Extended Day-Ahead Market Training

Body of State Regulators
September 19, 2025

Today's Trainer:
Radha Madrigal, Lead Customer Education Trainer

Today's Agenda

Introduction & CAISO Overview

- Safety Briefing
- Welcome and Overview of Agenda
- Group Introductions
- ISO Overview (Key Terms & Functions)

Navigating CAISO Markets

- Locational Marginal Pricing (LMP)
- WEIM Overview
- EDAM Overview
- Day-Ahead Market Processes & Timelines

Bidding & Settlements

- Resolution of Day-Ahead Positions in Real-Time
- Settlements
- Bidding Examples

Overlook Tour & Lunch

CAISO Market Design & Potential Future Topics

- Convergence Bidding
- Ancillary Services
- Congestion Revenue Rights

What is the CAISO's focus?

Coordinate, control and monitor the electrical power system.

Act as a marketplace for wholesale power.

Coordinate and consolidate transmission needs of the CAISO Balancing Authority Area.

Support ambitious environmental and regional goals with more distributed & clean power products.

The CAISO provides grid reliability and market operation services

grid operator

maintains **reliability** by:

- balancing supply and demand
- operating transmission system within limits
- ensuring grid is secure in case of a contingency event
- orchestrating restoration in case of a system outage

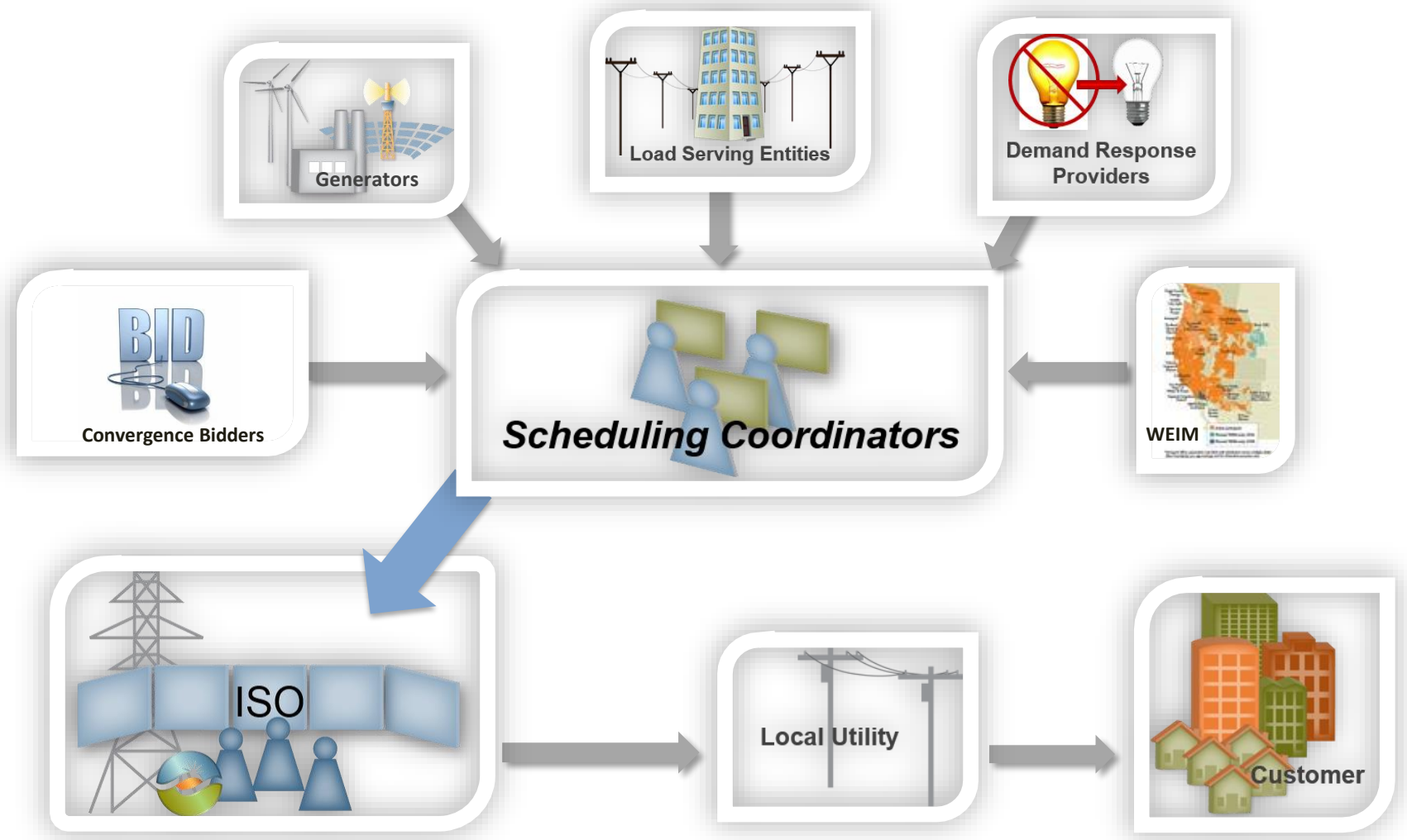
market operator

supports **reliability** by providing:

- a larger operational footprint
- cost minimization to balance supply and demand
- non-discriminatory grid access to supply and demand
- price transparency reflective of system conditions
- compensation for grid services

The ISO is also the Reliability Coordinator for the majority of the Western Electricity Coordinating Council (WECC) territory.

Participation with the CAISO depends on the service to be provided



Comparison of market participants to SCs:

- approx. 370 market participants
- most participants act as their own SC
- approx. 21% use an SC Agent

(as of 9/2/25)

Definition of Terms: BAA vs. BA

physical area & assets

Balancing Authority Area (BAA)

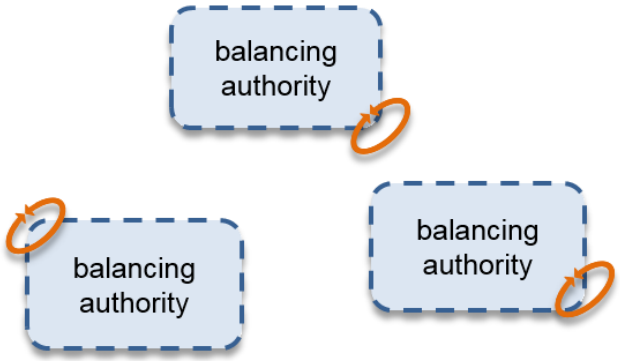
The collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area.

manages the area

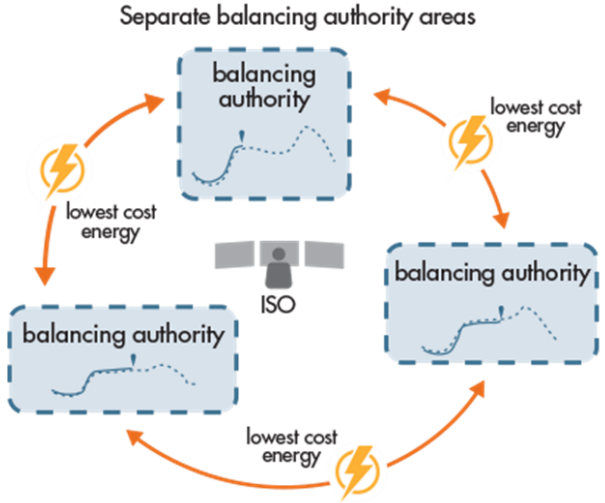
Balancing Authority (BA)

The responsible entity that integrates resource plans ahead of time, maintains load-interchange generation balance within a Balancing Authority Area, and supports interconnection frequency in real time.

