The information contained in these materials is provided for general information only and does not constitute legal or regulatory advice. The ultimate responsibility for complying with the ISO FERC Tariff and other applicable laws, rules or regulations lies with you. In no event shall the ISO or its employees be liable to you or anyone else for any decision made or action taken in reliance on the information in these materials.
## Course overview

### Agenda

- ISO Market Operation
  - Day-Ahead and Real-Time
- Market Pricing
- Supplier Bidding Examples
- Overview of Upcoming Market Changes
  - EDAM
  - DAME

### Materials

- Course Slides
- Reference material (via email)
ISO Market Operation

Day-Ahead Market Processes
Today’s ISO market operates in a day-ahead and real-time scope

**Day-ahead market (DAM)**
- T - 7 days
- 10:00: DAM process begins
- 13:00: Clear the market
- Publish market results

**Market Power Mitigation (MPM) – Step 1**

**Integrated Forward Market (IFM) – Step 2**

**Residual Unit Commitment (RUC) – Step 3**

**Real-time market (RTM)**
- T-1 after 13:00
- T-75min: Beginning at midpoint of each 5min period
- Bids/Base schedules submitted
- RTM processes begin
- Clear the market
- Receive dispatches
- Post market

Triggers real-time market
How does the Market decide which resources to commit?

Three-part energy bid includes:
- Start-up cost (one time)
- Minimum load cost (hourly)
- Energy bid curve above minimum load ($/MWh)
Market power mitigation (MPM)

• Ensures units cannot exercise market power by nature of where they reside

• NOTHING is scheduled or dispatched as a result of this process

• May result in mitigated bids based on predetermined calculations

DAM Processes Step 1
What do we do if Market power is determined?

ISO replaces bid with the higher of their default energy bid or the competitive LMP for generating resources and participating loads.

Calculation of default energy bid:

- Variable Cost Option | LMP Option
- Negotiated Rate Option | Variable Cost Option + Bid Adder
- Temporary Default Energy Bid | DEB for RMR
- Hydro DEB | Storage Resource Option
Elements of the ISO’s day-ahead market - Integrated forward market (IFM)

Clears bid-in supply against bid-in demand

- As a result, sufficient capacity may not be committed to meet forecast demand
- More on this during Step 3 (RUC)
Integrated forward market (IFM)

Clears bid-in supply against bid-in demand
- Day-ahead schedules
- Virtual awards

Procures 100% of reserves for CAISO BAA
- Ancillary service awards

Commit resources

DAM Processes Step 2
What clears in the IFM?

**Day-ahead** supply bids clear against demand bids.

**Real-time** supply clears against ISO load forecast.

Self-schedules are placed at the beginning of economic curves.

DAM Processes Step 2
Residual unit commitment (RUC)

- **Reliability**
  - Ensures grid reliability

- **Resource Sufficiency**
  - Selects from resource adequacy and other capacity bids

- **Capacity Procurement**
  - Capacity procurement from additional Day-Ahead supply for Real-Time

- **Real-Time Energy Market**
  - Awarded resources must submit an energy bid in the Real-Time Markets

**DAM Processes Step 3**
Residual unit commitment (RUC)

- Uses the same SCUC optimization as IFM
- Set up to meet high confidence demand forecast
- Removes virtual supply & demand bids from calculation
- Introduces ISO forecast for variable energy resources
How does RUC work?

Ensures sufficient capacity is available to meet forecast demand that was not committed in IFM.

