# Single Schedule Market Pricing Issues

# Phase 2 – Session 1 – Price Formation Options

**Presented by**

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# Topic Schedule - Fundamentals

- **June 2, 2017 - Stakeholder Engagement Session**
  - ✓ Module A - Energy Pricing
  - ✓ Module B - Reserve Pricing
  - ✓ Module C - Constraint Violation Penalties
  - ✓ Module D - Multi-interval Optimization and Pricing
  - ✓ Module E - Pricing Operating Restrictions and Operator Actions
- **June 29, 2017 - Stakeholder Engagement Session**
  - ✓ Module F - Load Pricing
  - ✓ Module G - Market Power Mitigation

**July 27, 2017 - Stakeholder Engagement Session**

- ✓ Module H - Make Whole Payments and Uplift

## SSM Design Elements – Options July 27, 2017

1. Energy Price - Congestion Component
2. Energy Reference Price
3. Energy Price - Loss Component
4. Ex Post vs. Ex Ante Pricing
5. Intertie Congestion Pricing
6. Supplier Pricing
7. Operating Reserve Reference Price
8. Operating Reserve Price - Congestion Component
9. Constraint Violations
10. Out-of-market Operator Actions
11. Multiple Interval Optimization
12. Price Setting Eligibility

# 1. Energy Price - Congestion Component

## Congestion Component Background

The IESO currently does not take account of congestion in calculating the uniform price:

- The current settlement price does not include a congestion component
- The shadow prices calculated in the IESO's constrained schedule include a congestion component

## Congestion Component Options

Including the cost of congestion in prices is a foundational feature of a single schedule market. There is only one viable option for this design element:

1. Include the cost of congestion in prices

## Congestion Component — Other ISOs

| | Congestion in Prices |
|---|---|
| PJM | Yes, since 1998 |
| New York ISO | Yes, since 1999 |
| ISO New England | Yes, since 2003 |
| MISO | Yes, since 2005 |
| SPP | Yes, since 2007 |
| California ISO | Yes, since 2009 |
| ERCOT | Yes, since 2010 |
| Western EIM | Yes, since 2014 |
| Mexico | Yes, since 2016 |

## Congestion Component Discussion

The benefits of including the congestion component in settlement prices include allowing the IESO:

- To provide an efficient price signal for the development and performance of resources able to help the IESO efficiently manage variations in intermittent resource output
- To implement new market design features that would help the IESO more efficiently manage variations in intermittent resource output
- Simplify settlements
- Reduce unwarranted out-of-market uplift payments
- To implement a day-ahead market

# 2. Energy Reference Price

## Energy Reference Price — Background

In a SSM, the only decision with regard to the energy reference price component is the specification of the reference location.

- The locational marginal price (LMP) at a location does not depend on the choice of the reference location
  - A change in the reference location will only affect the three components of price - not the total LMP price
- The IESO currently utilizes the Richview location as the reference location in the constrained schedule
- There is no reference location in the unconstrained schedule because it does not consider dispatch of the actual transmission grid

## Energy Reference Price Options

There are two main options for defining the reference location:

1. Continue to use Richview as the reference location
2. Use some other reference location

## Energy Reference Price — Other ISOs

| ISO | Reference Location | Vendor |
|---|---|---|
| PJM | Distributed Load | Alstom |
| New York ISO | Marcy/Tennessee | ABB |
| ISO New England | Distributed Load | Alstom |
| MISO | Distributed Load | Alstom |
| SPP | Distributed Load | Alstom |
| California ISO | Distributed Load | Siemens |
| ERCOT | Comanche Peak | ABB |

## Energy Reference Price — Discussion

Richview was originally chosen as the reference location because it is well connected to most parts of the province and because of its proximity to Ontario's major load centre.

- Risk of experiencing unanticipated performance issues with using a new location

# 3. Energy Price - Loss Component

## Loss Component Background

The current IESO prices do not reflect the cost of incremental losses in meeting load at each location.

The constrained schedule used to actually operate the Ontario transmission system does take account of the cost of incremental losses in dispatching generation at each location and this cost is reflected in the energy market shadow prices calculated in the constrained schedule.

## Loss Component Options

There are three broad approaches Ontario could use to take account of the cost of marginal losses:

1. Include the cost of marginal losses in the dispatch but exclude this cost from prices (status quo)
2. Exclude the cost of marginal losses from prices and from the dispatch
3. Include the cost of marginal losses in both the dispatch and prices

## Loss Component — Other ISOs

| | Marginal Losses in Prices |
|---|---|
| New York ISO | Yes, since 1999 |
| ISO New England | Yes, since 2003 |
| MISO | Yes, since 2005 |
| PJM | Yes, since 2007 |
| SPP | Yes, since 2007 |
| California ISO | Yes, since 2009 |
| ERCOT | No, but under discussion |

## Loss Component — Option 1

Retain the current design in which the real-time schedule takes account of the cost of marginal losses but settlement prices do not.

- This option would entail retaining a two schedule pricing design and would presumably include CMSC payments to take account of the difference between prices and dispatch instructions

## Loss Component — Option 2

Shift to a design in which the cost of marginal losses is not taken into account in either the economic dispatch or in prices. This option would:

- Not require CMSC payments since the dispatch instructions would be consistent with prices
- Increase the cost of meeting load
- Require changes in the design and implementation of the constrained schedule software

## Loss Component — Option 3

Continue to take account of the cost of marginal losses in the real-time economic dispatch and include the cost of marginal losses in settlement prices. This option would:

- Minimize the cost of meeting load and not require CMSC to account for losses
- Improve the efficiency of market price signal and reduce uplift
- Be consistent with the IESO's current constrained schedule and is best practice among ISOs coordinating single schedule markets

## Loss Component

Another consideration related to losses is whether the IESO should continue to dispatch the system using static loss factors for the initial SSM implementation or should shift to more dynamic loss factors for SSM implementation.

