

# Wind Integration Study Methods



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**Kansas City, Missouri**

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# Topics

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- Common elements
- Differences
- Integration costs
- Errors in integration analysis

Milligan, Ela, Lew, Corbus, Wan, Hodge, Kirby (2011) Operational Analysis and Methods for Wind Integration Studies. In review.

Milligan, Ela, Hodge, Kirby, Lew, Clark (2011) Cost-Causation and Integration Cost Analysis for Variable Generation. To appear.

# Common Elements of Integration Studies

- Combination of statistical analysis and production simulation.
- Most use hourly production simulation; growing use of sub-hourly models.
- General recognition of role of forecast errors:
  - Wind
  - Load
- Estimates of impact on regulation, load following.
- No recognition of cycling costs:
  - Leads to inefficient commitment and dispatch because marginal costs are wrong...
  - Insufficient data
  - Dispatch =  $f(\text{cost})$  and Cost =  $f(\text{dispatch})$

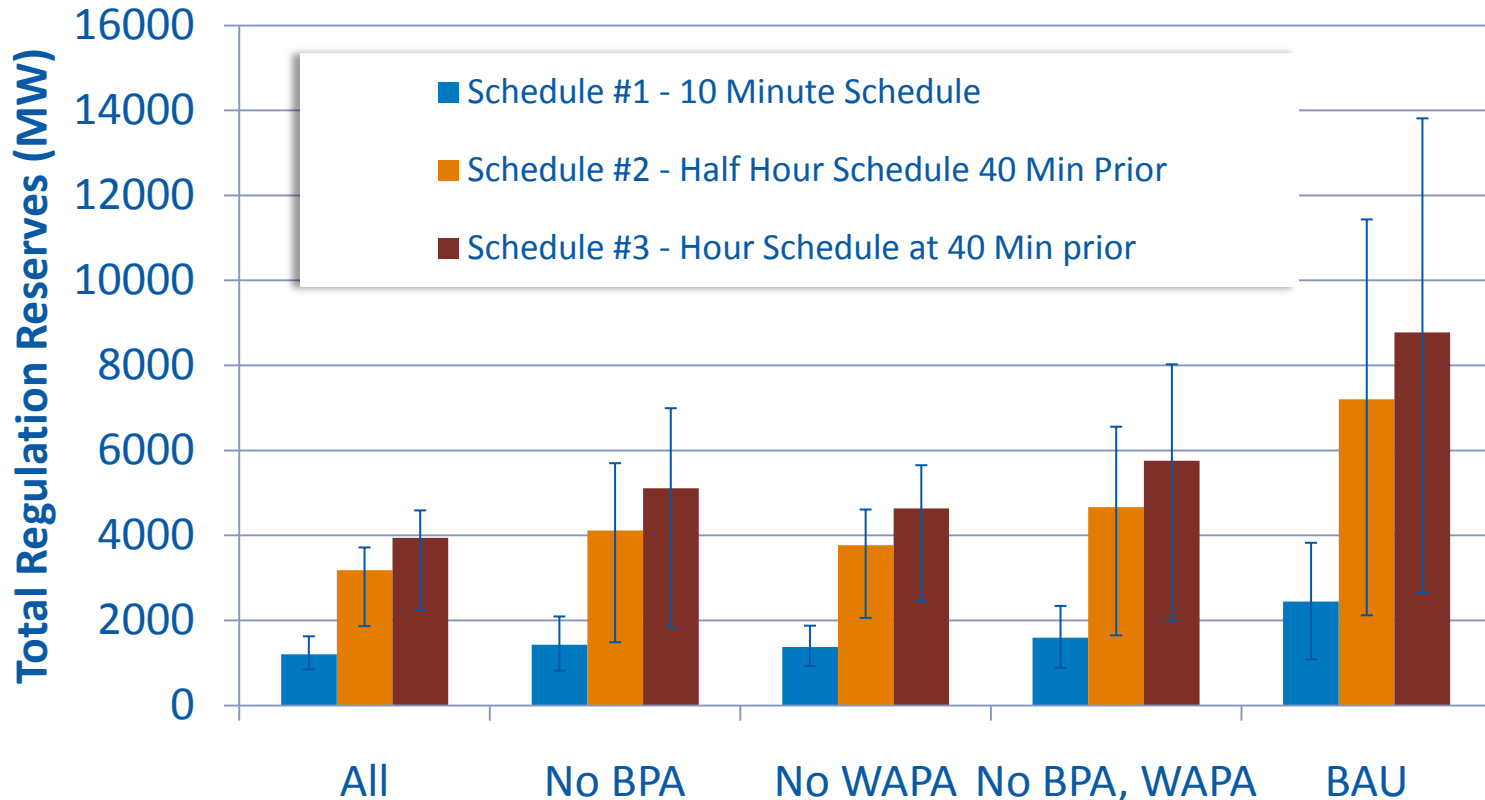
# Differences Can Drive the Results

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- Reserve methodology.
- System build-out assumptions.
- Operating/market rules of the future.
- Forecasting performance and gate-closing.
- Characteristics of generation fleet – i.e. how much flexibility in incumbent units.
- Relative fuel prices (coal, gas).
- Treatment of uncertainty;
  - Stochastic unit commitment?
- Rolling unit commitment or once/day?

# Reserve Depends on Scheduling and Footprint Size

## Total Regulation Reserve Requirements for 3 Schedules Footprint EIM By Case



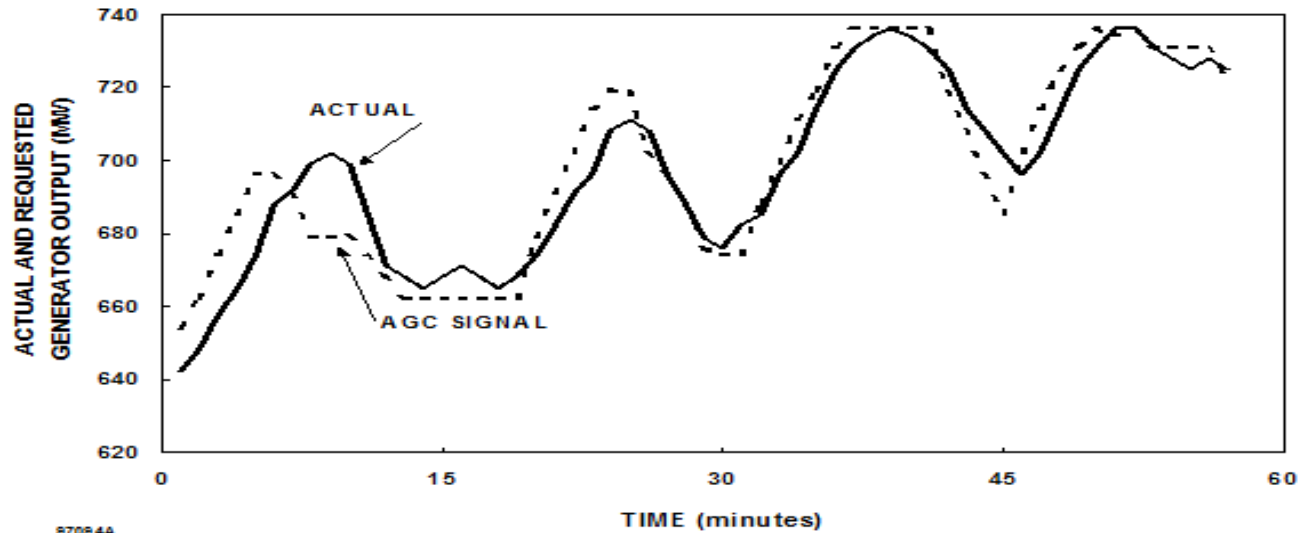
Milligan, Kirby, King, Beuning (2011), Operating Reserve Implication of Alternative Implementations of an Energy Imbalance Service on Wind Integration in the Western Interconnection. NREL Technical Report, to appear.

