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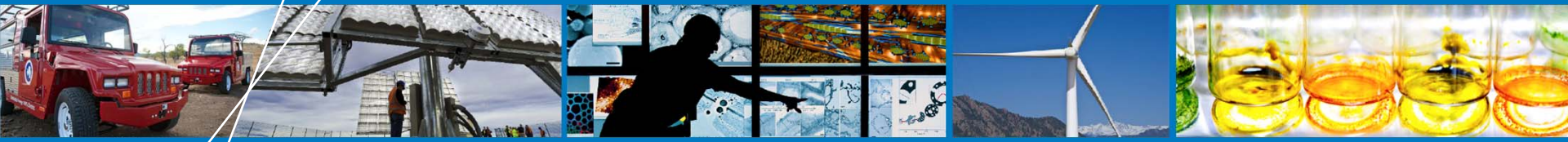
Session 3: Impact on U.S. Ancillary Services Markets from Variable Renewable Energy



Regulatory & Policy Framework for Ancillary Services & Alternative Energy Options in the Indian Power Sector

Jaquelin Cochran, Ph.D., NREL (USA)

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Overview

How are U.S. ancillary service markets changing due to variable renewable energy generation?

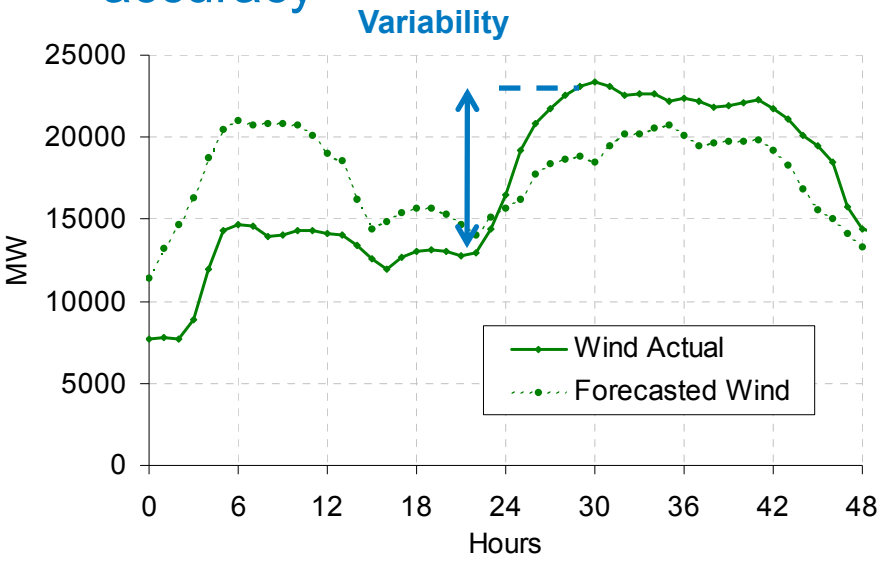
Presentation reviews

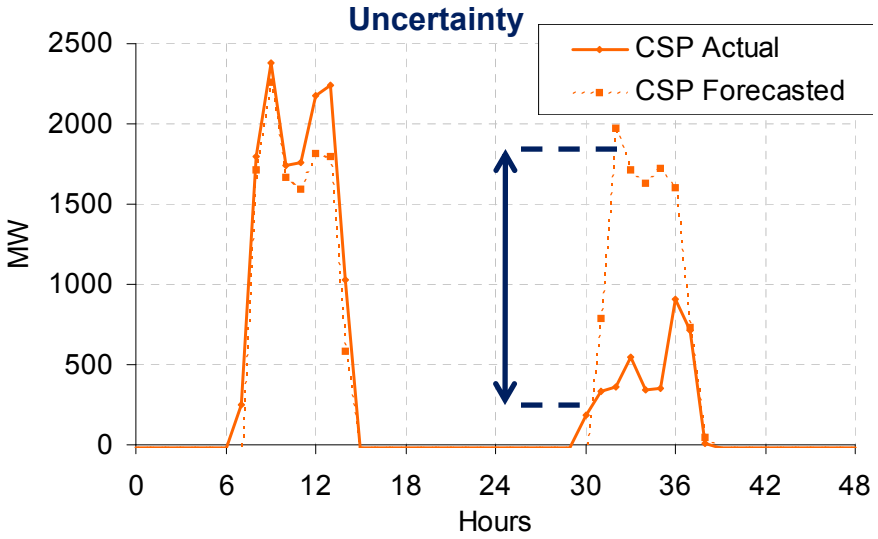
- Dynamic reserve requirements
- Primary frequency response
- System inertia
- Voltage control
- Load following
- Provision of ancillary services by renewables
  - Imbalance penalties and markets
  - Advanced forecasting

