WECC Operating Impacts

WindPowering America Summit
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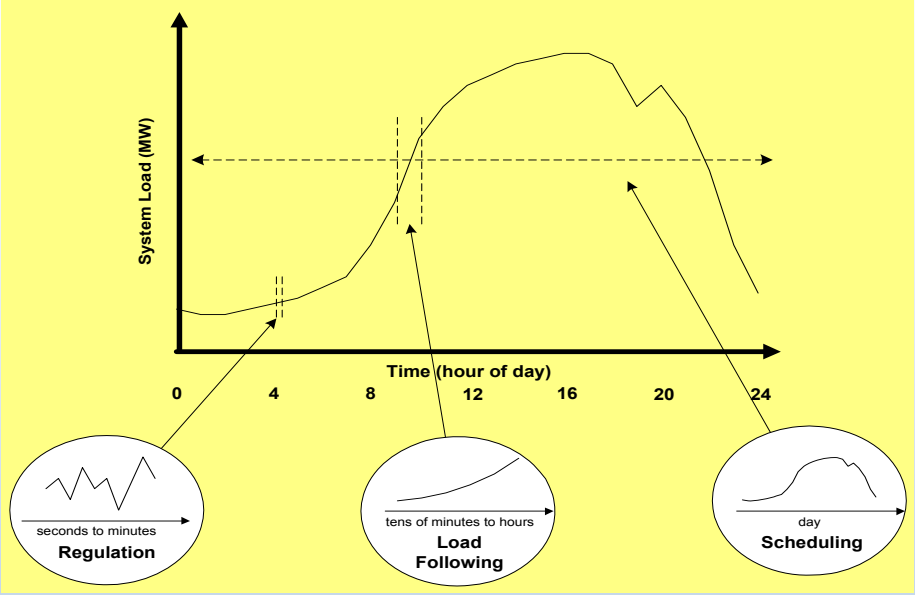
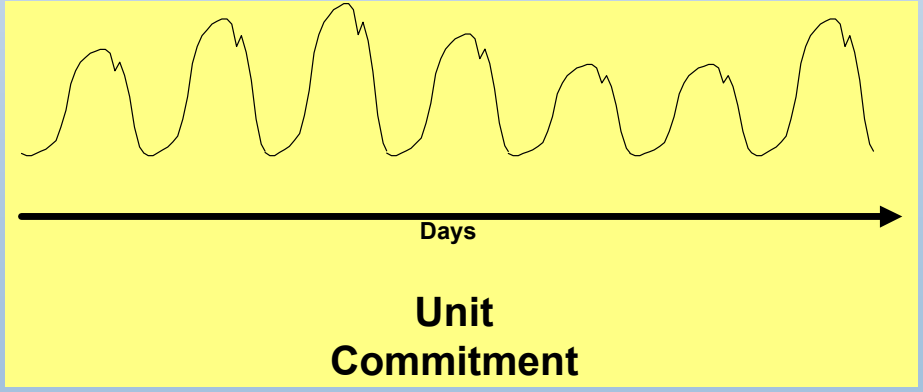
Michael Milligan
National Wind Technology Center
National Renewable Energy Laboratory
Golden, Colorado USA
303-384-6927
michael_milligan@nrel.gov

Presentation Outline

- Issues and time frames of importance
- What are wind's impacts, how are they measured?
- Best practices
- Stakeholder best practices
- Recent results
- Western Wind Integration Study

