Price Formation in Wholesale Electricity Markets

April 24, 2020
Introduction to Price Formation

Presented by:
Angela A. Amos
Office of Energy Market Regulation
Federal Energy Regulatory Commission

April 24, 2020
The views expressed are my own and do not necessarily represent those of the Commission, the Chairman, or any individual Commissioner.

FERC’s *ex parte* rules prohibit staff from discussing matters pending before the Commission (18 CFR 385.2201).
• What is Price Formation?
• FERC’s Price Formation proceedings
• Other Price Formation-related activity
Refresher: Locational marginal pricing is based on the theory of variable, least-cost pricing.

Resources offer their variable costs

Market clears in a least-cost manner

Market sends price signals based on marginal cost of production

However, market clearing prices do not typically reflect certain components of a resource’s actual operating costs (e.g., startup and no-load costs). Therefore, a resource must recover these costs during periods when the market clearing price exceeds its own marginal cost or, in some cases, through make-whole payments from the market operator.
Conceptually, Price Formation describes several principles related to market design.

Goals of Energy Price Formation:

1. Maximize market surplus for consumers and suppliers
2. Provide correct incentives for market participants to follow commitment and dispatch instructions, make efficient investments in facilities and equipment, and maintain reliability
3. Provide transparency so that market participants understand how prices reflect the actual marginal cost of serving load and the operational constraints of reliably operating the system
4. Ensure that all suppliers have an opportunity to recover their costs

NOTE: Although FERC’s discussion focused on RTO/ISO markets, similar technical and operational limitations affect the efficient commitment of resources operating in other market structures.
In AD14-14, FERC explored certain RTO/ISO practices that were not just and reasonable.

On June 19, 2014, in Docket No. AD14-14, the Commission initiated a proceeding on Price Formation in Energy and Ancillary Services Markets Operated by RTOs/ISOs. The Commission observed that locational marginal prices (LMPs) may not fully reflect the true marginal cost of production.
The Commission issued staff reports, NOPRs, and Final Rules.

- **Final Rules**
  - Order No. 825: Settlement Intervals and Shortage Pricing (June 16, 2016)
  - Order No. 831: Offer Caps (November 17, 2016)
  - Order No. 844: Uplift Cost Allocation and Transparency (April 19, 2018)

- **Notice of Proposed Rulemaking (NOPR)**
  - Fast Start Pricing (December 16, 2016)
Order No. 825 addressed settlement intervals and shortage pricing. (RM15-24-000)

<table>
<thead>
<tr>
<th>Need for Reform (Settlement Intervals)</th>
<th>Commission Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using an <strong>hourly</strong> price for real-time settlement and <strong>5-minute</strong> dispatch may:</td>
<td>The Commission required that each RTO/ISO align settlement and dispatch intervals by:</td>
</tr>
<tr>
<td>• Not reflect the value of providing a given service</td>
<td>• Settling RT energy transactions at the same interval it dispatches energy</td>
</tr>
<tr>
<td>• Contribute to a lack of response to actual operating needs</td>
<td>• Settling operating reserves transactions in RT at the same interval it prices operating reserves</td>
</tr>
<tr>
<td>• Discourage resources from following 5-minute dispatch instructions</td>
<td>• Settling intertie transactions in the same interval it schedules intertie transactions</td>
</tr>
<tr>
<td>• Increase the need for uplift payments</td>
<td></td>
</tr>
</tbody>
</table>
Order No. 825 addressed settlement intervals and shortage pricing. (RM15-24-000)

The Commission observed that:
- Some RTOs/ISOs restricted the use of shortage pricing
- Not invoking shortage pricing when there is a shortage distorts price signals
- Distorted price signals may not reflect the value that a resource provides to the system (See also Order No. 719)

The Commission required that each RTO/ISO establish a mechanism to trigger shortage pricing for any interval in which a shortage of energy or operating reserves is indicated during the pricing of resources for that interval.
Order No. 831 addressed energy market offer caps. (RM16-5-000)

<table>
<thead>
<tr>
<th>Need for Reform</th>
<th>Commission Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Commission stated that RTO/ISO offer caps may have been unjust and unreasonable because they:</td>
<td>The Commission required that each RTO/ISO:</td>
</tr>
<tr>
<td>• Prevented resources from recouping marginal costs</td>
<td>• Cap each resource’s incremental energy offer at the higher of $1,000/MWh or that resource’s verified cost-based incremental energy offer</td>
</tr>
<tr>
<td>• Suppressed LMPs below the marginal cost of production</td>
<td>• Cap verified cost-based incremental energy offers at $2,000/MWh when calculating LMP</td>
</tr>
<tr>
<td>• Might interfere with dispatch because resources’ true costs weren’t clear</td>
<td>• Consider (or adopt) provisions for imports, exports, and virtuals</td>
</tr>
<tr>
<td>• Might discourage supply resources from participating</td>
<td></td>
</tr>
</tbody>
</table>
**Order No. 844 addressed uplift allocation and transparency. (RM17-2-000)**

