National Renewable Energy Laboratory
Innovation for Our Energy Future

Wind Integration: Tri-State Public Process

Tri-State G & T

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Outline

- What do we know about wind integration?
- Relevance for Tri-State
- Physical impacts and potential improvement
- Tariff/cost considerations
- Recommendations

What do we know about wind integration?

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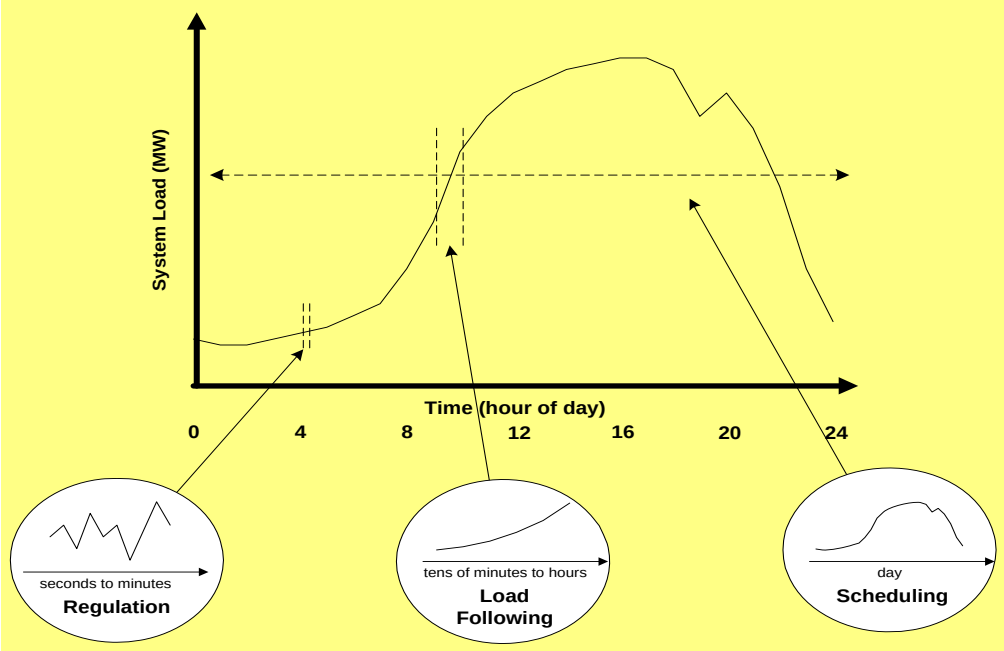
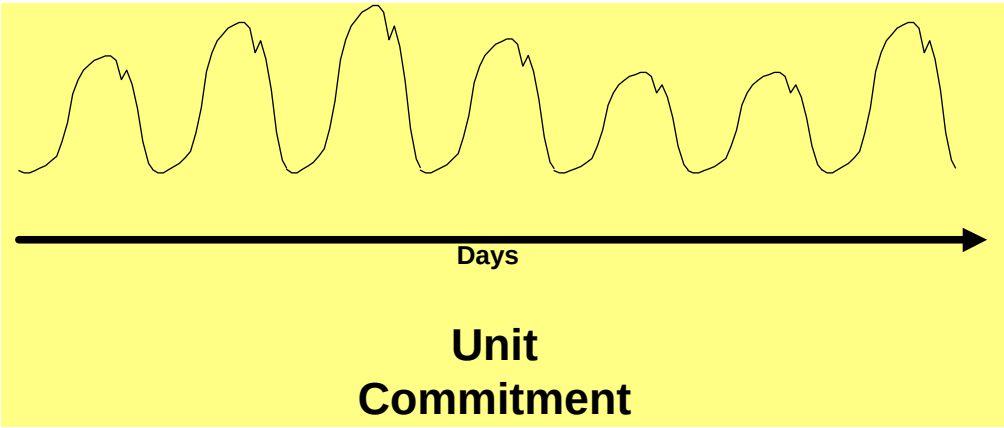
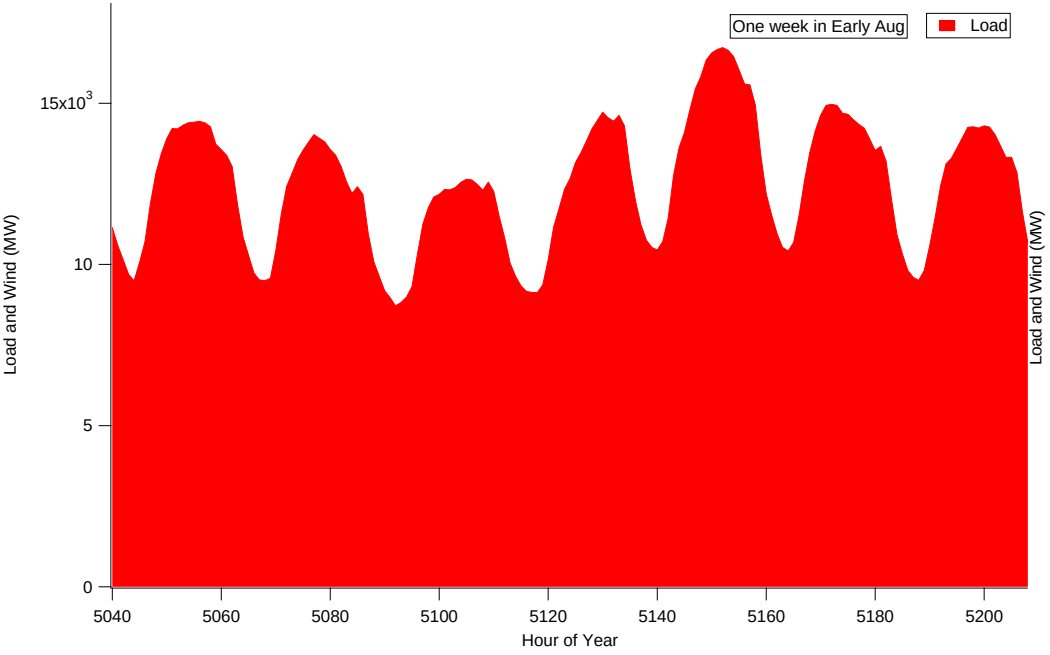


