Efficient Ramp Provisioning for Net Load Following with Variable Energy Resources

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Dhiman Chatterjee
Midwest ISO

What is Load Following?

- Load Following: The provision of generation and load response capability, including capacity, energy, and MANEUVERABILITY, that is dispatched within a scheduling period by the OPERATING AUTHORITY.
  - Meet the variable net load requirements
    - Adjusted for scheduled interchange and non-dispatchable generation
  - Maneuverability relates to ramp requirements
  - Scheduling period is the resource commitment horizon
  - Requirements are driven by dispatch frequency
  - Provisioning involves resource commitment and dispatch

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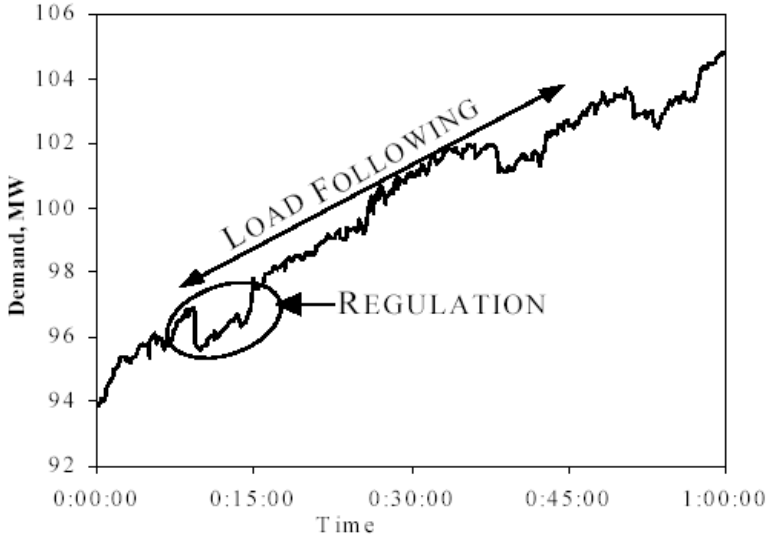
Reference:
NERC Operating Manual, Interconnected Operations Services

Load Following versus Regulation



Load Following

- Accomplished through targeted response to dispatch instructions
- Continuous requirements provisioned by unit commitment and dispatch processes
- Balancing at dispatch

Regulation

- Accomplished through immediate response to automated controls
- Triggered by frequency and interchange deviations
- Last resort to fill in for scheduling gaps and errors

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Reference:
NERC Operating Manual, Interconnected Operations Services

Ramp Management for Load Following

- Unpredictable resource ramping requirements due to variability and forecast errors of load, real-time net interchange and intermittent wind generation
  - Other notable factors are Generator deviation from set point and deliverability constraints due to forced transmission outages
- Current operational methods to manage this ramp include
  - Preemptive reliability commitment and use of fast start units with market wide cost uplift
  - Expensive Regulation resources
- Large-scale penetration of renewable resources will cause amplified ramp requirements due to further variability and forecast inaccuracy

