Single Schedule Market Pricing Issues

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Phase 1 - Session 2
Module C: Pricing Constraint Violations

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MODULE C: PRICING CONSTRAINT VIOLATIONS

CONSTRAINT VIOLATION — Hard Constraints

Constrained dispatch models sometimes cannot find a feasible solution based on bids and offers without violating one or more reliability constraints.

- Rules will be needed in order to set appropriate market prices when reliability constraints are violated in the SSM physical dispatch.
- If the constraints are enforced as “hard” constraints:
  - The model may not solve to provide prices or scheduling quantities.
  - The optimization might determine a feasible solution, but the re-dispatch cost to avoid violating a hard constraint might be unacceptably high.
- The potential for these outcomes is unavoidable when hard constraints are enforced in constrained dispatch models.

CONSTRAINT VIOLATION — Constraint Relaxation

One method of enabling a feasible solution is to relax hard constraints that cannot be satisfied by just enough to allow a solution where prices are set by submitted bids and offers rather than by constraint penalty prices.

- This was the typical approach 20 years ago.
- In complex dispatch models with a number of variables, it can result in:
  - Constraints being relaxed too much, resulting in low prices despite a violated reliability constraint.
  - Constraints being relaxed insufficiently, so that there is no feasible solution.

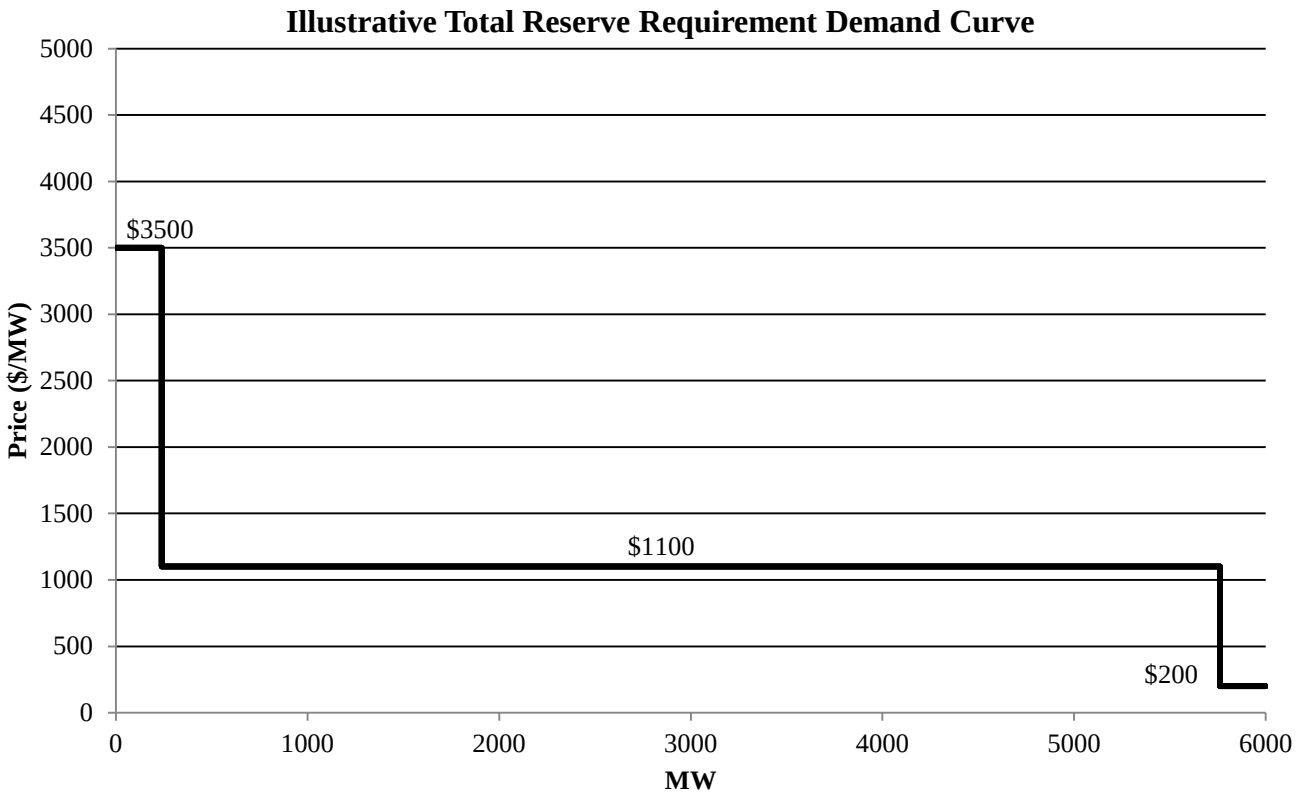
CONSTRAINT VIOLATION — Soft Constraints

ISOs have evolved towards employing “soft” constraints, which can be violated at a cost to enable constrained dispatch and pricing model runs to solve.