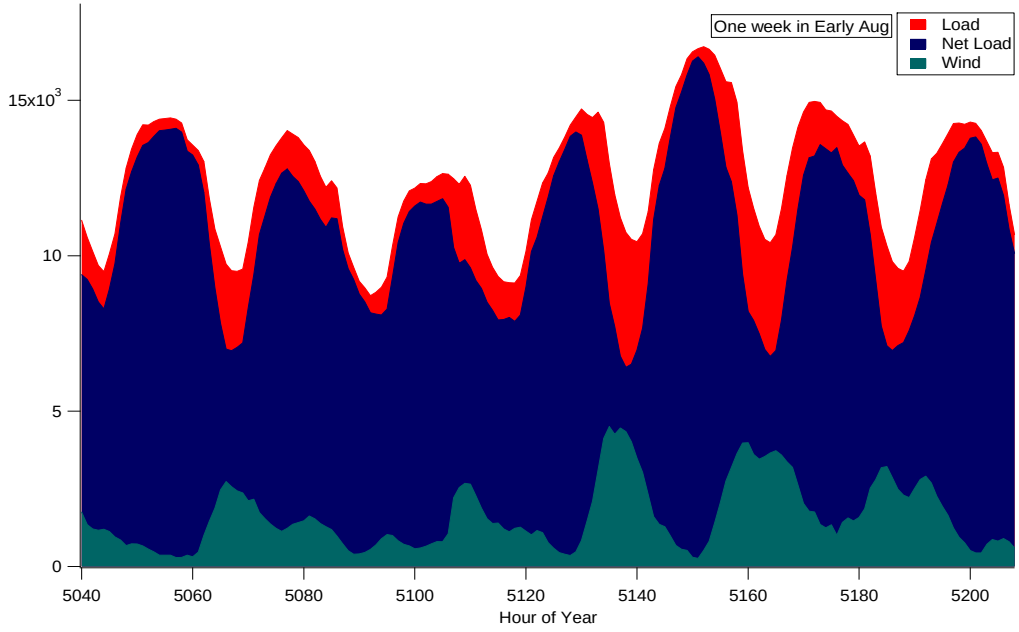


- Small regulation impact (larger in WECC w/hourly schedules)
- Load following impact is variable
- Unit commitment: need to be informed by wind and load forecasts
- Results around the world lead to consistent answers

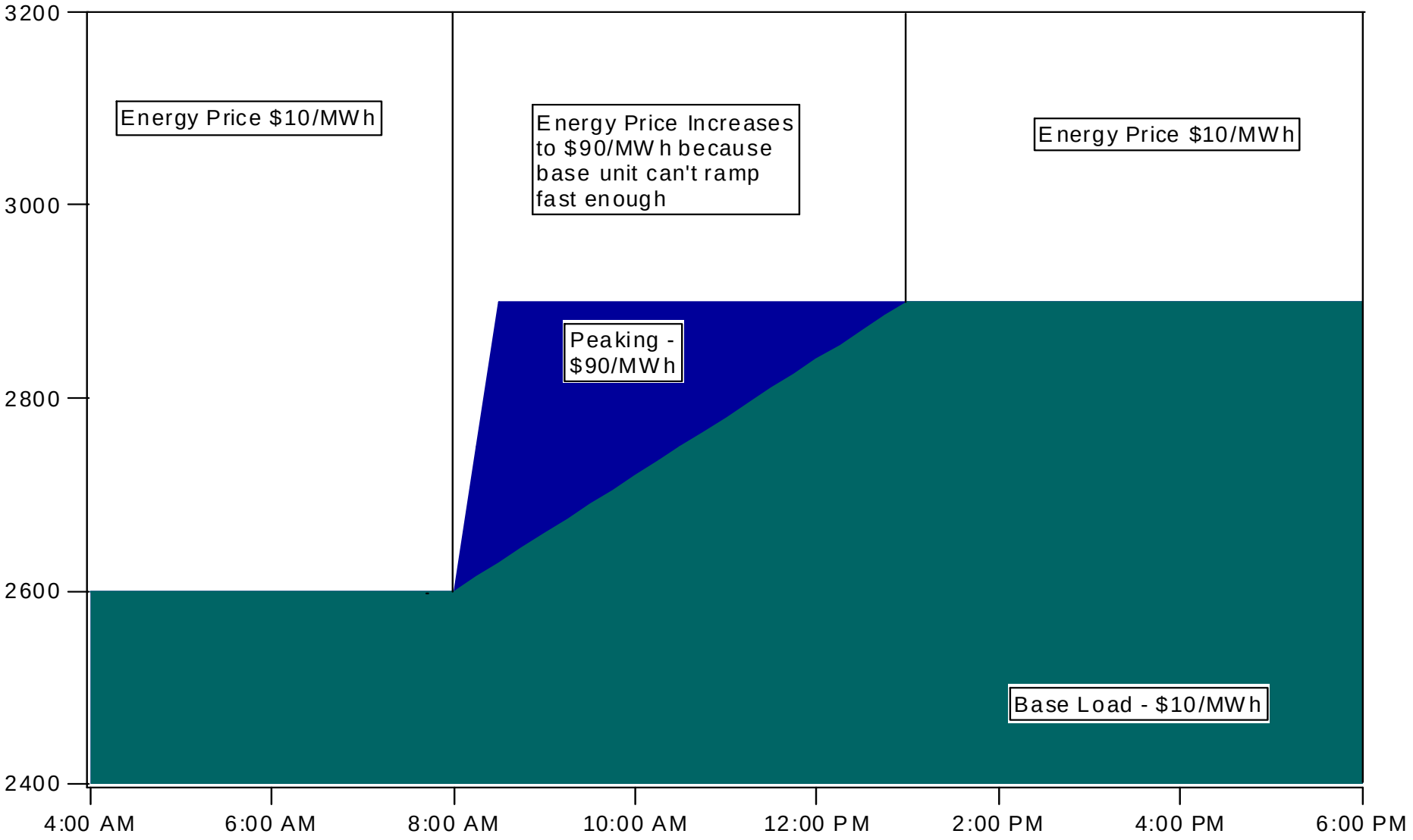
Impact of high wind penetration

- Examples from a 25% wind energy penetration case
- Faster ramping
- Lower min-load (minimum net load: load less wind)