BA of today outside of a market vs. market participation



- Focused on balanced schedules
- Load-serving entities (LSEs) within BA identify their supplies
- BA ensures sum of LSEs demand equals the sum of supplies
- BA ensures each LSE is sufficient
- Some drawbacks of this construct are:
  - LSEs lose economic benefits of regional supply
  - Supply may have limited number of LSEs to serve



- Market changes concept of LSE coming in with balanced schedule
- Instead, LSEs independently bid in demand and resources independently bid in supply
- Gives LSEs access to larger supply footprint and resources access to larger pool of demand customers
- Market finds the most economic supply to meet demand at least cost while respecting transmission constraints

Defining Roles & Responsibilities

Role	Definition
EDAM Entity	A Balancing Authority that participates in the EDAM market (this includes the CAISO BA). EDAM entities provide inputs such as market limits, outages and transmission constraints specifically for their BA. EDAM entities can also be an SC representing loads and resources within their BA should they hold such responsibilities.
Market Operator/ Real Time Market Operator	The Market Operator is a separate role within the CAISO that is staffed by personnel dedicated to the equal and independent operation of both regional markets – EDAM and WEIM.
Scheduling Coordinator (SC)	The SC is a certified entity that participates in the market by submitting bids and outages and managing the coordinated operations of its facilities.

The output from the day-ahead timeframe (EDAM) is reviewed and implemented in real-time (WEIM) with any necessary real time adjustments

Locational Marginal Pricing

Objectives:
Explain the concept of Locational Marginal Price (LMP)
Summarize updates to Day-Ahead energy pricing

What is Locational Marginal Pricing?

The **Locational Marginal Price (LMP)** for wholesale electricity is based on local supply and demand conditions. Locational Marginal Pricing reflects the price of energy at the time it is supplied to the grid or when it is used by load serving entities.

Depending on power flows, transmission lines may become congested. In these situations, it costs more to deliver energy to a congested location. More expensive generation may be used to mitigate congestion and deliver electricity to the destination.

How does the tariff define Locational Marginal Price?

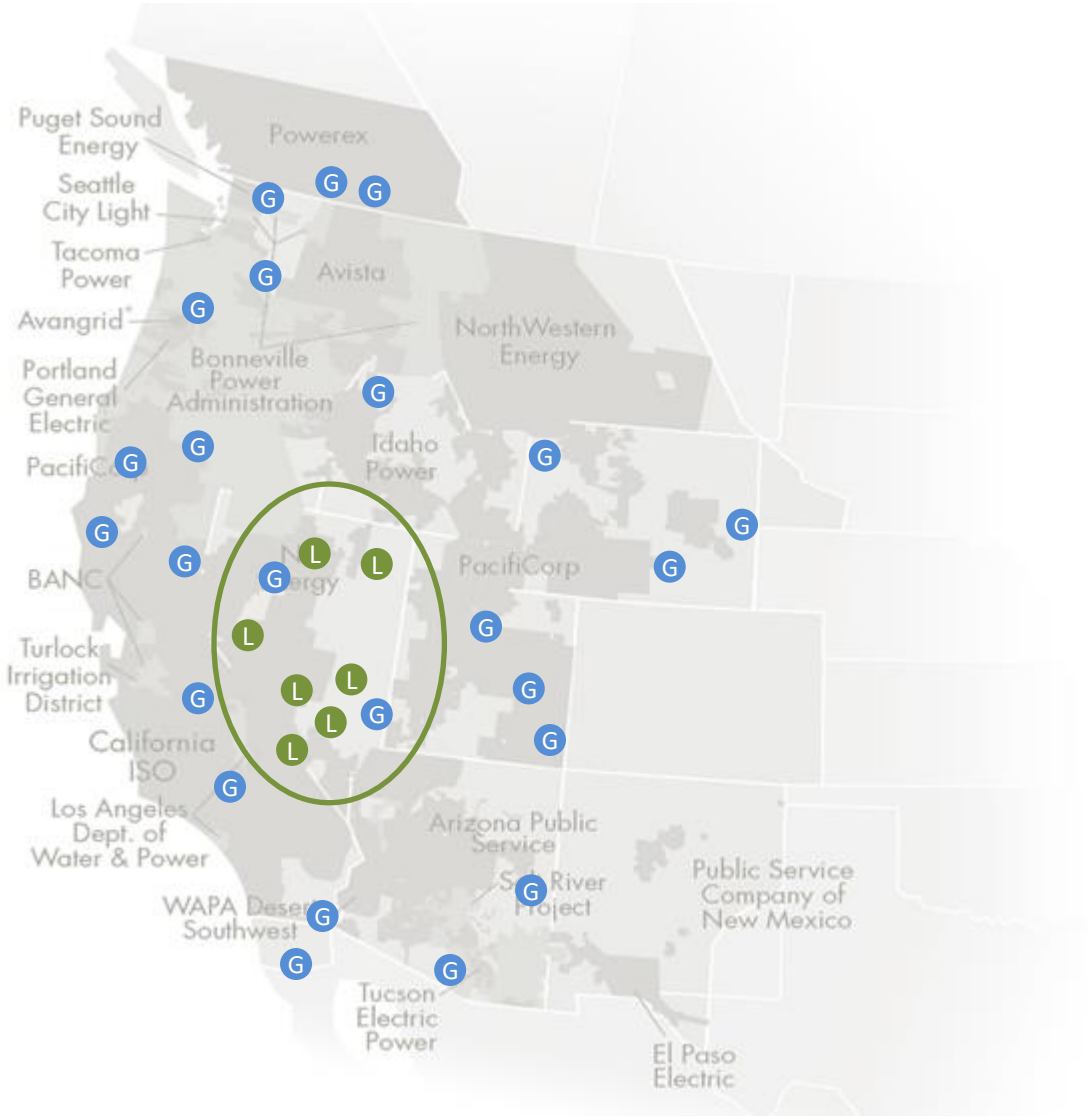
Locational Marginal Price (LMP)

The marginal cost ($/MWh) of serving the next increment of demand at that price node consistent with existing transmission constraints and the performance characteristics of resources.