Variability and Uncertainty

Variability: Wind and solar generator outputs vary on different time scales based on the intensity of their energy sources (wind and sun)

Uncertainty: Wind and solar generation cannot be predicted with perfect accuracy





Variability: Load varies throughout the day, conventional generation can often deviate from schedules

Uncertainty: Contingencies are unexpected, load forecast errors are unexpected

Source: Erik Ela, NREL (2011)

Impacts of Variable Renewable Energy

Three key impacts on ancillary services

1. Variability and uncertainty increases ancillary services requirements, affecting scheduling and pricing
2. Impacts vary depending on system conditions—thus more difficult to predict
3. Allowing renewables to participate in markets can offer more liquidity—and challenges

Dynamic Reserve Requirements

- Typically static operating reserves
- Integration studies: reserves should change with actual and predicted conditions; vary hourly
- Target high-risk periods of big wind changes; and reduce integration costs
- ERCOT: changed rules to incorporate wind forecast error statistics in its determination of up- and down-regulation reserve and non-spinning reserve

Photo from Invenergy LLC, NREL 16037

Frequency Responsive Reserve

- Conventional generators provided automated response through governors
  - Supply plentiful
  - Not compensated
- ISOs: Frequency response has declined
  - Governors reduce plant efficiency
  - Penalties for schedule deviations (frequency deviations above 90 mHz)
- Electronically coupled RE lack inherent ability to provide frequency response, but can be designed to provide

Market changes:

Eliminate disincentive

Provide positive incentive?

IEEE Task Force on Generation Governing

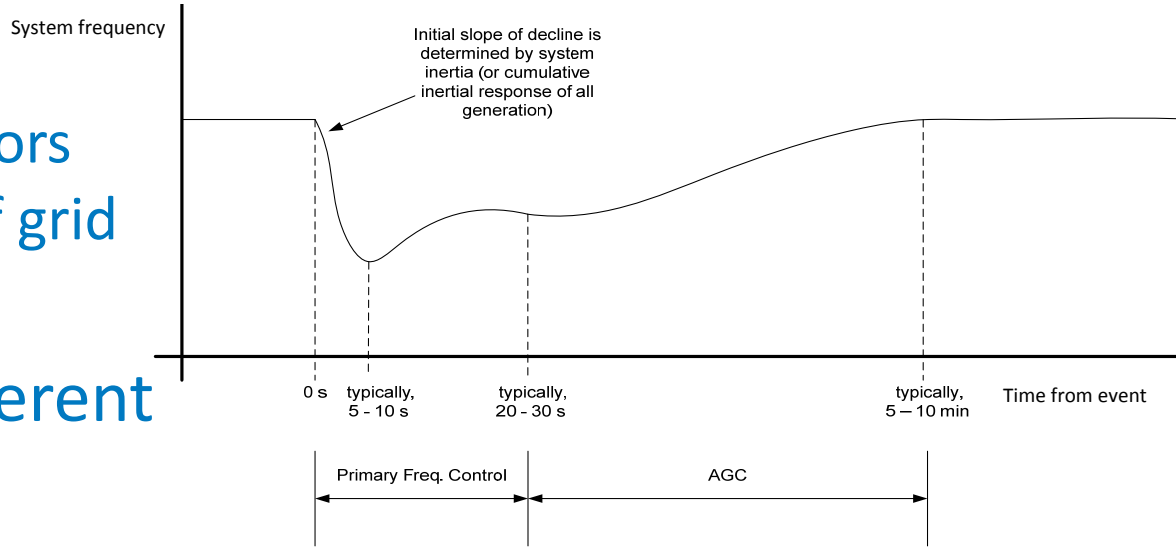
"The most promising path to address this problem in the new market based restructured environment is to include primary governing frequency response in the restructured markets and the reliability criteria used to assure reliability in those markets."

IEEE Task Force on Large Interconnected Power Systems Response to Generation Governing, *Interconnected Power System Response to Generation Governing: Present Practice and Outstanding Concerns*, IEEE Special Publication 07TP180, May 2007.