- This cost is referred to by a variety of names, such as “penalty price” or “violation cost”.
- Soft constraints (also called “penalty functions”) are expressed as the cost of each MWh of violation of the constraint.
  - Penalty functions can be constant or a stepwise or increasing function of the MWh quantity of the violation.
  - Penalty function calibration may be based on estimates of the increased probability of loss of load associated with each MWh violation of a constraint.

EXAMPLE Soft Constraints and Penalty Prices

Soft constraints penalty prices are also referred to as constraint "demand curves."



CONSTRAINT VIOLATION — Soft Constraints

With the use of soft constraints and penalty prices, the dispatch model can solve by allowing some violation of the constraint.

- This will occur when there is no lower cost way to achieve a feasible dispatch.
- Limited relaxation of a constraint can enable a cheaper dispatch solution at a relatively low violation cost.
  - Occurs whenever the penalty price is less than the re-dispatch cost of reducing the constraint violation.
  - Avoids more costly solutions, such as commitment of an additional unit, activation of demand response, or cutting exports.

CONSTRAINT VIOLATION Current Penalty Prices

The IESO uses the following constraint penalty prices in its constrained and unconstrained schedules. The magnitudes determine the priority for observing the different constraints.

Violation	Penalty Violation Cost
Total Reserve Requirement	$6,000/MW
10-Minute Total Reserve Requirement	$10,000/MW
10-Minute Spinning Reserve Requirement	$12,000/MW
Energy Balance	$30,000/MW
Import/Export Scheduling Limit or Net Interchange Scheduling Limit	$40,000/MW
Security Transmission Limit (Base case or Contingency)	$60,000/MW

CONSTRAINT VIOLATION — Status Quo Pricing

The IESO's current penalty prices:

- Are high to ensure that the dispatch model employs all available market options prior to incurring a violation.
- Impose a hierarchy on the violation of constraints, if necessary.

CONSTRAINT VIOLATION — Status Quo Pricing

The unconstrained pricing model used by the IESO employs constraint relaxation as well as soft constraints and penalty prices.

When a soft constraint is violated in the current unconstrained schedule it will not affect energy prices, except if the constraint is for power balance.