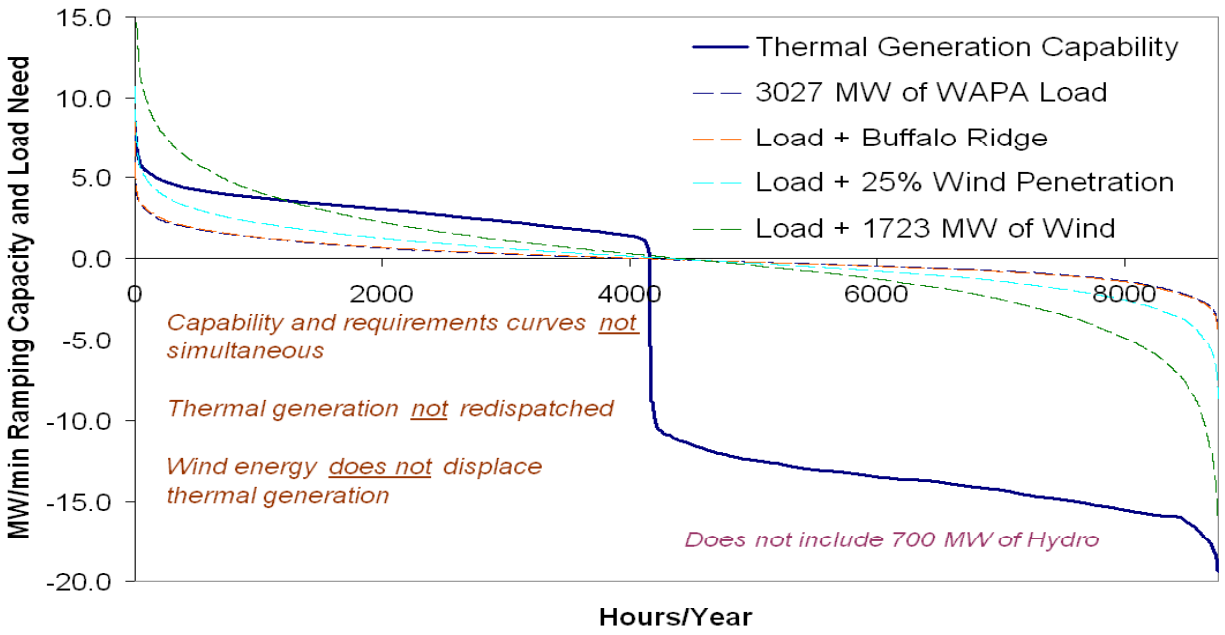


Can the non-wind fleet ramp quickly enough?



Better use of existing flexibility

- Tap into maneuverable generation that may be "behind the wall". Conclusion: significant thermal ramping capability, when added to actual hydro ramping and pumped storage, can integrate significant level of wind [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]



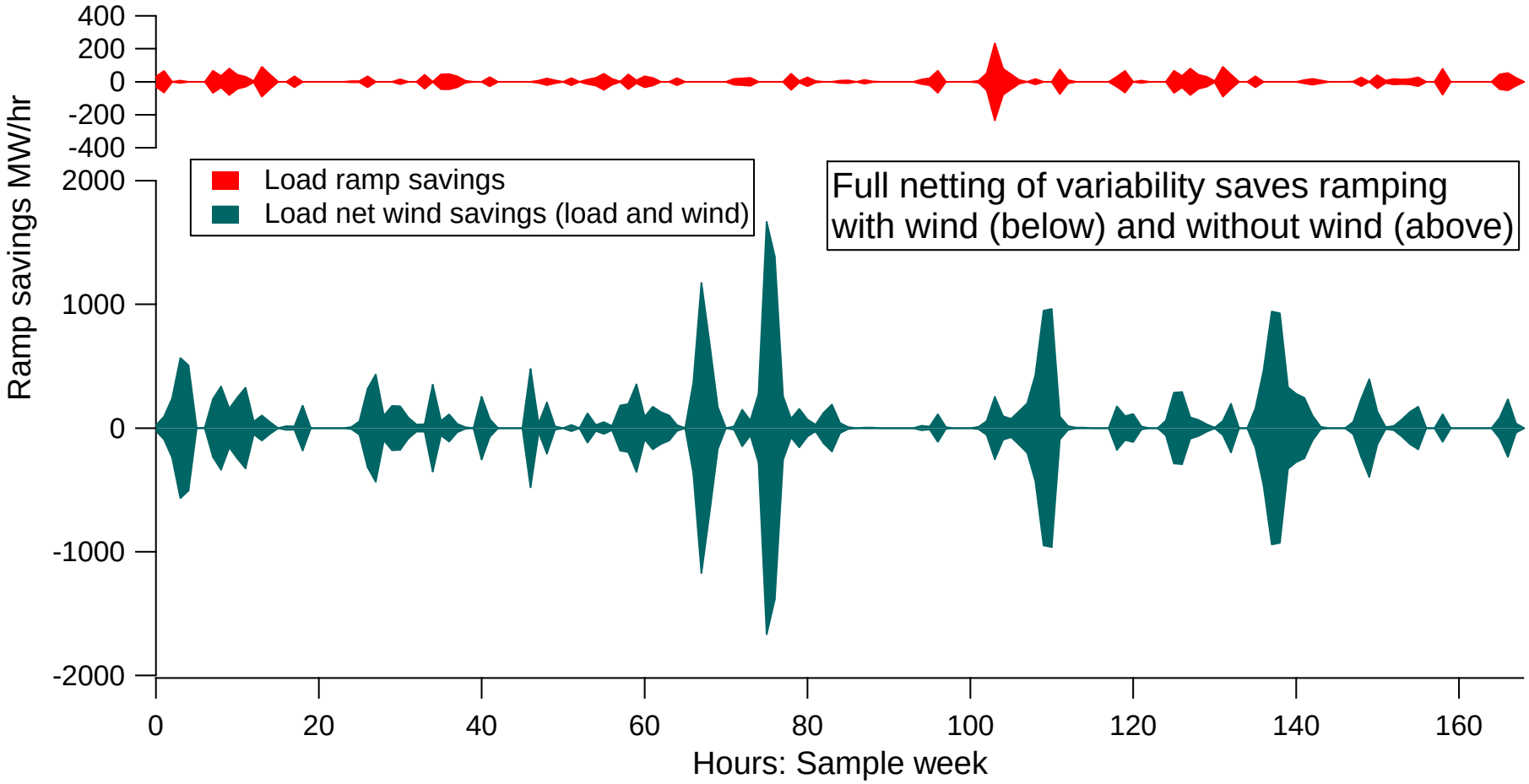
[1]Kirby & Milligan, 2005 Methodology for Examining Control Area Ramping Capabilities with Implications for Wind http://www.nrel.gov/docs/fy05osti/38153.pdf