<table>
<thead>
<tr>
<th>Need for Reform (Transparency)</th>
<th>Commission Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Commission stated that RTO/ISO practices of reporting uplift and operator-initiated commitments were insufficiently transparent (ex: data may have been aggregated).</td>
<td>The Commission required that each RTO/ISO report (often monthly):</td>
</tr>
<tr>
<td></td>
<td>• Total uplift payments for each transmission zone</td>
</tr>
<tr>
<td></td>
<td>• Total uplift payments for each resource</td>
</tr>
<tr>
<td></td>
<td>• For each operator-initiated commitment: the size, zone, reason, and start time of the commitment</td>
</tr>
<tr>
<td></td>
<td>• Certain information about Transmission Constraint Penalty Factors</td>
</tr>
<tr>
<td>The Commission also found a lack of transparency with regard to Transmission Constraint Penalty Factors, which could affect hedging and stakeholder engagement.</td>
<td></td>
</tr>
</tbody>
</table>

Federal Energy Regulatory Commission
The Commission did not issue a Final Rule on Fast Start pricing, but took other steps. (RM17-3-000)

<table>
<thead>
<tr>
<th>Need for Reform</th>
<th>Commission Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Commission observed that certain RTOs/ISOs may have:</td>
<td>The Commission did not require a uniform set of fast-start pricing requirements that would apply to all RTOs/ISOs.</td>
</tr>
<tr>
<td>• Prevented fast-start resources from setting prices</td>
<td>Instead, the Commission pursued the goals of the NOPR through 206 actions in:</td>
</tr>
<tr>
<td>• Maintained practices, such as not including commitment costs, that prevented prices from reflecting the cost of serving load</td>
<td>• PJM</td>
</tr>
<tr>
<td>• Incorporated offline resources in ways that distorted price</td>
<td>• NYISO</td>
</tr>
<tr>
<td>• Maintained practices that undermined price convergence</td>
<td>• SPP</td>
</tr>
</tbody>
</table>
In addition to its own generic proceedings, FERC considers Price Formation in other contexts.

- Market monitoring and mitigation
- Market power analyses (e.g., Order No. 861)
- Capacity markets
- Cost of service and formula rates
- Generator contingency and remedial action scheme modeling
- Flexible ramp products
- And more!
Thank you!
Price Formation in CAISO Markets

Don Tretheway
Sr. Advisor, Market Design Policy

Joint CREPC-WIRAB Webinar Series: Price Formation in Wholesale Electricity Markets
April 24, 2020
Price formation is a broad range of topics that ensures market results …

- Reflect system conditions and reliability constraints
- Incentivize resources to following dispatch
- Minimize the need for out-of-market actions
- Compensate resources for needed operational attributes
- Allocate costs appropriately and transparently
Price formation embedded in the significant market design enhancements in response to evolving grid

2009 - DA & RT Multi-Interval, Nodal Market
2011 - Renewable Integration: Market & Product Review
2012 - Multi-Stage Generator Modeling
2014 - 15-Minute Market, VER Bidding
2016 - Real-Time Flexible Ramping Product
2018 - CCE3, CCDEBE, GCARM, CME

Today - Flexible Ramping Product Refinements
Today - Day-Ahead Imbalance Reserve Product
In 2014, the 15-minute market addressed pricing differences that inflated real-time uplifts

<table>
<thead>
<tr>
<th>Price</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>Hourly average RTD</td>
<td>Hourly weighted average by interval forecast in FMM &amp; RTD</td>
</tr>
<tr>
<td>Internal Generation</td>
<td>10-minute average RTD</td>
<td>FMM &amp; RTD</td>
</tr>
<tr>
<td>Hourly Imports &amp; Exports</td>
<td>HASP</td>
<td>FMM &amp; RTD</td>
</tr>
<tr>
<td>15-Min Imports &amp; Exports</td>
<td>N/A</td>
<td>FMM &amp; RTD</td>
</tr>
</tbody>
</table>

RTD = Real-time dispatch  
FMM = Fifteen-minute market  
HASP = Hour ahead scheduling process
In 2016, added flexible ramping product (FRP) to real-time market to address three price formation areas

- Opportunity cost calculation of ramping resources that are dispatched out-of-merit
- Operational need for ramping capability to address net load uncertainty between market runs
- Introduce a demand curve to procure the product based upon its expected value
Settlement of FRP forecasted movement addresses opportunity cost issue

Multi-interval market run every 5-minutes

First interval is financially binding, next 2-13 advisory

Prior to FRP, if a resource is dispatched below its cost in Int. 1, the opportunity cost was reflected in Int. 2 price

In next market run, Int. 2 becomes binding, but no opportunity cost exists

After, FRP the opportunity cost is paid when Int. 1 is financially binding
Increasing volatility in the net load requires ramping capability to be managed to address uncertainty.