Nodal pricing is the price paid for electricity generated or consumed at a specific location

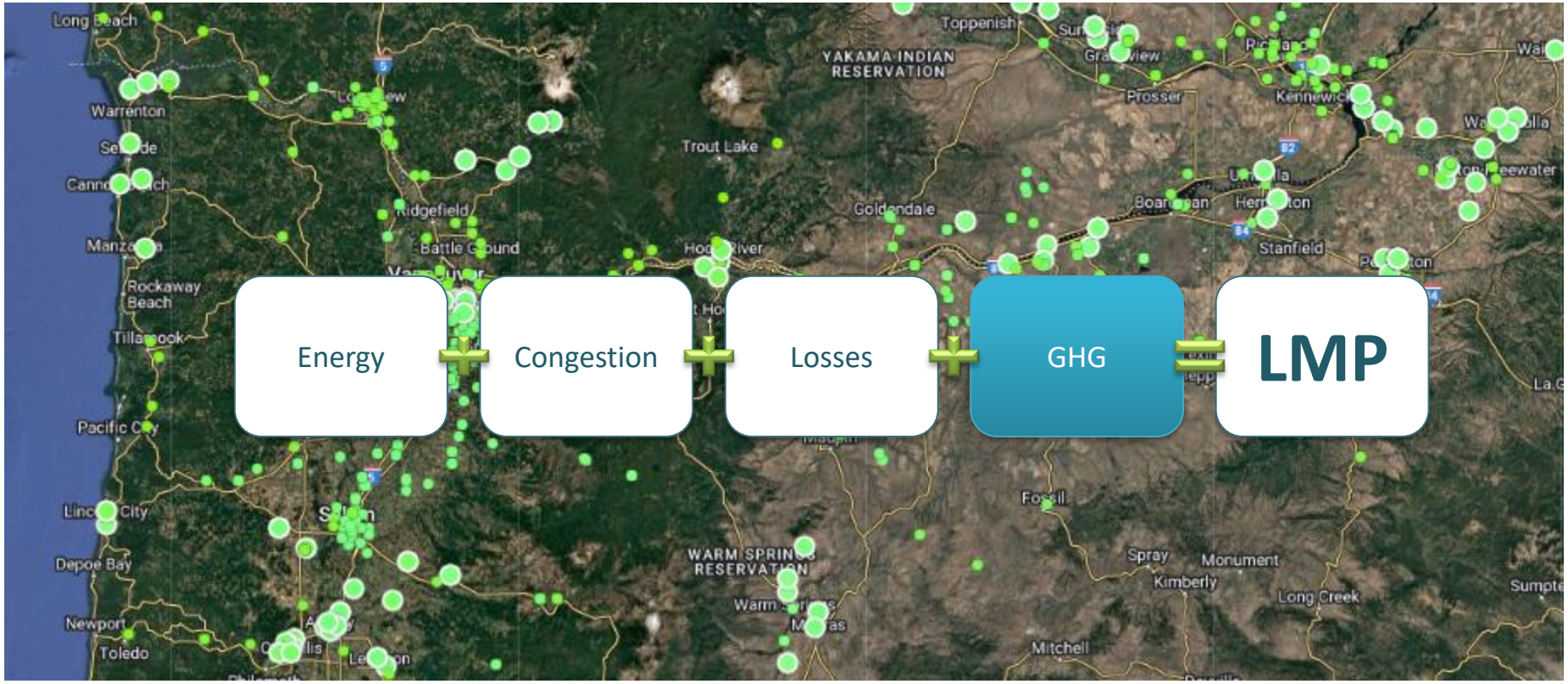
Resources are paid the nodal price at their physical location.

Load pays the weighed average price of all load nodes in its specific load aggregation.



Components of the Locational Marginal Price

Locational Marginal Pricing enables the actual operating conditions on the transmission system to be factored into the price of electricity at different locations.



Locational Marginal Price: Energy

NEW

Locational Marginal Price

Energy

Congestion

Losses

GHG

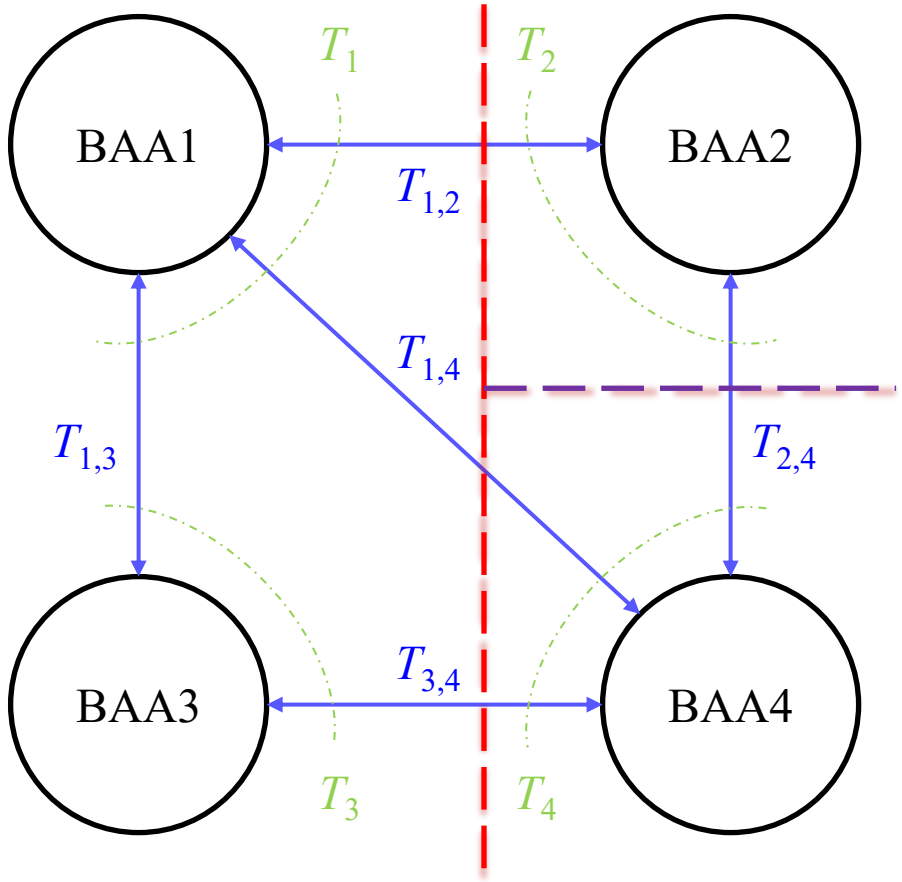
EDAM schedules energy for each hour of the next day by matching bid-in supply with bid-in demand.

Energy prices can vary by hour and across different Balancing Authority Areas. **This is a new aspect of the LMP with the introduction of EDAM.**

Transmission capacity is optimized to enable energy transfers, subject to scheduling constraints.

When transfer limits are reached, price differences occur between Balancing Authority Areas, resulting in distinct energy prices for each area.

This simplified example illustrates how price separation between BAAs can result in a different marginal energy cost (MEC) for each BAA.



