Pricing Mechanism for Time-Coupled Multi-interval Real-Time Dispatch

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Outline

- Background
- Proposed method
- Simple Example
- Alternate method
- Future work
Background

- MISO is evaluating whether to use a Look Ahead Dispatch for their Real Time SCED engine

- Current single interval SCED may result in sub-optimal overall solution due to time horizon based on single point
  - Time coupled multiple interval dispatch addresses this shortcoming

- LAD would have a look ahead time horizon of 1 hour, with 15 minute granularity
  - Only first interval would provide financially binding dispatch target
Background

• **MISO Benefit study indicates benefits of LAD implementation**
  – Substantial production cost savings.
  – Reduction in scarcities due to better pre-positioning of generation resources

• **MISO Staff is also evaluating different ex-post pricing engines to compliment LAD dispatch solution.**
  – Single interval ELMP will be in MISO production system mid 2014.
  – Now the issue will focus on how to apply multiple interval ELMP in the Real Time market.
Issues associated with multiple interval ELMP in the Real Time market

Cost shifting from interval to interval

- Future forecast information will affect current operation in both commitment and dispatch
  - Should both dispatch and commitment costs be considered in ex-post price calculations?

- Current operations affected by past operation decisions
  - Should the costs incurred in the past be considered in ex-post price calculations?
  - If commitment costs are considered in pricing, then we need to evaluate re-commitment.

- Should all costs be reflected in prices?
  - Which parts of cost should be reflected in prices?
  - When forecast information is off, should we still reflect costs incurred in the past?
Goals Suggested for RT pricing

• Treat DA commitment separate from RT commitment.
  – Assume DA commitment is fixed in RT.

• If resource was not committed in the past, we should not go back and commit it.
  – When modeling historical periods, only units physically committed in the RT market should be online in the real time pricing engine.

• Allow commitment related costs incurred in the past to affect future prices – so long as costs were incurred to meet forecast needs in the future.

• If past actions lead to sub-optimal position in present, prices going forward should reflect costs of reacting to existing conditions.
Recommended High Level Design for ex-post price calculation under LAD

• To address suggested goals, the following guiding principals for pricing under LAD Dispatch engine are proposed:
  
  – Costs incurred in the past for real time operations should be reflected in the current price calculation
  – If forecast information is way off, then cost occurring in the past should be treated as sunk costs
  – For past periods, only physically committed units should be considered in ex-post price calculation process
    • Dispatch costs for physically committed, non-fast start units
    • Commitment and dispatch costs for physically committed fast start units
Recommended High Level Design for LAD price calculation

- Simplified mathematical model

\[
\min \sum_{t=t_s}^{t_e} \left( \sum_i GenCost_{it}(g_{it}) \right)
\]

Subject to

\[-ramp_{it} \leq g_{it} - g_{it-1} \leq ramp_{it} \quad \forall i, t\]

\[\sum_{i \in G} g_{it} = D_t, \quad \forall t\]

\[Econmin_{it} \leq g_{it} \leq Econmax_{it} \quad \forall i, t\]

\(t_s, \) starting period
\(t_e, \) ending period

- Assume \(t_*\) represents the target study period. When the forecast is off, \(t_s < t_*\). When the forecast is accurate, \(t_s = t_*\). \(GenCost_{it}(g_{it})\) can include commitment costs depending on the type of unit.
Simple Example to demonstrate how proposed pricing method works

• Consider the following 2 unit, 3 interval example:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Econ Min (MW)</th>
<th>Econ Max (MW)</th>
<th>Energy Offer ($/MWh)</th>
<th>Ramp Rate (MW/Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>100</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>100</td>
<td>25</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>Load (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>110</td>
</tr>
<tr>
<td>2</td>
<td>130</td>
</tr>
<tr>
<td>3</td>
<td>132</td>
</tr>
</tbody>
</table>

• Assume the dispatch will look forward 1 interval.
• The total dispatch study horizon is 2 intervals.
Simple Example to demonstrate how proposed pricing method works

- Assume look back horizon of 1 interval and forecast information is the same as time moving forward

First run: Both dispatch and pricing study horizon intervals 1-2 (no look back)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Dispatch (MW)</th>
<th>Price ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interval_1 settlement binding interval</td>
<td>Interval_2 indicative dispatch</td>
</tr>
<tr>
<td>A</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>82</td>
<td>100</td>
</tr>
</tbody>
</table>

Second run: Dispatch study horizon is intervals 2-3, pricing study horizon is intervals 1-3, with look back of 1 interval