[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

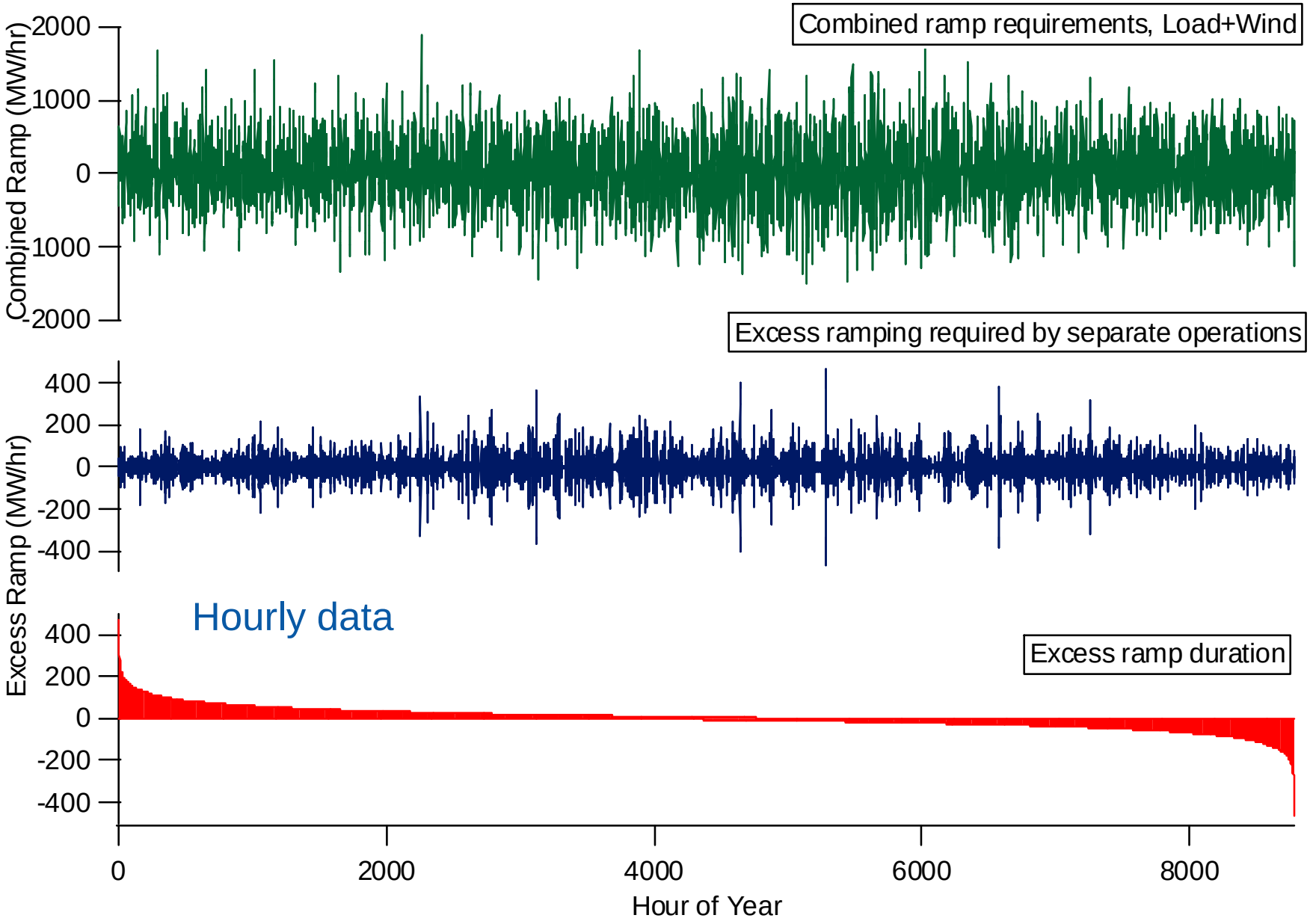
Acquire additional flexibility across BAs

