Price Formation Enhancements

Fast-Start Pricing

Policy Development Working Group

November 14, 2024

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- The meeting is structured to stimulate dialogue and engage different perspectives.
- Please keep comments professional and respectful.
- Please try and be brief and refrain from repeating what has already been said so that we can manage the time efficiently.

Instructions for raising your hand to ask a question

- Open the Participant and Chat panels from the bottom right.
- If you are connected to audio through your computer or used the “call me” option, select the raise hand icon located at the bottom of the participant panel.

  -Note: *3 only works if you dialed into the meeting.
- Please remember to state your name and affiliation

  before making your comment.
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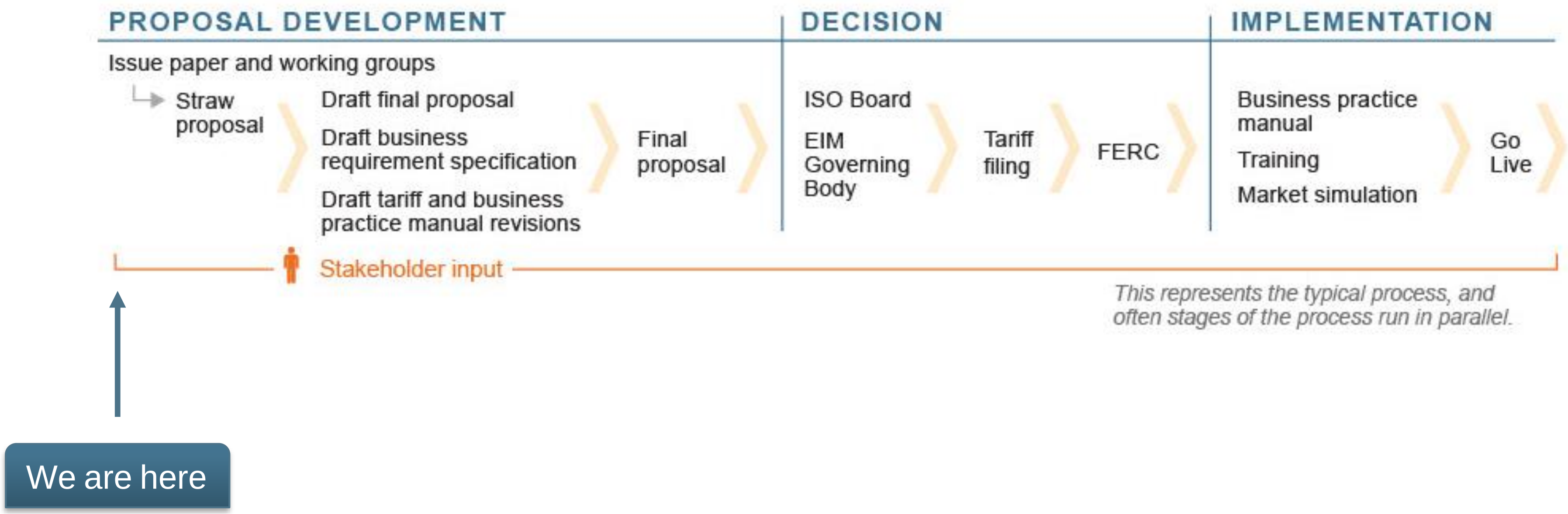
- You may also send your question via chat to either Brenda Marquez or to all panelists.

CAISO Policy Initiative Stakeholder Process



Workshop Objectives

By the end of this workshop, participants will:

- Understand the fundamentals and purpose of fast-start pricing.
- Explore and evaluate different methods for integrating commitment costs into LMP.
- Apply core fast-start pricing design principles to define eligibility criteria for fast-start resources.