E. Ela, A. Tuohy, M. Milligan, B. Kirby, and D. Brooks, "Alternative approaches for a frequency responsive reserve ancillary service market," *The Electricity Journal,* vol. 25, no. 4, pp. 88-102, May 2012.

System Inertia

- Not compensated
  - Conventional generators provide this as part of grid connection
- Wind and PV lack inherent inertial response
- Studies show frequency response degrades in high wind, low load



Source: Erik Ela, NREL (2011)

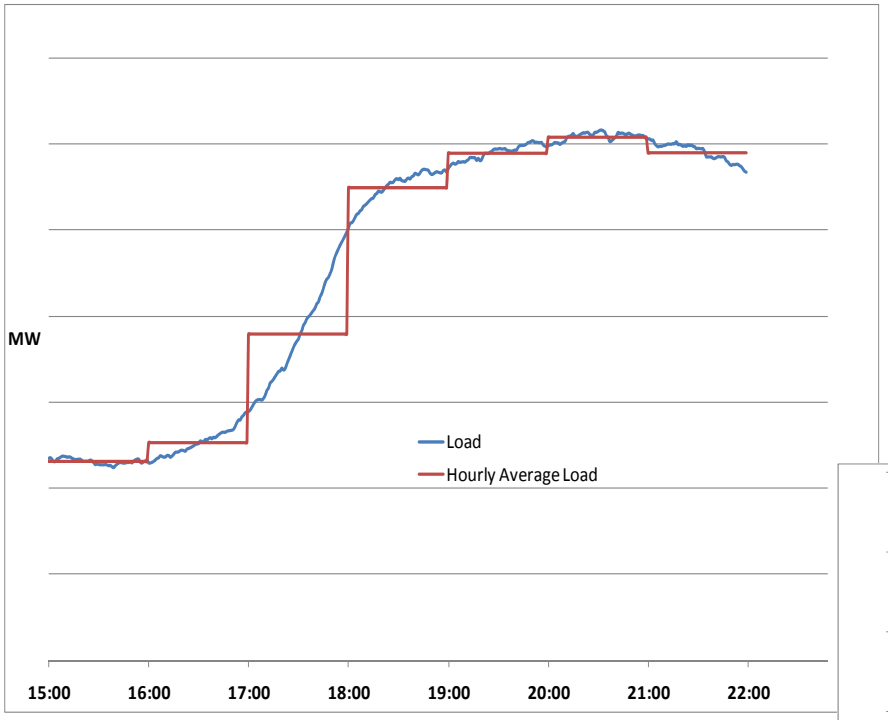
But wind can emulate this response through power electronic converter

NEW Market Product?

Voltage control

- Reactive power for voltage control
  - Does not travel far
  - Supply is local; inhibits competitive market
- All plants except wind required to provide
- Compensated fixed costs plus opportunity cost
- As RE increases, may need to require wind to provide, at added cost
- When should a system operator start requiring and imposing these costs?