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

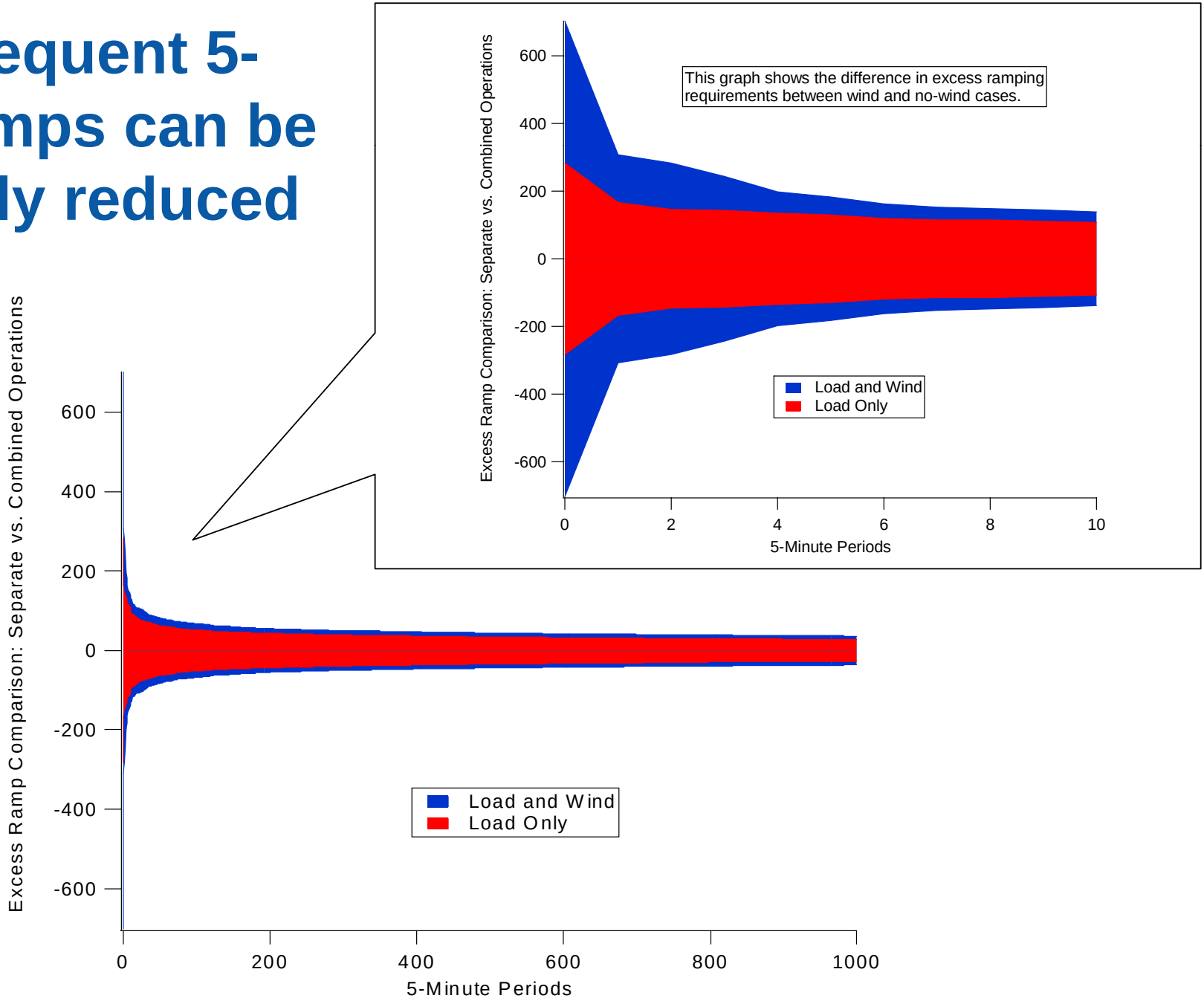


Milligan & Kirby, To Appear, and Milligan & Kirby 2007, Impact of Balancing Areas Size, Obligation Sharing, and Ramping Capability on Wind Integration . http://www.nrel.gov/docs/fy07osti/41809.pdf