Time Frames of Wind Impact



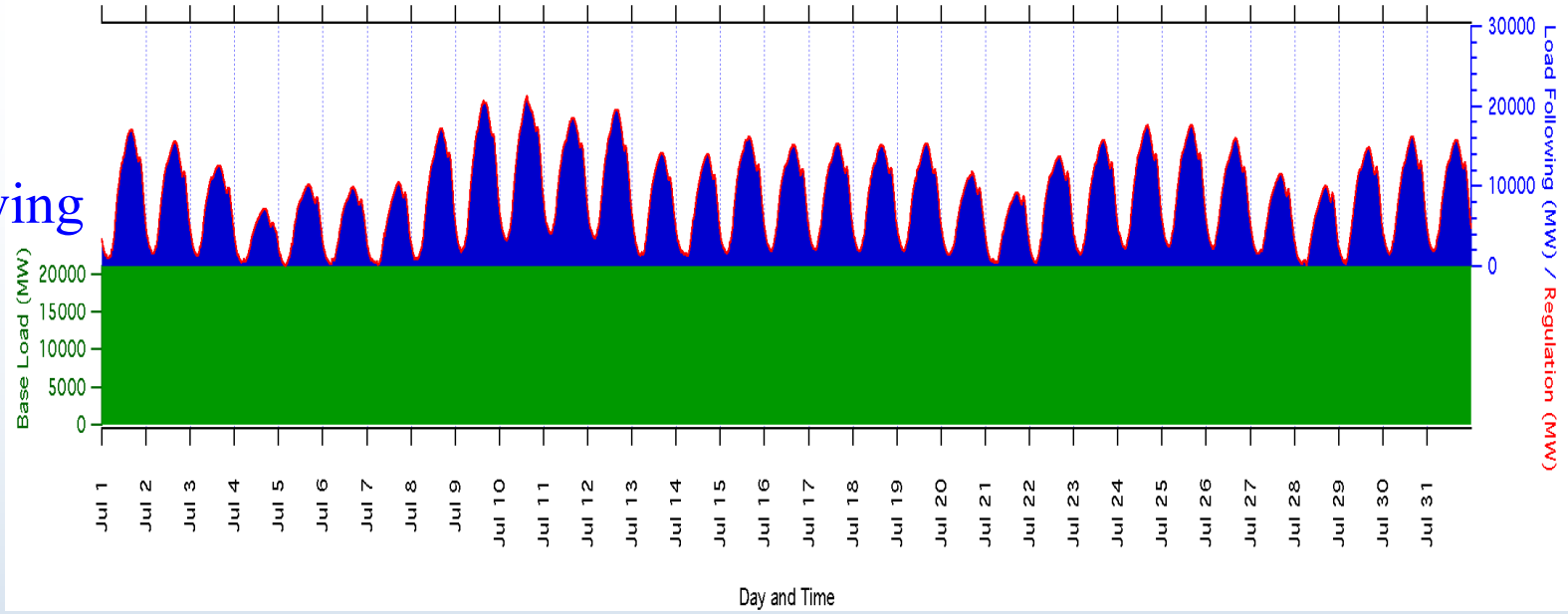


- Typical U.S. terminology
  - Regulation -- seconds to a few minutes -- similar to variations in customer demand
  - Load-following -- tens of minutes to a few hours -- demand follows predictable patterns, wind less so
  - Scheduling and commitment of generating units -- hours to several days -- wind forecasting capability?
  - Capacity value (planning): based on reliability metric (ELCC=effective load carrying capability)

