Adapting Ancillary Service Markets, Products, and Scheduling to Accommodate Intermittent Generation

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Overview

The integration of a materially increased proportion of intermittent generation resources has the potential to lead to both quantitative and qualitative changes in ancillary service market design and procurement, and to require associated changes in energy market pricing and dispatch.

Topics

- Ramping requirements, pricing, and energy market design
- Potential changes in regulation market procurement, pricing, and deployment
- Potential changes in reserve market requirements and activation practices

Ramping and Energy Market Operation

Traditional security constrained least cost dispatch minimized the cost of meeting load over a five- or ten-minute dispatch period, without regard to the cost of meeting load in subsequent intervals.

- Intemporal optimization of real-time dispatch as implemented by the New York ISO (2005) and California ISO (2009) also optimizes over time to account for *expected* future ramp requirements, such as those associated with top of the hour changes in net-interchange, a pump storage unit going on or off-line, or a generation unit going on or off-line.

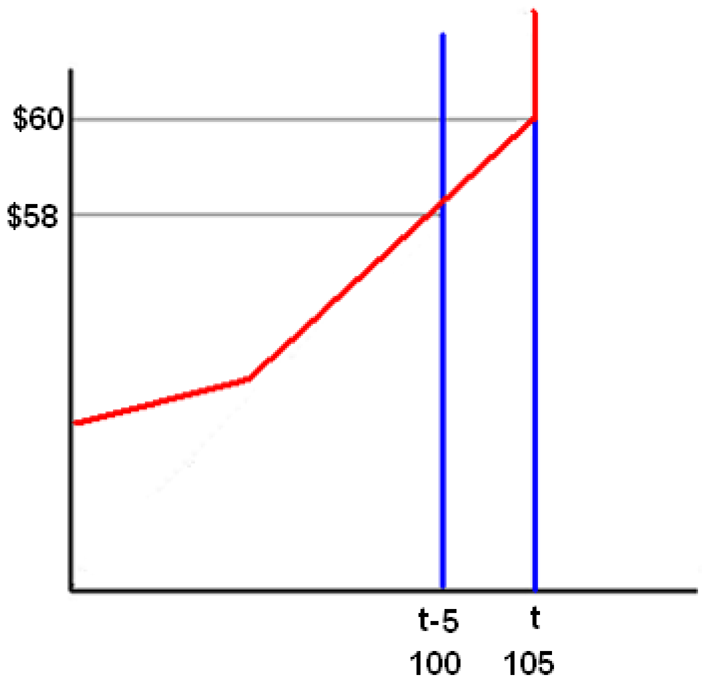
Ramping and Energy Market Dispatch

How can inter-temporal optimization create additional upward (or downward) ramp capability?

- Dispatching resources whose available upward ramping capability is capacity limited down out-of-merit, creating additional upward ramping capability.
- Replacing their output with the output of higher cost units whose available ramping capability is not capacity constrained.
- Additional downward ramp capability can be created by dispatching up out-of-merit resources whose downward ramping capability is limited by their minimum load point.

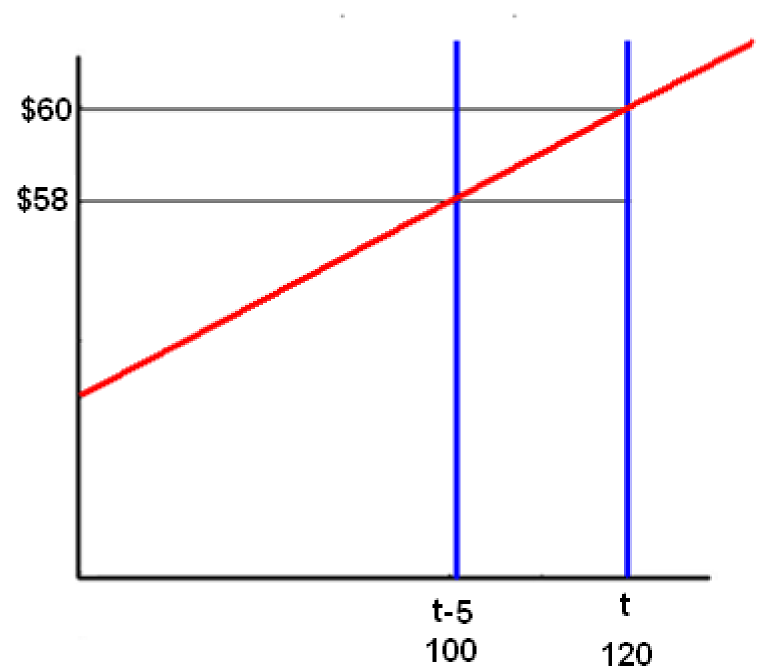
Conventional Dispatch: 30 Megawatts Upward Ramp Available t to t+5