# Some Studies Estimate Integration Cost

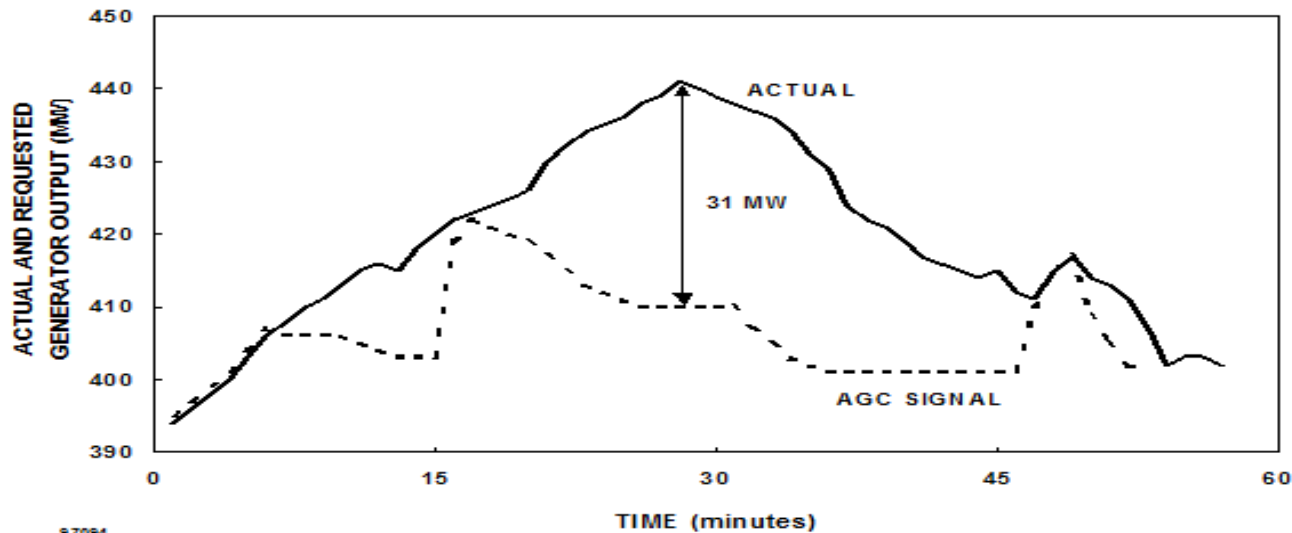
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- Rarely utilize the same methods → comparing apples to oranges.
- The *concept* of integration cost is more widely accepted than agreement of whether it can be accurately calculated.
- Growing awareness of the difficulties involved in calculating integration costs → less acceptance.