## Loss Component — Other ISOs

| | Dynamic Losses | Calculation Frequency |
|---|---|---|
| New York ISO | Yes | 5 minutes |
| PJM | Yes | 5 minutes |
| ISO NE | Yes | 5 minutes |
| MISO | Yes | 5 minutes |
| SPP | Yes | 5 minutes |
| CAISO | Yes | 5 minutes |
| ERCOT | n.a. | n.a. |

# 4. Ex Post vs. Ex Ante Pricing

## Ex Ante/Ex Post Pricing — Background

Ex Post pricing designs use information that was not available at the time dispatch instructions were sent to calculate settlement prices.

- The IESO currently utilizes a form of ex post pricing to calculate prices in the unconstrained schedule

Ex Ante pricing designs use prices calculated based on the dispatch and hence only use information that was available at the time dispatch instructions were sent to calculate settlement prices.

- The energy shadow prices calculated in the IESO constrained schedule are ex ante prices

## Ex Ante/Ex Post Pricing — Options

There are two options relating to ex ante and ex post pricing:

1. Ex Post pricing (status quo)
2. Ex Ante pricing

# Ex Ante/Ex Post Pricing — Other ISOs

| | Uses Ex Post Pricing? |
|---|---|
| PJM | Yes |
| New York ISO | No |
| ISO New England | No [1] |
| MISO | No [2] |
| SPP | No |
| California ISO | No |
| ERCOT | No |

1. ISO New NE switched to Ex Ante pricing April 2015.
2. MISO switched to Ex Ante pricing early 2009.

## Ex Ante/Ex Post Pricing — Option 1

Ex Post Pricing:

- Useful if ISO does not have sophisticated dispatch software, which is not relevant to IESO
- Complex to implement in a way that does not lead to pricing anomalies
- Past implementations have sent inefficient price signals during reserve shortages or ramp constrained periods

## Ex Ante/Ex Post Pricing — Option 2

Ex Ante Pricing:

- Consistent with the IESO's current constrained schedule
- Is considered best practice
- Avoids sending inefficient price signals during reserve short or ramp constrained periods

# 5. Intertie Congestion Pricing

## Intertie Congestion Pricing — Background

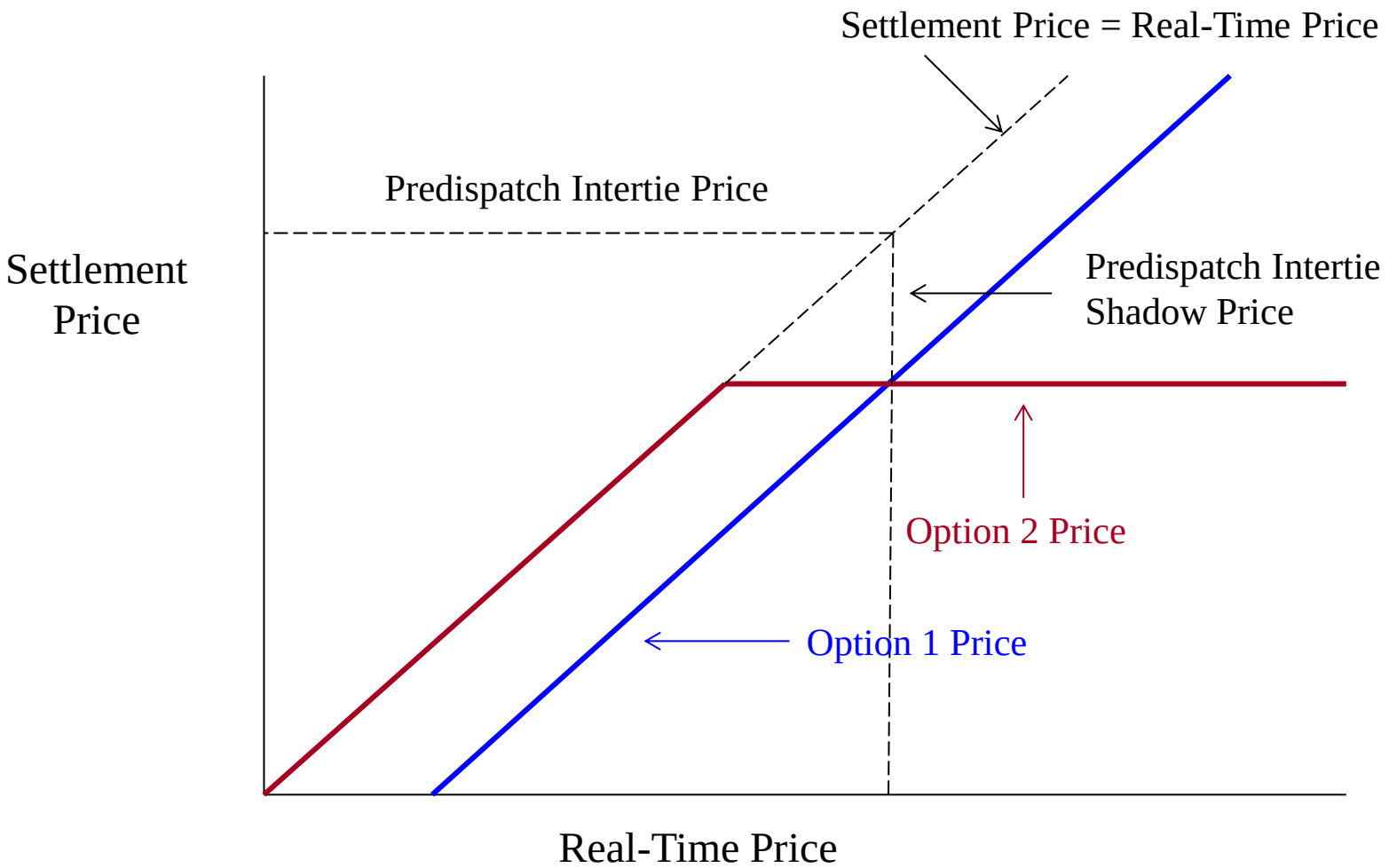
The IESO currently utilizes the congestion charge in the unconstrained pre-dispatch for intertie congestion pricing.

