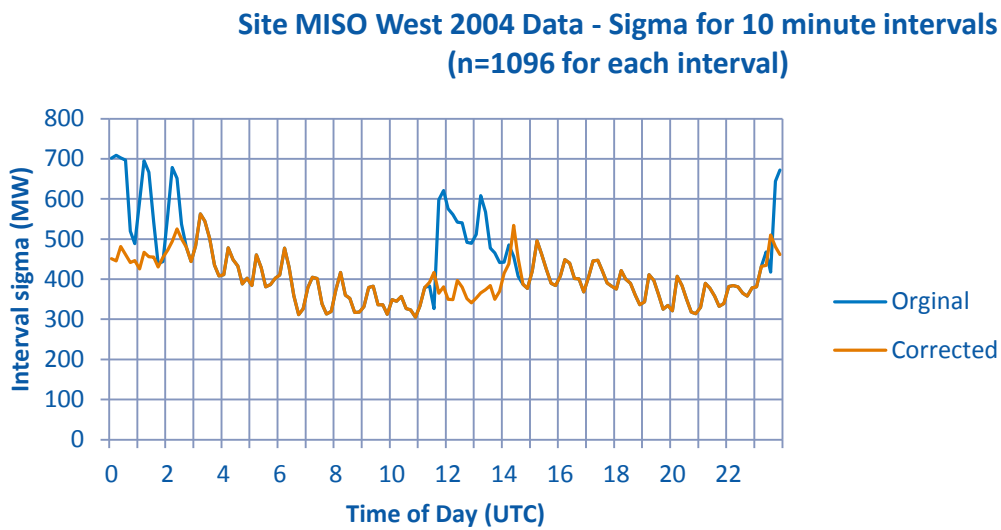
These results are for a 3-hour window (from 30 min before assimilation to 2.5 hours after).