Total cleared physical supply and demand  
ISO forecast of actual demand

DAM Processes Step 3

Total cleared demand (physical + virtual)
RUC looks out further than the next trade date

- Extremely long-start commitment (ELC) process applies to:
  - Resources with start times >18 hours
  - Contractual intertie resources that must receive commitment instructions by 0600 hours one day ahead

- Commitments are generated by RUC or manually notified by the ISO operator and the process considers bids in the Day-Ahead Market up to two days out
ISO Market Operation

Real-Time Market Processes
Elements of the ISO’s **real-time market**

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larger market footprint that including WEIM participants</td>
<td></td>
</tr>
<tr>
<td>WEIM participation is for energy only and does not include ancillary services</td>
<td></td>
</tr>
<tr>
<td>Load forecasts for each entity drive market awards</td>
<td></td>
</tr>
<tr>
<td>Each entity ensures sufficiency of resources available for their area on an hourly basis</td>
<td></td>
</tr>
</tbody>
</table>

Balancing ✔️  Bid Capacity ✔️  Flex Ramp ✔️  Feasibility ✔️

**Real-Time Market**
Inputs and outputs of the Real-Time Market

From **Day-Ahead**:
- System info
- Energy schedules
- Reserves awards
- Master file

From **Real-Time**:
- State estimator
- Supplemental energy & ancillary service bids
- Base schedules
- Outages
- Transmission limits

---

Real-Time Market

- Real-time dispatches
- Reserves awards
- Start-ups/shut downs
- Multi-stage generator transitions
- Settlements
Market process timelines: Real-Time

Day-ahead market (DAM)
- T - 7 days
- Bids and schedules submitted
- DAM process begins
- Clear the market
- Publish market results
- 10:00
- 13:00

Real-time market (RTM)
- T-1 after 13:00
- T-75min
- Bids/Base schedules submitted
- RTM processes begin
- Clear the market
- Receive dispatches
- Post market
- Beginning at midpoint of each 5min period

Hour Ahead Scheduling Process (HASP)

Short Term Unit Commitment (STUC)

Fifteen Minute Market (FMM) / Real-Time Pre-Dispatch (RTPD)

Five-Minute Market / Real-Time Dispatch (RTD)
# Market process timelines: Real-Time

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hour Ahead Scheduling Process (HASP)</strong></td>
<td>- Produces HASP advisory schedules and advisory AS awards&lt;br&gt;- Binding HASP intertie schedules with hourly block bids&lt;br&gt;- Advisory schedules for internal resources and intertie resources that do not have hourly block bids/schedules</td>
</tr>
<tr>
<td><strong>Short Term Unit Commitment (STUC)</strong></td>
<td>- Occurs once per trade hour&lt;br&gt;- Examines the potential demand requirements for the next 4 ½ trade hours&lt;br&gt;- Issues start up/shut down instructions to short start resources to meet anticipated demand</td>
</tr>
<tr>
<td><strong>Fifteen Minute Market (FMM) / Real-Time Pre-Dispatch (RTPD)</strong></td>
<td>- Issues start-up/shut down instructions to short and fast start units, and transition instructions to multi-stage generators&lt;br&gt;- Procures ancillary services as needed&lt;br&gt;- Provides advisory instructions for as many as 7 future 15-min intervals</td>
</tr>
<tr>
<td><strong>Five-Minute Market / Real-Time Dispatch (RTD)</strong></td>
<td>- Occurs every five minutes to meet energy imbalances&lt;br&gt;- Resources dispatched in real-time&lt;br&gt;- Provides advisory dispatch instructions for as many as 12 future dispatch intervals</td>
</tr>
</tbody>
</table>
Real-time milestones

- **5 hours ahead**
  - Forecast conditions reviewed and any additional power needed committed

- **75 minutes prior to trade hour**
  - Start-up/shut down instructions sent
  - Additional ancillary services procured
  - Energy paid at Day-Ahead or Real-Time prices, based on when resource was awarded

- **15 minutes ahead of energy flow**
  - Market closes and real-time processes begin

- **5 minutes ahead of energy flow**
  - 5-minute prices set and energy dispatched
ISO Market Operation

Resource Adequacy (RA) / Forward Contracting
Resource Adequacy

Purpose: Forward planning and procurement process to ensure sufficient capacity is made available to energy Markets in the right places and at the right times.
Load Serving Entity’s RA Obligation vs. Supplier’s RA Showing

Supplier’s Showing, which becomes their MOO
Pricing and Bidding

Locational Marginal Pricing, Scarcity Pricing & Transmission Constraints
What does the Tariff say?