BA variability pooling reduces ramp requirements

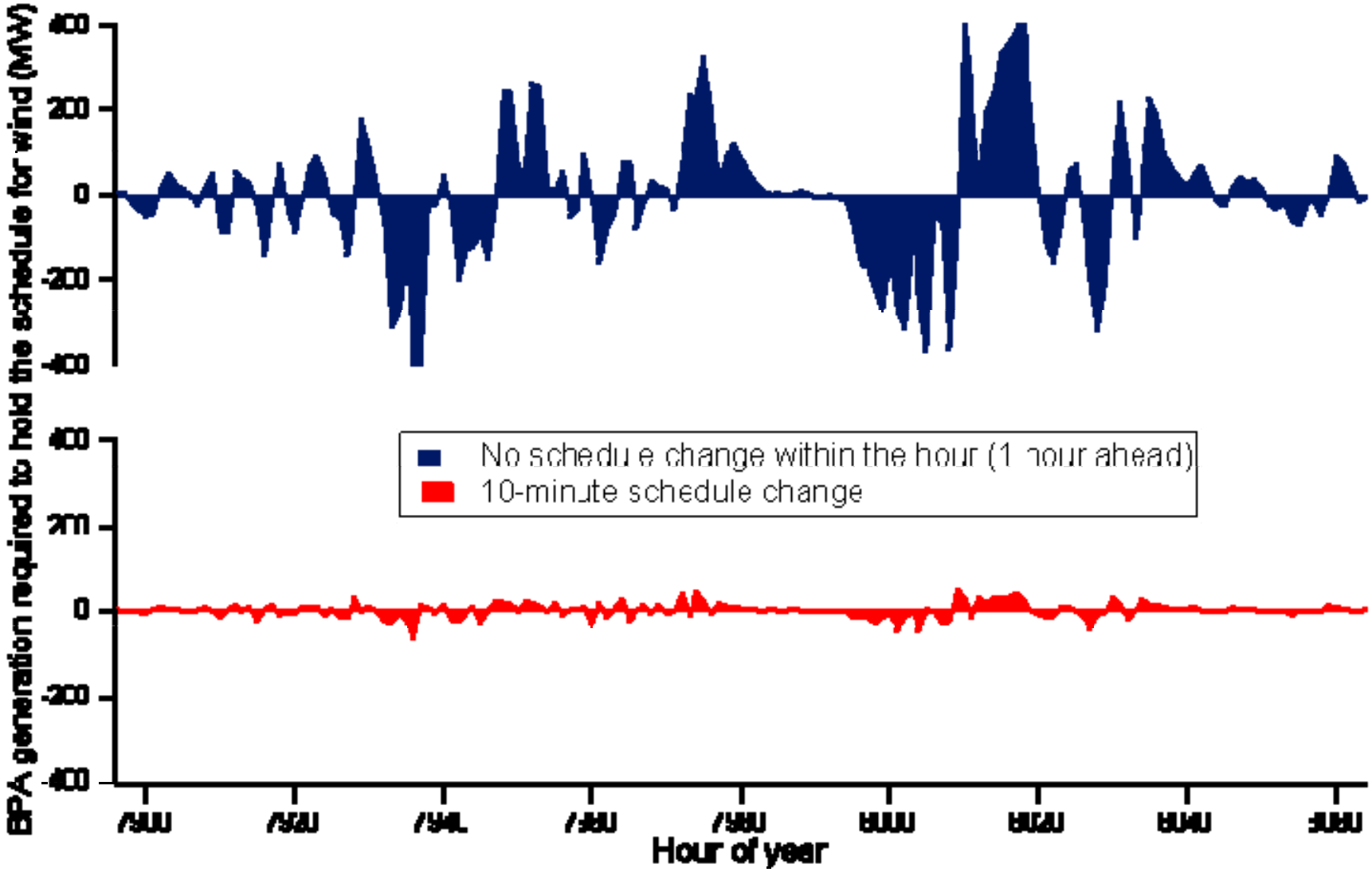


Large, infrequent 5-Minute Ramps can be significantly reduced



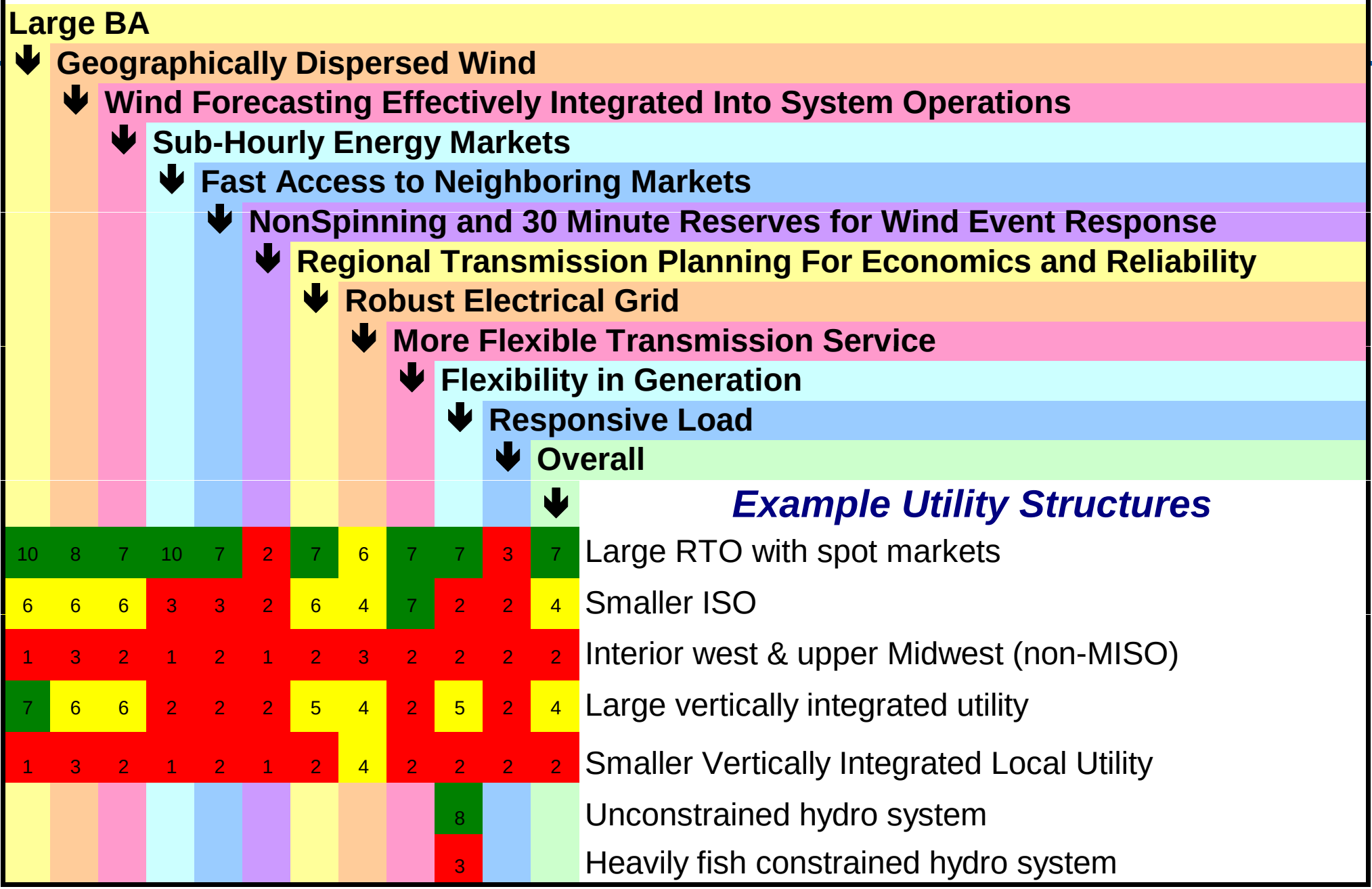
Milligan & Kirby 2008, An Analysis of Sub-Hourly Ramping Impacts of Wind Energy and Balancing Area Size .

Impact of hourly scheduling on inter-BA capacity requirements



Kirby, B., Milligan M. (2009) Capacity Requirements to Support Inter-Balancing Area Wind Delivery. National Renewable Energy Laboratory Technical Report. NREL/TP-550-46274. Available at http://www.nrel.gov/docs/fy09osti/46274.pdf.