- The intertie congestion charge in the unconstrained pre-dispatch (which includes intertie constraints) is added to the real-time MCP (a five-minute dispatch price) to determine the settlement price for imports and exports at each relevant intertie
- Intertie congestion costs are not reflected in either the constrained or unconstrained 5 minute dispatch price because intertie schedules are fixed during a given hour
- No shadow prices are currently calculated for real-time intertie schedules in the constrained dispatch

## Intertie Congestion Pricing Options

There are two possible approaches to intertie pricing in the near-term for SSM:

1. Charge intertie transactions based on the congestion charge in the *constrained* pre-dispatch and the price at the intertie in the real-time *constrained* schedule (similar to status quo)
2. Charge intertie transactions based on:
   - The real-time schedule price if there is no congestion
   - When export constrained - the higher of the nodal price in real-time or pre-dispatch
   - When import constrained - the lower of the nodal price real-time or pre-dispatch price


Settlement Price = Real-Time Price
Predispatch Intertie Price
Settlement Price
Predispatch Intertie Shadow Price
Option 2 Price
Option 1 Price
Real-Time Price

# Intertie Congestion Pricing

Under option 1, the intertie settlement price will be equal to the real-time intertie price less the intertie shadow price in the pre-dispatch. (the example assumes the intertie is import congested)

Under option 2, the intertie settlement price will be equal to the pre-dispatch price if the real-time price is higher.

## Intertie Congestion Pricing Options

In the longer-term, the IESO might choose to implement a Coordinated Transaction Scheduling (CTS) design with the New York ISO and/or MISO, using pricing rules agreed upon with those ISOs. Such a design would:

- Presumably be similar to the New York ISO's current pricing rules with PJM and ISO New England
- Add ½ of the congestion component in the scheduling process to the real-time price in the exporting balancing area
- Subtract ½ of the congestion component in the scheduling process to the real-time price in the importing balancing area

# Intertie Congestion Pricing — Other ISOs

| | Price Intertie Congestion in Real-time? | Coordinated Transaction Scheduling |
|---|---|---|
| New York ISO | Yes | PJM, ISO-NE |
| PJM | No | NYISO, MISO Fall 2017 |
| ISO NE | No | NYISO |
| MISO | No | PJM Fall 2017 |
| SPP | No | No |
| CAISO | Yes | 2014 |
| ERCOT | No | No |

## Intertie Congestion Pricing — Discussion

Options for changes in intertie congestion pricing need to be evaluated in conjunction with changes in intertie scheduling that will be considered in other work streams:

- Implementation of a single schedule market would enable the IESO to implement any of the designs described above

- All of these designs would require the IESO to calculate shadow prices at the interties in the constrained dispatch

# 6. Energy Pricing for Suppliers

## Energy Pricing for Suppliers — Background

The IESO currently pays suppliers based on the uniform market clearing price (MCP).

Constrained-on and constrained-off payments compensate suppliers for differences between their theoretical (unconstrained) and actual (constrained) schedules.

## Energy Pricing for Suppliers — Options

There are two options for paying suppliers for energy:

1. Zonal Prices
2. Nodal Prices

## Energy Pricing for Suppliers — Other ISOs

| | Generator Pricing Design |
|---|---|
| PJM | nodal since 1998 |
| New York ISO | nodal since 1999 |
| ISO New England | nodal since 2003 |
| MISO | nodal since 2005 |
| SPP | nodal since 2007 |
| California ISO | nodal since 2009 |
| ERCOT | nodal since 2010 |

## Energy Pricing for Suppliers — Option 1

Shift to a **zonal** pricing system, with somewhat reduced levels of constrained on and off payments. Choosing this option would:

- Reduce - but not eliminate - the inefficiency and uplift costs associated with the current design
- Continue to handicap the IESO in:
  - Accommodating higher levels of intermittent resources
  - Implementing potential improvements, such as a day-ahead market, coordinated intertie scheduling and/or ramp capability dispatch
- Mean shifting to a design that other ISOs (California and ERCOT) have abandoned in recent years

## Energy Pricing for Suppliers — Option 2

Shift to the **nodal** LMP pricing design used by all other ISOs with single schedule market designs. Choosing this option would:

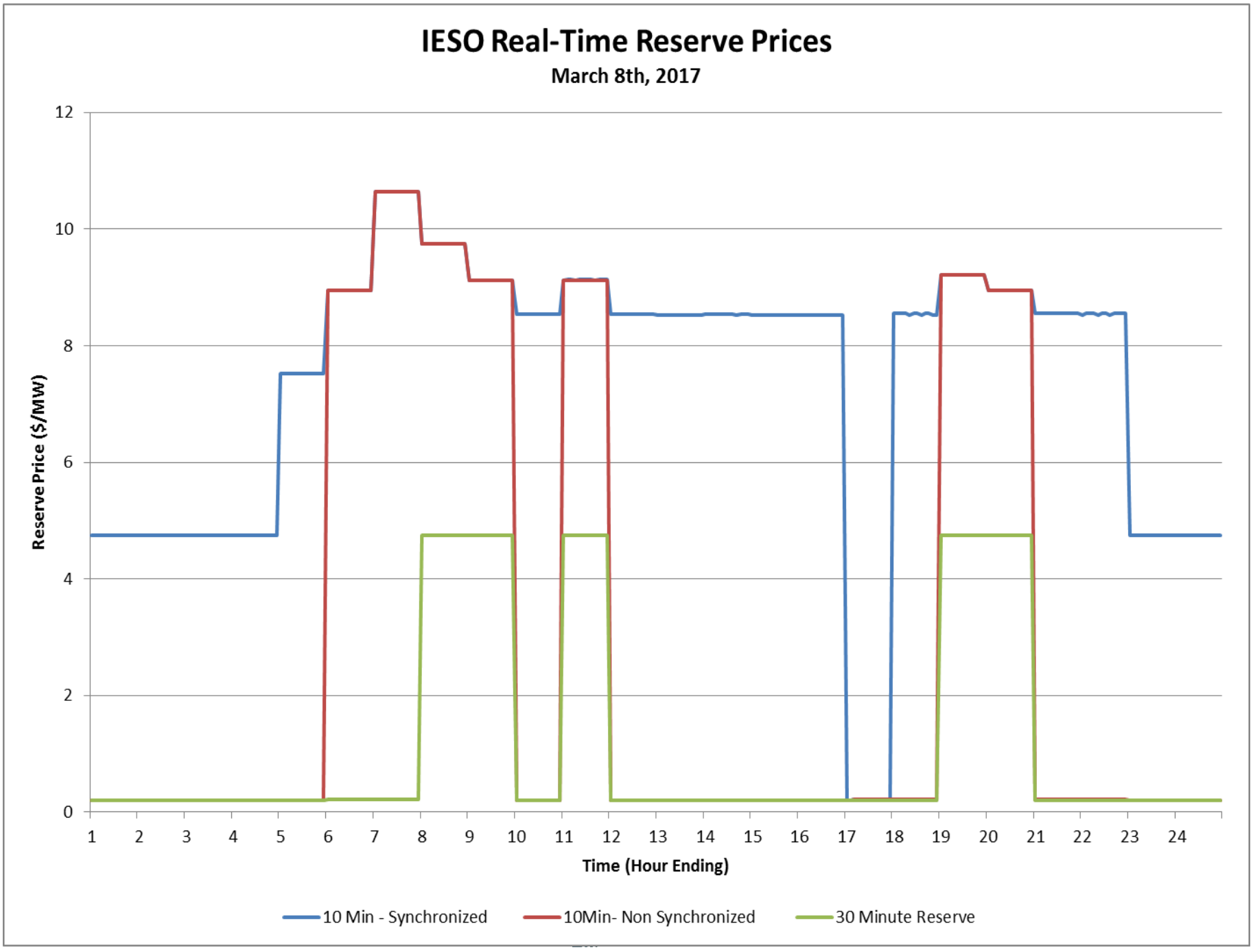
- Improve market efficiency and reduce uplift costs

- Aid the IESO in accommodating higher levels of intermittent resource output by providing spot market incentives for resources able to provide the required flexibility

- Also allow potential future improvements, such as implementing a day-ahead market, coordinated intertie scheduling and/or ramp capability dispatch, that require single schedule pricing for their implementation

# 7. Operating Reserve Reference Price

Both the IESO unconstrained and constrained schedule simultaneously optimize and price energy and operating reserves in real-time.


IESO Real-Time Reserve Prices
March 8th, 2017
Reserve Price ($/MW)
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Time (Hour Ending)
10 Min - Synchronized
10Min- Non Synchronized
30 Minute Reserve

## Operating Reserve Pricing Options

There is one option:

1. Co-optimize energy and operating reserve (status quo)

The IESO's current design is best practice for SSM markets. There is no reason to spend resources developing less efficient alternatives.

## Operating Reserve Pricing — Other ISOs

| | Simultaneous Optimization of Reserves and Energy in Real Time Dispatch |
|---|---|
| New York ISO | Yes – since 2005 |
| ISO New England | Yes – since 2006 |
| MISO | Yes – since 2009 |
| PJM | Yes – since 2012 |
| SPP | Yes – since 2014 |
| California ISO | Not in 5 minute dispatch; Partly in 15 minute market; considering implementing in 5 minute dispatch and fully re-optimizing in 15 minute market |
| ERCOT | No |

# 8. Operating Reserve Price - Congestion Component

## Operating Reserve Price - Congestion Background

The IESO currently pays a uniform price for operating reserve.

- Constrained-on and constrained-off payments compensate for differences between the uniform prices and actual offer/opportunity costs of real-time operating reserve schedules

The IESO's constrained schedules for operating reserves and energy reflect industry best practice.

- Co-optimizes the dispatch of energy and scheduling of operating reserves in real-time, while enforcing locational minimum and maximum operating reserve constraints across the province

## Operating Reserve Price - Congestion Options

Similar to the choice to include congestion costs in the energy price, there is really only one option for operating reserve congestion pricing:

1. Include the cost of congestion

Ignoring locational reserve constraints in the constrained schedule is not a feasible option because most of these constraints represent reliability obligations or have been implemented to better maintain reliable electric system operations in Ontario.

# Operating Reserve Price - Congestion — Other ISOs

| | Multiple Reserve Zones | Nested Zones | Locational Reserve Pricing |
|---|---|---|---|
| New York ISO | Yes | Yes | since 2002 |
| PJM | Yes | Yes | since 2005 |
| ISO New England | Yes | Yes | Yes |
| MISO | Yes | Yes | Yes |
| SPP | No | N.A. | No[1] |
| California ISO | Yes | Yes | Yes |
| ERCOT | No | N.A. | No |

1. SPP market rules provide for zonal reserve prices if they are needed. Five Zones were enforced from May 2014 until September 2014 when transmission expansions eliminated the need for the Zonal targets.