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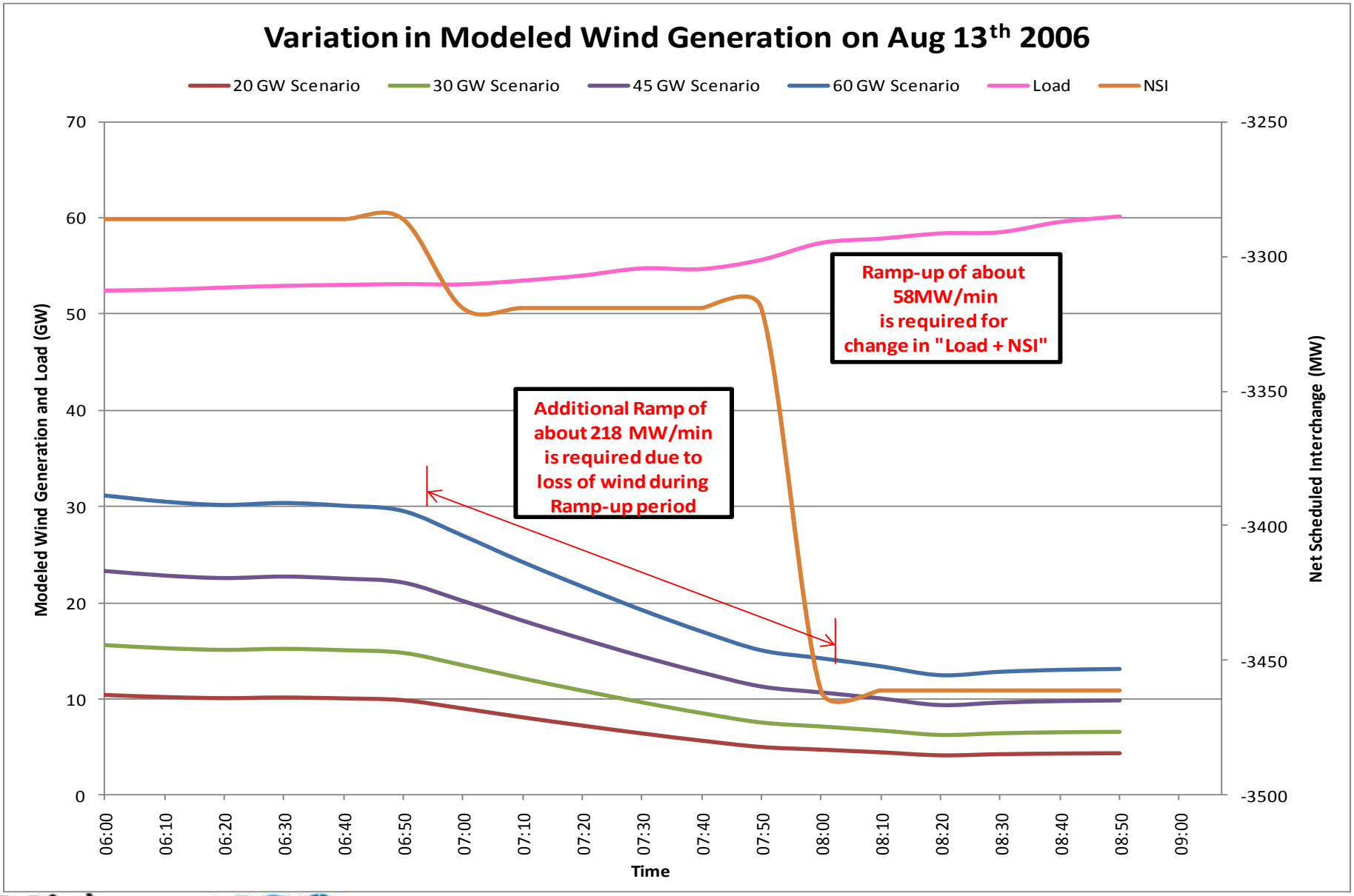

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Based on Historical NREL data for potential zones proposed by RGOS I
Load and NSI are actual Midwest ISO values

Efficient Ramp Management

- Systematic approach to determine resource ramping requirement incorporating net load variability and uncertainties resulted from forecast functions
- Economic and transparent ramp provisioning through robust commitment and dispatch process
- Market based products with participants responding to price signals and providing required ramp avoiding (or reducing) scarcity conditions