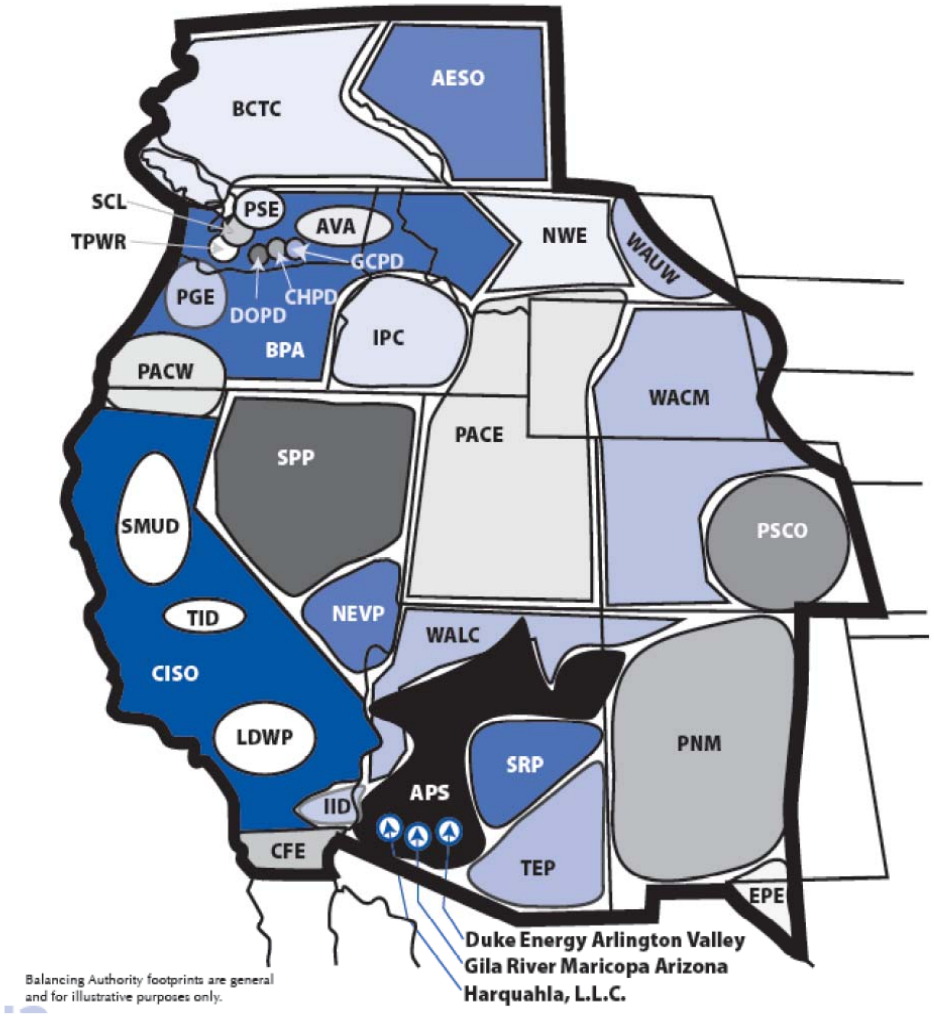
Accommodating Wind Integration

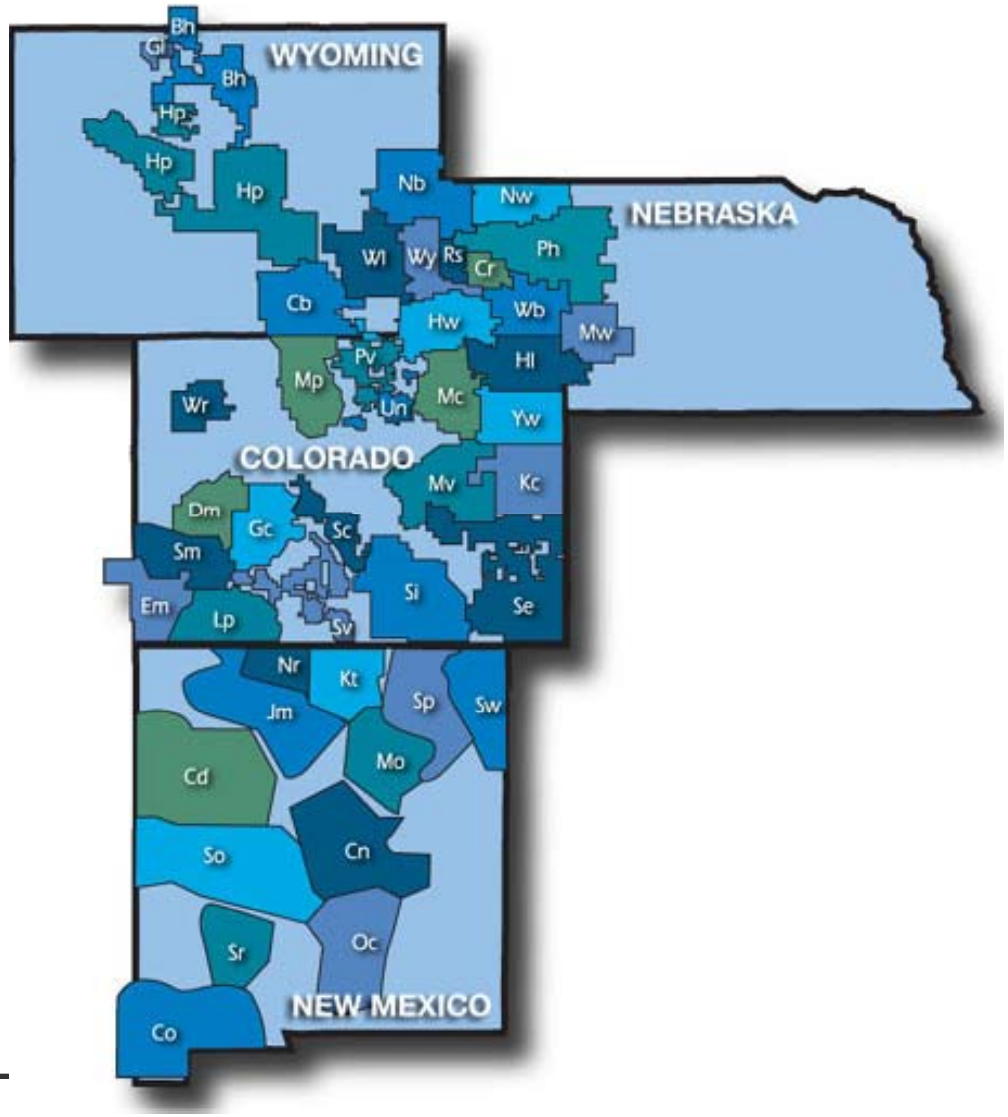


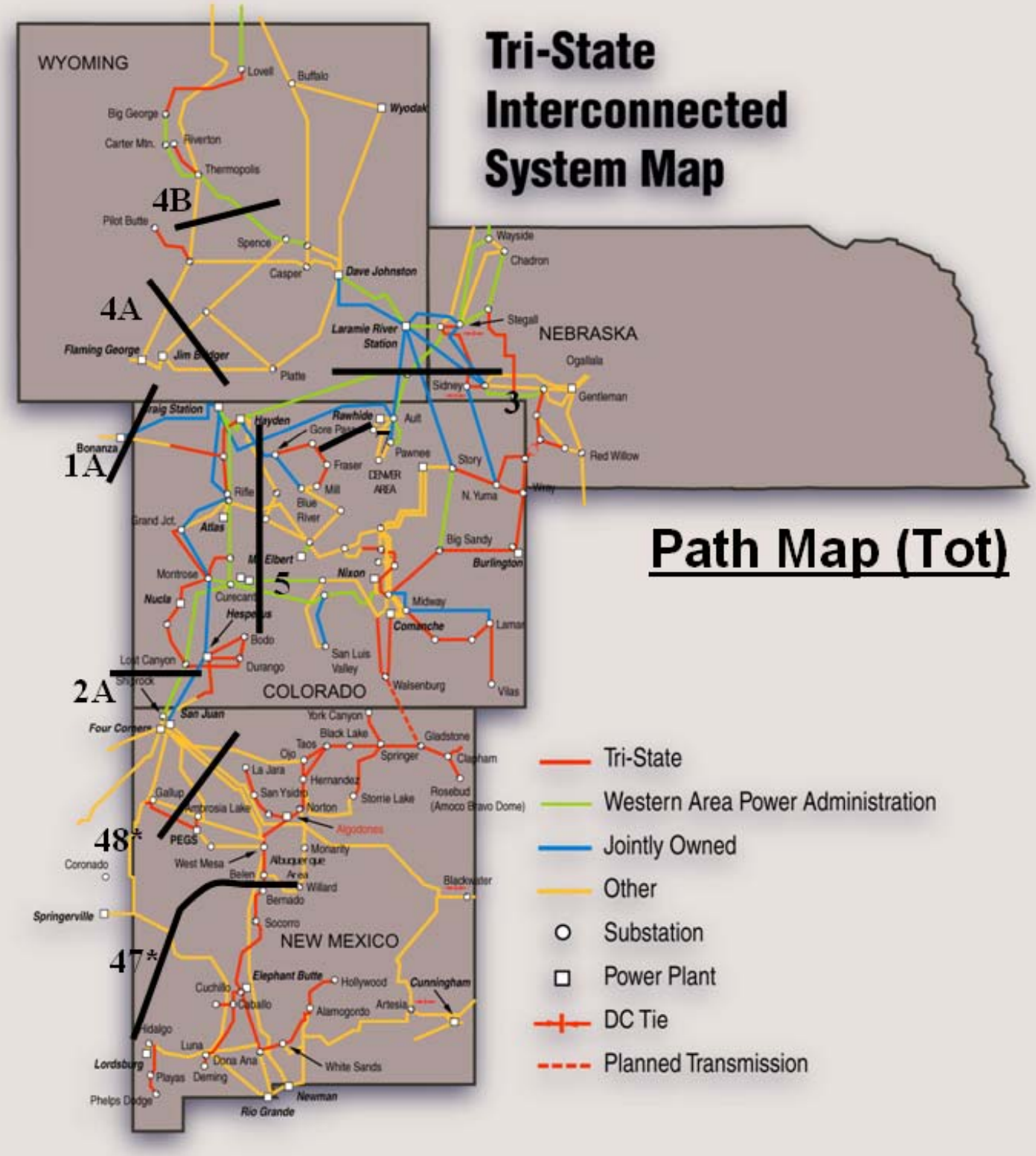
Kirby, B.; Milligan, M. (2008). Facilitating Wind Development: The Importance of Electric Industry Structure. 26 pp.; NREL Report No. TP-500-43251. http://www.nrel.gov/docs/fy08osti/43251.pdf

Relevance for Tri-State

Challenge of multiple balancing authorities






Tri-State
Interconnected
System Map
Path Map (Tot)
WYOMING
NEBRASKA
COLORADO
NEW MEXICO
4B
4A
1A
3
5
2A
48*
47*
Lovell
Buffalo
Wyodak
Big George
Carter Mtn.
Riverton
Thermopolis
Pilot Butte
Spence
Casper
Dave Johnston
Flaming George
Jim Bridger
Platte
Laramie River Station
Wayside
Chadron
Stegall
Ogallala
Sidney
Gentleman
Red Willow
Craig Station
Hayden
Rawhide
Ault
Gore Pass
Bonanza
Pawnee
Fraser
Story
DENVER AREA
Mill
Rifle
Blue River
N. Yuma
Grand Jct.
Atlas
Big Sandy
Burlington
Mt Elbert
Nixon
Monitrose
Curecanti
Nucla
Hesperus
Midway
Comanche
Lamar
Bodo
Lost Canyon
Durango
San Luis Valley
Shiprock
Walsenburg
Vilas
San Juan
Four Corners
York Canyon
Black Lake
Gladstone
Taos
Ojo
Springer
Clapham
La Jara
Hernandez
Gallup
San Ysidro
Stornie Lake
Rosebud (Amoco Bravo Dome)
Norton
Algodones
PEGS
Monarity
Coronado
West Mesa
Belen
Willard
Blackwater
Bernado
Springerville
Socorro
Elephant Butte
Hollywood
Cunningham
Cuchillo
Caballo
Artesia
Alamogordo
Hidalgo
Luna
Dona Ana
White Sands
Lordsburg
Playas
Deming
Phelps Dodge
Newman
Rio Grande
Tri-State
Western Area Power Administration
Jointly Owned
Other
Substation
Power Plant
DC Tie
Planned Transmission

Physical Issues

Where will wind be located and delivered?