Fast-Start Pricing Schedule Update

	Phase 2		
	Scarcity Pricing / BAA-Level MPM	Fast-Start Pricing (Policy)	Fast-Start Pricing (Policy)
Oct-24	Working group preparation	Working group preparation	Working group preparation
Nov-24	Proposal development and iteration	Conduct working groups	Proposal development and iteration
Dec-24			
Jan-25			
Feb-25			
Mar-25			
Apr-25			
May-25	Straw Proposal	Discussion paper and stakeholder recommendations	Straw Proposal
Jun-25	Proposal development and iteration	Conduct working groups (if needed)	Proposal development and iteration
Jul-25			
Aug-25			
Sep-25		Proposal development and iteration	
Oct-25			
Nov-25			
Dec-25			
Jan-26			
Feb-26			
Mar-26	BOG/GB meeting		BOG/GB meeting
Apr-26			
May-26			
Jun-26			
Jul-26			
Aug-26			
Sep-26			
Oct-26			
Nov-26			
Dec-26			
Jan-27		BOG/GB meeting	

Scarcity/MPM and FSP will continue on parallel tracks, with FSP now progressing on the same targeted timeline.

The working group will meet **weekly** (alternating topics) to deliver straw proposals in May 2025.

A new detailed schedule will be posted shortly after this meeting.

Timeline of Fast-Start Pricing Working Group Discussions

Date	Topic
November 14, 2024	Explore initial design concepts; review modified offer curve method to amortize commitment costs into market prices
December 5, 2024	Explore initial design concepts (continued)
December 19, 2024	Pending availability: Explore the integer relaxation method to amortize commitment costs into market prices (featuring guests representing PJM or MISO) and fast-start pricing perspectives from their market monitors
January 16, 2025	Pending availability: Explore the integer relaxation method to amortize commitment costs into market prices (featuring guests representing PJM or MISO) and fast-start pricing perspectives from their market monitors
January 30, 2025	Discuss interactions with flexible ramping product
February 13, 2025	Discuss interactions with multi-interval optimization and impacts to storage resources
February 27, 2025	Discuss interactions with DAM / HASP / FMM, including interactions with EDAM / WEIM transfers and WEIM base scheduling practices
March 13, 2025	Discuss interactions with GHG constraints and design
March 27, 2025	Discuss interactions between scarcity pricing and fast-start pricing
April 3, 2025	Discuss needed changes to scheduling run / pricing run and interactions with pricing run penalty prices

Today's Agenda

Topic	Presenter	Time
Welcome and Introductions	Brenda Corona	10 minutes
Level Setting and Mechanics	James Friedrich	30 minutes
Establish Core Design Features • Defining a fast-start resource • Review "modified offer curve" method of amortizing commitment costs into market prices	James Friedrich Mike Cadwalader	80 minutes
Open Discussion and Q&A	All	1 hour

Fast-Start Pricing

LEVEL SETTING AND MECHANICS

Fast-Start Pricing

- **Fast-start pricing** is a market mechanism that incorporates the commitment costs of fast-start resources directly into LMPs paid to all resources.

- **Fast-start resources** are units that can start up quickly (typically within a few minutes to an hour) and are often dispatched to their minimum output levels.

- The goal of fast-start pricing is to reflect the full cost of using fast-start resources in LMPs to better reflect the incremental cost of serving load.

Fast-start resources are often unable to set the locational marginal price (LMP)

- Standard LMP calculations consider only the incremental cost of producing one additional unit of electricity (marginal energy cost) and ignore commitment costs like start-up and no-load costs.
- Traditional pricing logic requires a resource to be flexibly dispatched (able to move up or down) to set price, but fast-start resources often have operating constraints that prevent them from doing this.
  – This leads to a situation where lower-cost flexible units set the price even though the total system cost includes the commitment of higher-cost fast-start units.
- Therefore, this logic may produce market prices that are insufficient to cover the costs incurred by these units.
- This shortfall necessitates out-of-market uplift (BCR) payments to ensure that fast-start resources recover their costs.