## Operating Reserve Price - Congestion Option 1

Shift to a design in which operating reserves are settled based on locational prices for reserve zones, so are generally consistent with operating reserve schedules. This option:

- Will reduce or eliminate inconsistencies between operating reserve schedules, offer prices and clearing prices that are currently resolved with CMSC payments
- Will provide a more efficient price signal for investments that would allow demand side and storage resources to provide reserves in higher priced regions

Reserve shadow (congestion) prices are currently produced with the IESO constrained schedule

- Consistent with design in most other ISO single schedule markets

# 9. Constraint Violations

# Constraint Violation Penalties — Background

The IESO uses constraint penalty prices in its constrained and unconstrained schedules. The magnitudes determine the priority for observing the different constraints. Below is a sample of such prices.

| Violation | Penalty Violation Cost |
|---|---|
| Control Action Operating Reserve | $30/MW |
| 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 |

These penalty prices are currently reflected in constrained schedule shadow prices when the constrained schedule is not able to observe these constraints.

## Constraint Violation Penalties Options

The IESO has three basic options for applying constraint violation pricing, with a few additional choices for how some of the options would be implemented.

- The constraints referred to in this section are associated with operating reserve shortages and transmission limits

- Under all of these options, operating reserve and energy prices would continue to be capped at $2,000/MWh
  - There would be a potential for some inconsistencies between energy and reserve prices when the price cap was binding

- The IESO could implement different options for operating reserve pricing than for transmission constraint pricing

## Constraint Violation Penalties Options

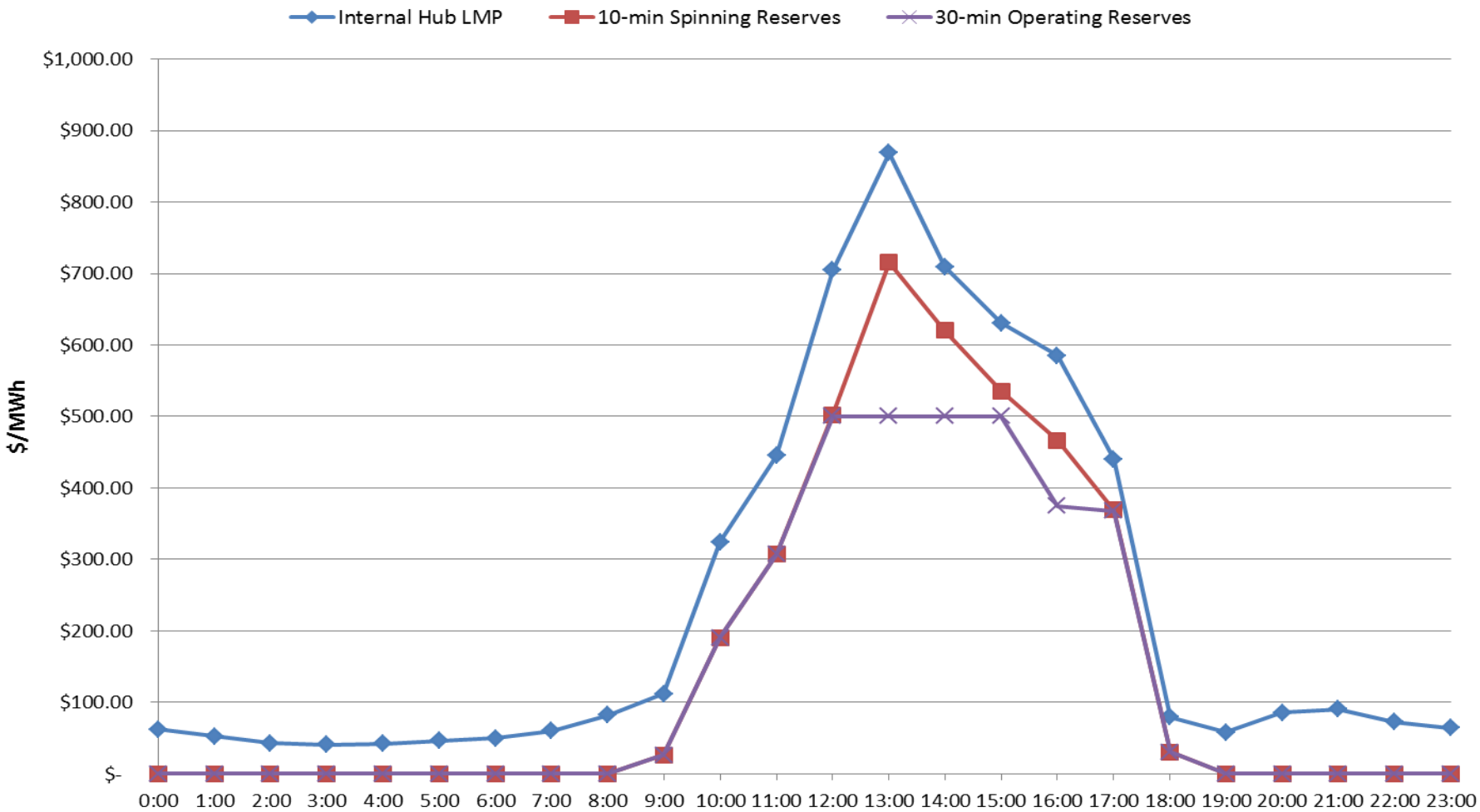
1. Apply current penalty prices in dispatch, but use ‘relaxation’ and other adjustments for pricing (status quo)
2. Use the same set of penalty prices for both dispatch and pricing
    a) Use current penalty prices
    b) Create new penalty prices (hierarchy needed)
    c) Create a demand curve for penalty prices
3. Apply current penalty prices in dispatch, but use a different set of penalty prices in pricing
    a) Create new penalty prices (hierarchy needed)
    b) Create a demand curve for penalty prices

## Constraint Violation Penalties — Other ISOs

All system operators utilize penalty prices of these types in their dispatch software:

- ISOs operating single schedule markets have evolved away from using arbitrarily large penalty prices and towards choosing penalty values that are consistent with the cost ("reliability value") of actions the ISO would take to resolve those conditions
- Costs that should be incurred to resolve violations have historically been reflected in the type of in-market/out-of-market actions taken by operators
- Increasing need to make complex dispatch and commitment decisions in software systems makes it important to pre-determine appropriate penalty prices for use in these systems

# 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 Penalties — Other ISOs -- Reserves

| | Reserve Penalty Factors Can Set Prices |
|---|---|
| PJM | real-time |
| New York ISO | Day-ahead and real-time |
| ISO New England | real-time |
| MISO | day-ahead and real-time |
| SPP | day-ahead and real-time |
| California ISO | day-ahead and 15 minute |
| ERCOT | real-time |

## Constraint Violation Penalties Other ISOs-Transmission

Most ISOs employing SSM pricing have evolved first towards using transmission violation penalty prices in the real-time dispatch and then towards using transmission violation demand curves in the real-time dispatch.

- Most system operators utilize transmission margins in dispatching the system, so that the actual reliability limit is not exceeded when the transmission constraint first binds or for small overloads

# Constraint Violation Penalties — Other ISOs-Transmission

| | Transmission Constraint Penalties Set Price | Multiple Penalties for Constraint Types [1] | Multiple Penalties for Overloads [2] |
|---|---|---|---|
| New York ISO | Yes | No | Yes |
| PJM | No | N.A. | N.A. |
| ISO New England | No | N.A. | N.A. |
| California ISO | Yes | No | No |
| MISO | Yes | Yes | Yes |
| SPP | Yes | No | Yes |

1. These designs have transmission penalty factors that vary by line voltage and between system operating limits and interconnection reliability operating limits.
2. These designs have multiple penalty factors for a given constraint that vary with the amount of the overload.

## Constraint Violation Penalties — Other ISOs

The trend in other single schedule market ISOs is therefore to utilize penalty prices that both cause the ISO software systems to make appropriate decisions from the standpoint of both economics and reliability and to flow these penalty prices through into settlement prices to provide efficient incentives for market participants to respond to these prices.

## Constraint Violation Penalties — Option 1

Utilize the penalty prices currently implemented in the constrained schedule, but relax violated constraints and determine settlement prices based on incremental energy and/or operating reserve offer prices.

- Current penalty prices may exceed the reliability value of respecting constraints leading to commitment decisions that are more expensive than other manual operator actions that could be taken to resolve the constraint
- The use of constraint relaxation to calculate prices can lead to:
  - Settlement prices that are too low to incent efficient actions in response to violations
  - Settlement prices that exceed the reliability value associated with a particular violation, raising cost for consumers

## Constraint Violation Penalties — Option 2a

Utilize penalty prices currently implemented in the constrained schedule and allow them to flow through into settlement prices.

- Current penalty prices may exceed the reliability value of respecting constraints leading to commitment decisions that are more expensive than other manual operator actions that could be taken to resolve the constraint violation

- If these penalty prices were reflected in settlement prices, subject to the $2,000 price cap, the settlement prices may cause generators and dispatchable or price responsive loads to take actions whose cost exceeds the reliability value associated with a particular violation

## Constraint Violation Penalties Option 2a

It should be kept in mind that although transmission constraint penalty prices would be set at $60,000/MWh, the price impact at any location would be proportional to the impact of that location on the binding transmission constraint.

The calculated price could be:

- below the price cap at locations with low impact on a constraint
- well above the price cap at locations with large impacts on a violated constraint

## Constraint Violation Penalties — Options 2b and c

Develop a new set of penalty prices that would be used both in dispatch and pricing.

- These penalty prices could be set at levels that would produce commitment results inline with the reliability value of respecting constraints and result in settlement prices that would incent efficient actions in response to violations
- The IESO and stakeholders would need to develop an initial set of penalty prices. These penalty prices could be modified from time to time as operating practices and challenges evolve

## Constraint Violation Penalties — Options 3a and b

Utilize penalty prices currently implemented in the constrained schedule to determine the commitment and dispatch, but develop a different set of penalty prices that would be used to determine settlement prices.

- Current penalty prices may exceed the reliability value of respecting constraints leading to commitment decisions that are more expensive than other manual operator actions that could be taken to resolve the constraint violations
- Settlement prices based on a lower set of penalty prices could at times result in additional uplift costs when IESO software made commitment decisions based on the current penalty prices

## Constraint Violation Penalties — Options 3a and b

- The penalty prices in the pricing pass could be set at levels that would incent efficient actions in response to constraint violations
- The IESO and stakeholders would need to develop an initial set of penalty prices to use in pricing. These penalty prices could be modified from time to time as operating practices and challenges evolve
- These constraint penalty prices could be set either at single values or as demand curves with different penalties for varying levels of violations

# 10. Out-of-market Operator Actions

IESO operators may take a number of actions to maintain electric system reliability during shortage conditions.

These actions include:

- Voltage reductions
- Export curtailments
- Emergency imports/exports.

## Pricing of Operator Actions — Background

Other operator actions that can be taken to maintain local electric system reliability that could impact prices include:

- Supplying emergency curtailable exports to adjacent control areas that are counted as Ontario operating reserves
- Curtailing imports during low load conditions
- Committing resources out of merit to provide voltage support, operating reserves or address area control error
- Committing resources out of merit for transmission security
- Constraining off energy limited resources in order to be able to meet load later in the operating day

## Pricing of Operator Actions — Options

The basic options are whether to allow some or all of these operator actions to set market prices in some circumstances:

1. Control actions are priced at maximum MCP or some other level, for one or more of the following:
    a) Voltage reductions
    b) Curtailment of exports for adequacy
    c) Scheduling of emergency imports
2. Control actions are not priced

All of these options interact with the design for operating reserve shortage pricing as some would only be taken if there were also a significant shortage of operating reserves.