Regulation

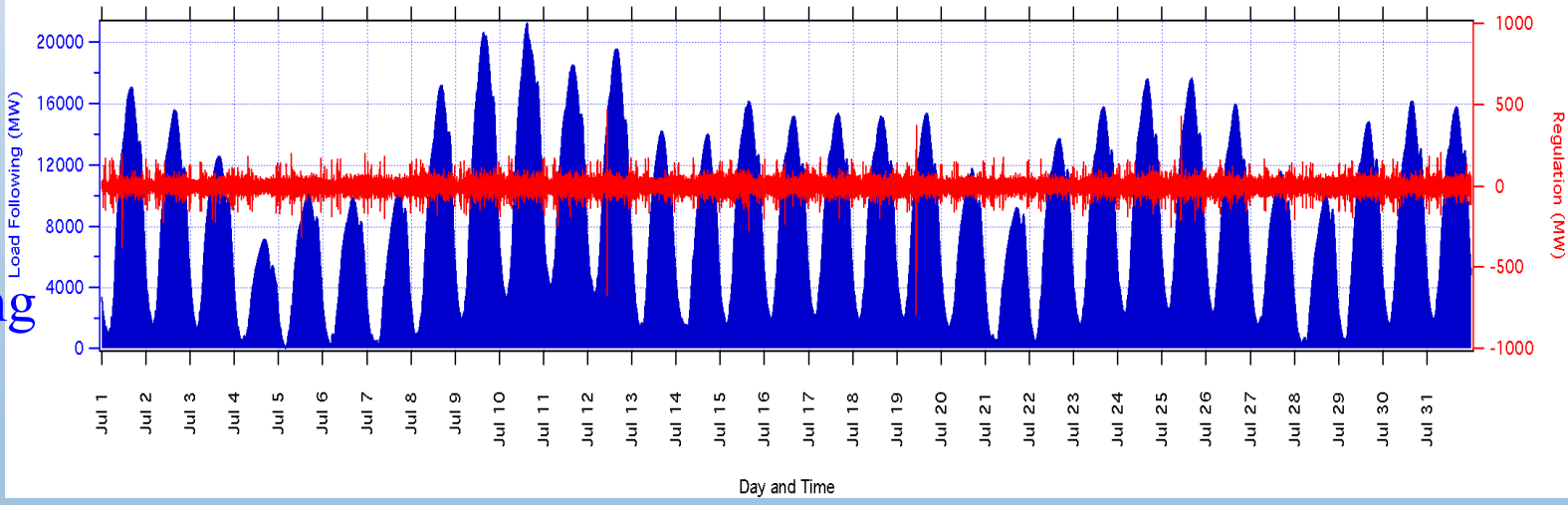
Load following

Base



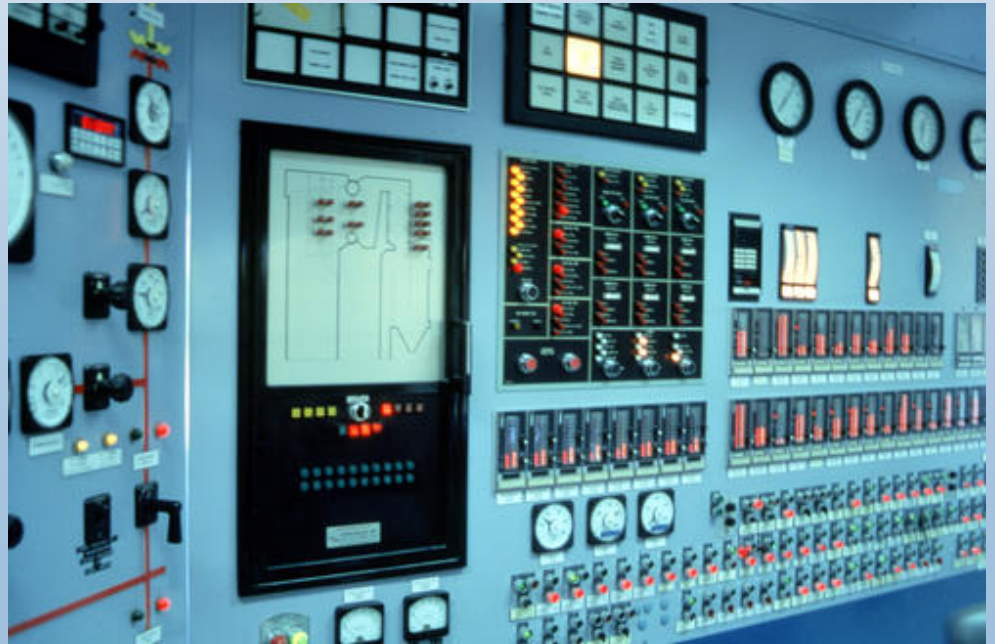
Regulation

Load following



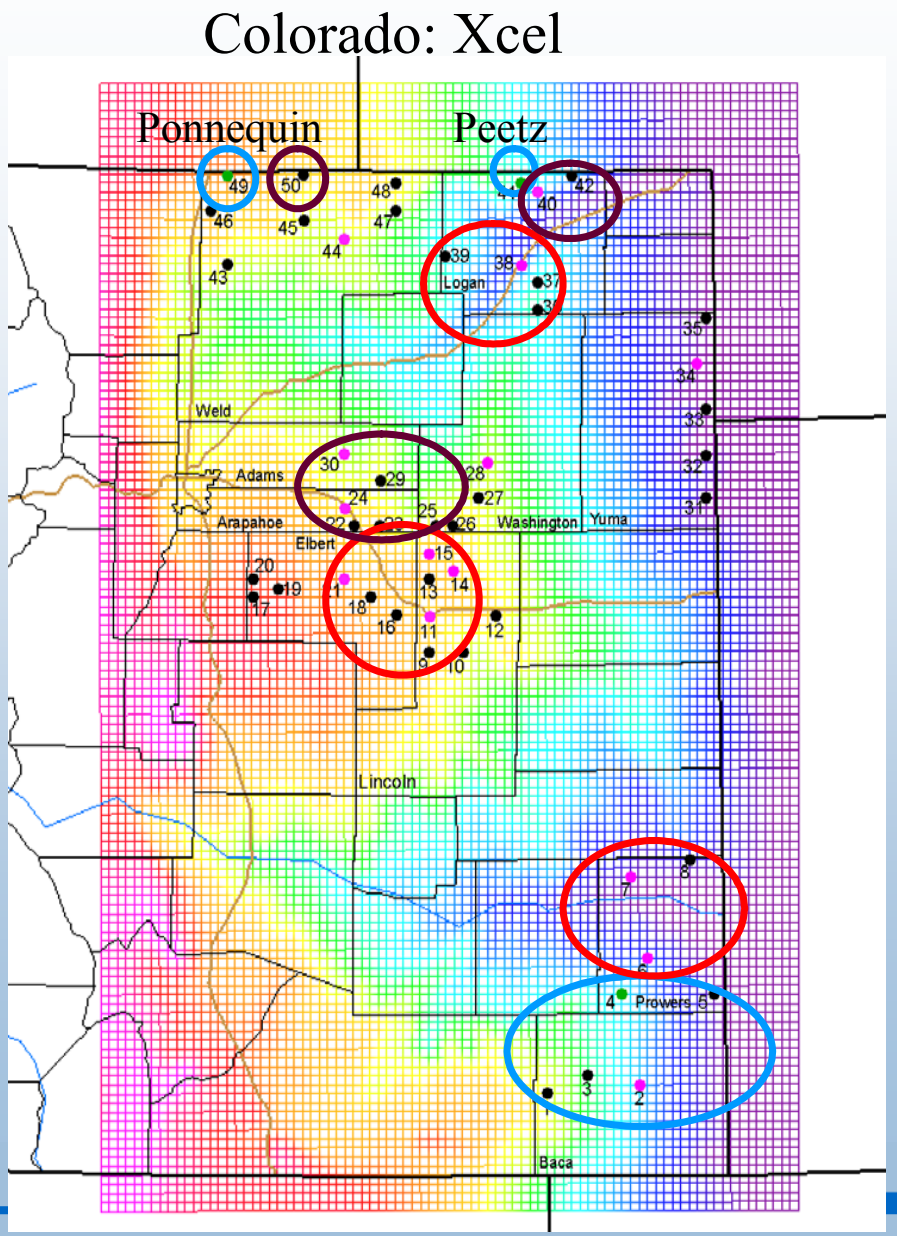
Study Methods

- Simulate power system with/without wind
- Integration costs must have physical cause
- System operator must balance loads=resources (within statistical tolerance)
- Key implication: ***It is not necessary or desirable to match wind's movements on a 1-1 basis***



Where Does Wind Data Come From?

- Meso-scale meteorological modeling that can “re-create” the weather at any space and time
- Model is run for the period of study and must match load time period
- Wind plant output simulation and fit to actual production of existing plants
- Scaling up single wind turbine to represent wind plant is invalid



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

Date	Study	Wind Capacity Penetra-tion (%)	Regula-tion Cost ($/MWh)	Load Following Cost ($/MWh)	Unit Commit-ment Cost ($/MWh)	Gas Supply Cost ($/MWh)	Total Operating 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 Multi-year	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**