Relationship to other pricing mechanisms

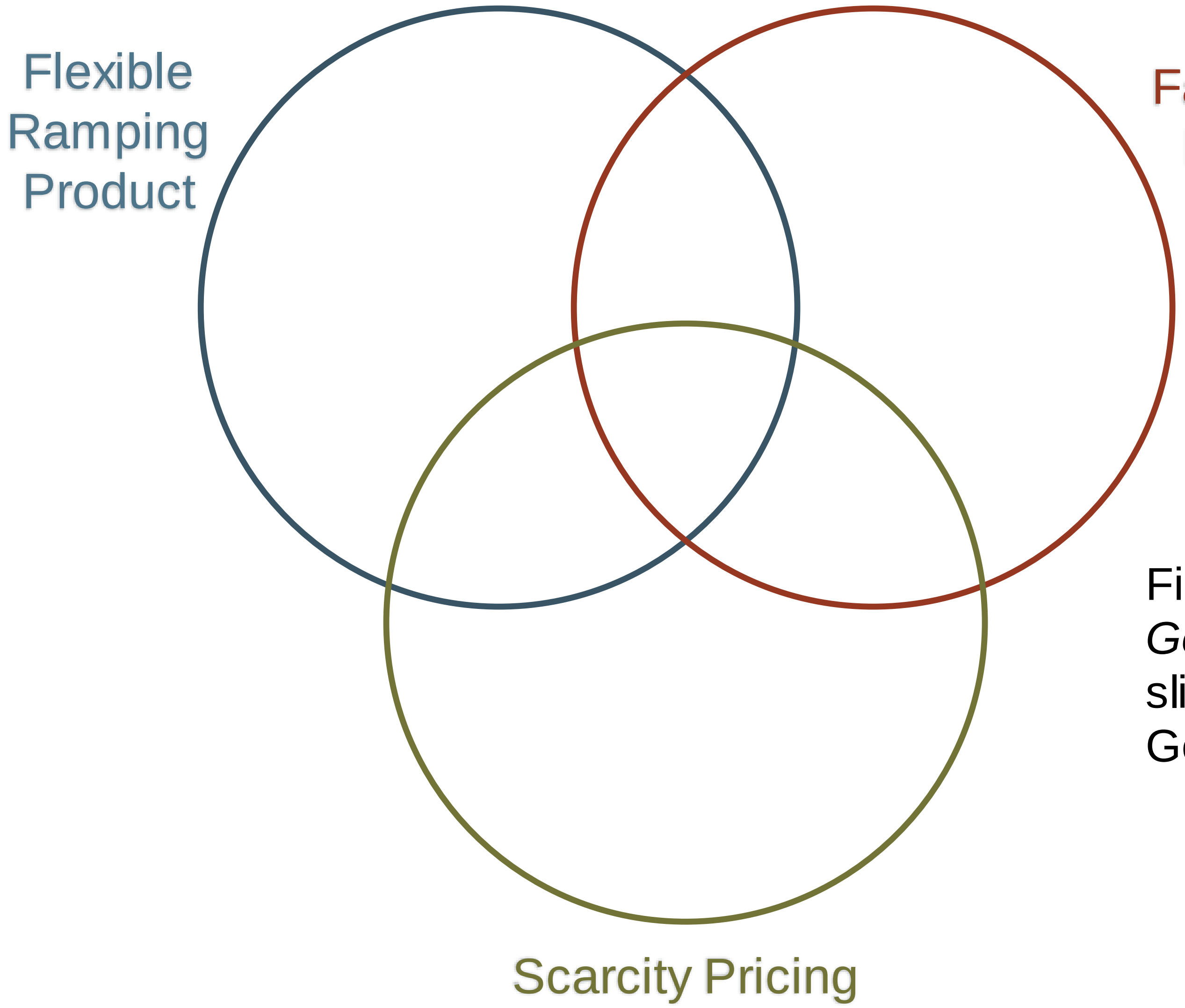


Figure adapted from Susan L. Pope, *Briefing by WEIM Governing Body Market Expert on Fast-Start Pricing*, slide 5, presentation, WEIM Governing Body Meeting, General Session, March 19, 2024.