- In this example, each BAA is associated with one transfer location (green lines & text)
- Arrows indicate transfers between BAAs (blue lines & text)
- When a line reaches its transfer limit and can no longer accommodate additional energy flows, it can lead to price separation across interfaces where all transfers are constrained
  - Export Transfer$_{1,2}$, Export Transfer$_{1,4}$, and Export Transfer$_{3,4}$ are constrained (red line)
    - MEC1 = MEC3 < MEC2 = MEC4
  - Export Transfer$_{2,4}$ also constrained (purple line)
    - MEC1 = MEC3 < MEC2 < MEC4
- Price separation across transfers yields transfer revenue

How will the new Locational Marginal Price formation impact the Real-Time Market and WEIM?

In today's market, the energy component of the LMP is a System Marginal Energy Cost, which means the energy component is the same across the market footprint.

With the implementation of EDAM and the change to a Marginal Energy Cost that reflects price separation, the potential for a different Marginal Energy Cost per BAA and the concept of transfer revenue will be introduced to WEIM as well.

– This is because the Real-Time Market is an imbalance settlement from the Day-Ahead Market; as such, the LMP formulation should be the same.

Note that the Marginal Energy Cost can be the same across multiple WEIM BAAs.

– If this is the case, it means the market did not have a binding transfer constraint between those BAAs.

Locational Marginal Price: Congestion

Locational Marginal Price

Energy

Congestion

Losses

GHG

Congestion occurs when electricity cannot flow freely to an area due to high transmission use, limited capacity, or outages.

To mitigate congestion, more expensive generation may be used, increasing load-serving costs.

These costs are reflected in the congestion component of the LMP, affecting charges to demand and payments to supply.

In addition to scheduling constraints, market prices are also affected by transmission constraints.

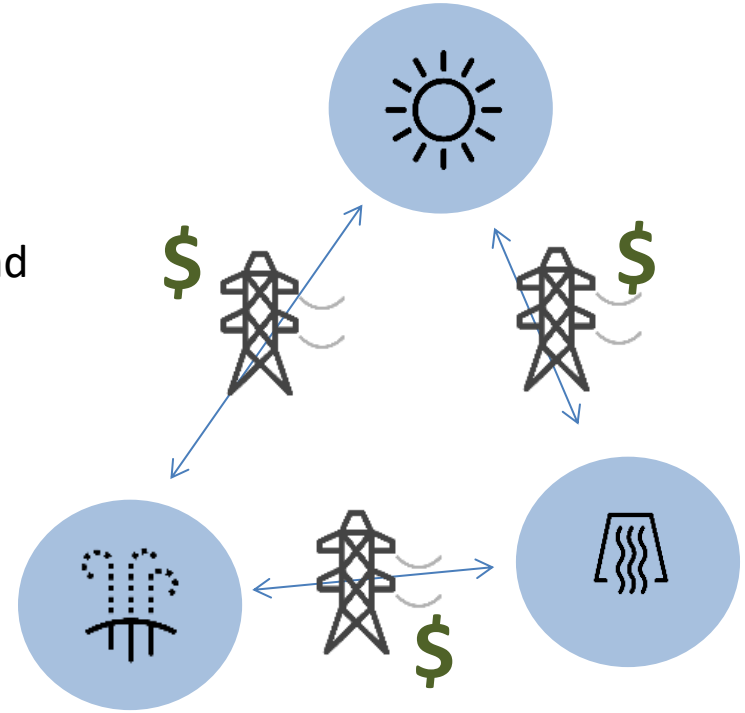
Transmission Constraints: Physical and operational limits that restrict electricity flow across regions, impacting grid reliability and efficiency.

Line Capacity: Determined by thermal limits, voltage stability, and engineering standards—exceeding these can damage equipment or destabilize the grid.

Congestion Management: Pricing mechanisms are used to reduce congestion and prevent overloading.

Key Questions:

- *What is the line rating?*
  - (Defines the maximum safe capacity of a transmission line)
- *What is the cost of the next MW?*
  - (Reflects the marginal cost of delivering one more megawatt across a constrained line)



Locational Marginal Price: Losses

Locational Marginal Price

Energy

Congestion

Losses

GHG

Energy losses occur as electricity is transmitted across transmission lines due to wire resistance.

Losses are similar to a light dimming as you move farther away from the source.

The market uses the Full Network Model to calculate actual losses but bases the LMP loss component at a node on marginal losses from serving an additional increment of load from an injection at that node.

Locational Marginal Price: Greenhouse Gas (GHG)

Locational Marginal Price

Energy

Congestion

Losses

GHG

Participants can use voluntary bid adders to indicate their willingness to serve demand in GHG regulation areas.

EDAM's GHG regulation model minimizes market-wide costs using price signals that account for different state regulations that price GHG emissions.

The GHG component is separate to ensure that supply and demand in non-GHG areas avoid GHG costs, while resources outside GHG areas can earn additional revenue to offset GHG regulation costs.

Energy delivered to GHG areas will have an LMP that includes GHG costs for imports.

Western Energy Imbalance Market (WEIM) Overview

Objectives:

Summarize today's Real-Time Market in the context of WEIM

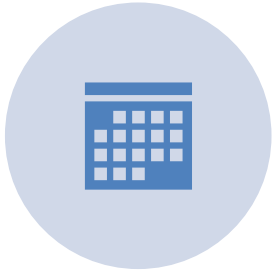
Western Energy Markets operated by the California ISO

Today's Markets

REAL-TIME MARKET
(CAISO BA & WEIM)

DAY-AHEAD MARKET
(CAISO BA)