Locational Marginal Price (LMP)
The marginal cost (\$/MWh) of serving the next increment of Demand at that PNode consistent with existing Transmission Constraints and the performance characteristics of resources.
There are thousands of price nodes throughout the system

**SUPPLY RESOURCES**

Price calculated based on their location on the system

**DEMAND**

Generally charged at a price associated with a load aggregation point (LAP), an average of the demand node prices within specific zones

ISO Price Map on Today’s Outlook
Nodal pricing is the price paid for electricity generated or consumed at a specific location

Resources are paid the nodal price

Load pays the weighted average price of all load nodes in the service territory

Imports and exports are paid, or pay, the price at the scheduling point
Components of the locational marginal price

Energy + Congestion + Losses = LMP
LMP with Greenhouse Gas

Energy Congestion Losses +GHG
LMP
WEIM’s approach for GHG emissions accounting is a voluntary, resource-specific framework

<table>
<thead>
<tr>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas partial unit available w/ GHG bid adder</td>
<td>100 MW gas unit offers a 50 MW bid PLUS $15/MWh GHG bid adder</td>
<td>A 100 MW wind resource bids 100 MW at $0/MWh GHG bid adder</td>
</tr>
<tr>
<td>• Indicates half of its resource is available to serve to a GHG region</td>
<td>• A 100 MW gas unit does not bid or bids 0 MW</td>
<td>• Indicates they are not making that resource available to a GHG region but do not face a GHG cost of compliance</td>
</tr>
<tr>
<td></td>
<td>• Indicates they are not making that resource available to a GHG region</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Clean resource with $0 GHG bid adder</td>
</tr>
</tbody>
</table>
Scarcity pricing intends to reward available suppliers during tight system conditions.

Occurs when the next available MW will not help relieve congested area.

Scarcity Pricing

$
Transmission Constraints

- Pricing mechanism to reduce congestion to avoid overloading a transmission line
  - What is the line rating?
  - What is the cost of the next MW?

How transmission constraints effect pricing
Bidding Examples

- Conventional Resource
- Solar Resource
Bidding Activity – Day-Ahead: Generator

Submits day-ahead supply bids:

- The same MWs are being offered to the Market across a variety of products
- The Market co-optimizes the offers for **energy** and **ancillary services** along with those from all of the other resources to determine the optimal solution across the entire day
Bidding Activity – Real-Time: Generator Potential Market Outcome

Submits supply bids:
- 80 MW self-schedule
- 53 MW Economic bids for energy

<table>
<thead>
<tr>
<th>Trade Date</th>
<th>Resource</th>
<th>Product</th>
<th>Schedule type</th>
<th>HE11 [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>04/01/2023</td>
<td>VANILLA</td>
<td>A/S</td>
<td>Cleared</td>
<td>43.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04/01/2023</td>
<td>VANILLA</td>
<td>A/S</td>
<td>Market</td>
<td>40.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04/01/2023</td>
<td>VANILLA</td>
<td>A/S</td>
<td>Self</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04/01/2023</td>
<td>VANILLA</td>
<td>Energy</td>
<td>Cleared</td>
<td>80.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04/01/2023</td>
<td>VANILLA</td>
<td>Energy</td>
<td>Market</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04/01/2023</td>
<td>VANILLA</td>
<td>Energy</td>
<td>Self</td>
<td>70.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RUC</td>
<td>Capacity</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Market</td>
<td></td>
</tr>
</tbody>
</table>
Treatment of variable energy resource (VER) forecasts in Day-Ahead vs. Real-Time