The two main components of fast-start pricing

- **Minimum output limit relaxation:** This involves assuming that fast-start resources can operate at any level between 0 MW and their minimum output level in the pricing run. This allows them to be considered as potentially setting the price, even when operating at their minimum output level. This relaxation is applied only in the pricing run -- the actual dispatch instructions still respect the unit's physical minimum output constraints.

- **Inclusion of commitment costs in pricing:** This involves spreading the unit’s commitment costs over its output or the relevant time period to reflect these costs in the energy price. There are two common methods to do this – through modified offer curves with an FSP adder or through integer relaxation (extended LMP) methods, both of which we will explore further in this working group series.

Scheduling Run & Pricing Run

- **Scheduling run:** Uses the actual resource parameters to determine the optimal schedule/dispatch.
- **Pricing run:** Uses modified assumptions about resource parameters (minimum output relaxation and commitment cost inclusion) to calculate LMPs.
- The need for two runs exists because the market cannot ignore physical constraints in actual dispatch.
- CAISO has a separate scheduling and pricing run, but since implementation of Price Inconsistency Market Enhancements (PIME) policy, both schedules and prices are based from the pricing run. This policy would need to be unwound to implement fast-start pricing.

Examples

- Presentation - Price Formation Enhancements - Dec 16, 2022

Fast-Start Pricing

ESTABLISH CORE DESIGN FEATURES

DEFINING A FAST-START RESOURCE

Eligibility Criteria

- Markets must define which resources qualify as “fast-start”

- Start with FSP’s core purpose

- Fast-start pricing aims to better reflect costs of resources that:
  1. Can respond quickly to system needs
  2. Have significant commitment costs relative to energy revenues
  3. Operate frequently at minimum load
  4. Are often economically committed in real-time

Suggested Criteria

- Implementation in other markets
- Fleet characteristics
- Operational patterns
- Market impacts
- Market alignment

Implementations from Other Markets

Market	Fast-start Resource Definition
ISO-NE	Start-up time: <= 30 mins Minimum run time: <= 1 hour
MISO	Start-up time: <= 1 hour Minimum run time: <= 1 hour
NYISO	Start-up time: <= 30 mins Minimum run time: <= 1 hour
PJM	Start-up time: <= 1 hour Minimum run time: <= 1 hour
SPP	Start-up time: <= 10 mins Minimum run time: <= 1 hour

Different SUTs
Same MRTs

Analyze Fleet Characteristics

Study the generation fleet's technical capabilities and look for breakpoints:

- Start-up times
- Minimum run time requirements
- Minimum load levels
- RT BCR cost structures

CAISO Analysis

- About 14% of WEIM gas capacity qualifies as fast start with 15 minute or less start up
- 19% at 30 minutes
- No change at 60 minutes

- See slides 50-51. https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Price-Formation-Enhancements-Apr8-2024.pdf

Operational Patterns

Analyze how different resource types are typically used and look for breakpoints:

- Which units are frequently committed in real-time?
- Which units often operate at minimum load?
- What's the typical duration of commitment?

Market Impacts

Consider impacts on:

- Average energy prices
- Peak price changes
- Make-whole payments
- Total incremental costs
- Lost opportunity costs

Market Alignment

- The Real-Time Unit Commitment (RTUC) process runs every 15 minutes with a look-ahead horizon of 60 to 105 minutes.
- RTUC commits units that have start-up times short enough to allow commitment within the RTUC horizon.
  - Commitments become binding when subsequent RTUC runs would not provide enough time to commit the resource.

Fast-Start Pricing

ESTABLISH CORE DESIGN FEATURES

REVIEW “MODIFIED OFFER CURVE” METHOD

Why does fast-start pricing include commitment costs in the LMP?