Capacity Limited Unit



105 megawatt capacity
5 megawatt ramp rate

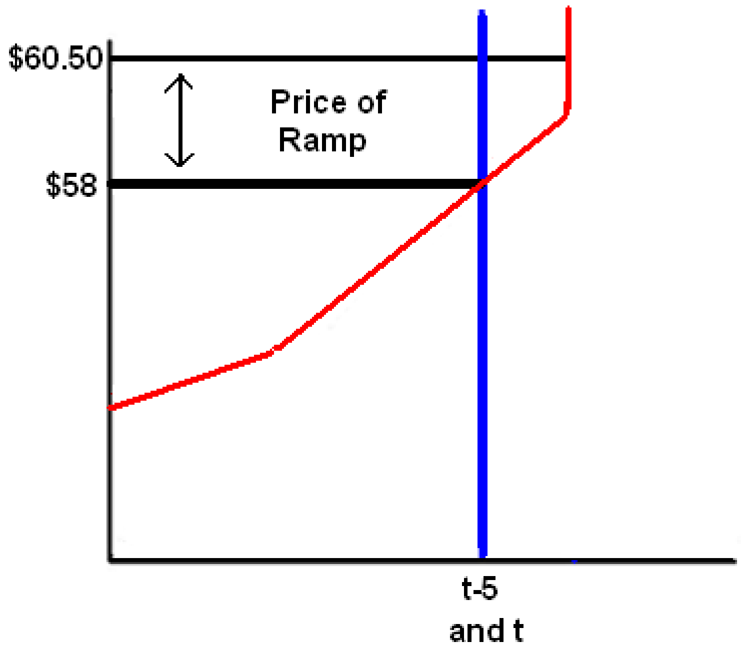
Ramp Limited Unit



200 megawatt capacity
30 megawatt ramp rate

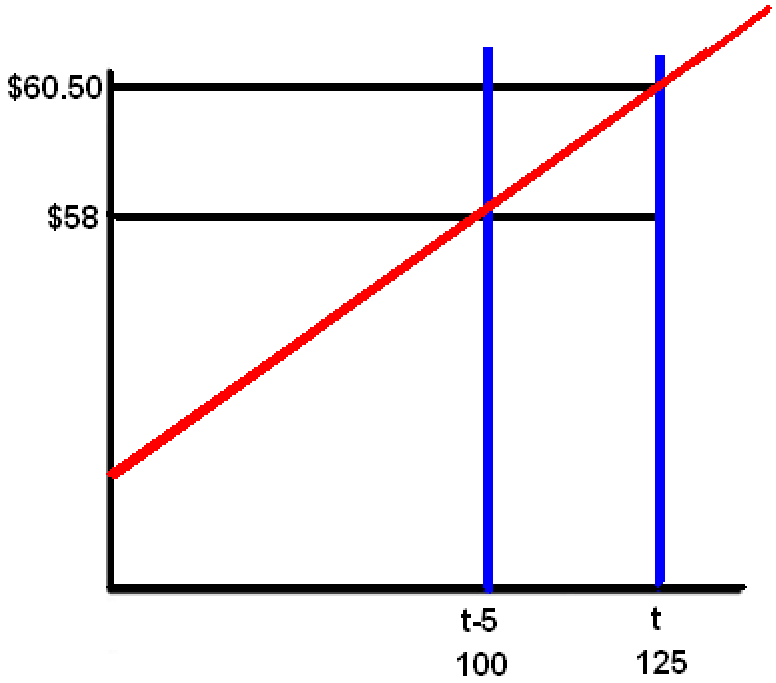
Out of Market Dispatch to Increase Upward Ramp: 35 Megawatts of Upward Ramp Available t to t+5

Capacity Limited Unit



105 Megawatt Capacity

Ramp Limited Unit



200 Megawatt Capacity

Ramping and Energy Market Dispatch

Current inter-temporal optimization schedules generation to provide additional ramp capability to avoid ramp constraints that are anticipated for future intervals based on known future conditions.