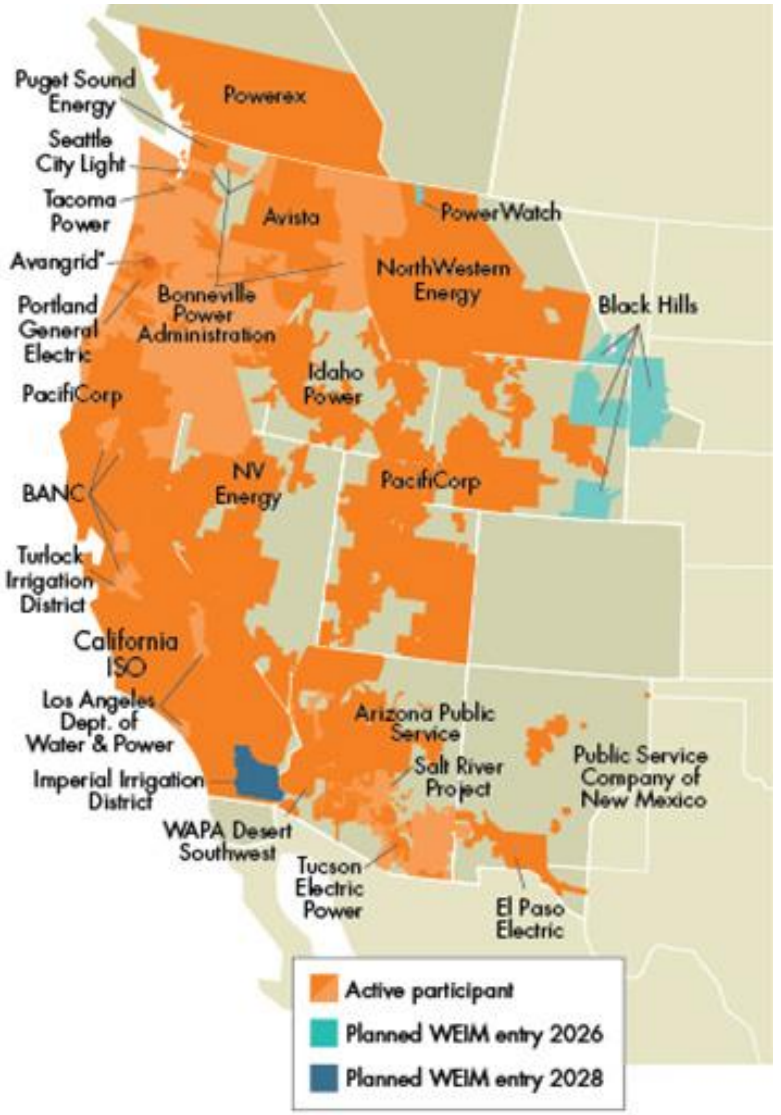
Coming in Spring 2026



EXTENDED DAY-AHEAD MARKET
(CAISO BA & BAAS THAT OPT-IN)

Real-Time Market: Overview

- Operates across a large footprint in the West
- Procures additional energy to manage deviations or imbalances from the hourly market and scheduled transactions across the market footprint
- Enables optimized transfer of energy across the West using available transmission
- The market procures energy and ancillary services for the CAISO BAA
- “Energy only” for all other BAAs



*Avangrid office; generation only BAA with distribution across multiple states.
Map boundaries are approximate and for illustrative purposes only.

Real-Time Market: Key elements

Hourly Resource Sufficiency Evaluation

- Market footprint includes WEIM participants
- WEIM participation is for energy only and does not include ancillary services
- Load forecasts for each entity drive market awards
- Each entity ensures sufficiency of resources available for their area on an hourly basis

Balancing

Bid Capacity

Flex Ramp

Feasibility

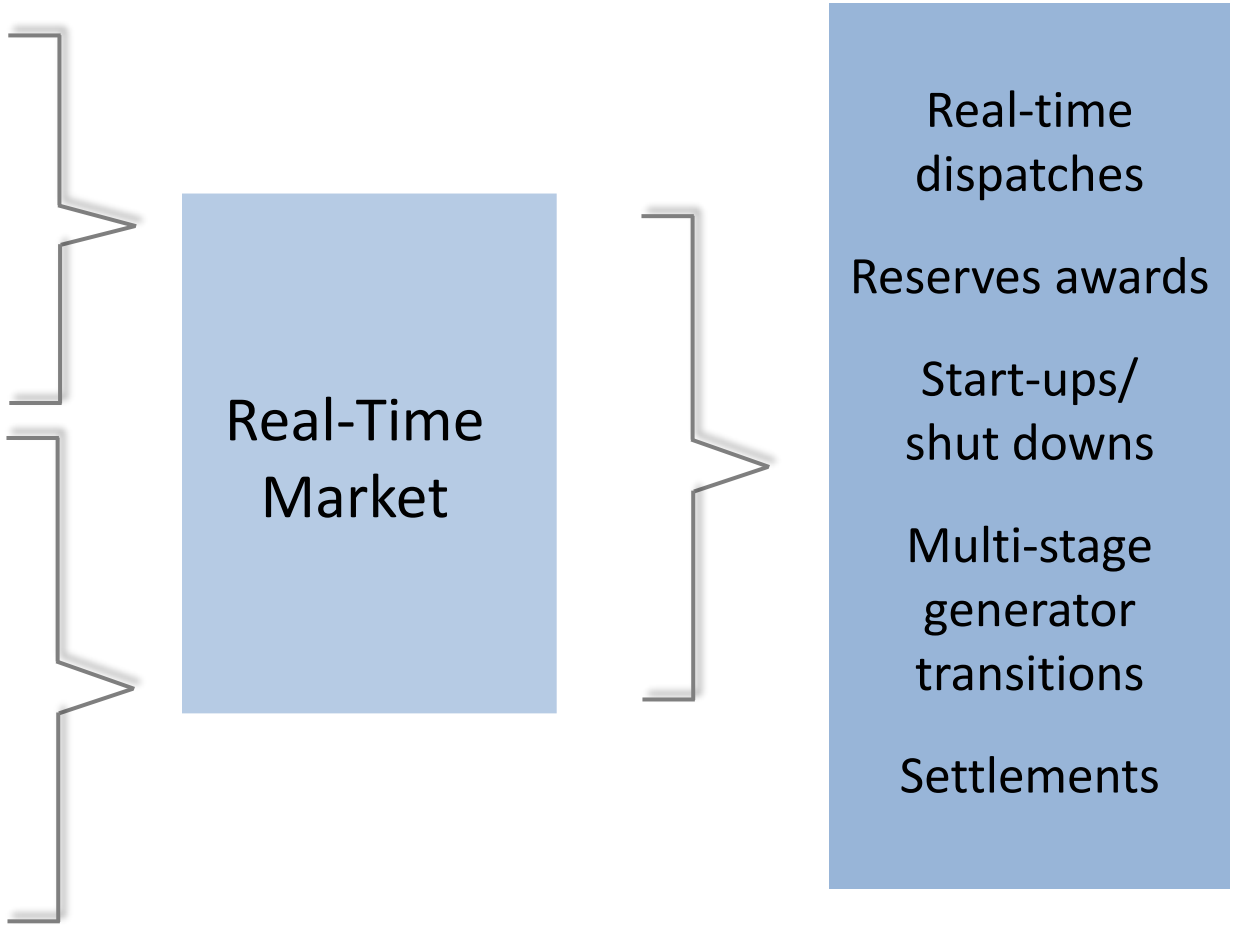
Real-Time Market: Inputs and outputs

From **Day-Ahead**:

- System info
- Energy schedules
- Reserves awards
- Master file

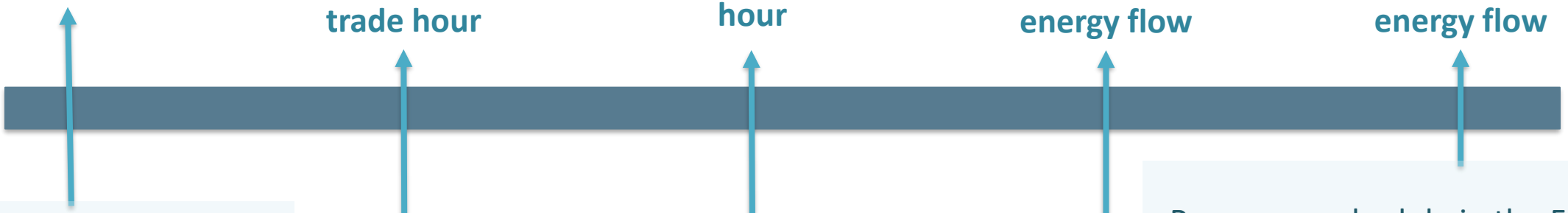
From **Real-Time**:

- State estimator
- Supplemental energy & ancillary service bids
- Base schedules
- Outages
- Transmission limits



Day-Ahead results set the plan for the following day, while the Real-Time Market adjusts to meet actual conditions based on real-time forecasts.