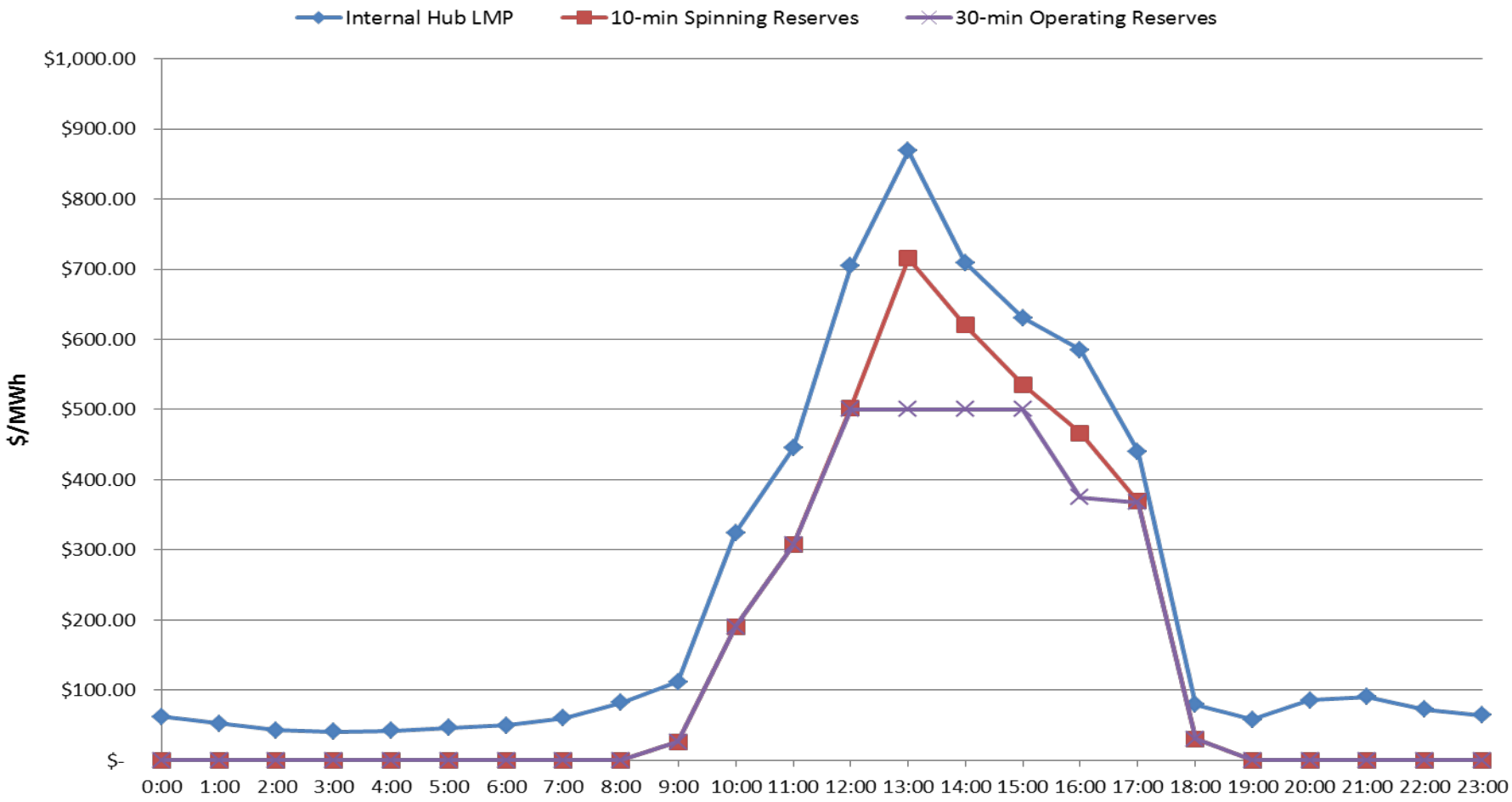
- A power balance constraint is violated if energy injections are out of balance with withdrawals.
- Currently, if the power balance constraint is violated, the energy price is set by the constraint shadow price in the unconstrained schedule ($30,000/ MWh), and the MCP is administratively set at $2,000 for settlement.

CONSTRAINT VIOLATION — Status Quo Pricing

If any other constraint (or constraints) is violated, the unconstrained pricing model is run a second time - with the constraint relaxed - so that it will not bind when determining unconstrained prices from the bids and offers.

- If an operating reserve requirement is violated, the price of the associated reserve type is set to the greater of the energy price or the highest dispatched offer for the reserve type.

ISO-NE Internal Hub LMP and Rest of System Reserves, 7/19/2013



Note: Reserve Prices presented are for the Rest of System reserve zone.

Sources: ISO-NE Final Real-Time LMPs and Final Hourly Reserve Zone Prices and Designations: http://www.iso-ne.com/markets/hst_rpts/hstRpts.do?category=Hourly

CONSTRAINT VIOLATION SSM Constrained Pricing

With constrained pricing as implemented in markets such as those of NYISO, MISO and ISO New England, when a soft constraint is violated in the dispatch, the cost of the constraint violation impacts prices for both energy and reserves.

- Energy Price: The marginal cost of serving an increment of load at a location (i.e., the SSM energy price) will include the penalty cost of any incremental constraint violation from the re-dispatch to serve this load.
- Reserve Price: The marginal cost of an incremental increase in the global reserve requirement for any type of reserves, (i.e., the SSM reserve price) will include the penalty cost of any incremental constraint violation in the re-dispatch necessary to schedule the incremental reserves.

CONSTRAINT VIOLATION Phase 2 Discussion Issues

A number of implementation issues for SSM violation pricing will be discussed in Phase 2:

- The level of the penalty prices in the current constrained schedule, and whether these should continue to be used in the single schedule dispatch and pricing model runs.
- Whether to implement scarcity pricing by modifying the current uniform penalty prices for reserves into operating reserve demand curves or step functions to reflect increasing costs of decreasing levels of reserves.
- Whether to use constraint relaxation in determining pricing.
- Whether to introduce penalty functions and pricing for other constraints.