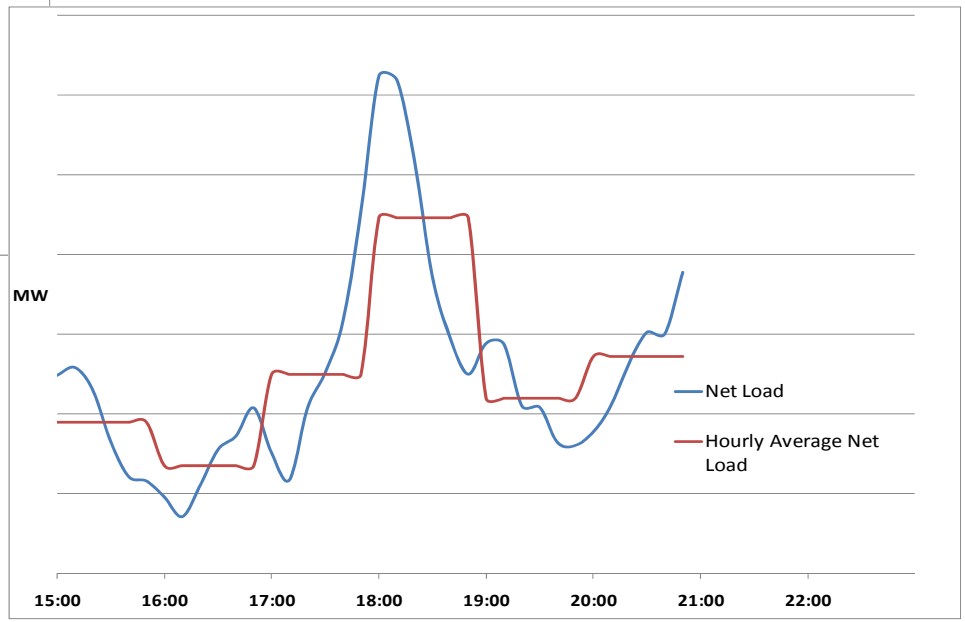
Load Following



Net Load Today

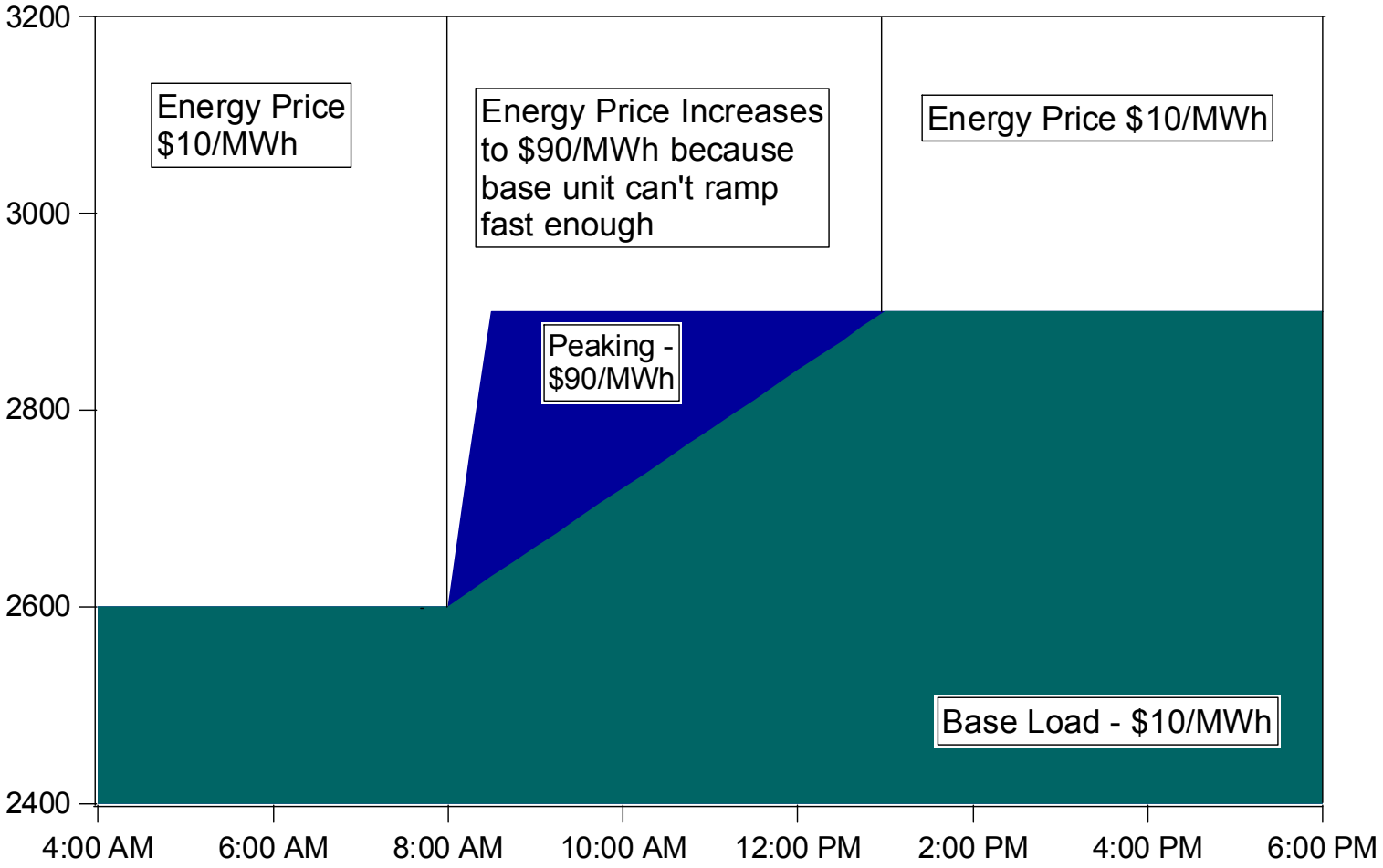
How does load following interact with regulation, spinning, and non spinning reserve