- Load-ratio share of wind to each BA?
- Opportunity to share variability with others?
  - Use dynamic schedule to pool Tri-State wind with PSCo wind → reduced per-unit variability for all
  - Similar approach for other BA's?
- Wide-area wind variability pooling with load-ratio (or other) pro-rata sharing
- Participation in ACE Diversity Interchange
- Deliver all wind to least-expensive BA, based on integration tariff
- Potential for the WECC SIS EIS to help manage variability

Hourly dispatch and scheduling

- …will increase the challenge
  - Regulation impact is larger
  - Units that may economically respond within the hour are restricted by rules/practice from helping

Tariff/cost issues

Tariff issues

- What are integration tariffs for each relevant BA and how do costs compare?
- Some tariffs do not pass the “cost-causation” test, suggesting potential business solutions that will reduce payments even though variability is unchanged (Western is one example[1]).

[1]Kirby, B.; Milligan, M.; Wan, Y. (2006). Cost-Causation-Based Tariffs for Wind Ancillary Service Impacts: Preprint. 26 pp.; NREL Report No. CP-500-40073. http://www.nrel.gov/docs/fy06osti/40073.pdf

Other

- Xcel/CO study indicates high value of pumped storage – examine role of WAPA pumped storage

Recommendations

- Examine alternative wind delivery and integration scenarios
- Estimate the impact of alternative delivery scenarios on different BA tariffs
- Examine potential pooling opportunities with neighboring utilities and BAs
- Continuation of the public process with periodic technical review
- Longer-term: participation in efforts to improve scheduling efficiency

Questions?