## Pricing Of Operator Actions — Other ISOs

| | Voltage Reductions Set Price | Export Curtailments Set Price | Emergency Imports Set Price |
|---|---|---|---|
| PJM | Yes | No | Yes |
| New York ISO | No | No | No |
| ISO New England | No | No | No |
| MISO | No | No | No |
| SPP | No | No | No |
| California ISO | No | Yes in FMM | No |

## Pricing of Operator Actions — Option 1a

Voltage reductions set price at the price cap or some other level.

- Reflecting the need for voltage reductions in real-time prices would provide an additional signal for generation and load resources to take actions to increase generation and reduce load

- This could result in discrepancies between the dispatch and prices but this is very unlikely as voltage reductions would only be taken when there are significant reserve shortages, so all resources should be scheduled either for reserves or energy

- This would require some changes in constrained schedule or implementation of a pricing pass.

## Pricing of Operator Actions — Option 1b

Curtailment of exports in the pre-dispatch sets prices at the cap or at some other level.

- This would provide a stronger price for generation and load resources to take actions to increase generation and reduce load

- If the export curtailments eliminated reserve shortages, setting prices at the price cap would create inconsistencies between the dispatch and prices in which some resources would not be scheduled or compensated to provide either reserves or energy despite high prices

## Pricing of Operator Actions — Option 1b (cont.)

Intra-hour curtailment of exports sets prices at the cap or at some other level.

- This would provide a stronger price for generation and load resources to take actions to increase generation and reduce load
- This could result in discrepancies between the dispatch and prices but this is very unlikely as intra-hour curtailments would likely only be taken when there are significant reserve shortages so all resources would be scheduled either for reserves or energy
- This would require some changes in constrained schedule or implementation of a pricing pass

## Pricing of Operator Actions — Option 1c

Scheduling of emergency imports sets prices at the cap or at some other level.

- This would provide a stronger price for generation and load resources to take actions to increase generation and reduce load
- This could result in discrepancies between the dispatch and prices but this is unlikely as emergency imports would likely only be scheduled when there are significant reserve shortages so all resources would be scheduled either for reserves or energy
- This would require some changes in constrained schedule or implementation of a pricing pass and rules to determine when it would cease to be applied as load fell and the imports were no longer needed

## Pricing of Operator Actions — Option 2

Not reflecting operator actions in prices would:

- Not provide an additional signal for generation and load resources to take actions to increase generation and reduce load
- Not require any changes in constrained schedule or introduction of a pricing pass
- These operator actions are rarely used, but the value of load reductions from the additional price signal may be very high.

# 11. Multiple Interval Optimization

## Multiple Interval Optimization — Background

The IESO currently utilizes multiple interval optimization based on five critical periods to determine generator and dispatchable load schedules in the constrained schedule.

- However, the unconstrained prices that are used for settlements are based on a single interval dispatch

## Multiple Interval Optimization Options

There are two basic options relating to multiple interval optimization:

1. Use multiple interval optimization to determine schedules but not prices (similar to status quo)
2. Use multiple interval optimization to determine schedules and prices

# Multiple Interval Optimization — Other ISOs

| | Use MIO [1] |
|---|---|
| PJM | No |
| New York ISO | Yes, since 2005 |
| ISO New England | No |
| MISO | No |
| SPP | No |
| California ISO | Yes, since 2009 |
| ERCOT | No |

1. Use multi-interval optimization for dispatch and in setting prices.

## Multiple Interval Optimization — Option 1

Use multiple interval optimization to determine physical schedules but use single interval optimization to determine prices.

- Similar to current design with respect to multi-interval pricing but SSM pricing would take account of actual ramp rates, transmission congestion and minimum load blocks in calculating prices as well as constrained schedules
- Preserves benefits of multiple interval optimization
- Potential for inconsistencies between dispatch and prices

## Multiple Interval Optimization Option 2

Use multiple interval optimization both to determine physical schedules and to determine prices.

- Preserves benefits of multiple interval optimization
- Reduced potential for inconsistencies between dispatch and prices

# 12. Price Setting Eligibility

## Operating Restrictions — Background

When determining the MCP in today's unconstrained schedule the following operating restrictions are eligible for partial scheduling and can set the unconstrained price:

- Minimum load blocks of on-line internal resources
- Minimum load blocks of off-line quick start resources (5-minute dispatch time frame)
- Forbidden regions

In the unconstrained schedule the following operating restrictions are not eligible for partial scheduling and cannot set the unconstrained price:

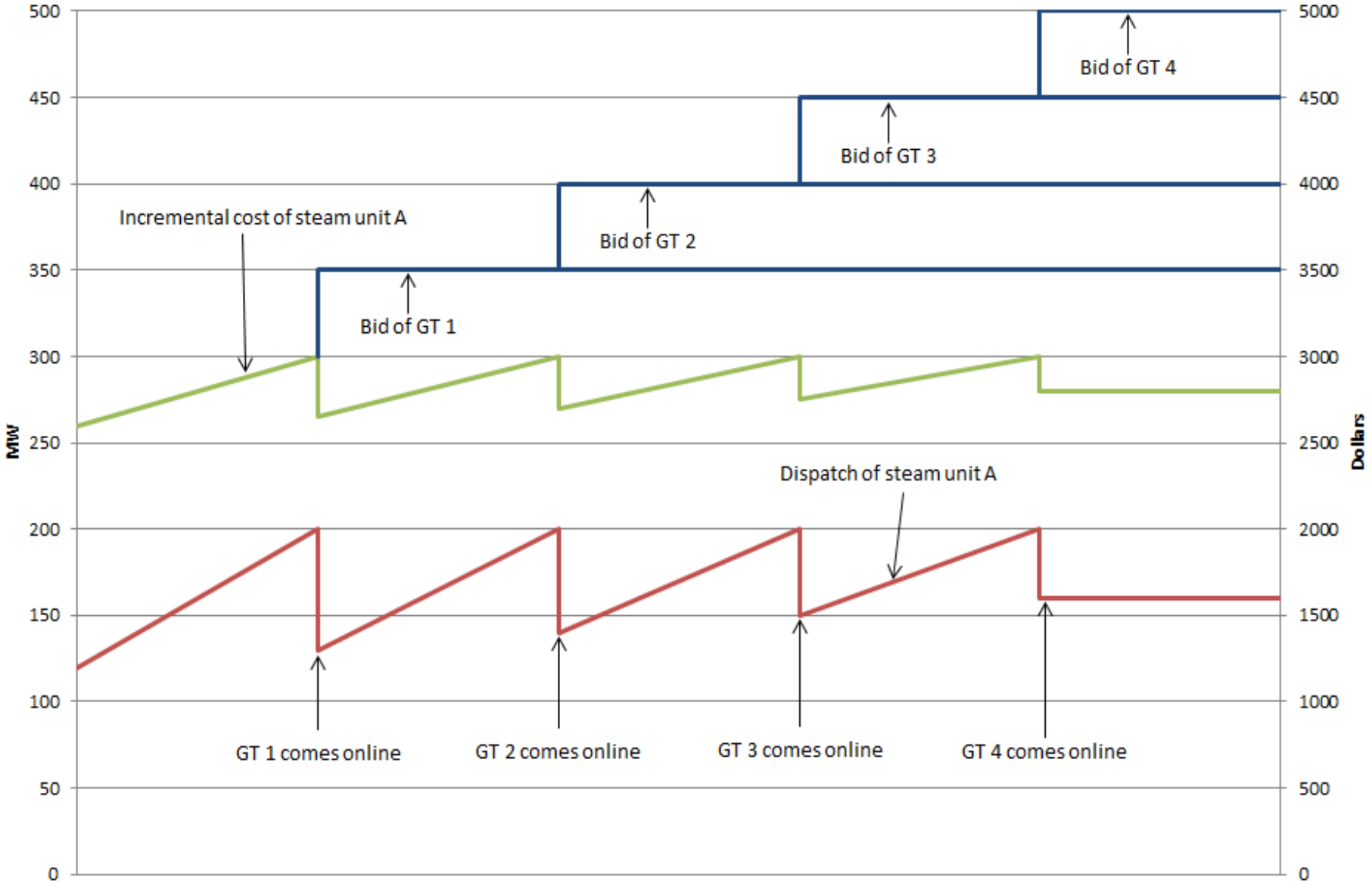
- Interchange transactions
- Operating ranges scheduled to provide regulation

## Operating Restrictions Options

There are two core options:

1. Do not allow any resources' restricted MW's (e.g. minimum loading point) to set or impact price (status quo in the constrained schedule)
2. Allow fast start online resources' restricted MW's to set or impact price

# ILLUSTRATION OF NYISO HYBRID PRICING



## Operating Restrictions

The ‘hybrid pricing’ design in New York ISO was motivated by a desire to send an efficient price signal when fast-start gas turbines (with minimum loading points) are committed to meet incremental load near real-time.

- NYISO allows fast-start gas turbines to set price, so long as they are marginal and not simply still online because of minimum run-time considerations (hence the name ‘hybrid’)
- Average cost offers (inclusive of speed-no-load but not start up costs) are used by the NYISO to set the price in these situations
- Intended to provide a more efficient price signal and reduce uplift
  - Better signals for intertie transactions and price-responsive load

## Operating Restrictions — Other ISOs

| | Allow on-line fast-start unit to Set Price? |
|---|---|
| New York ISO | Yes |
| PJM | Rarely |
| ISO New England | Yes |
| MISO | Yes |
| California ISO | Rarely |
| SPP | No |
| ERCOT | No |

## Operating Restrictions Dispatch Discontinuous

Because suppliers with operating restrictions cannot necessarily increment or decrement their output one megawatt at a time, their physical dispatch can cause discrete changes in the dispatch points of other resources.

- A common situation is that a gas turbine with an minimum loading point, generally one which can be committed and started-up quickly close to real-time, may be needed on the margin to serve load
  - For example, if only 30 MW of a unit with an minimum loading point of 80 MW is needed to meet incremental load, then another, less costly, supplier(s) must reduce its output by 50 MW

## Operating Restrictions Pricing Issue

When an operating restriction results in a discontinuous physical dispatch on the margin, the SSM pricing run rules must explicitly address how this will be taken into account in calculating prices, taking the physical commitment and dispatch as optimal.

- Continuing the prior illustration, if 30 MW of a unit with a minimum loading point of 80 MW is part of the least-cost dispatch, should the price be
  - The average offer cost of the unit's minimum loading point output? This unit was committed because its output was needed to serve load at least cost; OR
  - The incremental offer cost of the cheapest supplier whose dispatch was reduced to accommodate the extra 50 MW of the block-loaded unit's output? This is the incremental offer cost to serve the next MW of load.

## Operating Restrictions — Option 1

Utilize price setting rules consistent with the calculation of shadow prices in the constrained schedule:

- This approach would not require changes in the prices determined by the constrained schedule
- This approach could at times set prices that would be inconsistent with the commitment of fast starting resources with MLP's (Ontario currently has few such resources)

## Operating Restrictions — Option 2

The rules for whether and when the minimum load blocks of on-line units may set price under SSM will need to take into account:

- The capabilities of the commitment models the IESO runs close to real-time
- The variability of net load
- The time step for interchange scheduling