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

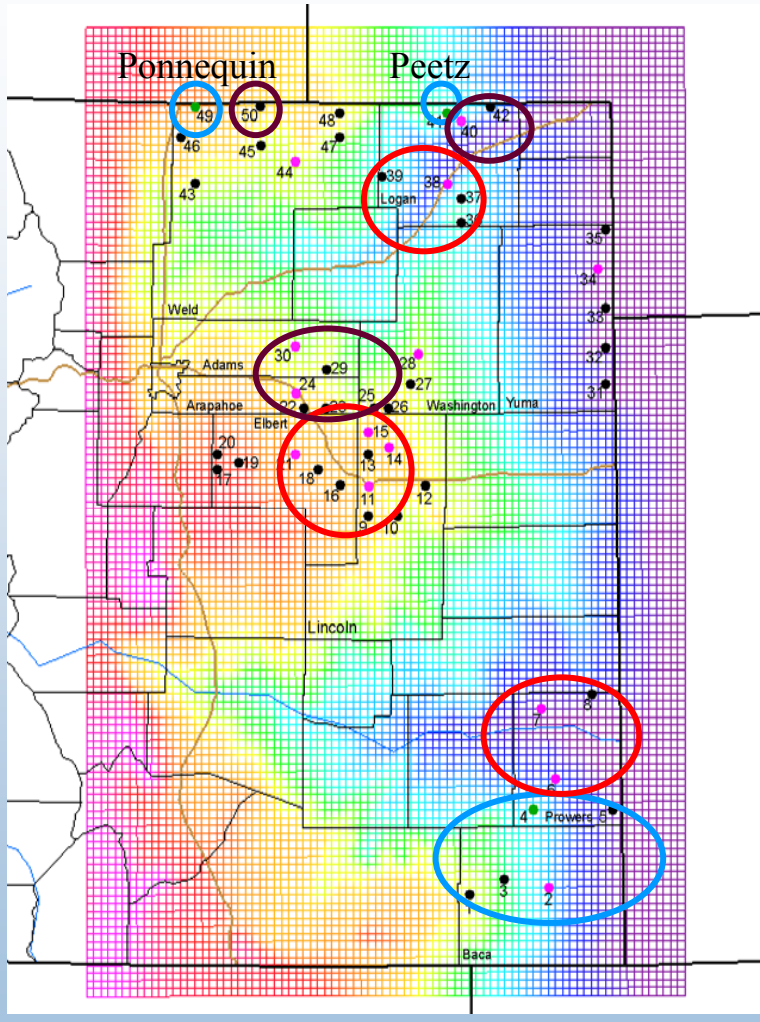
** highest integration cost of 3 years; 30.7% capacity penetration corresponding to 25% energy penetration; 24.7% capacity penetration at 20% energy penetration

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

Recent Results in the West

Xcel Colorado/Enernex Study

- 10%, 15%, and 20%* penetration (wind nameplate to peak load) examined for ~7 GW peak load
- Gas storage & nominations
  - Gas imbalance
  - Extra gas burn for reserves
- Gas price sensitivity
- O&M increase for increased start/stops
- Real-time market access



* 20% case is currently underway

Xcel Colorado/Enernex Study

Penetration Level	10%	15%
Hourly Analysis	$2.26/MWh	$3.32/MWh
Regulation	$0.20/MWh	$0.20/MWh
Gas Supply (1)	$1.26/MWh	$1.45/MWh
Total	**$3.72/MWh**	**$4.97/MWh**

(1) Costs includes the benefits of additional gas storage

Additional work is underway to analyze a 20% penetration case.

- **Without use of 300 MW pumped hydro unit, costs at 10% would be $1.30/MWh higher**

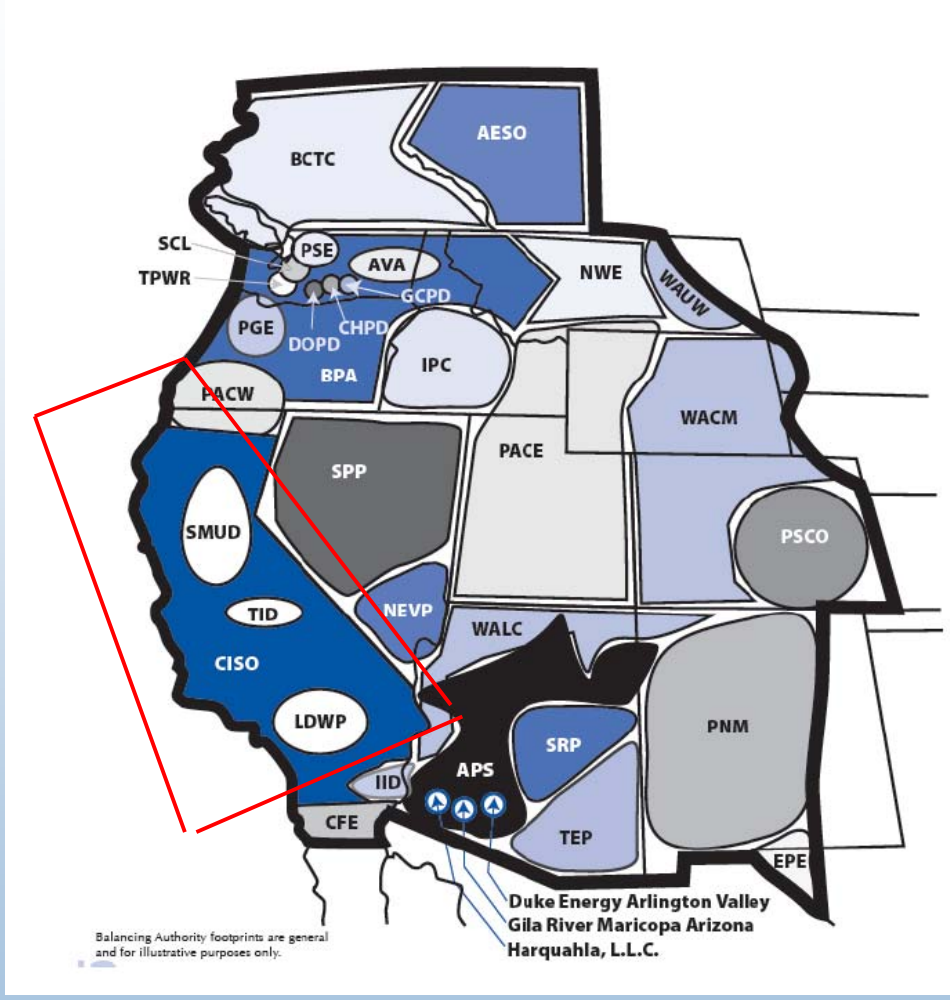
Gas Storage Benefits/Results

- Summer/winter arbitrage
  - Cost savings in filling in summer and withdrawing in winter
- Reduction in need for financial hedge (call option)
  - Because the price of the gas in the storage field is known, there is no need to financially hedge the market price of the gas