Real-Time Market: Milestones



4.5 hours ahead

Real-time market processes begin with short term unit commitment run

75 minutes prior to trade hour

Market closes

Bid submission deadline

40 minutes prior to trade hour

Base schedule submission deadline (WEIM)

15 minutes ahead of energy flow

Resources scheduled to meet demand forecast in the fifteen-minute market (FMM). Settled against day-ahead or base schedules.

Start-up/shut down instructions. Incremental ancillary service procurement (CAISO BA).

5 minutes ahead of energy flow

Resources schedule in the FMM are re-optimized in 5-minute increments.

Settled against the FMM.

Real-Time Market: Processes

Short Term Unit Commitment	• Occurs once per trade hour • Examines the potential demand requirements for the next 4 ½ trade hours • Issues start up/shut down instructions to short start resources to meet anticipated demand
Hour-Ahead Scheduling Process	• Produces HASP advisory schedules and advisory AS awards • **Binding** HASP intertie schedules with hourly block bids • **Advisory** schedules for internal resources and intertie resources that do not have hourly block bids/schedules
Fifteen-Minute Market	• Issues start-up/shut down instructions to short and fast start units, and transition instructions to multi-stage generators • Procures ancillary services as needed • Provides advisory instructions for as many as 7 future 15-min intervals
Five-Minute Market	• Occurs every five minutes to meet energy imbalances • Resources dispatched in real-time • Provides advisory dispatch instructions for as many as 12 future dispatch intervals

Real-Time Market: Review of 15-minute and 5-minute market activity

- For each **fifteen-minute** interval the market is:
  - Starting-up or shutting down resources
  - Transitioning multi-stage generators
- For each **five-minute** interval the market is:
  - Issuing real-time dispatch instructions
- These market instructions are communicated to participants through an automated dispatch system (software application)

Extended Day-Ahead Market (EDAM) Overview

Objective:
Summarize the upcoming changes to the Day-Ahead Market

Implementation of an extended day-ahead market (EDAM)

- Day-ahead capabilities extended to WEIM participants who voluntarily opt in, providing additional benefits
- ISO market will manage energy schedules and optimize efficient transfers of energy between balancing authority areas (BAAs)
- Expands access to full complement of wholesale energy market services and builds upon WEIM to optimize commitment of generation a day in advance

What are some of the ways EDAM will provide benefit to participants?

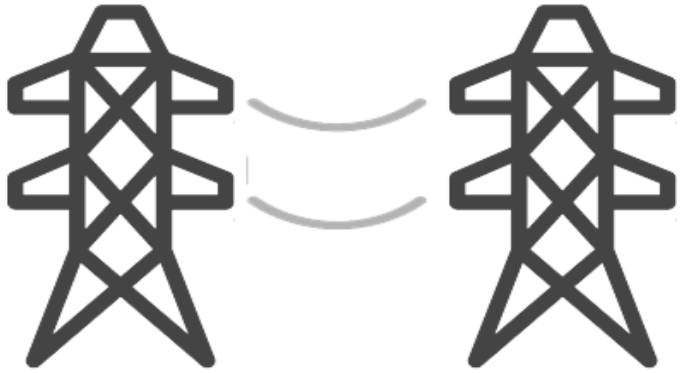
- Enhances, supports, and complements bilateral trading activity that takes place today
- Increases reliability due to greater situational awareness
- Lowers greenhouse gas emissions
- Allows participants to share surplus renewable energy across a broad footprint
- Participating BAs retain resource planning, transmission planning, and reliability functions

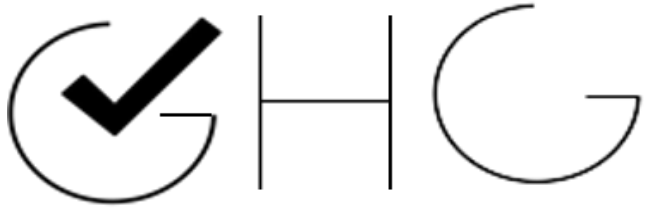
Elements of the EDAM program

- 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





What should market participants keep in mind when preparing for EDAM?

What changes?

- All loads and resources in EDAM area submit offers (economic bids or self-schedule bids).
- Base schedules will no longer be submitted in EDAM areas.
- “Non-participating” resources will no longer exist.
- New market products: Imbalance Reserves, Reliability Capacity.
- Settlement of day-ahead transactions.

What stays the same?

- EDAM entities continue to retain their resource planning, transmission planning and reliability functions.

Decisions to make:

- EDAM entities and EDAM SCs work together to determine who will schedule:
  - Third-party resources
  - Third-party load

Key Points: Western Energy Markets operated by the California ISO

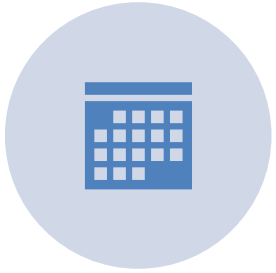
Today's Markets

REAL-TIME MARKET
(CAISO BA & WEIM)

WEIM participation is for energy only

DAY-AHEAD MARKET
(CAISO BA)

Coming in Spring 2026



EXTENDED DAY-AHEAD MARKET
(CAISO BA & BAAS THAT OPT-IN)