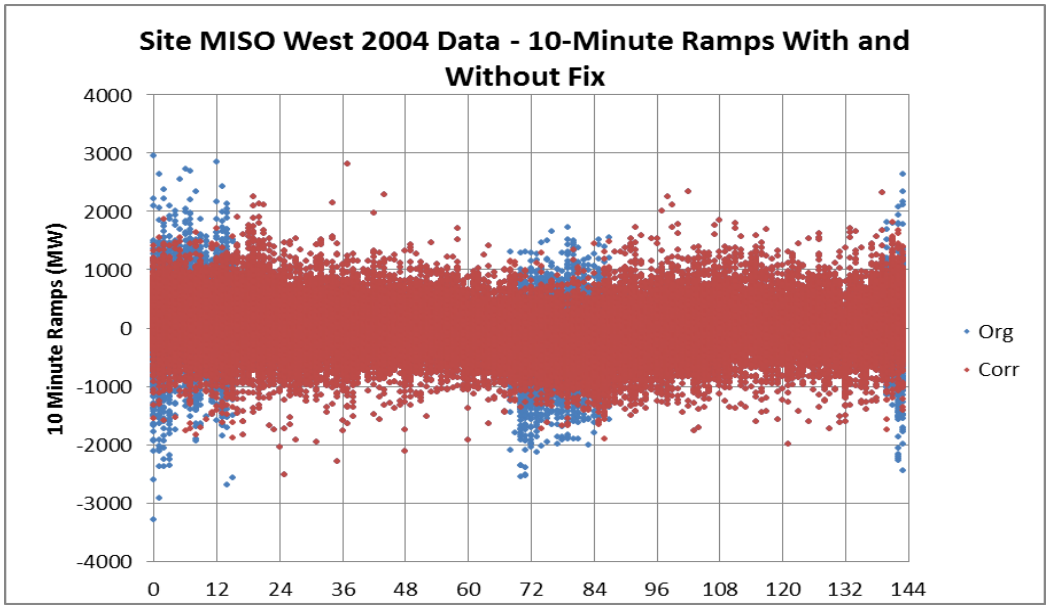
Nine Individual Plants w/ and w/o Fix



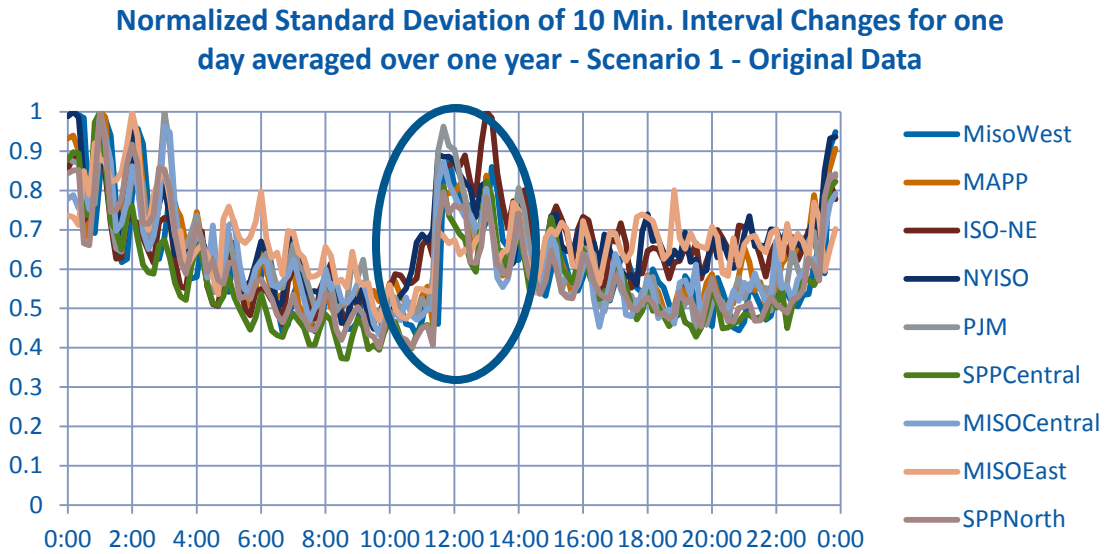


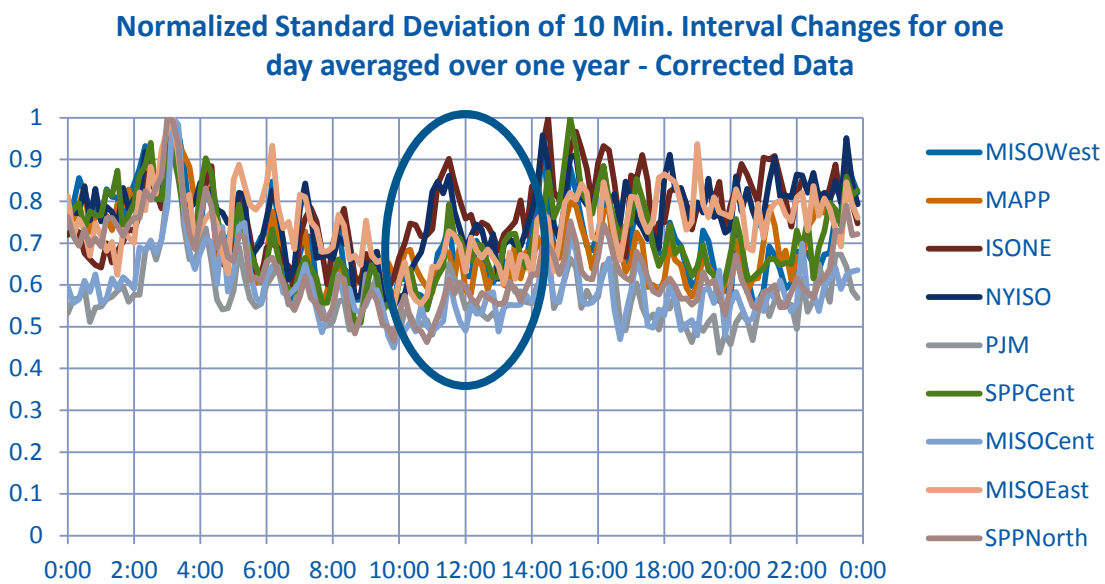
Aggregate Wind w/ and w/o Fix





Nine Aggregates w/ and w/o Fix





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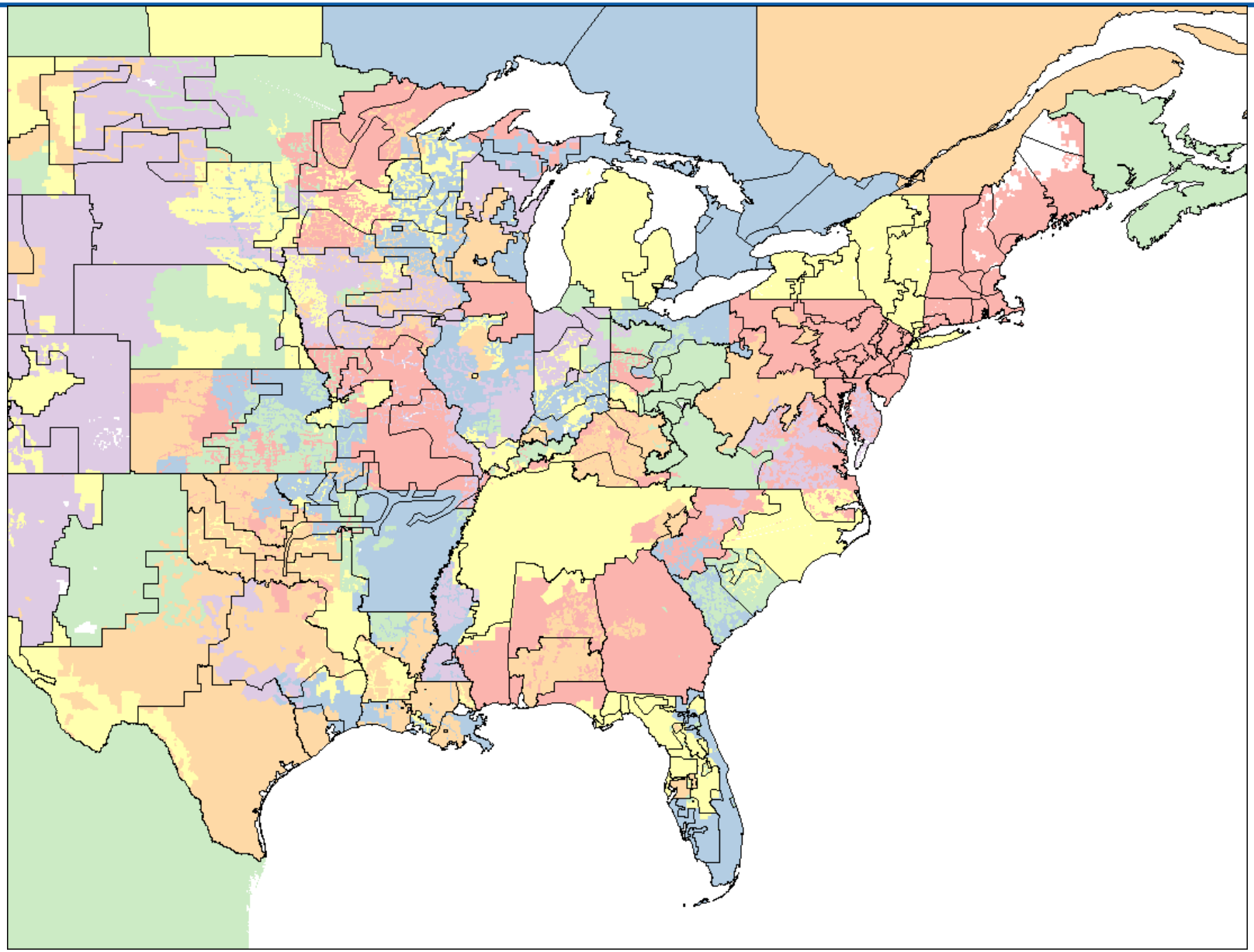
MISOEast	0	0%	4	8%
SPPNorth	2	4%	8	16%
All	10	20%	3	6%

Exploration of BA vs. Transmission Zone

- Goal to improve modeling resolution to BA level if possible
  - EWITS used Ventyx transmission zones aggregated to RRO, ISO/RTO
  - Data required for 2004 to 2006 period
- FERC planning regions
  - FERC planning region data based on FERC Form 714
    - Availability to 2006, exploring other sources to fill in
  - Planning regions map fairly well to BAs (n to 1 relationships)
  - Disadvantage – No GIS data available, large number of regions (152)
- Ventyx transmission zones
  - Designed by Ventyx based on transmission systems
  - Hourly load data assembled by Ventyx
  - Doesn't map well to BAs in the Eastern Interconnect
  - GIS Data is available
- Recommendations
  - Planning regions are more meaningful and closer to BA representation, but…
    - Without 2004, 2005 data and GIS, not as useful
  - Transmission zones appear to be most viable