Net Load Tomorrow



Source: Erik Ela, NREL (2012)

Ramp products to supplement energy markets



Source: Milligan et al. (2012) NREL Report No. CP-5500-56212

Variable Renewables in A/S Markets

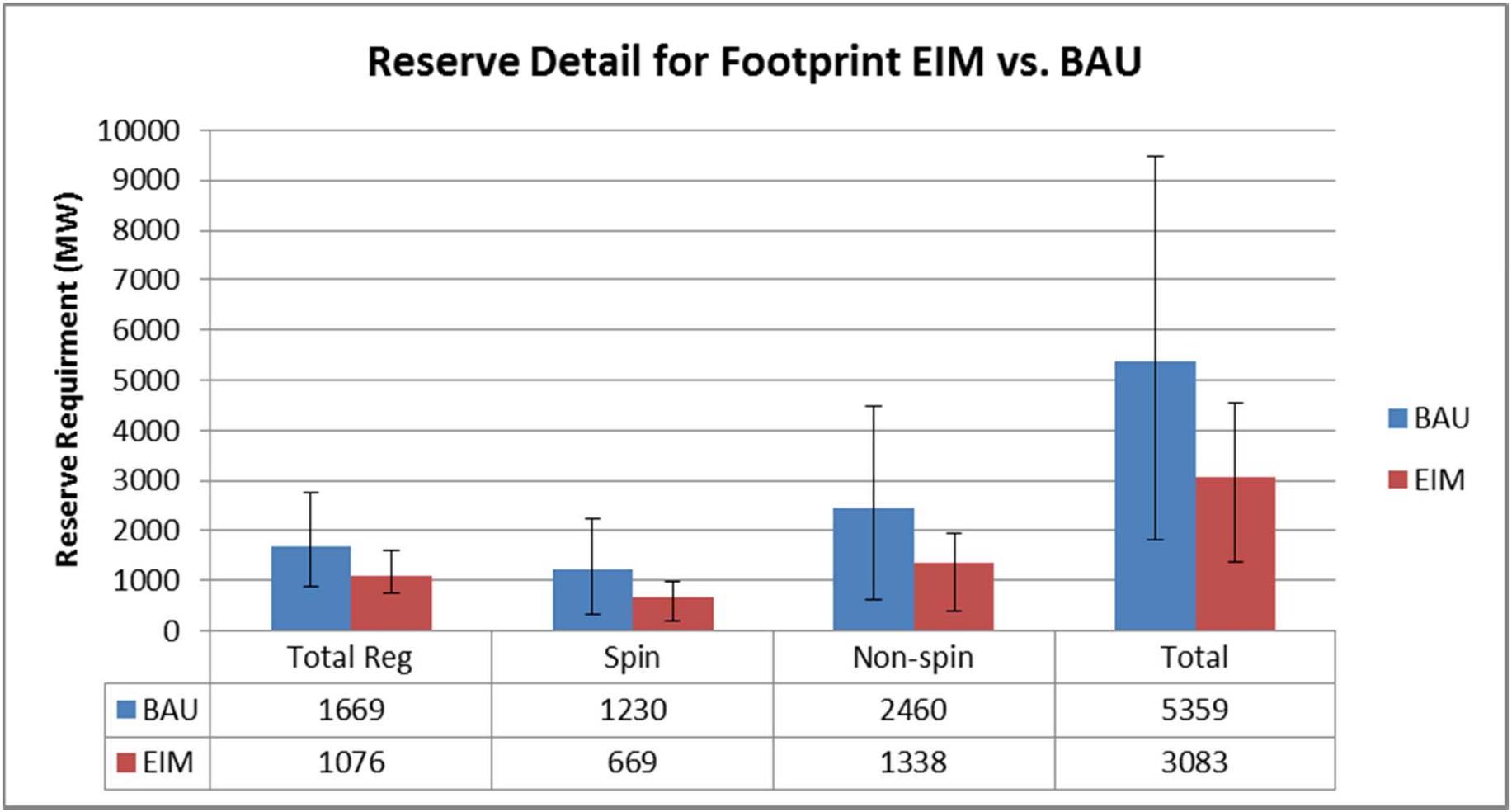
- Currently wind does not provide ancillary services in any U.S. ISO market
- Many markets have penalties for not producing the schedule that was given to them
  - How do U.S. markets address variable renewable generation?
- How do renewables participate in the market if they cannot predict production?
  - Wind forecasting