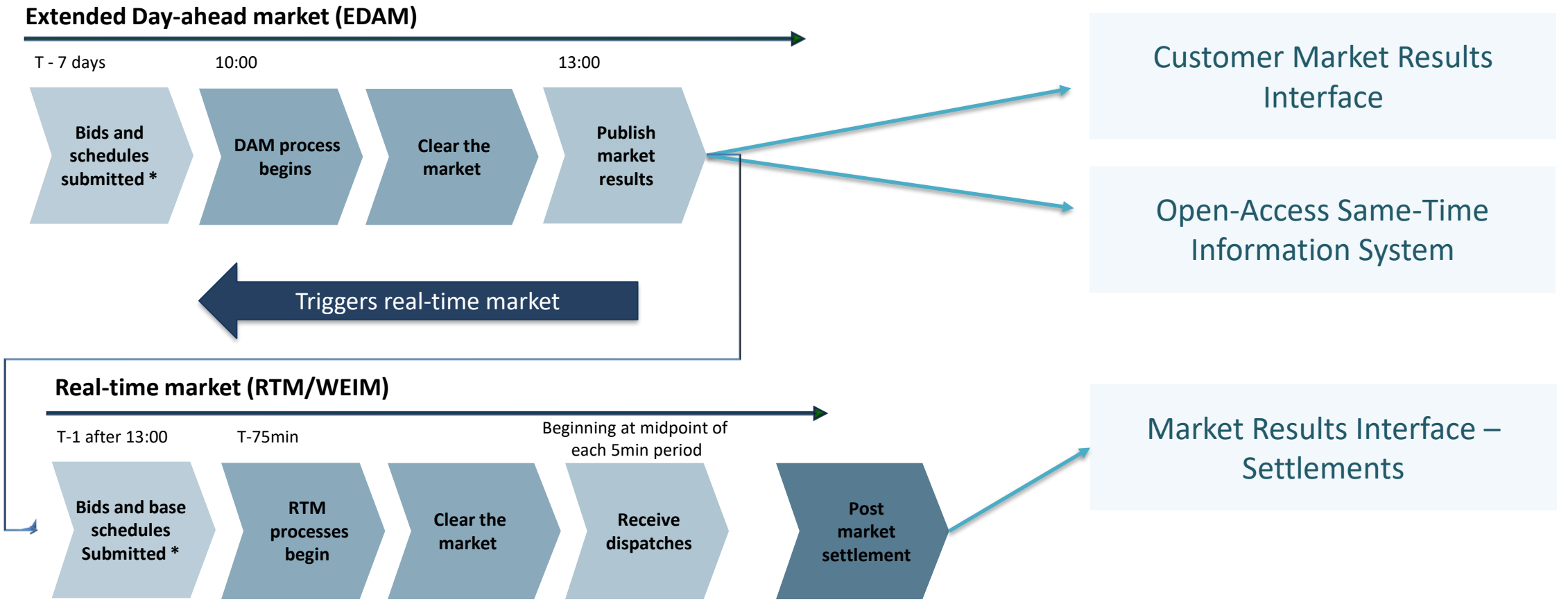
NEW

This market will procure:
- Energy
- Imbalance Reserves
- Reliability Capacity
- Ancillary Services (CAISO BA only)

Day-Ahead Market Processes & Timelines

Objectives:
Describe the new Extended Day-Ahead Market processes
Distinguish which processes procure each new market product

Market timeline and data flow from bid to settlement



Comparison of the current CAISO-Only Day-Ahead Market processes vs. the new Extended Day-Ahead Market processes

NEW

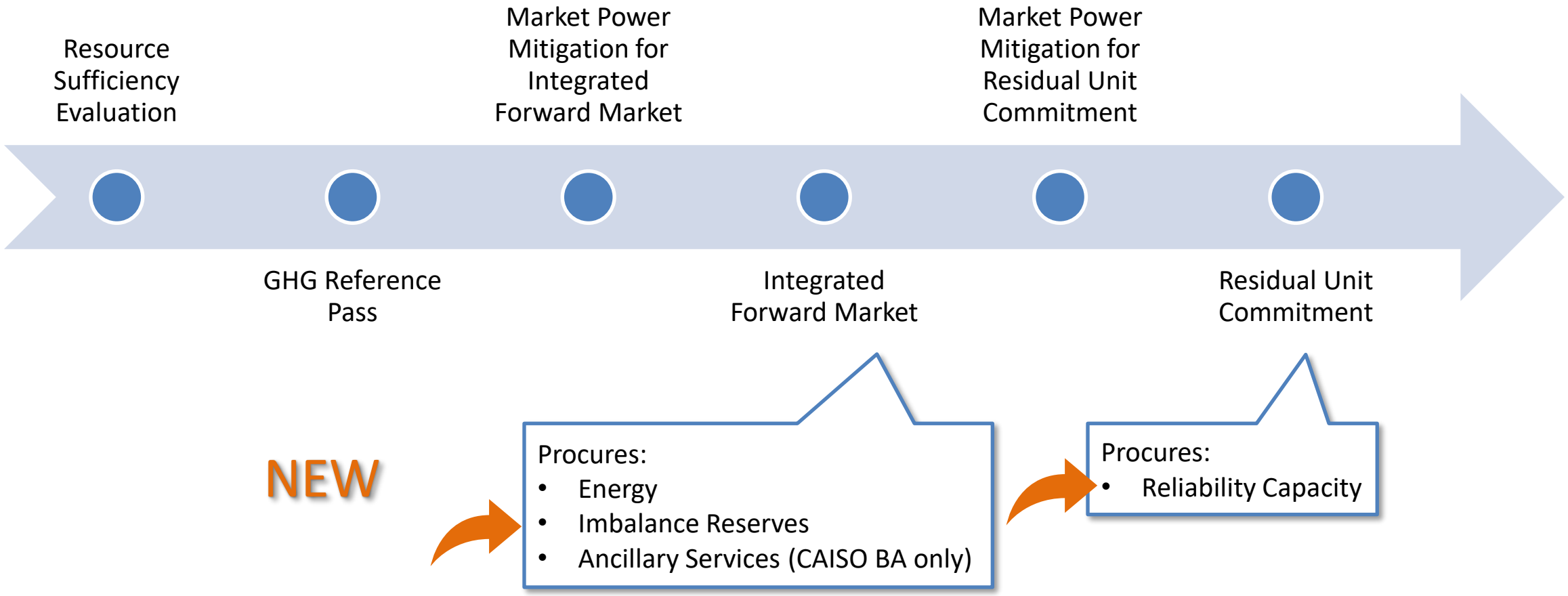
Current Day-Ahead Market Processes

MPM	• Market Power Mitigation
IFM	• Integrated Forward Market
RUC	• Residual Unit Commitment

Extended Day-Ahead Market Processes

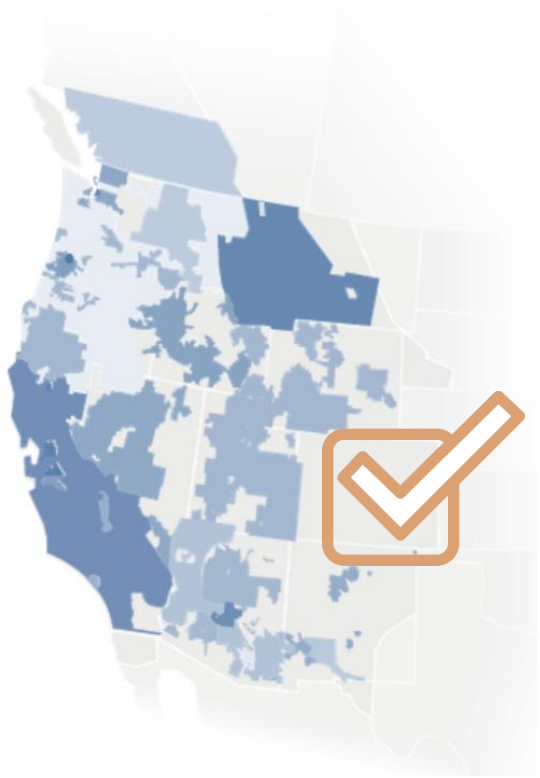
RSE	• Resource Sufficiency Evaluation
GHG	• Greenhouse Gas Reference Pass
MPM-IFM	• Market Power Mitigation for Integrated Forward Market
IFM	• Integrated Forward Market
MPM-RUC	• Market Power Mitigation for Residual Unit Commitment
RUC	• Residual Unit Commitment

Which processes procure each new market product?



Let’s review each process, starting with the Resource Sufficiency Evaluation!

Daily Resource Sufficiency Evaluation (RSE) for each BAA



Each BAA's offered supply is evaluated against its demand forecast, imbalance reserve requirements and ancillary service requirements across the 24 hourly intervals of the day-ahead market.