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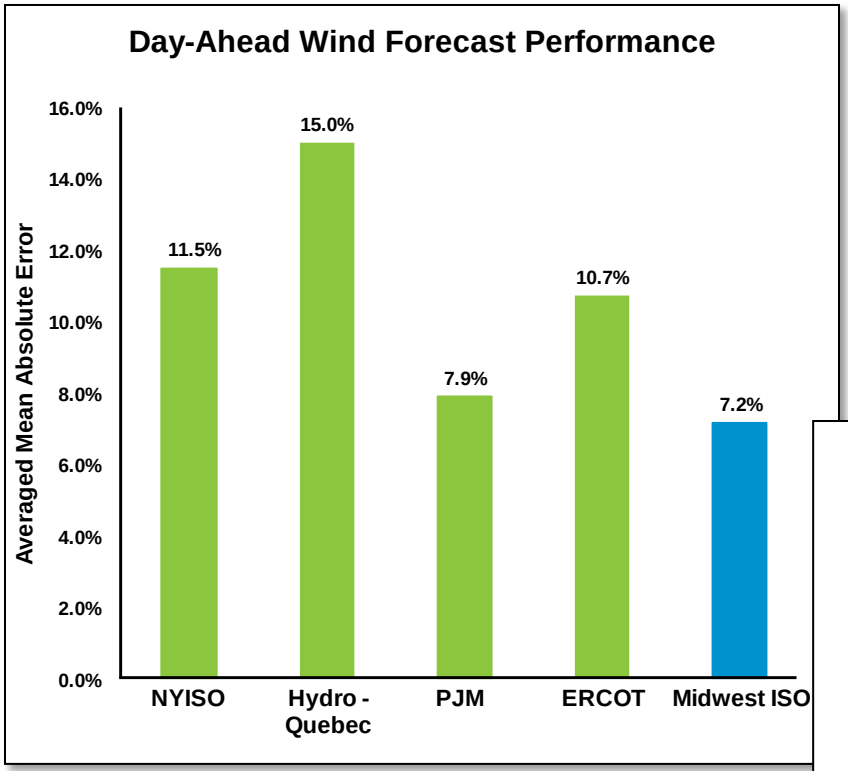
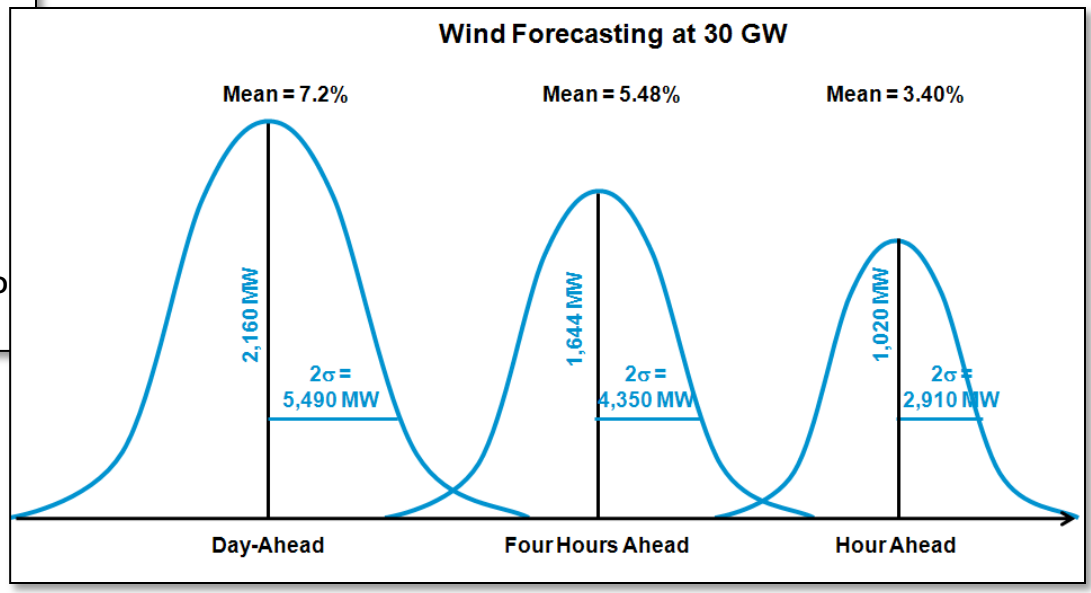
Wind generation forecast accuracy