- Standard LMP calculations consider only the incremental cost of producing one additional unit of electricity (marginal energy cost) and ignore commitment costs like start-up and no-load costs.
- Fast-start units may not recover their full operating costs through energy prices alone.
- Fast-start pricing modifies the pricing algorithm to include commitment costs in the calculation of the LMP.

What is the modified offer curve method?

- So far the working group has discussed the “modified offer curve” method to incorporate commitment costs into the LMP.
- The modified offer curve method takes the fast-start unit's energy offer curve, amortizes the unit’s commitment costs, and distributes these costs across the unit’s output.
- Amortization in this context refers to the process of distributing a fast-start unit's fixed commitment costs across time to create a per-MWh adder to the unit's energy offer curve.
  – We will discuss what time period is appropriate in a future session

The working group has discussed three variations of the modified offer curve method

- Simple constant adder
- Adjusted constant adder
- Minimum average cost

Simple constant adder approach

- Link to review (slides 24-31): https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Price-Formation-Enhancements-Apr8-2024.pdf

- The method uses a formula to calculate a single adder (δ) that gets applied uniformly across the entire variable cost bid curve (under the assumption that the offer for the first incremental bid segment also applies to output at levels between 0 and Pmin).
- The formula is:

$$\delta = \frac{MLC}{Pmax} + \frac{SUC}{\frac{\Delta t}{60} * max\left\{1, \left\lceil \frac{MUT}{\Delta t} \right\rceil\right\} * Pmax}$$

MLC = Minimum Load Cost ($/hr)
SUC = Start-up Cost ($ per start)
MUT = Minimum Up Time (minutes)
Δt = Market interval
Pmax = Maximum capacity of the unit (MW)

Simple constant adder approach (continued)

- The analysis presentation provided an example:
  - MLC = $5,000/hr
  - SUC = $2,000 per start
  - MUT = 1 hr
  - Pmax = 450 MW
- Plugging these into the formula:
  - δ = ($2,000 + $5,000)/450 MW = $15.56/MWh

*Assumes costs are amortized over the MUT

Simple constant adder approach (continued)

- Key characteristics of this method:
  - The adder is constant - it gets applied uniformly across all bid segments. The result is that every bid segment gets shifted upward by the same amount ($15.56/MWh in the example)
  - The first segment is extended down to 0 MW to enable the unit to set price below its minimum output

Adjusted constant adder approach

- The adjusted constant adder approach is similar to the simple constant adder but with one key difference - it accounts for the cost of the first bid segment when calculating the adder because some of the minimum load costs are already captured in the first bid segment (β_1).
- The formula is:

$$\delta = \frac{MLC - max\{0, \beta_1 Pmin\}}{Pmax} + \frac{SUC}{\frac{\Delta t}{60} * max\left\{1, \left|\frac{MUT}{\Delta t}\right|\right\} * Pmax}$$

β_1 = price of the first bid segment ($)
Pmin = minimum operating level (MW)

Adjusted constant adder approach (continued)

- Using the same example from the presentation:
  - MLC = $5,000/hr
  - STUC = $2,000 per start
  - MUT = 1 hr
  - β_1 * Pmin = $35 * 100 MW = $3,500 (this represents the cost of the first bid segment)

- Plugging into the formula:
  - δ = ($2,000 + ($5,000 - $3,500))/450 MW
    = ($2,000 + $1,500)/450 MW
    = $7.78/MWh

Adjusted constant adder approach (continued)

- Key differences from the simple constant adder:
  - The resulting adder will be smaller (e.g., $7.78/MWh vs $15.56/MWh) because it accounts for costs already covered in the first bid segment
  - Like method #1, it still extends the first segment down to 0 MW
  - The adder is still constant across all bid segments
  - Provides a more accurate representation of the additional costs that need to be recovered through the LMP

