Wind Integration Issues For the Western Grid

WIEB/WIRAB/CREPC

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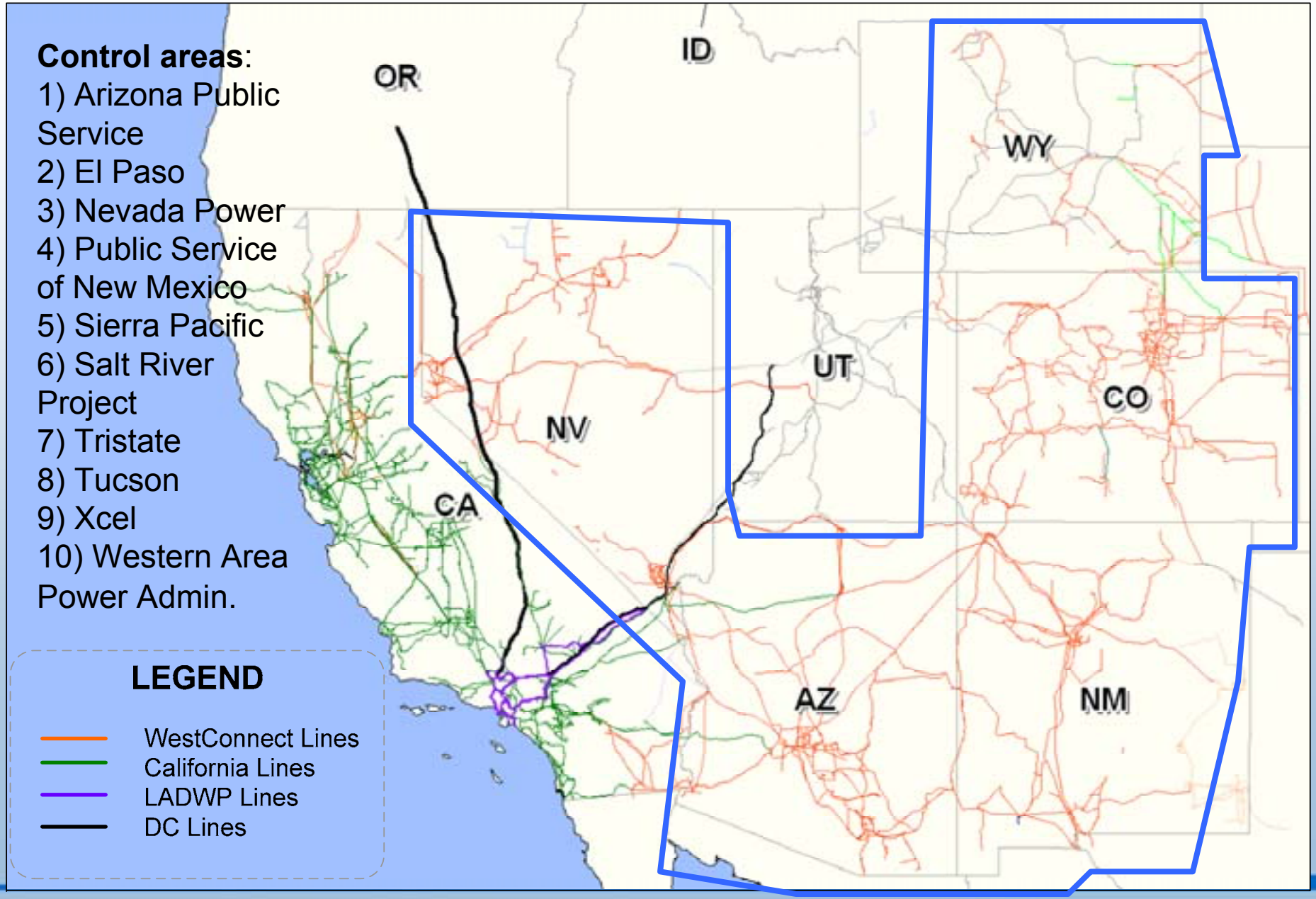
Systems Integration: A Grid and DOE/NREL Priority

- 20% Wind Vision
  - Further examine the implications of a national 20% wind vision
- Conduct regional studies to look at effects of larger balancing areas and feed into transmission planning
  - Western US - southwest and mountain
  - Eastern US - excluding southeast
- Generate consistent time-series wind dataset to capture geographic diversity issues for planning, operational, and transmission expansion analyses.