BAs and Transmission Zones



Solar Data Synthesis

- Satellite Data
  - SUNY, 0.1deg grid,1 hour, spatial representation of cloud cover
- Ground Data
  - Individual sites, 1 min resolution, point source measurement
- Clearness Index Classes
  - I = clear & constant to V = variable
  - Determine distribution of 1-min data
- Synthesize Solar MW Profile
  - Algorithms superimpose 1-min irradiance data on hourly data
  - Assume PV plant footprint per PV capacity (MW/km^2)
  - Filter irradiance profile
  - PV Watts turns it into a MW profile
- Vet Synthesized Data
  - Compare synthesized and measured ramps

Benchmark Scenario

- Objectives
  - Credible benchmark, reflecting realistic future
  - Consistent with later production simulation work
- Assumptions
  - 2025 study year
  - Load growth
    - 1%/year in all regions
    - Regional mix
  - Initial area definitions per previous discussion
  - State RPS goals achieved (% energy)
    - Primarily with wind
      - On-shore = 95%, Off-shore = 5%
    - Remainder is PV, if solar component of RPS
      - PV mix?
      - WWSIS is using 40% rooftop PV, 20% population located utility scale PV and 40% best resource located utility scale PV
    - In-state resources
  - Additional wind and/or solar in non-RPS states?
    - Size, type, location?