Wind Penetration	10%	15%
$/ MWH Gas Impact No Storage Benefits	$2.17	$2.52
$ / MWH Gas Impact With Storage Benefits	$1.26	$1.45

California Intermittency Analysis Project

- Up to 24% wind (rated capacity to peak)
- Savings
  - WECC nearly $2B
  - CA $760M
- Wind forecast benefit $4.37/MWh
- Regulation cost up to $0.67/MWh
- Unit commitment w/forecast results in sufficient load following capability (and no load following cost)



12,500 MW wind, 2,600 MW solar

•http://www.energy.ca.gov/pier/notices/

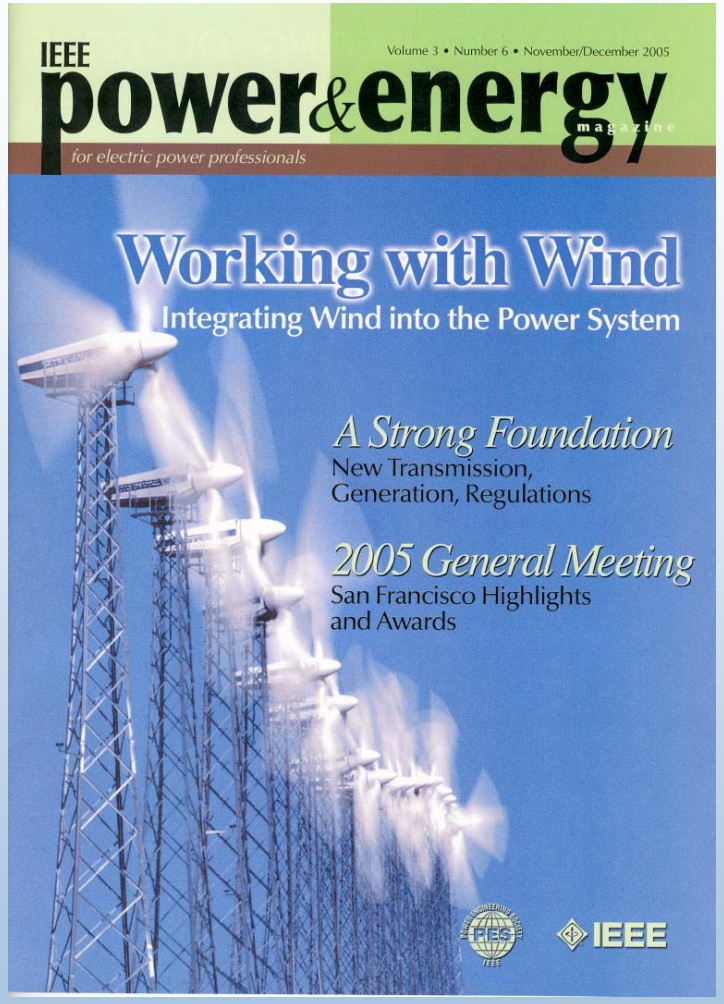
Stakeholder Review Best Practices

- Technical review committee (TRC)
  - Bring in at beginning of study
  - Discuss assumptions, processes, methods, data
- Periodic TRC meetings with advance material for review
- Examples in Minnesota, Colorado, California, New Mexico, Arizona, and interest by other states

Northwest Wind Integration Action Plan

- www.nwcouncil.org
- "There are no fundamental technical barriers to operating 6,000 megawatts of wind in the Pacific Northwest. "
- Series of recommendations for the NW to successfully integrate 6 GW of wind
  - Control area cooperation
  - Sub-hourly markets
- Avista, Idaho Power, and BPA integration work
  - No peer-review or TRC
  - Avista and Idaho results quite high, utilities have been very responsive to discussion and suggestions for improvement

