Overview of Fast-Start Pricing in MISO

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Topics Covered

- Two issues led MISO to develop a new pricing approach.
- Quick review of how MISO commits and dispatches resources in its markets.
- Issues that arose from using marginal-cost based prices to settle the markets.
- Setting prices that minimize required uplifts.
- Simplifications that led to Extended LMP.

Reason MISO Developed a New Pricing Approach…

MISO used Locational Marginal Prices (LMPs) to settle energy transactions. Two issues led MISO to develop a new pricing approach:

1) After committing and dispatching a Fast-Start Resource, MISO found that LMPs often did not cover a Fast-Start Resource's costs.
   - The Market Monitor recommended using NYISO approach to Fast-Start Pricing.
2) As load increased and MISO neared shortage conditions, MISO could issue an alert and call on Emergency Demand Response (EDR).
   - LMPs could drop. This was a poor price signal since it indicated that the value of energy dropped when supply was getting tighter.
   - FERC ordered MISO to address this issue.

Fundamentals of Existing MISO Markets

- Resources submit three part offers for energy and offers to supply reserves.
- MISO develops demand curves for reserves.
- MISO commits and dispatches resources to maximize market surplus:
  - Bid value of demands served

  minus
  - Offer costs of resources dispatched.
- MISO uses Security Constrained Unit Commitment (SCUC) to commit resources and Security Constrained Economic Dispatch (SCED) to dispatch committed resources.

Original Pricing Approach at Start of MISO Markets

- MISO set the price for a product at a location to the marginal cost of providing the product.
  - The marginal cost at a location is the rate at which total cost changes as optimal schedules change in response to an infinitesimal change in requirement at the location.
    - Only the schedules of committed resources or reserve shortages would change in response to an infinitesimal change in requirement.
    - Commitment does not change for an infinitesimal change so commitment costs are not included in calculated marginal costs.
  - SCED produced the marginal costs.

LMPs and Uplifts

- If prices alone provide adequate incentives for profit-maximizing participants to follow the SCUC and SCED commitment and dispatch, the prices are:
  - Market clearing prices.
  - Efficient prices.
- LMPs for energy and marginal costs for reserves may not be market clearing prices.
  - Paying a resource the LMP for energy provided and marginal cost price for reserves provided may not cover its costs.
  - A resource may require a side-payment (or uplift) to completely cover its costs.

Alternate Approach to Defining Market Prices

- Market clearing prices would give each participant the incentive to follow the optimal commitment and dispatch.
  - No side payments would be needed for profit-maximizing participants to be willing to follow the optimal commitment and dispatch.
- There may not be market clearing prices.
  - In this case, it may be possible to set prices that would minimize the side-payments needed for each participant to be willing to follow the optimal commitment and dispatch.

Example Showing the Issue

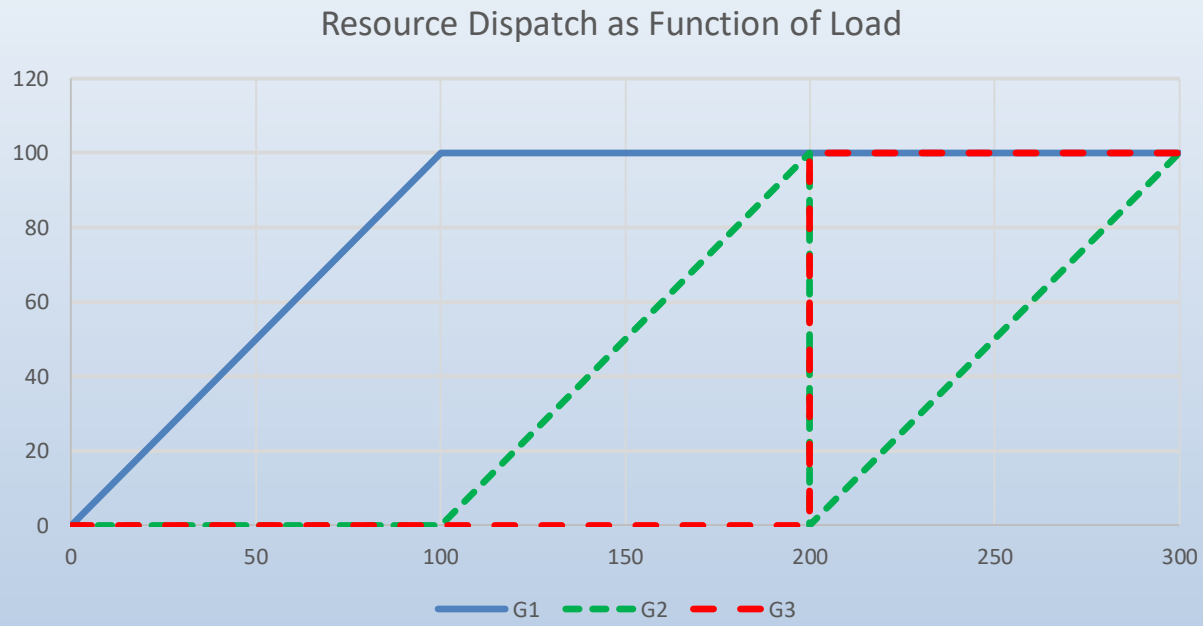
Three generators:

- G3 is a Fast-Start Resource that is available to commit
- G1 and G2 are committed non-Fast-Start Resources

Single period

	Minimum Dispatch if Committed MW	Maximum Dispatch if Committed MW	Incremental Energy Cost $/MWh	No Load Cost $/hr
G1	0	100	50	0
G2	0	100	60	0
G3	50	100	2	6800

Example Showing the Issue



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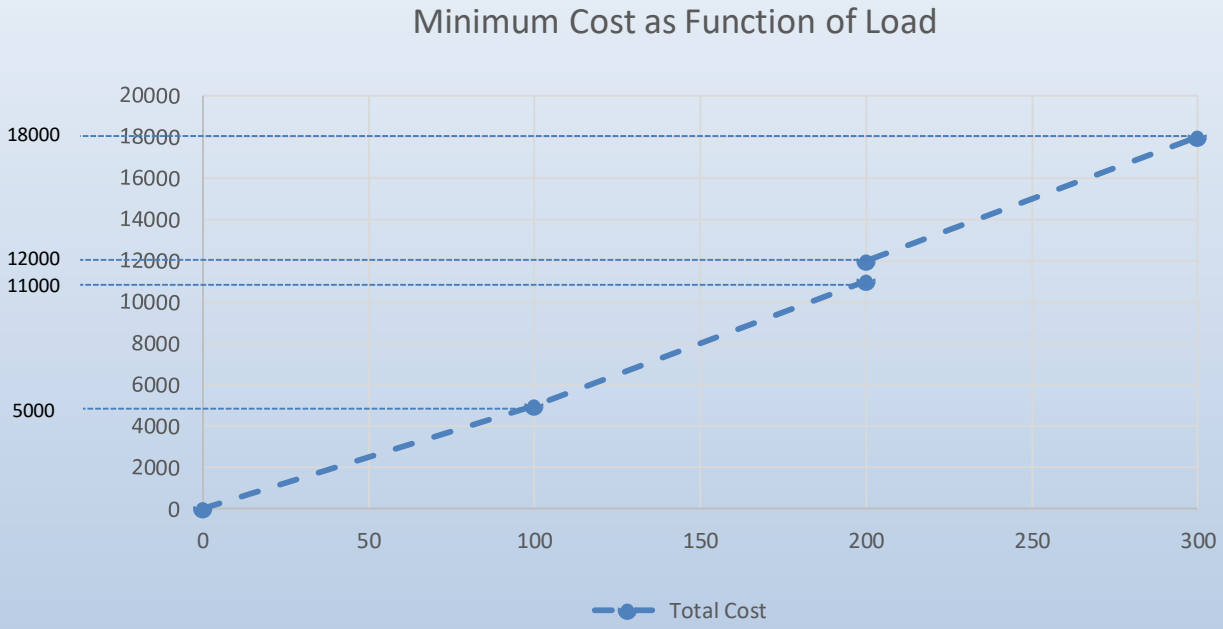