- Accommodating intermittent generation entails scheduling additional ramping capability to respond to ramp constraints that cannot be projected, but could arise because of unpredictable changes in load or intermittent generation output.

Ramping and Energy Market Dispatch

If a penalty value were attached to maintaining additional upward or downward ramp capability in the objective function for the real-time dispatch, the real-time dispatch would dispatch generation to maintain additional ramp capability if the capability were available at a cost lower than the specified penalty value.

- If the transmission system became ramp constrained, the ramp capability would be used to meet load and the penalty value of using up the extra ramp capability would be reflected in the spot price of energy.

Ramping and Energy Market Dispatch

In this design there would also be a market price of ramp capability.

- When the target amount of ramp capability was available, the price of ramp would be set by the opportunity cost of ramping capability, which could be zero.
- When less than that target amount of ramp capability is scheduled, the price of ramp would be set by the penalty value for scheduling ramp.
- The price of ramp would be paid to all resources with undispatched ramp capability in the physical real-time-dispatch.

Energy Market Design and Performance

The real-time energy pricing system can also impact the supply of ramping capability providing incentives for generators to participate in the economic dispatch, and to offer higher ramp rates (to the extent they are able).

- Regulation shortage values: reflected in energy prices when regulating capacity is used to provide energy needed because the system is ramp constrained.
- Reserve shortage values: reflected in energy prices when reserves are used to provide energy needed because the system is ramp constrained.

Higher shortage values increase the returns to being on dispatch and being able to ramp up or down more rapidly.

Other Energy Market Changes

If managing ramp constraints, whether due to load variability or the output variability of intermittent generators, requires maintaining additional ramp capability, this should be supported by other energy market design features.

- Replacing time weighted hourly pricing for generators with five minute pricing
- Lowering bid floors to levels materially below zero

Regulation Market Impacts

Accommodating materially higher levels of intermittent output may also require changes in regulation markets.

- Regulation quantities and performance characteristics
- Shortage values

Regulation Market Impacts

An obvious potential impact of increased intermittent generation is an increased regulation requirement to balance unexpected variations in intermittent generation output, but exactly which requirements will need to increase is uncertain.

- Will the system operator need more fast responding regulation capability to quickly balance generation and load against variations in intermittent output?
- Will the system operator need more regulation energy to balance generation and load when sustained changes in intermittent generation cause the real-time energy dispatch to be ramp constrained and unable to replace regulation energy with the output of on dispatch resources?

Regulation Market Impacts

Accommodating higher levels of intermittent generation, and energy limited regulating resources, may also require changes in relative shortage values.

- Higher regulation shortage values will retain more regulation capacity to balance generation and load within the dispatch cycle.
- Higher regulation shortage values will also produce more real-time price volatility, greater incentives for generation to be on dispatch, and higher returns to faster ramping resources.
- Retaining more regulation than is needed to balance load and generation within the dispatch cycle raises the cost of meeting load.

Reserve Market Impacts

Higher levels of intermittent generation may also require qualitative changes in reserve scheduling and activation.

- Changes in reserve requirements
- Changes in reserve type
- Changes in reserve shortage values and activation practices

Reserve Market Impacts

At low levels of intermittent generation penetration, the difference between expected output and minimum output is so small that it does not matter much how it is accounted for in defining reserve requirements.

- At high levels of intermittent generation penetration, committing conventional generation without regard to expected intermittent generation output will be expensive– too much conventional generation would be on-line, incurring start-up and minimum load costs.
- But significant deviations over the day between actual and expected intermittent generation will be more frequent than equivalent generation outages and will need to be accounted for in defining reserve requirements.

Reserve Market Impacts

With increased penetration of intermittent generation having more frequent variations between actual and expected output, it may be necessary to rethink the measurement of 10-minute reserves.

- For the purpose of evaluating reserve adequacy for unit commitment, should the nominal amount of 10 minute reserves available be adjusted down when intermittent output is high to reflect the greater likelihood the reserves will not be available in the event of an outage because they would have been needed to replace intermittent generation.

Reserve Market Impacts

Deviations in intermittent generation output from the expected level are likely to be shorter term as well as more frequent than the outages of major conventional generating units.

- The minimum run and minimum down-times of quick start generation may make these resources less well suited to responding to the output variations of intermittent resources than to generation and transmission outages.
- As intermittent generation output becomes more significant relative to reserve requirements, the proportion of on-line dispatchable reserves may need to be increased.

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