Increasing Attention in North America



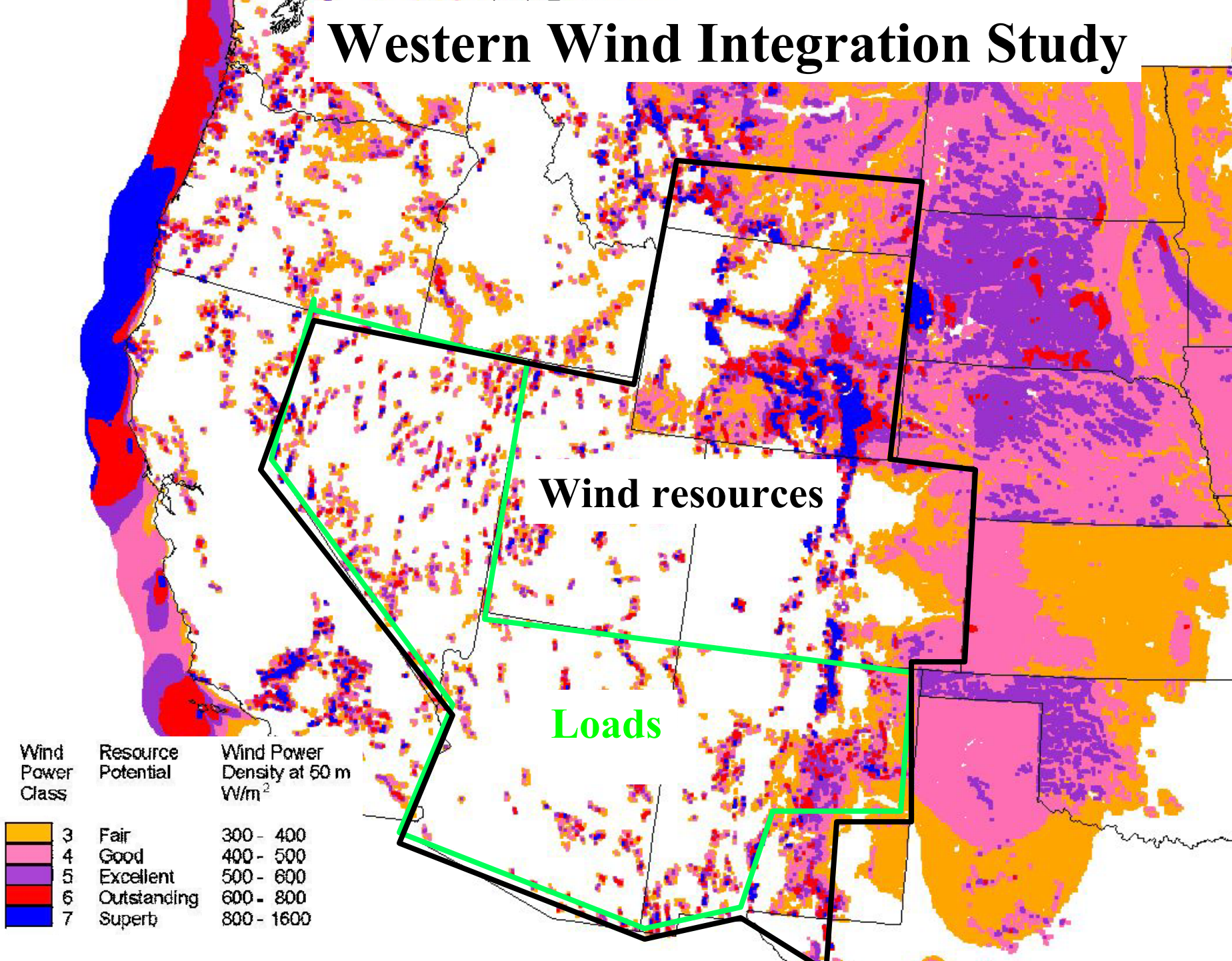
- IEEE Power Engineering Society Magazine, November/December 2005
- Update in Nov/Dec 2007
- Wind Power Coordinating Committee kickoff June 2006, Montreal PES meeting
- www.uwig.org
- Recommend utility membership and involvement in UWIG to learn from other utilities

UWIG Utility Wind Integration Group

Accelerating the Integration of Wind Generation into Utility Power Systems

New Study
Western Wind Integration Study

Western Wind Integration Study



Status

- First Stakeholder Meeting May 23 at NREL
- Input on questions to address in study
- Data for study
- Scheduling of study outputs
- Contact Debbie Lew at debra_lew@nrel.gov or 303-384-7037

Questions to address

- What additional aggregate system operational impacts or costs are imposed by wind variability? What kinds of mitigation measures help to manage that incremental variability?
- Is it cheaper to use local wind resources or import better class resources from out-of-state? How do out-of-state resources compare to local wind resources for matching load profiles?
- What are the benefits from long distance transmission that accesses multiple wind resources that are geographically diverse?
- How does hydro help with wind integration?
- What is the role and value of wind forecasting?
- What benefit does Balancing Area cooperation or consolidation bring to wind variability management?
- How does each wind area contribute to reliability and capacity value?