Prior to FRP, market optimization solved precisely the net load in each interval.

Very little extra ramping capability was committed.

Changes in system conditions between market runs resulted in insufficient capability.

Operators address through out of market actions.

After FRP, additional ramping capability held to upward and downward uncertainty.
FRP is procured using a demand curve based upon its expected value

- Assume no FRU purchased, then 10% chance LMP will be $1000. Would not want to pay more than $100 for insurance.

- **Intended** scarcity pricing design would gradually increase energy costs as FRP requirements is reduced

- Current initiative to address procuring undeliverable FRP prior to relaxing the power balance constraint
New imbalance reserve product to address uncertainty between day-ahead and real-time market

- **Forward Capacity Procurement**
  - CAISO Resource Adequacy
  - EDAM Integrated Resource Plan
  - EDAM Resource Sufficiency Evaluation
  - RA Day-Ahead Must Offer Obligation
  - Voluntary Bids

- **Day-Ahead Market Products**
  - Day-Ahead Market co-optimization across EDAM footprint
    - Energy
    - Ancillary Services
    - **Imbalance Reserves**
  - EIM Resource Sufficiency Evaluation
  - EIM Base Schedules
  - IR Real-Time Must Offer Obligation
  - Voluntary Bids

- **Real-Time Market Products**
  - Real-Time Market co-optimization across EIM footprint
    - Energy
    - Incremental AS
    - Flexible Ramping Product
  - Voluntary Bids
ISO committed to discuss price formation topics as part of the extended day-ahead market initiative

- Bundle 1 – Resource Sufficiency Evaluation, Transmission Provision, Congestion Revenue

- Bundle 2 – Accounting for GHG costs, ancillary services, FNM Phase 2, EDAM administrative fee

- Bundle 3 – Price formation, convergence bidding, external resource participation, market power mitigation, other issues

**Anticipate starting bundle 3 in Q2 2021**
The EIM Entities Recognize The Importance Of Price Formation

• “In addition to governance, there are several critical market design topics - including resource sufficiency, transmission access and compensation, *price formation*, and greenhouse gas program application - that have the potential to greatly impact not only the *magnitude of total regional benefits* that may be achieved, *but also the distribution* of those benefits between and among participating EIM Entities and the CAISO”

• “…the core design elements of EDAM must be *considered carefully and not simply extended* from the EIM or from the CAISO’s existing day-ahead market design”

• “Key market design choices *must effectively balance a variety of potentially competing interests and priorities*, ultimately providing an opportunity for participation in a well-functioning competitive market”

• “CAISO, the EIM Entities, and stakeholders must carefully evaluate *a variety of options and industry best practices* related to price formation”

Source: Extended Day-Ahead Market Principles and Elements of the EIM Entities, September 16, 2019
The EIM Entities Are In The Early Stages Of Evaluating Price Formation Issues and Potential Approaches

- The EIM Entities have not yet had the opportunity to explore, in detail, each of the price formation topics that are relevant to a regional day-ahead organized market

- The EIM Entities look forward to stakeholder discussions on each applicable price formation topic, including an examination of FERC policy, as well as approaches applied in western bilateral markets, CAISO, and other ISO/RTOs

- The following slides represent Powerex’s perspective on price formation, informed by its experience participating in:
  - CAISO
  - AESO
  - SPP
  - MISO
  - PJM
  - ISO-NE
  - NYISO
What Is Fast Start Pricing And Why Is It Important?

“…incorporating commitment costs of fast-start resources in prices more accurately represents the marginal cost of serving load.”
FERC Order Instituting Paper Hearing re: NYISO (2017), Docket No. EL18-33

Are gas peaker operating costs generally included in market clearing prices?