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Example Showing the Issue

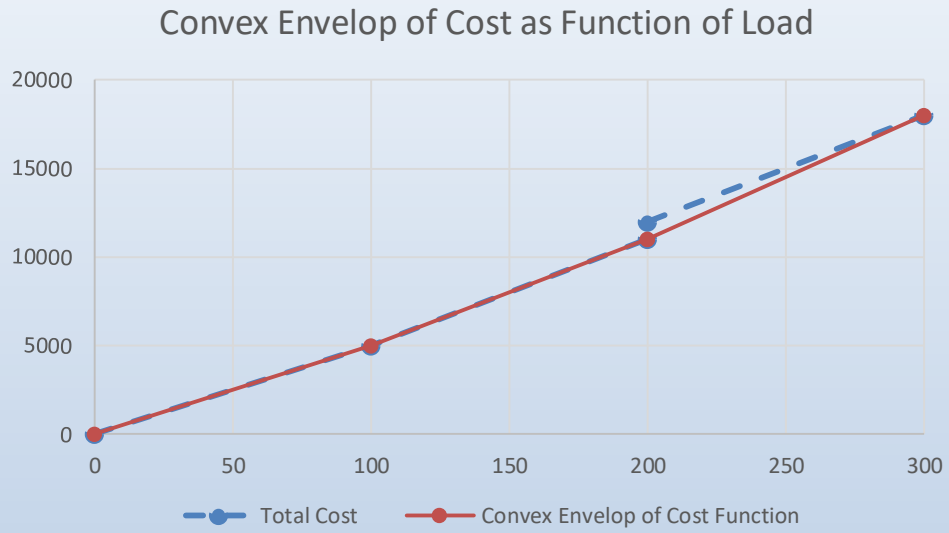
- The LMP at a Load is the slope of the total cost function.
- In this case, uplift is the generator's cost not covered by LMP.
  - For load above 200 MW and below 300 MW:
    - G3 is dispatched at 100 MW.
    - G2 responds to changes in Load.
    - LMP is $60/MW
  - At LMP of $60/MWh, G3 receives $6000.
  - Cost to G3 of producing 100 MW is $7000/hr.
  - G3 requires an uplift of $1000/hr to cover its costs.

Load MW	LMP $/MWh	Uplift $/hr
0 to 100	50	0
100 to 200	60	0
200 to 300	60	1000

There is no Market Clearing Price when 200 MW < Load < 300 MW

- At no price would the resources maximize their profits by producing above 200 MW and below 300 MW.
  - For $60/MWh < price < $70/MWh, profits maximized at
    - G1 = 100 MW, G2 = 100 MW, G3 = 0 MW.
  - For price = $70/MWh, profits maximized at
    - G1 = 100 MW, G2 = 100 MW, and G3 = 0 MW or
    - G1 = 100 MW, G2 = 100 MW, and G3 = 100 MW.
  - For $70/MWh < price, profits maximized at
    - G1 = 100 MW, G2 = 100 MW, G3 = 100 MW.