<table>
<thead>
<tr>
<th>Unit</th>
<th>Dispatch (MW)</th>
<th>Price ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interval_2 settlement binding interval</td>
<td>interval_3 indicative dispatch</td>
</tr>
<tr>
<td>A</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

- This method produces the same price ($45/MWh) for interval 2 in both pricing runs
Simple Example to demonstrate how proposed pricing method works

- Assume look back horizon of 1 interval and first assume forecast information is the same as time moving forward

<table>
<thead>
<tr>
<th>Unit</th>
<th>Dispatch (MW)</th>
<th>Price ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

- This method produces the same price ($45/MWh) for interval 2 in both pricing runs
Simple Example to demonstrate how proposed pricing method works

- Now assume forecast information will change as time moves forward
  - At interval 1, the forecast load for interval 2 is 130MW
  - At interval 2, the updated forecast load for interval 2 now is 121MW, which means the load forecast was off in interval 1

<table>
<thead>
<tr>
<th>Period</th>
<th>Interval 1</th>
<th>Interval 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load (MW)</td>
<td>110</td>
<td>121</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Period</th>
<th>Interval 1</th>
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<td>123</td>
</tr>
</tbody>
</table>
Simple Example to demonstrate how proposed pricing method works

- Now assume forecast information will change as time moving forward and in this case
  - At interval 1, the forecast load for interval 2 is 130MW
  - The dispatch and pricing run results are:

<table>
<thead>
<tr>
<th>First Run: Both dispatch and pricing study period from 1-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch (MW)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Interval_1 settlement binding interval</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
</tbody>
</table>
Simple Example to demonstrate how proposed pricing method works

- At interval 2, the updated forecast load for interval 2 now is 121MW, which means the load forecast for interval 2 at interval 1 was off. Under this situation, costs incurred before interval 2 will be treated as sunk costs. So we will set $t_s = t_*$

<table>
<thead>
<tr>
<th>Dispatch (MW)</th>
<th>Price ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interval_2</strong></td>
<td><strong>Interval_3</strong></td>
</tr>
<tr>
<td>settlement</td>
<td>indicative</td>
</tr>
<tr>
<td>binding interval</td>
<td>dispatch</td>
</tr>
<tr>
<td>interval_3</td>
<td>settlement</td>
</tr>
<tr>
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<td>interval_3</td>
</tr>
<tr>
<td>dispatch</td>
<td>indicative</td>
</tr>
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<td>interval_2</td>
<td>price</td>
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<td>settlement</td>
<td></td>
</tr>
<tr>
<td>binding interval</td>
<td></td>
</tr>
</tbody>
</table>

- Interval 2’s price drop to $35/MWh occurs because we do not consider costs incurred in the past.
Challenges of the proposed price calculation method

- **Duration of Look Back horizon**
  - MISO current design:
    - Look Ahead Commitment has 3 hour look ahead horizon over which it can commit/de-commit units
    - Look Ahead Dispatch has 1 hour horizon over which it can re-dispatch units
  - **Should ex-post Price Engine have 1 hour look back horizon?**
    - For periods prior to present/target period, all information is fixed. What if a unit is not following ISO’s dispatch signal? Should we treat these part of units differently?
    - What criteria is used to determine whether forecast information is off?
Alternate pricing method for LAD

- Main challenges of the proposed method are associated with how to treat costs incurred in past.
- If we ignore all the costs incurred in the past, then the pricing model under LAD will be similar to the dispatch model, which can be expressed as:

\[
\min_{t=t_*} \sum_{t} \left( \sum_{i} \text{GenCost}_{it}(g_{it}) \right)
\]

Subject to

\[-\text{ramp}_{it} \leq g_{it} - g_{it-1} \leq \text{ramp}_{it} \quad \forall i, t\]

\[\sum_{i \in G} g_{it} = D_t, \quad \forall t\]

\[\text{Econmin}_{it} \leq g_{it} \leq \text{Econmax}_{it} \quad \forall i, t\]

\[t_*, \text{starting period which is target period}\]

\[t_e, \text{ending period}\]
Alternate pricing method for LAD

Potential issue with the alternate pricing method for LAD

• Possible sudden price reductions caused by ignoring costs incurred in previous intervals
  – Extra uplift
  – Unit may not want to follow ISO’s dispatch signal
Future work plan

• **How large is the forecast error?**
  – Should magnitude of the forecast error determine whether costs incurred in the past should be considered in price calculation?

• **How meaningful is the difference between the proposed and alternate methods?**
  – Price volatility differences
  – Uplift payment differences
  – Total load payment differences