Energy Imbalance

Typically service of real-time markets balancing out the imbalance from the forward markets

	Imbalance Penalties on Variable Renewable Energy
FERC 890	For wind and solar imbalances greater than 1.5% or 2 MW: settle net monthly imbalances at 90% decremental costs and 110% incremental costs
PJM	Self-schedulers that follow dispatch: no penalty and can earn operating reserve credits. Not follow dispatch: no charges if deviation less than 5% or 5 MW.
ISO-NE	Deviations between day ahead (DA) & real time (RT) settled at RT LMP; wind exempt from share of certain uplift costs based on deviations
CAISO	Participating Intermittent Resources Program (PIRP): hourly deviations settled at a monthly weighted market-clearing price and accumulated for the monthly average of energy imbalances. Not in PIRP: subject to 10-min imbalance energy charges
NYISO	Buy/sell deviations at RT LMPs. Up to 3,300 MW of installed wind and solar exempt from under-generation penalties when output differs from RT schedule during unconstrained operations
ERCOT	Wind can be charged a penalty for deviations more than 10% from RT dispatch
MISO	Dispatchable Intermittent Resources: Excessive or deficient penalties if exceed 8% tolerance band for 4+ consecutive 5-min intervals within an hour

Benefits of Sharing Reserves



	Total Reg	Spin	Non-spin	Total
BAU	1669	1230	2460	5359
EIM	1076	669	1338	3083

King, J.; Kirby, B.; Milligan, M.; Beuning, S. (2012). NREL Report No. TP-5500-54660

Forecasting Reduces A/S Needs

- Uncertainty: larger impact on ancillary service requirements compared to variability
- Improved forecasting
  - Reduces need for modifying or adding ancillary services markets
- Improved forecasting supports participation by renewables
  - Markets would need to evolve to allow this capability

Summary

- Wind and solar can affect the way that power systems are operated
- Ancillary service market designs may need modification, new designs may be needed
- Variable generators can have capabilities to provide services and bid into markets
- Rules for imbalance penalties can impact market participation
- Advanced forecasting can reduce ancillary service requirements

Photo by Dennis Schroeder, NREL 20423

Appendix: Impacts of Variable Generation on Ancillary Services

Name	Impact
Primary Reserve	Variable generation (VG) probably does not have impact. However, most VG resources are built without this capability thereby reducing the amount of resources that can provide it. It should be evaluated how they can assist.
Regulating Reserve	Variability on this time frame usually does not have large impact due to geographic diversity and the large variability in loads. The forecast errors can have impact since dispatch is moving units to one schedule point and must have the regulating reserve fix that error.
Following Reserve	Load trends nicely, so requirements usually are not needed do to the changing hourly unit commitment. With VG, there may not be as much trend in this time frame, and potential for actual Following Reserve to account for this variability and uncertainty may be needed.
Contingency Reserve	Not much change to this requirement. Contingencies need fast response, wind events do not occur rapidly. Any large mega-farms may have multiple connections to transmission system. Large transmission inter-ties built to transfer large VG long distances could have impact.
Ramping Reserve	Certain regions can have large amounts of wind power moving in same direction. Regions should evaluate how often this type of event can happen and look at the ramp rate, capacity, and duration of the event to determine any needed requirements.

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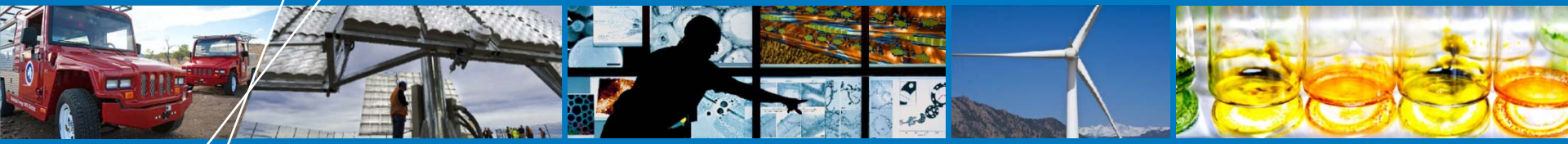

Thank you!

Jaquelin.Cochran@nrel.gov