**Day-Ahead**
- The forecast is advisory and the Market doesn’t consider the forecast when awarding/optimizing

**Real-Time**
- For **self-schedules**, the Market defaults to the forecast amount
- For **economic bids**, the Market will cap or extend the awarded MWs to the forecasted amount, or to the MW amount that respects the bid curve

The Market assumes the economic bid extends to the PMAX of the resource
Supplier: **Real-Time** bidding activity

Variable Energy Resource

\[ \text{PMAX} = 100 \text{ MW} \]
\[ \text{PMIN} = 0 \text{ MW} \]

The Market award extends the Self-Schedule quantity to match the forecast amount

- **SUNNY**
  - **Self-Schedule**
  - **90 MW Forecast**
  - **70 MW**
Upcoming Market Changes

Extended Day-Ahead Market (EDAM)
Day-Ahead Market Enhancements (DAME)
Implementation of an extended day-ahead market

- Day-ahead capabilities extended to WEIM participants
- Multi-month onboarding process for voluntary participation
- Requires completion of an initial agreement followed by an approximately 18 month long onboarding process
Extension of the ISO day-ahead market across the west

- Builds on WEIM to optimize commitment of generation a day in advance
- Allows for harnessing economic, grid reliability and environmental benefits of a day-ahead market throughout the West
- Participating BAs retain resource planning, transmission planning, and reliability functions
Elements of the EDAM program

- Daily resource sufficiency evaluation (RSE) across full 24-hour time horizon
  - RSE is universal adaptor that connects entities with varying resource adequacy programs to efficiently commit/dispatch resources

- Transmission capability on internal system and interties with other EDAM BAs made available to optimize transfers between participating areas

- Bidding and attribution to multiple state greenhouse gas regulation areas as well as accommodation for non-priced GHG programs

Daily RSE for each BAA
Day-Ahead Market Enhancements
Parallel effort: Day-ahead market enhancements (DAME)

- ISO day-ahead market will undergo a series of enhancements as part of the DAME initiative
- DAME establishes two new market products:
  - Imbalance Reserves
  - Reliability Capacity
New IFM imbalance reserve products

- Hourly procurement of imbalance reserve products (up and down) for each BAA
- Requirements based on tomorrow’s forecast as well as historical uncertainty in the day-ahead
- Bids for imbalance reserves will come from participants throughout the market footprint
IFM co-optimization of energy schedules and transfers

- IFM will manage energy schedules and optimize efficient transfers of energy between BAs
- Imbalance reserves included in co-optimization
  - Reserve resources’ flexible ramping capability for real-time dispatch
  - Commit resources needed to provide ramping capability
Imbalance reserves optimize scheduling of flexible reserves across market footprint

- Meets each participant’s net load uncertainty and real-time ramping needs
- Maximizes diversity benefit of large market footprint
New RUC reliability capacity products

- Existing RUC process procures additional capacity to meet forecasted demand
- Reliability capacity provides both upward and downward dispatch capability
- Hourly requirement at the BAA level, awarded at the resource level
- Reliability capacity bids from across the market footprint
RUC compares demand forecast to physical supply that clears IFM

reliability capacity up
greater demand forecast

lower demand forecast

reliability capacity down
What are some other changes with EDAM?

**Changes**

- All loads and resources in EDAM area submit offers (economic or self-schedule)
- No more “non-participating” resources
- Settlement of Day-Ahead Market Transactions

**Stays the Same**

- EDAM entities continue to retain their resource planning, transmission planning and reliability functions
What are some of the ways EDAM and DAME will provide benefit to participants?

- Economic benefits through commitment of least-cost generation
- Improved situational awareness across BAs
- Enhanced reliability
- Lower greenhouse gas emissions
changes targeted for spring
2026
Wrap Up

Summary, Q&A
Thank you for your participation!

For more detailed information on anything presented, please visit our website at: www.caiso.com

Or send an email to: CustomerReadiness@caiso.com