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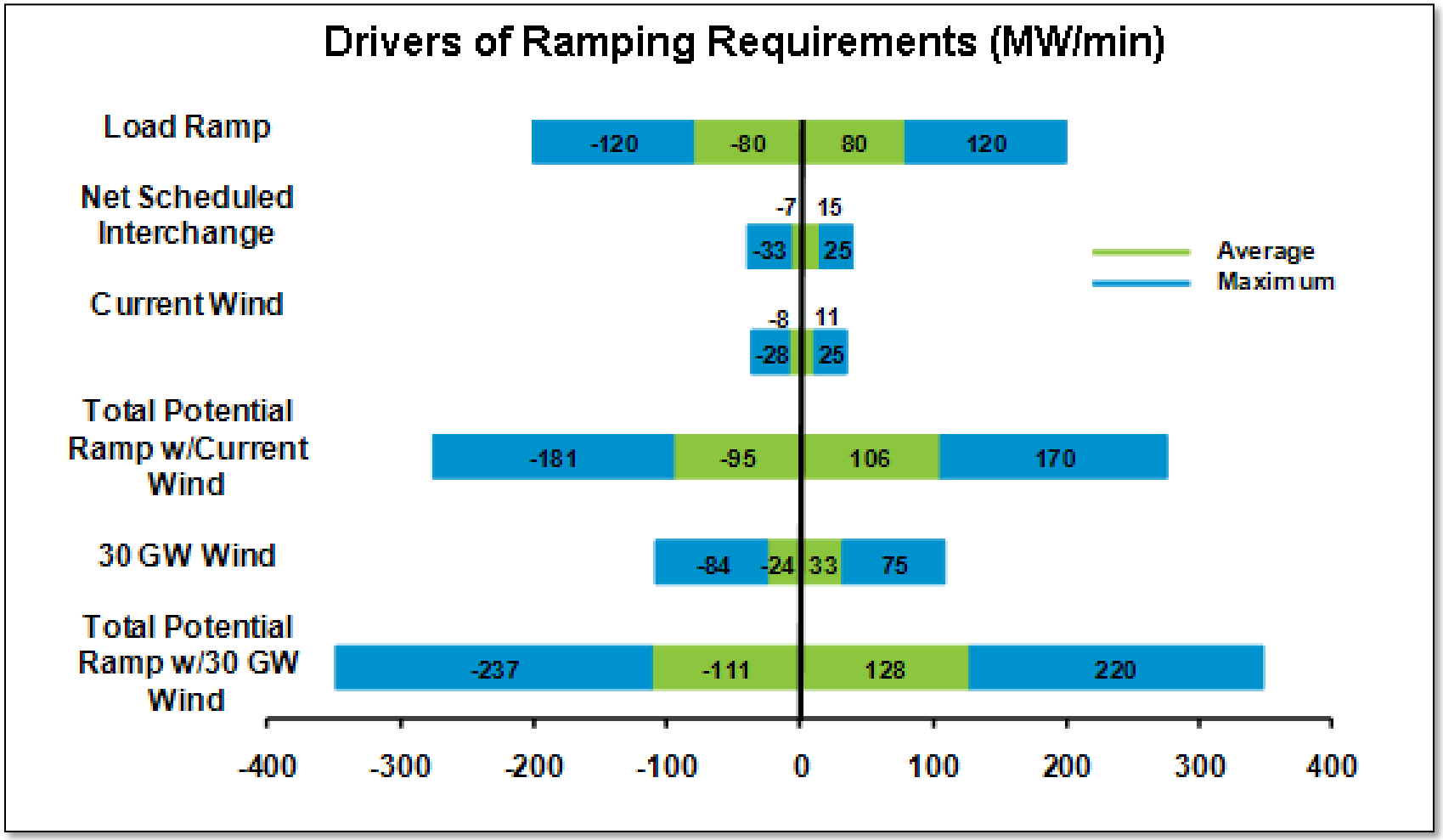
Note: Day-Ahead Forecast Performance Metrics graph is based on the data from Central Wind Power Forecasting Programs in North America by Regional Transmission Organizations and Electric Utilities report by Exeter Associates, Inc. Where a range of data is provided, higher end of the range is used.
Note: 2 sigma event equates to a 95% confidence level (95% of the time event will be less than 2 sigma)

Wind Impact on Ramping Requirement



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Day-Ahead Commitment Enhancement

- Address granularity of hourly Day-Ahead Market versus continuous Real-Time nature of demand
  - Traditionally ramp capacity supports integrated demand but not instantaneous demand
  - Hourly ramp requirement derived from hourly load forecast
- Additional 30 minute ramp up/down requirements imposed in Day-Ahead Market Unit Commitment
- Better Day-Ahead procurement of ramp-able resource capacity in hours with large load changes
- Improved market efficiency
  - Lower combined production cost for Day-Ahead and Real-Time markets due to better selection of resources
  - Less overall uplift of commitment cost

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Additional Commitment Enhancements

- Incorporate variability and forecasting errors associated with Real-Time interchange and intermittent generation into determination of ramp requirements
  - Uncertainties could be addressed through scenarios, stochastic modeling or financial risk management principles
- Follow through from Day-Ahead market into the Reliability Commitment processes closer to Real-Time
  - Progressive reduction in level of uncertainty
  - Sub-hourly granularity for commitment decisions
- Recovery of generator opportunity cost remain socialized among market players

Ancillary Product

- Definition
  - Add constraint in SCED (Security Constrained Economic Dispatch) to procure needed ramp in each direction with every dispatch solution
  - Hourly requirements based on empirical studies and adjusted for current operational conditions
  - Provisioned with current dispatch for deployment, as needed, in meeting future dispatch
  - Unit participation in ramp requirement is capped
- Market
  - Day-Ahead and Real-Time Market

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Ancillary Product

- Model Solutions
  - Multi-interval look-ahead optimization to determine the optimal generation dispatch level in each interval
  - Positioning of resources for potential future ramping conditions
  - Separate cost functions for ramp up and ramp down
- Pricing
  - Based on availability offer or opportunity cost if requirement constraint binds
  - Based on sloped demand curve during shortage conditions
- Settlement
  - Payment based on cost causation (i.e. could be targeted to variable interchanges and non-dispatchable generation
  - Performance penalties tied to failure to follow dispatch instructions

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Questions?

- Contact Information:

Dhiman Chatterjee

dchatterjee@midwestiso.org

(317) 249-5144

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