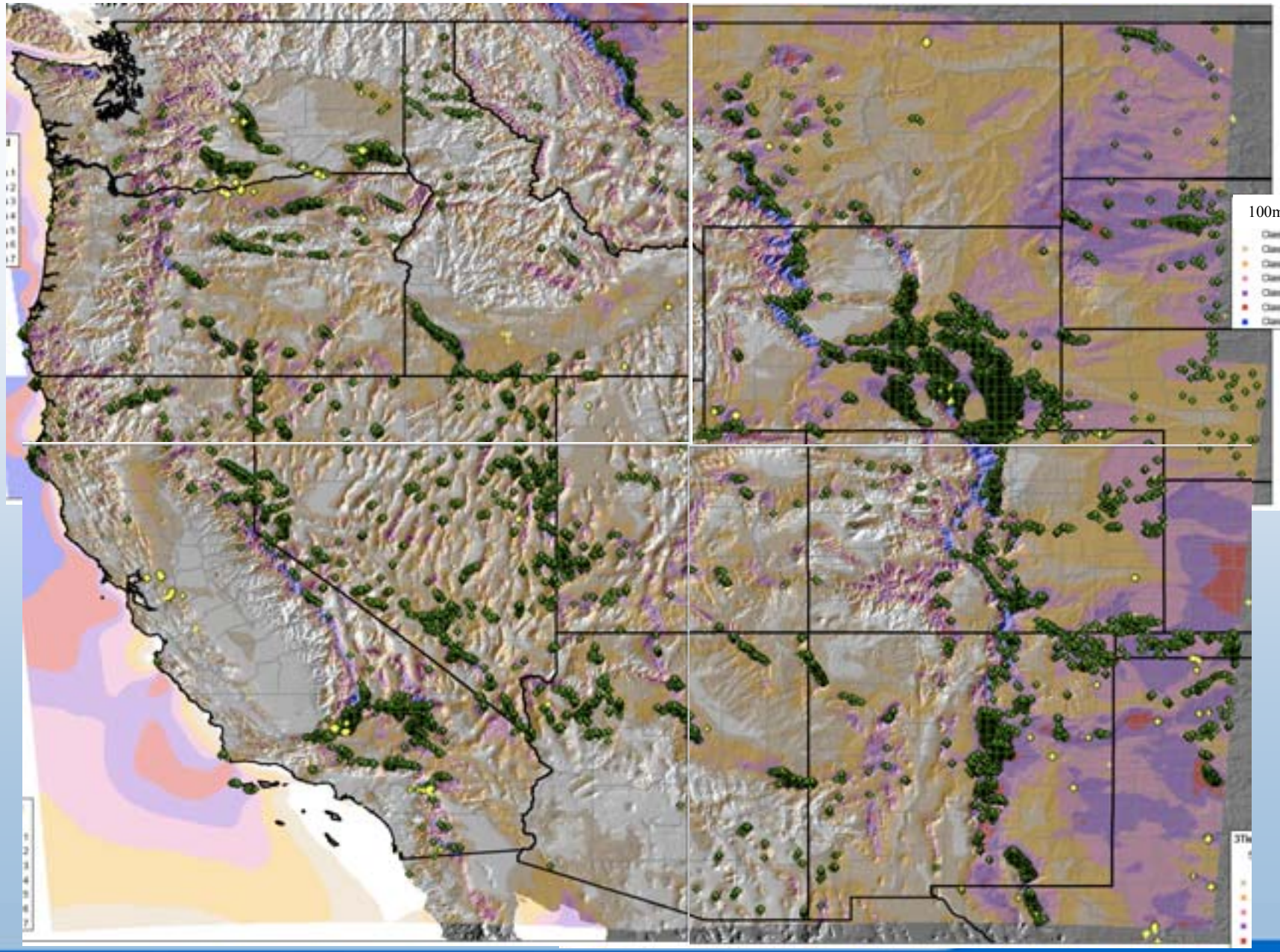
NREL WWSIS Study Footprint (WestConnect w/o CA)



Wind and Solar Modeling

- 3TIER running wind mesoscale model for western US
  - 10 minute intervals for 2004-2006
  - 1 arc-minute resolution (approx 2-km x 2-km grid)
  - Wind speed data - 5 hub heights for entire western US
  - Wind plant output data – 100-m hub height, 10 x 3-MW Vestas turbines incl. statistical variation in output, selected 30,544 grid points (900 GW) to model; web interface to be developed in summer
- Perez of SUNY ran solar model for US
  - 1-hour intervals for 2004-2006, 10-km grid, direct normal and global insolation
  - PV plant output by NSRDB weather station site (150 sites for western US) using template of different orientations and tracking
  - Concentrating Solar Power (CSP) plant output - parabolic trough plants with 6 hours thermal storage.