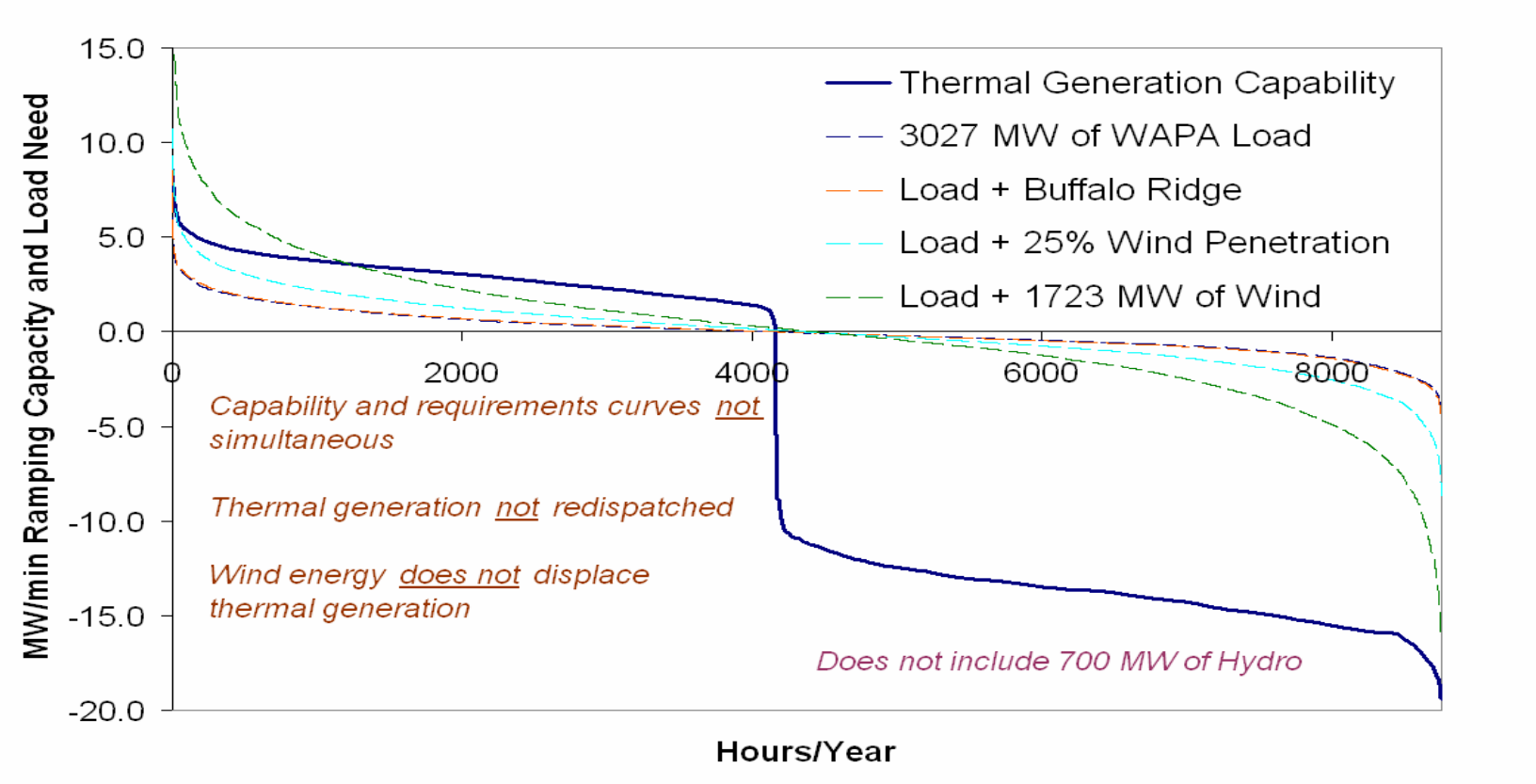
Wind Integration for Tri-State

- Challenges and recommendations:
  - Tri-State is not control area operator
  - WAPA hydro allocation implies any integration study should be carried out jointly with WAPA (perhaps others)
  - Xcel/CO study indicates high value of pumped storage – examine role of WAPA pumped storage
  - Coordinate with Western Wind Integration Study
  - WAPA Administrator Meeks: One of top 3 priorities is wind integration
  - NREL/NWTC has broad, in-depth experience and can assist in technical review process if desired

Wind Integration for Tri-State (cont)

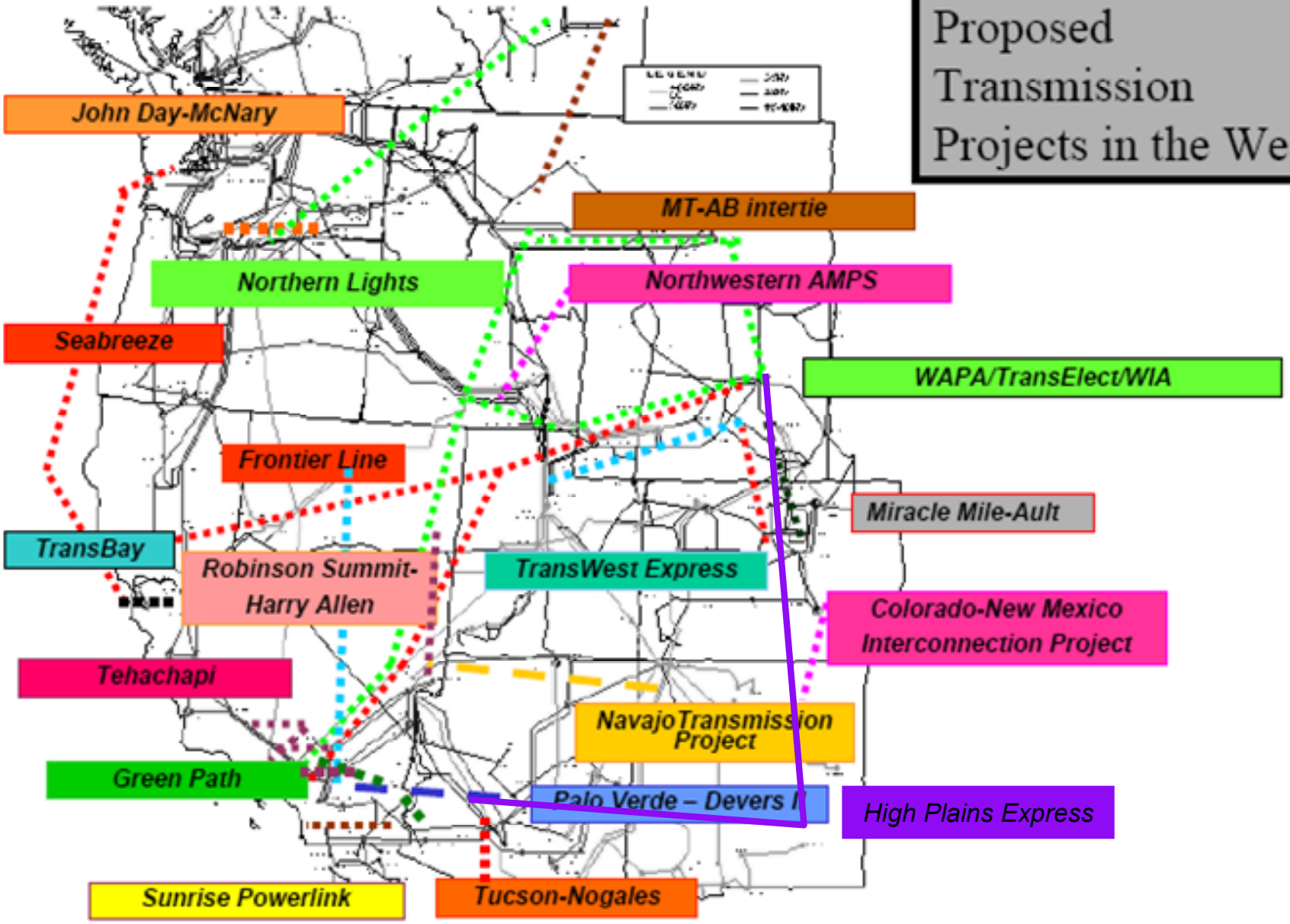
- Access to generator flexibility is important with wind
  - Tri-State ancillary services provided by WAPA
  - AGC and imbalance not provided from Tri-State units, but could be (physical capability exists, but is not available to the Balancing Authority
- Western power markets and access in Colorado very limited, increasing the challenge of integration
- Solution: creation of regional markets or agreements with neighboring systems to access physical ramping capability
  - Increase Tri-State's ability to integrate wind at lower cost
  - Provide opportunity for more economically efficient operations without wind