Minimum average cost approach

- Rather than applying a uniform adder, it tries to find the point on the bid curve that minimizes the unit's average total cost.
- First, it calculates the total production cost at each segment i using this formula:

$$\varphi_i = SUC + \frac{\Delta t}{60} * max\left\{1, \left\lceil \frac{MUT}{\Delta t} \right\rceil\right\}\left\{MLC + \sum_{k=1}^{i}(p_k - p_{k-1})\beta_k\right\} \forall i \in I$$

p_i = Generation level at each breakpoint
β_k = Bid price for each segment
k indexes the segments up to segment I

- Then it finds the minimum average cost across all segments:

$$\delta_m = min\left(\frac{\varphi_i}{\frac{\Delta t}{60} max\left\{1, \left\lceil \frac{MUT}{\Delta t} \right\rceil\right\} p_i}\right)$$

Minimum average cost approach (continued)

- Using the same example from the presentation:
  - MLC = $5,000/hr
  - STUC = $2,000 per start
  - MUT = 1 hr
- At Pmin (100 MW):
  - δ_0 = ($2000 + $5000)/(100 MW) = $70/MWh
- For the first segment (150 MW):
  - δ_1 = ($7000 + 35 * 50)/(100 + 50 MW) = $58.33/MWh
- The method continues calculating these averages and uses the segment with the minimum average cost as the reference point for constructing the modified bid curve.

Minimum average cost approach (continued)

- Key differences from the constant adder approaches:
  – The modified bid curve extends to 0 MW at the segment with the minimum average cost level
  – For points beyond the minimum average cost segment, it uses the original bid curve
- Potential advantages of this method:
  – Better reflects the actual cost structure of the resource
  – Helps prevent over-recovery of costs

Independent market expert opinions about the three approaches

- Constant adder approach
  - Results in higher LMPs compared to other approaches because it overstates the cost of operating the generator. That's because the adder includes the full MLC, but it is added to an offer curve that assumes that the offer for the first incremental bid segment also applies to output at levels between 0 and Pmin. Therefore, that cost is double-counted.
  - Will produce lower BCR payments but higher LOC (Lost Opportunity Cost) payments
- Adjusted constant adder approach
  - Can also produce higher LMPs (although not as high as the constant adder approach) because the modified offer curve at Pmax exceeds the cost offered to operate at that output level
  - Suppliers could strategically manipulate their first MW bid above Pmin to affect pricing without changing physical dispatch
- Minimum average cost approach (preferred)
  - Produces market-clearing prices that minimize BCR and eliminate LOC payments
  - Is less susceptible to gaming
  - Provides more accurate price signals by reflecting the unit's true costs

Gaming concerns with the adjusted constant adder approach

- To illustrate the concern about gaming, suppose that the fast-start generator was to modify its offer by splitting the first bid segment in two.
- The first portion of this bid segment would cover only 1 MW and would be offered at a price of zero.
- The second portion would be offered at the same price as was originally offered.
- Plugging this into the formula yields an adder of:
  - δ = (\$2,000 + (\$5,000 - \$0))/450 MW
    = (\$2,000 + \$5,000)/450 MW
    = \$15.56/MWh
- Thus, the adder that results is the same as the adder that was obtained using the constant adder approach.

Stakeholder opinions about the three approaches

- CPUC Public Advocates Office and CAISO Department of Market Monitoring recommend discontinuing the simple constant adder methodology because it over-counts minimum load costs

Future discussions

- There is another common method to incorporate commitment costs into LMPs: the integer relaxation approach.
  – Used in various forms by MISO and PJM.

- We will invite representatives from those market to present to the PFE working group. Then, we will revisit the tradeoffs between all options.

Open Discussion

Next Steps

Next Steps

- Visit the Price Formation Enhancements - Working Group Phase 2 - Schedule 2024 -2025: https://stakeholdercenter.caiso.com/InitiativeDocuments/Price-Formation-Enhancements-Working-Group-Phase-2-Schedule-2024-2025.pdf

- Visit initiative webpage for more information:
- https://stakeholdercenter.caiso.com/StakeholderInitiatives/Price-formation-enhancements
- If you have any questions, please contact isostakeholderaffairs@caiso.com

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