Site Selection



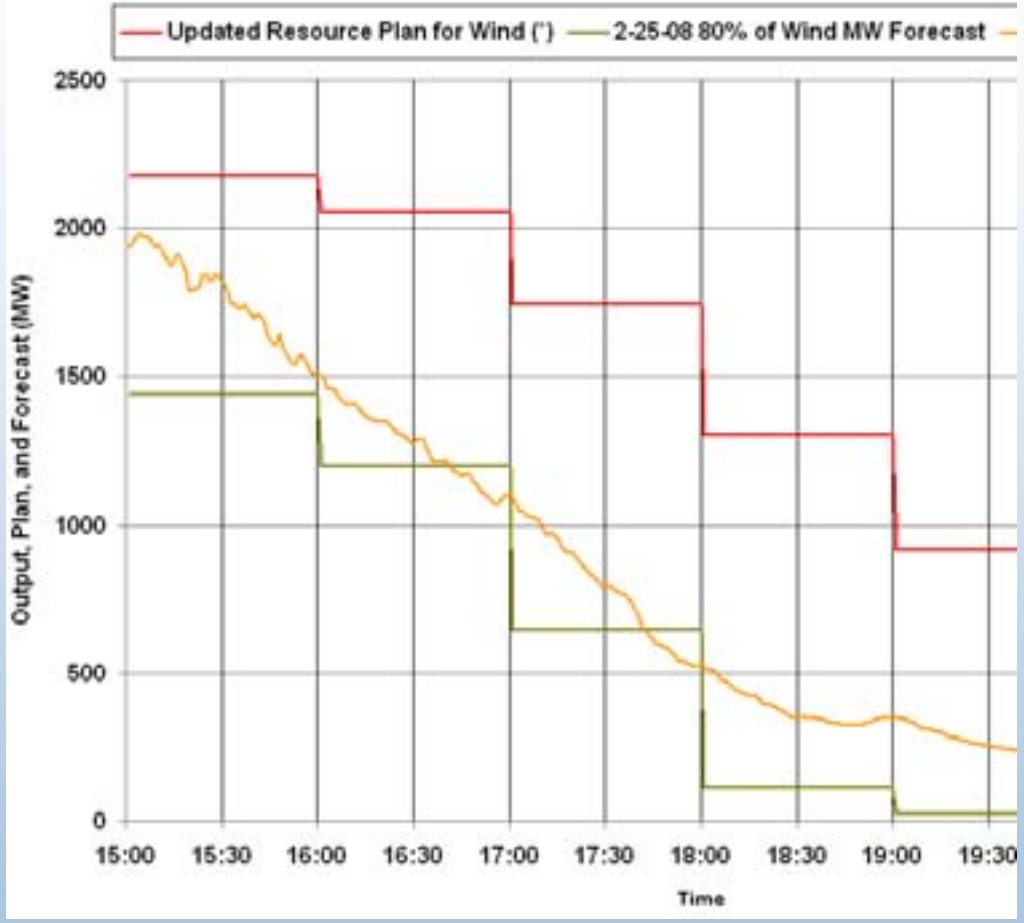
Observations on Study Issues: Reliability Assessment

- Treatment of wind is far from standardized by grid entities across the country
- Statistical ELCC/LOLP treatment of wind resource delivery times is recommended (Milligan)
- Multi-year, actual performance data sets are not available => approximations necessary
- Geographic diversity effects are key:
  - How much difference in reliability depending on wind deployment locations and scenarios?
  - What is the reliability value of wind from multiple states? (e.g. High Plains transmission from WY, CO, and NM to Phoenix and Las Vegas loads).

Large Wind Ramps are NOT Reliability Events

Conventional generation contingencies require dedicated spinning reserves and immediate response (2300 MW of ERCOT Responsive Reserve Service).

Multi-hour wind ramps give the system operator time to utilize market responses, load response, supplemental reserves, or non-spinning reserves.



All of these operational options are much cheaper than maintaining and deploying spinning reserves required for conventional generation.

Observations on Study Issues: Operational Integration of Variable RE

- There is a growing body of analysis and experience that 15 - 25% wind and solar is doable with operational modifications at reasonable cost (and with significant fuel cost risks and benefits)
- We've only just begun…
  - Modification of conventional fleet dispatch and operations
  - BA cooperation and integrated operations
  - Motivate geographic dispersion of sites
  - Integrate wind forecasting and risk assessment into operational procedures
  - Hydro resource re-optimization at high wind %
  - Dispatchable load
  - Selective wind curtailment for ramps and hold-back for spin when system risk is high
  - Storage: pumped hydro, gas, V2G PHEV's, CAES etc.