<table>
<thead>
<tr>
<th>Market</th>
<th>Current</th>
<th>Enhancements</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISO</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>SPP</td>
<td>No</td>
<td>December 2019 Compliance Filing</td>
</tr>
<tr>
<td>PJM</td>
<td>No</td>
<td>August 2019 Compliance Filing</td>
</tr>
<tr>
<td>ISO-NE</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>NYISO</td>
<td>No</td>
<td>December 2019 Compliance Filing</td>
</tr>
<tr>
<td>ERCOT</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Western Bilateral</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>CAISO</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Why is it important?
1. Accurate price signals for supply availability
2. Equitable, non-discriminatory compensation (including for imports)
What Is Scarcity Pricing And Why Is It Important?

• Several ISOs/RTOs, as well as FERC have recognized the need for prices to rise as the market gets close to running out of supply to serve firm demand:
  “shortage pricing ... will help ensure that prices rise sufficiently and appropriately to allow supply to meet demand during an operating reserve shortage, and thus will more accurately reflect the value a resource provides.” FERC Order No. 825 at P 163 (2016)

• There are numerous opportunities for CAISO to implement improved scarcity pricing
  o Would better encourage voluntary supply participation, resource availability, demand response

• A new high-priority stakeholder process focused on “system market power mitigation” is underway
  o Would lower prices when California is importing, particularly during tight conditions
  o Important to consider relationship and timing of improved scarcity pricing and any new market power mitigation measures
What Is The Economic Magnitude Of Price Formation Issues?

*Data Source: BPA, PGE, PSEI OASIS

~40 Million MWh of Northwest surplus energy delivered to California annually*

<table>
<thead>
<tr>
<th>Price Formation Impact ($/MWh)</th>
<th>Resulting Annual Value Transfer Between Regions ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1</td>
<td>$40 Million</td>
</tr>
<tr>
<td>$2</td>
<td>$80 Million</td>
</tr>
<tr>
<td>$5</td>
<td>$200 Million</td>
</tr>
<tr>
<td>$10</td>
<td>$400 Million</td>
</tr>
<tr>
<td>$15</td>
<td>$600 Million</td>
</tr>
</tbody>
</table>
How Can The West Make Informed Price Formation Decisions?

<table>
<thead>
<tr>
<th>Organized Market</th>
<th>Number Of States</th>
<th>Internal Market Monitor</th>
<th>External Market Monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISO</td>
<td>15</td>
<td>No</td>
<td>Potomac Economics</td>
</tr>
<tr>
<td>SPP</td>
<td>14</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>PJM</td>
<td>13</td>
<td>No</td>
<td>Monitoring Analytics (Former Internal MM)</td>
</tr>
<tr>
<td>ISO-NE</td>
<td>6</td>
<td>Yes</td>
<td>Potomac Economics</td>
</tr>
<tr>
<td>NYISO</td>
<td>1</td>
<td>No</td>
<td>Potomac Economics</td>
</tr>
<tr>
<td>ERCOT</td>
<td>1</td>
<td>No</td>
<td>Potomac Economics</td>
</tr>
<tr>
<td>CAISO*</td>
<td>1*</td>
<td>Yes</td>
<td>None</td>
</tr>
</tbody>
</table>

*CAISO also operates the multi-state Western Energy Imbalance Market

Diverse, knowledgeable, perspectives are critical to achieving price formation approaches consistent with industry best practices.
Thank You

Powerex Corp.
1300-666 Burrard Street
Vancouver, British Columbia
Canada V6C 2X8

604 8915000
1800 2204907
powerex.com

Supply. Flexibility. Commitment.
Incorporating resource flexibility into energy market prices

Eric Hildebrandt, Ph.D.
Executive Director, Department of Market Monitoring
California Independent System Operator

CREPC-WIRAB Webinar
Price Formation in Wholesale Electricity Markets
April 24, 2020
Overview

- CAISO and EIM balancing areas facing increased need for flexible capacity that can be ramped up/down quickly to manage high level of renewable resources (e.g. wind, solar).

- To manage need for more flexible ramping capacity, CAISO grid operators make significant manual or out-of-market actions which can have a significant impact on energy market prices.

- CAISO seeking to develop market products to allow flexible ramping capacity to be procured and compensated through the ISO’s market.
  - This would allow the cost/value of flexible ramping capacity to be incorporated in energy market prices and reduce need for manual and out-of-market actions.

- DMM recommends changes in the design of these flexible ramping products to address issues that are limiting the effectiveness of these market mechanisms.
Energy market prices throughout the West are now driven by “net loads” (i.e. total loads less wind and solar)

* excludes behind-the-meter solar
To increase upward flexible ramping capacity, CAISO grid operators make significant upward adjustments to the demand for energy used by the real-time market software to dispatch bids.
Upward adjustments of the hour-ahead load forecast are aimed at increasing imports in the hour ahead scheduling process.