NERC Load Projections

~1%/year through 2035

Source: EIA, http://www.eia.gov/forecasts/aeo/

	Energy, GWH			Summer Peak, MW		
	2010	2019	Average Annual % Change	2010	2019	Average Annual % Change
FRCC	223,174	257,592	1.6%	46,006	51,982	1.4%
MRO US	225,167	264,174	1.8%	42,240	46,990	1.2%
NPCC US	291,540	313,681	0.8%	60,215	65,716	1.0%
RFC	961,436	1,171,860	2.2%	201,350	234,674	1.4%
SERC	1,027,470	1,181,812	1.6%	201,350	234,674	1.7%
SPP	211,438	240,019	1.4%	43,395	49,739	2.0%
Average			1.6%			1.4%

Source: NERC's Regional and National Peak Demand and Energy Forecast Bandwidths 2010-2019, December 2010.

Eastern Interconnection State RPS Summary

State	Solar	Type	Year	Total	Mandatory	Year	Other
Connecticut				23%	Y	2020	
Delaware	3.5%	PV	2026	25%	Y	2025	
Illinois	1.5%	PV	2025	25%	Y	2025	
Iowa				105 MW	Y	1999	
Kansas				20% Peak Load	Y	2020	
Maine				40%	Y	2017	
Maryland	2.0%		2022	20%	Y	2022	
Massachusetts	400 MW	PV	2020	11.1%	Y	2009	+1% per year
Michigan				10%	Y	2015	
Minnesota				25%	Y	2025	Xcel, 30% by 2020
Missouri	0.3%		2021	15%	Y	2021	
New Hampshire	0.3%		2014	23.8%	Y	2025	
New Jersey	5,316 GWh		2026	22.5%	Y	2020	
New York	0.5%		2015	30%	Y	2015	
North Carolina	0.2%		2018	12.5%	Y	2021	for IOUs (10% for coops & munis)
North Dakota				10%	N	2015	
Ohio	0.5%		2025	12.5%	Y	2024	
Oklahoma				15%	N	2015	
Pennsylvania	0.5%	PV	2021	8.5%	Y	2020	
Rhode Island				16%	Y	2019	
South Dakota				10%	N	2015	
Vermont				20%	N	2017	
Virginia				15%	N	2025	
Washington, D.C.	2.5%		2023	20%	Y	2020	
Wisconsin				10%	Y	2015	

Sources: Figure 38. State RPS Policies and Non-Binding Renewable Energy Goals (as of June 2011) from 2010 Wind Technologies Market Report, and DSIRE (http://www.dsireusa.org/summarymaps/index.cfm?ee=1&RE=1)

Offshore Projections

State	MW
NJ	1,055
MA	468
DE	450
TX	300
RI	29
OH	20
	2,322

Source: Figure 6. Proposed Offshore Wind Power Projects in a Relatively Advanced State of Development from 2010 Wind Technologies Market Report

	Goal	Year	Goal	Year
ME	300	2020	5,000	2030
NJ	1,100	NA		

	Project	Developer
RI	1,000	Deepwater
Mid Atlantic	7,000	Google TX

Source: 2010 Wind Technologies Market Report

Current Solar Projects (>= 1 MW)

Technology	Operating	Under Construction	Under Development	Total
CSP	514	1,059	7,756	9,329
PV	409	2,459	19,162	22,030
Total	923	3,518	26,918	31,359

Technology	Operating	Under Construction	Under Development
CSP	57	30	29
PV	43	70	71
Total	100	100	100

Source: SEIA major solar projects in the US updated 10/24/11

State	Operating	Under Construction	Under Development	Total
Delaware	10			10
Florida	127	10	622	759
Georgia	1		1	2
Illinois	10		62	72
Massachusetts	2	5	41	48
Maryland		16	45	61
Minnesota			2	2
North Carolina	18		2	20
New Jersey	16	30	151	197
New York			57	57
Ohio	12	10	65	87
Pennsylvania	6	1	52	59
Tennessee	1	6		7
Vermont			4	4
Total	203	78	1,104	1,385

Study Scenario 1

- Objective
  - Test higher penetration levels
  - Consistent with later production simulation work
  - Other ?
- Assumptions
  - Same study year, load growth, area definitions as benchmark
  - Same ramp time frames as benchmark
- Renewable generation penetration levels
  - % energy?
  - By which regions?
  - Wind/solar mix?
  - On-shore/off-shore mix?
  - Solar mix?

Next Steps

- To be posted on NREL website (http://wind.nrel.gov/public/ergis)
  - TRC call slides
  - Summary of discussion/decisions
  - Also in email to stakeholder list
- Two weeks for written comments (Dec 16, 2011)
- Analytical activities
  - Identify/implement wind data fix
  - Evaluate wind forecast data
  - Solar database development
  - Perform statistical analysis
- Next TRC and stakeholder webinar in 2012

Thanks!

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