Comparison of Cost-Based U.S. Operational Impact Studies

Date	Study	Wind Capacity Penetration (%)	Regulation Cost ($/MWh)	Load Following Cost ($/MWh)	Unit Commitment Cost ($/MWh)	Gas Supply Cost ($/MWh)	Tot Oper. Cost Impact ($/MWh)
May '03	Xcel-UWIG	3.5	0	0.41	1.44	na	1.85
Sep '04	Xcel-MNDOC	15	0.23	na	4.37	na	4.60
June '06	CA RPS	4	0.45*	trace	na	na	0.45
Feb '07	GE/Pier/CAIAP	20	0-0.69	trace	na***	na	0-0.69***
June '03	We Energies	4	1.12	0.09	0.69	na	1.90
June '03	We Energies	29	1.02	0.15	1.75	na	2.92
2005	PacifiCorp	20	0	1.6	3.0	na	4.60
April '06	Xcel-PSCo	10	0.20	na	2.26	1.26	3.72
April '06	Xcel-PSCo	15	0.20	na	3.32	1.45	4.97
Dec '06	MN 20%	31**					4.41**
Jul '07	APS	14.8	0.37	2.65	1.06	na	4.08

* 3-year average; total is non-market cost

** Highest integration cost of 3 years; 30.7% capacity penetration corresponding to 25% energy penetration; 24.7% capacity penetration at 20% energy penetration

*** Found $4.37/MWh reduction in UC cost when wind forecasting is used in UC decision

Other Integration Study Efforts

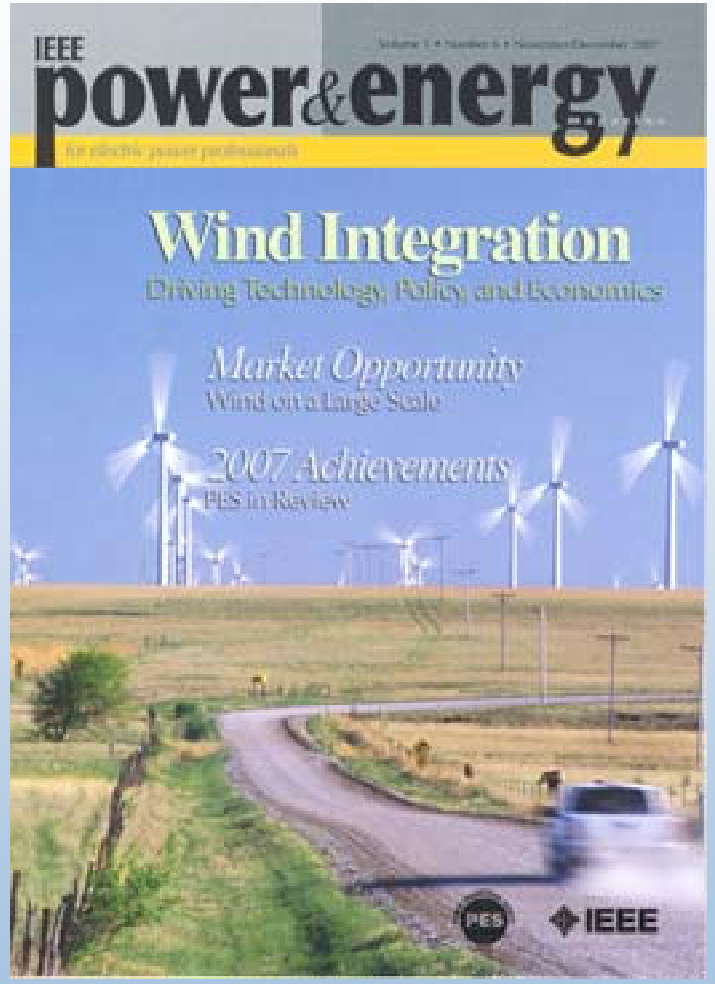
- NREL solicitation for WAPA customer studies
- Ongoing CA examinations
- Northwest Wind Integration Action Forum follow-on efforts
- Regulatory integration rate efforts in ID and by BPA
- Utility specific in WECC
  - Grant County PUD
  - Nevada: not public
  - SMUD
  - Public Service of New Mexico.

Observations on Study Issues: Transmission Expansion Planning

- Deployment of new generation needs will require backbone upgrades, wind exacerbates the issue due to locational dependence.
- Hard to predict generation development patterns (wind has short lead times), but widespread resource availability means wind will deploy near transmission.
- Planning for simultaneous full wind output from all locations is likely not the most economic solution.
- WREZ effort addresses key issues:
  - Multi-state cooperation
  - Likely locations
  - Line siting (leading to permitting applications)
  - Cost allocation and cost recovery (Texas REZ lessons).

Conclusions

- Mesoscale data sets will allow significant improvements in analysis for all 3 study areas
- Lab and DOE research priorities are in line with regional needs
- Growing interest demonstrated through UWIG as a utility informational resource and IEEE, NERC, and FERC activities
- Innovative thinking and approaches will be needed.



"May you live in interesting times" – Ancient Chinese Curse