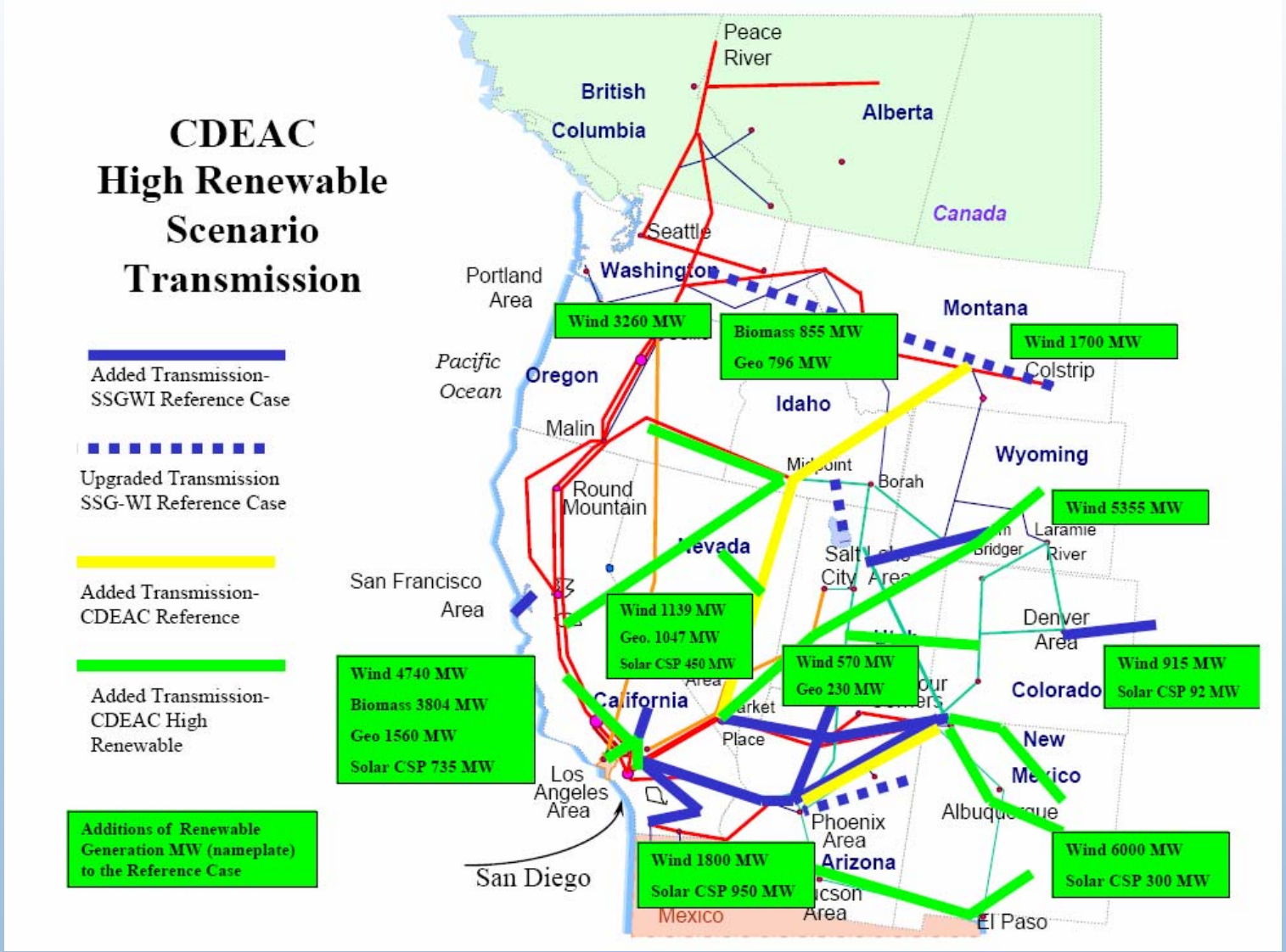
Thermal-Only Ramping Capability in WAPA Control Area and Wind Simplified Analysis



Conclusion: significant *thermal* ramping capability, when added to actual hydro ramping and pumped storage, can integrate significant level of wind (Milligan & Kirby, http://www.nrel.gov/docs/fy05osti/38153.pdf

Proposed Transmission Projects in the West



- Western Governors' Clean and Diverse Energy Plan

http://www.westgov.org/wga/initiatives/cdeac/index.htm