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

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Outline

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

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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.

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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

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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

$$-ramp_{it} \leq g_{it} - g_{it-1} \leq ramp_{it} \qquad \forall i, t$$

$$\sum_{i \epsilon G} g_{it} = D_t, \qquad \forall t$$

$$Econmin_{it} \leq g_{it} \leq Econmax_{it} \qquad \forall i, t$$

$$t_{s,}\ starting\ period$$

$$t_{e,}\ ending\ period$$

- **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.**
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Simple Example to demonstrate how proposed pricing method works

- **Consider the following 2 unit, 3 interval example:**

Unit	Econ Min (MW)	Econ Max (MW)	Energy Offer ($/MWh)	Ramp Rate (MW/Interval)
A	20	100	35	2
B	0	100	25	100
Period	1	2	3	
Load (MW)	110	130	132	

- 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)

	Dispatch (MW)		Price ($/MWh)	
Unit	Interval_1 settlement binding interval	Interval_2 indicative dispatch	Interval_1 settlement binding interval	Interval_2 indicative price
A	28	30	25	45
B	82	100	25	45

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

	Dispatch (MW)		Price ($/MWh)		
Unit	Interval_2 settlement binding interval	interval_3 indicative dispatch	Interval_1 indicative price	Interval_2 settlement binding interval	interval_3 indicative price
A	30	32	25	45	35
B	100	100	25	45	35

- **This method produces the same price ($45/MWh) for interval 2 in *both* pricing runs**

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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**

	Dispatch (MW)		Price ($/MWh)	
Unit	Interval_1 settlement binding interval	Interval_2 indicative dispatch	Interval_1 settlement binding interval	Interval_2 indicative price
A	28	30	25	45
B	82	100	25	45

- **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

Load forecast at Interval 1				
	Period	1	2	3
	Load (MW)	110	130	N/A
Load forecast at Interval 2				
	Period	1 (actual)	2	3
	Load (MW)	110	121	123

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:

First Run: Both dispatch and pricing study period from 1-2				
	Dispatch (MW)		Price ($/MWh)	
	Interval_1 settlement binding interval	Interval_2 indicative dispatch	Interval_1 settlement binding interval	Interval_2 indicative price
A	28	30	25	45
B	82	100	25	45

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 $t_s = t_*$

Second Run: Both dispatch and pricing study period from 2-3				
	Dispatch (MW)		Price ($/MWh)	
	Interval_2 settlement binding interval	interval_3 indicative dispatch	Interval_2 settlement binding interval	interval_3 indicative price
A	21	23	35	35
B	100	100	35	35

- 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:**

$$\min \sum_{t=t_*}^{t_e} \left(\sum_i GenCost_{it}(g_{it}) \right)$$

Subject to

$$-ramp_{it} \leq g_{it} - g_{it-1} \leq ramp_{it} \qquad \forall i, t$$

$$\sum_{i \epsilon G} g_{it} = D_t, \qquad \forall t$$

$$Econmin_{it} \leq g_{it} \leq Econmax_{it} \qquad \forall i, t$$

$$t_{*,}\ starting\ period\ which\ is\ target\ priod$$

$$t_{e,}\ ending\ period$$

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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

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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