# Integration Cost is Not Unique to Wind, Solar

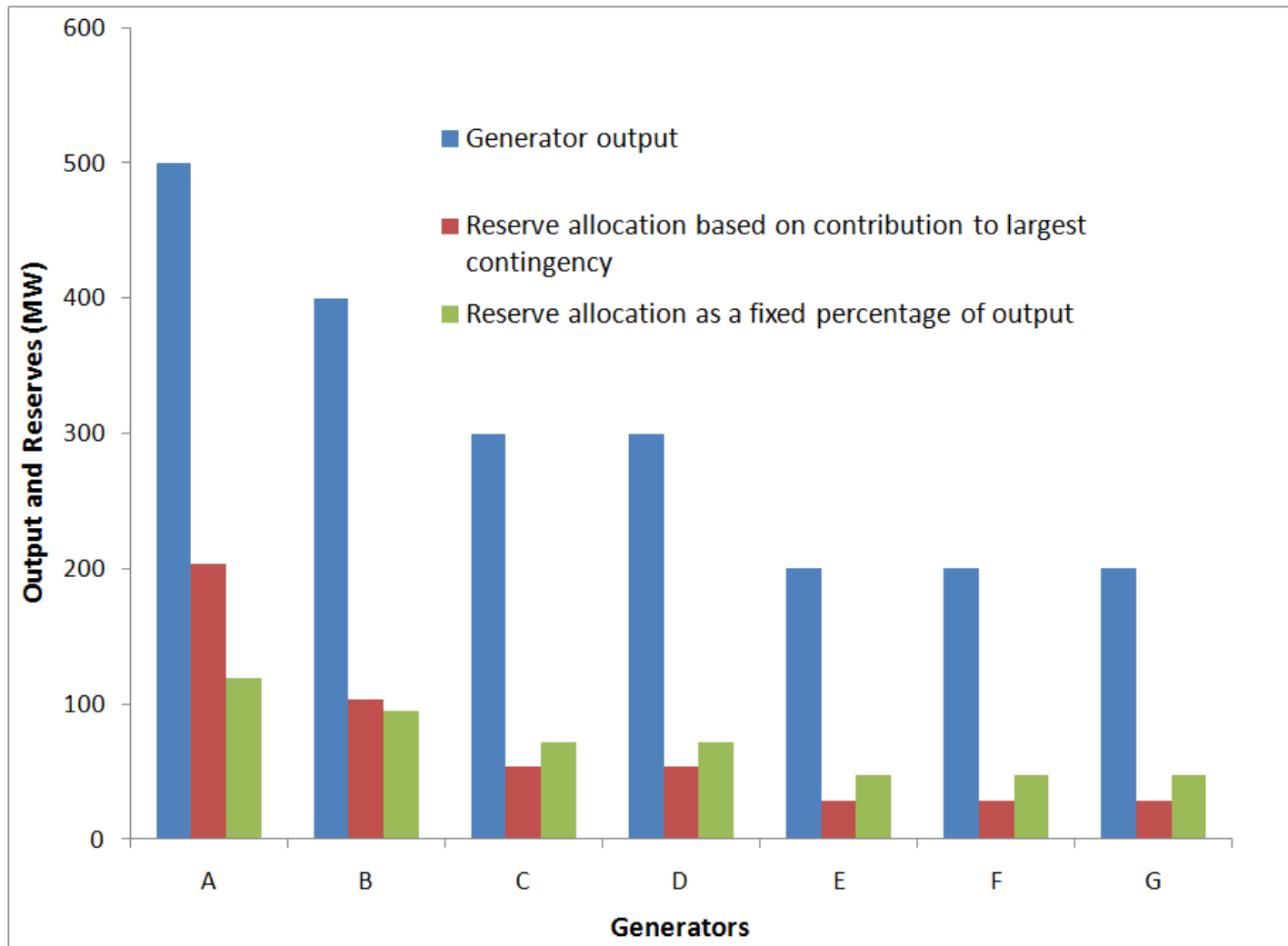


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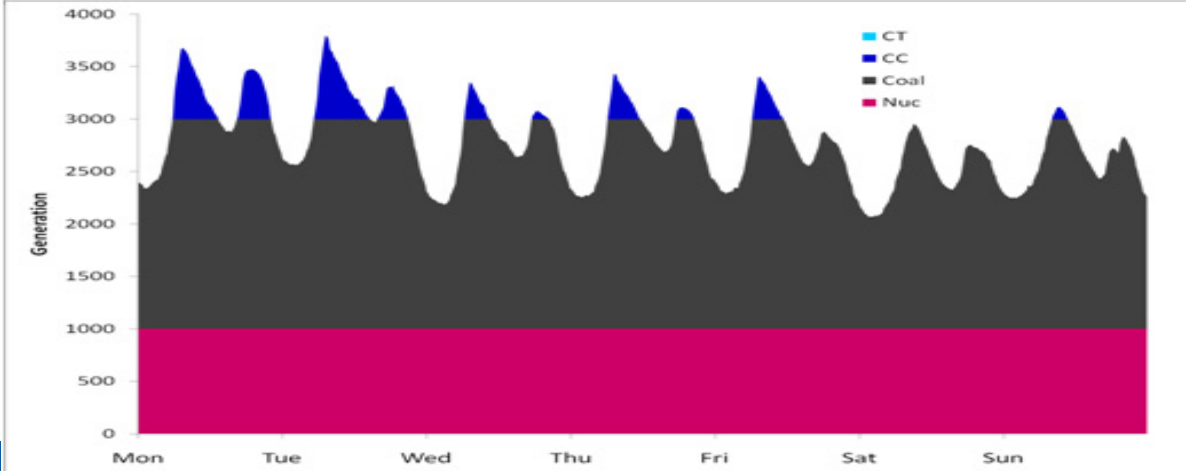
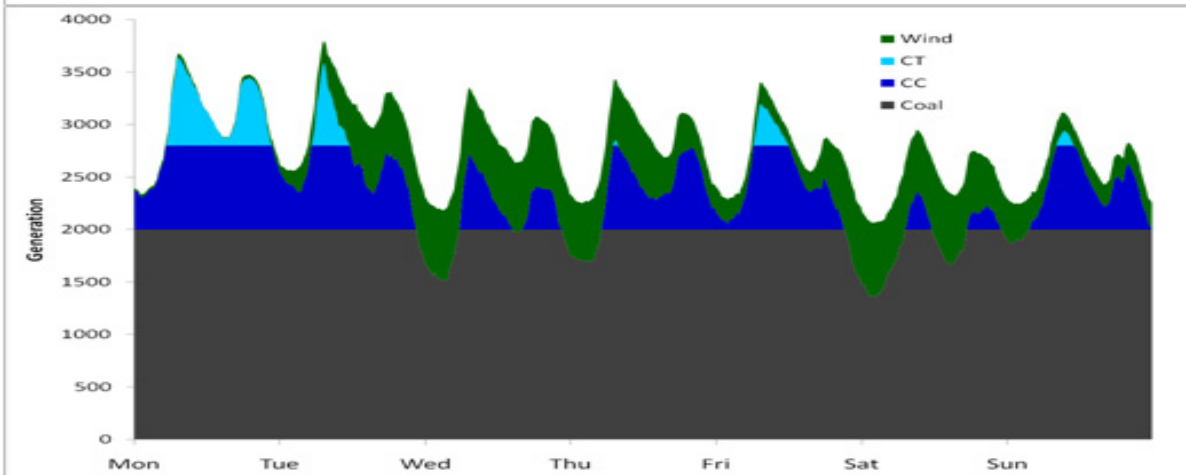
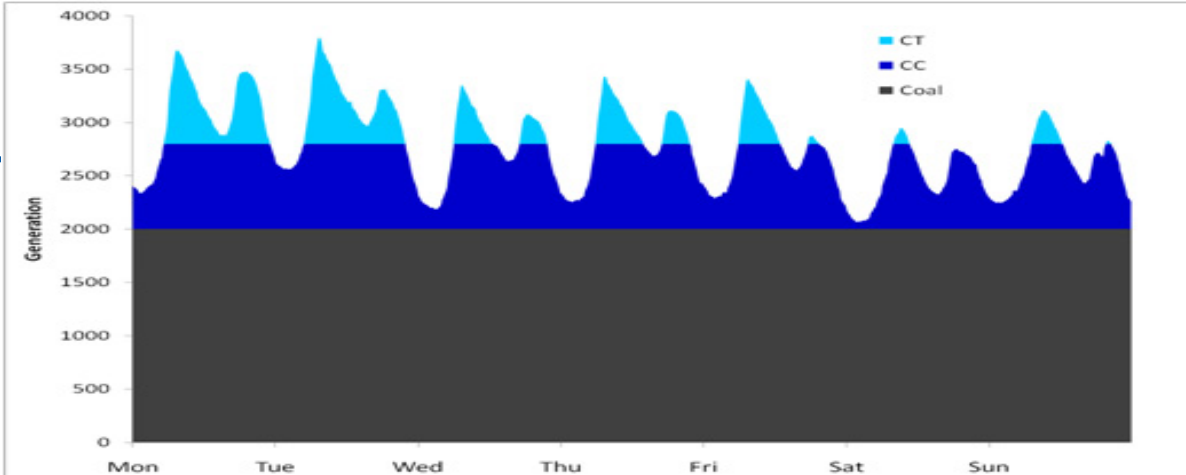
# Contingency Reserve Has an “Integration Cost” That is Not Calculated or Assessed



E. Hirst, B. Kirby, 2003, *Allocating Costs of Ancillary Services: Contingency Reserves and Regulation*, ORNL/TM 2003/152, Oak Ridge National Laboratory, Oak Ridge TN, June