The increase in hourly imports then increases the amount of flexible ramping capacity within the CAISO that is available for dispatch in the 15-minute and 5-minute markets.
CAISO operators also commit extra gas-fired capacity after the day-ahead and ramp units up in real-time to create more upward ramping capacity. These are referred to as *out-of-market* or *exceptional dispatches*.
The Flexible Ramping Product (FRP) is designed to create and compensate more flexible capacity in the real-time market.

- The amount of upward FRP that is procured by the market software is designed to cover the expected change in net loads plus an margin to account for net load uncertainty.

- Procurement of FRP can cause changes in short term dispatches that directly or indirectly creates extra ramping capacity in next 15-minute interval.

- Prices for FRP are based on the “shadow price” of procuring ramping capacity (or incremental change in market costs due to provision of FRP).

- Prices for FRP also cover any opportunity costs incurred by units with lower priced energy bids which are “held back” to provide flexible ramping capacity.

- FRP requirements are set for each balancing area in the Western EIM, as well as for overall CAISO/EIM system.
  - Additional FRP supply from one balancing area can be used to meet overall system ramping requirements.
The FRP appears to be having limited impact in terms of creating and compensating more flexible capacity in real-time market.

- In 2019, the FRP constraint for CAISO/EIM system was rarely binding (which creates a positive FRP price):
  - Positive price for upward FRP in only 6% of 15-minute intervals.
  - Positive price for downward FRP in only 1% of 15-minute intervals.

- Total FRP payments in 2019 were only $6.3 million for entire CAISO/EIM system.

- Since FRP was implemented in 2016, manual load adjustments and out-of-market dispatches by operators to increase ramping capacity in real-time market appear to have increased – not decreased.

- Fortunately, since 2016 the growth of the Western EIM has added significant amount of 15-minute and 5-minute transfer capacity that can quickly address the ramping needs of different balancing areas in real time market.
DMM has recommended improvements in the FRP design to improve price signals and reduce manual operator actions.

1. Implement locational procurement of FRP which takes transmission constraints into account.
   - Currently, a large portion of FRP is procured in EIM balancing areas which have limited unused transmission to rest of CAISO/EIM system (e.g. Northwest).
   - This creates “stranded” FRP capacity which cannot be used in other areas, and artificially lowers overall FRP prices and compensation.
   - CAISO addressing this issue as part of ongoing market initiative.

2. Extend the time horizon of the FRP beyond 15-minutes
   - Grid operators take manual and out-of-market actions more than 15-minutes in advance due to lead times needed for actions to position resources to provide more ramping capacity.
   - DMM recommends longer period for FRP that allows resources to be “positioned” to ramp up or down more quickly (e.g. 1-3 hours?).
The new day-ahead product (called Imbalance Reserves) is being designed to increase ramping capacity in real-time.

- This new Imbalance Reserve product is part of CAISO’s effort to enhance day-ahead market and then extend day-ahead market to entities participating in the Energy Imbalance Market.

- Similar to FRP, but will be procured for each hour as part of 24-hour optimization used in day-ahead market.

- DMM recommendations on day-ahead Imbalance Reserve product:
  - Unless the time frame of the real-time FRP is increased, units positioned or “held back” to provide ramping in day-ahead market will be re-dispatched by real-time software based on the unit’s bid prices.
  - This re-dispatch is likely to “undo” much of extra ramping capacity that was created in day-ahead market schedules by the Imbalance Reserve product.
  - Thus, procurement of Imbalance Reserve product may increase day-ahead market costs and prices, while providing limited benefits.
A few comments on scarcity pricing …

Good in theory but ..... 

- Scarcity pricing is actually highly administrative – not market driven.
- Energy bid cap already $1,000/MW (up to $2,000/MW)
- Energy-only markets (such as Texas) require extreme price spikes to incent new generation, but Western states have adopted a resource adequacy/capacity market design.
- Scarcity pricing creates even stronger incentive for strategic withholding of energy from market at high load levels.
  - Withholding small amount of energy can trigger very large price spikes.
  - No must offer requirement in EIM to prevent withholding.
  - Impossible for CAISO or market monitor to accurately account for all potential supply.
Bids and market clearing prices increase sharply (above actual costs) as supply becomes tight but no scarcity exists.

*Scarcity pricing can increase incentive to withhold even more supply at high load levels.*

Even without scarcity pricing, withholding relatively small amounts of supply can create large increase in market clearing price.
For more information …..

- Department of Market Monitoring webpage

- Comments on flexible ramping issue.
  - Comments on Flexible Ramping Product Refinements: Issue Paper and Straw Proposal, December 5, 2019