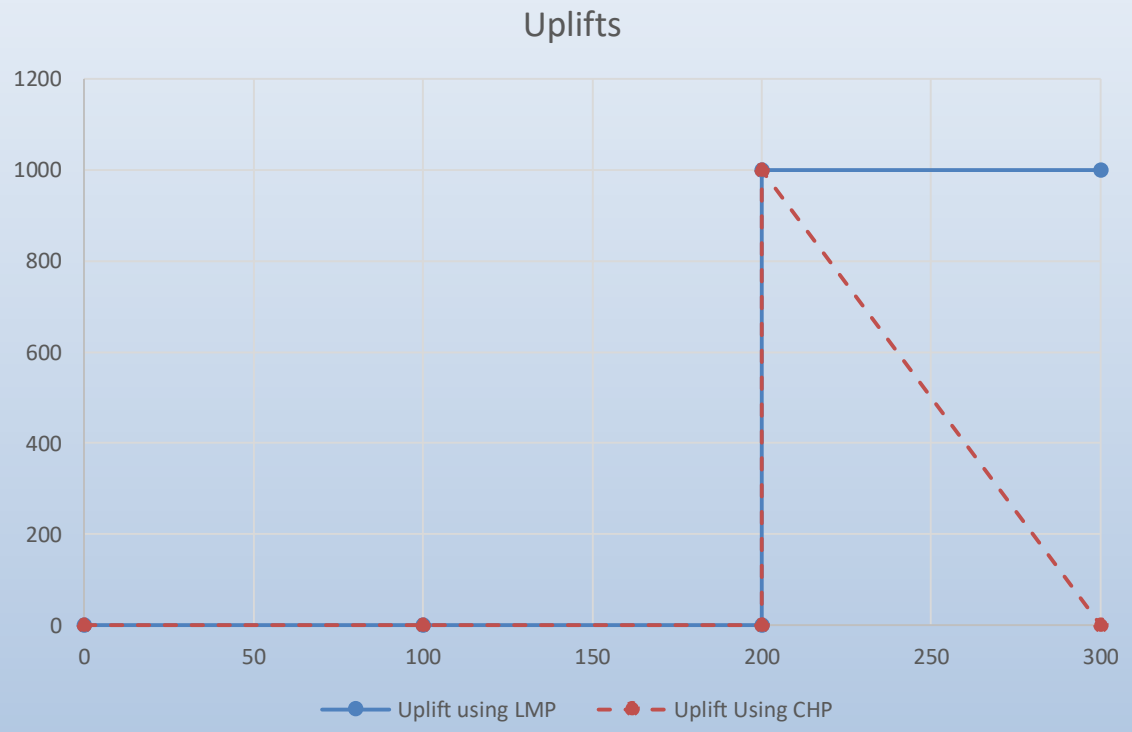
Example Showing the Issue



- MISO showed that the slope of the convex envelope of the total cost as a function of load gives prices that minimize side-payments needed to incentivize following schedules[1].
  - MISO termed this the Convex Hull Price (CHP).
  - For 200 MW < Load < 300 MW, the convex hull price is $70/MWh.

[1]Paul R. Gribik, William W. Hogan, and Susan L. Pope, Market-Clearing Electricity Prices and Energy Uplift, 2007, available online: Microsoft Word - Gribik_Hogan_Pope_Price_Uplift_123107.doc (harvard.edu).

CHP Minimizes Uplift



- Using CHP, G2 experiences an opportunity cost when optimally dispatched for Load between 200 MW and 300 MW.

Extended LMP

- Calculating CHPs can be computationally intensive.
- MISO also studied simpler models that gave prices close to CHPs.
  - MISO studied calculating prices by allowing fractional commitment of Fast-Start Resources and EDRs.
    - Commitment can be any value between 0 and 1.
    - This is not the same as simply relaxing the minimum operating point for a committed resource to 0.
  - The resulting prices were called Extended LMPs (ELMPs).
    - MISO found that ELMPs were close to CHPs.
    - In many situations ELMPs were that same as CHPs.

Single Interval Pricing

- MISO studied calculating CHPs and ELMPs simultaneously for multiple intervals over a scheduling horizon.
- MISO decided to implement ELMP sequentially for single intervals.
  - MISO amortized resource start-up costs over minimum run times for single interval pricing runs.
  - Tests indicated acceptable results.
- This was the final version of MISO's Fast-Start pricing.

Expanding the Definition of Fast Start Resource

- Initially, MISO defined Fast-Start Resources as resources that could be committed with 10 minutes notice and that had a minimum run time of 1 hour or less once committed.
- After several years of experience with ELMP, MISO expanded the set of the resources to which it applies ELMP.
  - MISO defined a Fast-Start Resource to be a resource that can be committed with notification of 1 hour or less and has a minimum run time of 1 hour or less once committed.
  - MISO applied ELMP to EDRs that require notification of 4 hours or less and have a minimum run time of less than 4 hours.
- MISO found benefits to expanding the set of resources to which it applies ELMP.

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