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

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.
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

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**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.”


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

But wind can emulate this response through power electronic converter

NEW Market Product?

Source: Erik Ela, NREL (2011)
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

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

Net Load Today

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

<table>
<thead>
<tr>
<th>Imbalance Penalties on Variable Renewable Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FERC 890</strong></td>
</tr>
<tr>
<td>For wind and solar imbalances greater than 1.5% or 2 MW: settle net monthly imbalances at 90% decremental costs and 110% incremental costs</td>
</tr>
<tr>
<td><strong>PJM</strong></td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td><strong>ISO-NE</strong></td>
</tr>
<tr>
<td>Deviations between day ahead (DA) &amp; real time (RT) settled at RT LMP; wind exempt from share of certain uplift costs based on deviations</td>
</tr>
<tr>
<td><strong>CAISO</strong></td>
</tr>
<tr>
<td>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</td>
</tr>
<tr>
<td><strong>NYISO</strong></td>
</tr>
<tr>
<td>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</td>
</tr>
<tr>
<td><strong>ERCOT</strong></td>
</tr>
<tr>
<td>Wind can be charged a penalty for deviations more than 10% from RT dispatch</td>
</tr>
<tr>
<td><strong>MISO</strong></td>
</tr>
<tr>
<td>Dispatchable Intermittent Resources: Excessive or deficient penalties if exceed 8% tolerance band for 4+ consecutive 5-min intervals within an hour</td>
</tr>
</tbody>
</table>
Benefits of Sharing Reserves

Reserve Detail for Footprint EIM vs. BAU

<table>
<thead>
<tr>
<th></th>
<th>BAU</th>
<th>EIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Reg.</td>
<td>1669</td>
<td>1076</td>
</tr>
<tr>
<td>Spin</td>
<td>1230</td>
<td>669</td>
</tr>
<tr>
<td>Non-spin</td>
<td>2460</td>
<td>1338</td>
</tr>
<tr>
<td>Total</td>
<td>5359</td>
<td>3083</td>
</tr>
</tbody>
</table>

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
# Appendix: Impacts of Variable Generation on Ancillary Services

<table>
<thead>
<tr>
<th>Name</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Reserve</td>
<td>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.</td>
</tr>
<tr>
<td>Regulating Reserve</td>
<td>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.</td>
</tr>
<tr>
<td>Following Reserve</td>
<td>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.</td>
</tr>
<tr>
<td>Contingency Reserve</td>
<td>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.</td>
</tr>
<tr>
<td>Ramping Reserve</td>
<td>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.</td>
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</tbody>
</table>
Thank you!

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