**New cheap baseload imposes additional cycling and lower capacity factors on other generation.**



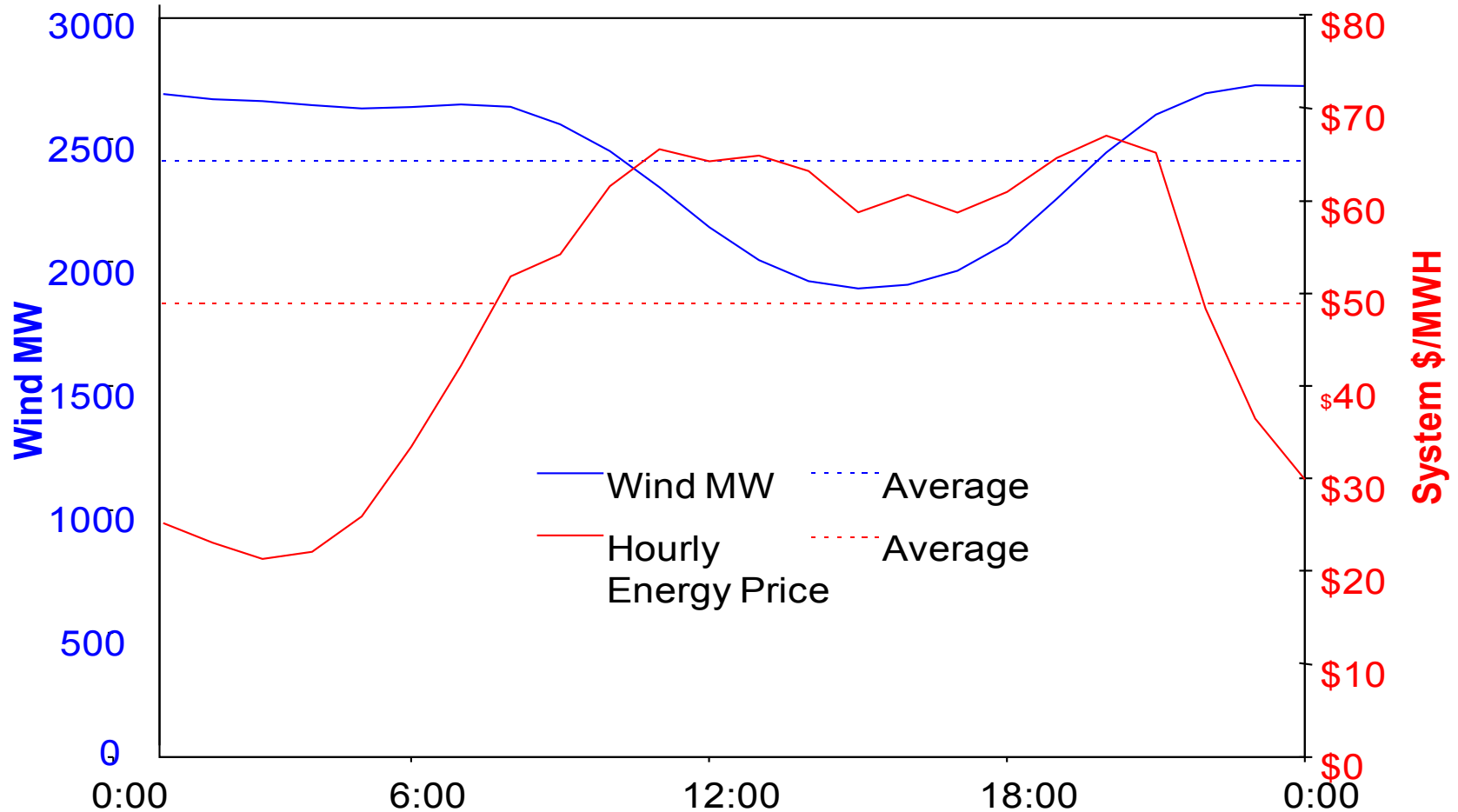
# Are Wind Integration Cost Estimates Based on Cost-causation?

- Individuals who cause the cost should pay.
- Individuals who mitigate the cost should pay less, or be paid.
- Joint costs should be allocated to system users based on relative use.
- Recognize the need for aggregate balance, not individual balance.
- Cost-causation based tariffs should result in an economically efficient allocation of resources.

Kirby, Milligan, Wan (2006) Cost-causation-based Tariffs for Wind Ancillary Service Impacts. <http://www.nrel.gov/docs/fy06osti/40073.pdf>

# Value vs. Cost

## MISO LMP and Wind (2004)



Milligan, M.; Kirby, B. (2009). Calculating Wind Integration Costs: Separating Wind Energy Value from Integration Cost Impacts. <http://www.nrel.gov/docs/fy09osti/46275.pdf>

# Some Studies Still Commit Fundamental Errors

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- Incorrect separation of regulation and load following that can lead to double-counting.
- Modeling errors that fail to separate impacts of load forecast error from wind forecast error.
- Constant hourly reserve for wind.
- Analysis of wind variability alone; not accounting for system variability.
- Failure to “true up” the implication for ad hoc balancing methods on CPS2: resulting in unknown implied CPS performance of system with wind.

# Some Studies Do Not Identify Assumptions That Drive Results

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- Fuel prices.
- Generation mix.
- Hydro operation/fixed schedules.
- Operating practice:
  - BA configuration.
  - Market characteristics.
  - Seams issues, coordination.
  - Fixed import-export schedules.
- Transmission.

# Questions?