The EDAM Entity is actively involved in the RSE process and works to pass the sufficiency test which is designed to ensure that each entity has enough supply to meet the next day's obligations.

If an EDAM entity fails the RSE, the entity may be exposed to surcharges which act as an incentive to take proactive actions to meet the RSE requirements.

1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 24:00

24-hour time horizon

Resource Sufficiency Evaluation occurs today in **Real-Time** for all WEIM BAs

To ensure that Balancing Authorities come into **each real-time hour** able to support their own load with their native or imported generation, the WEIM created the Resource Sufficiency Evaluation (RSE) which tests:

Balancing

Compares schedules to demand forecast to ensure each BAA has the capability of balancing their area for each operating hour to avoid leaning on neighbors

Feasibility

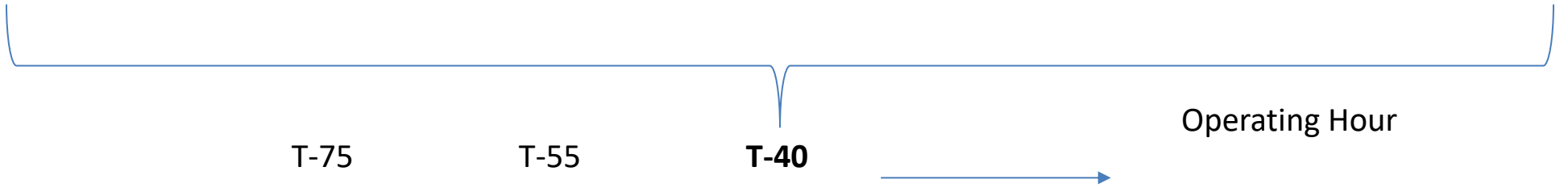
Market performs power flow feasibility to identify potential transmission constraints to ensure that schedules would not overload a line

Flex Ramp Capacity

Ensures WEIM BAAs have sufficient ramping capability to meet forecasted uncertainties such as demand, VERs, uninstructed deviation, or forced outages.

Bid Range Sufficiency

Ensures a flexible bid range, both up and down on participating resources



Evaluations for each operating hour

Resource Sufficiency Evaluation: EDAM

The binding day-ahead RSE test occurs each day at 10:00am, prior to running the Day-Ahead Market. The Day-Ahead Market RSE evaluates three different aspects:

1

Bids: assesses whether there are sufficient energy bids or self-schedules to meet an EDAM entity's forecasted load needs.

2

Ancillary Services: ensures that a BA has sufficient contingency reserve capacity available per AS requirements.

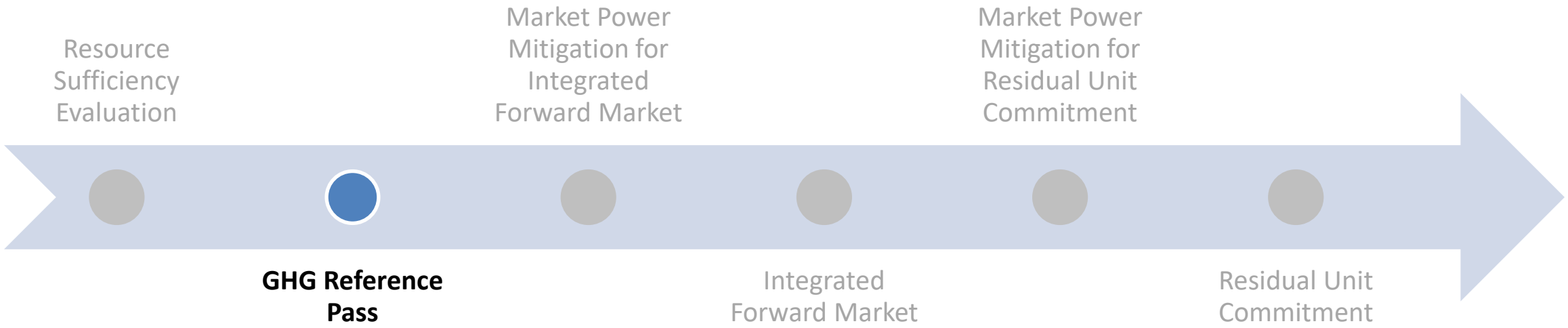
3

Imbalance Reserves: ensures the EDAM entity has sufficient bid-in capacity to meet uncertainty between day-ahead and real-time. Like real-time Flex Ramp Sufficiency test, with key differences

- **EDAM Entity:** bids in specific values for both Imbalance Reserve Up and Imbalance Reserve Down
- **WEIM Entity:** value is determined by the market based on energy bids

Evaluations covering 24-hour period

Market Process: GHG Reference Pass



Let’s review the GHG Reference Pass!

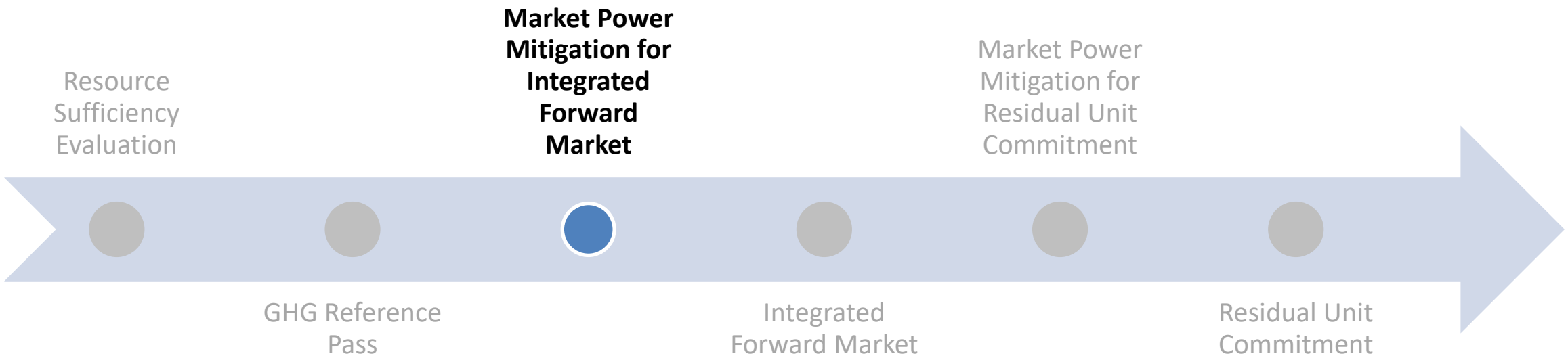
Greenhouse Gas (GHG) Reference Pass

- EDAM's expanded GHG regulation model incentivizes resources from multiple western states to supply energy to climate-focused states.
- Participants can indicate their willingness to serve demand in GHG regulation areas through voluntary bid adders to their energy bids.
- To reduce emissions leakage, the reference pass establishes a GHG attribution baseline prior to the binding market run.
- The baseline is determined by calculating resource dispatch levels in a market simulation with no energy exported to a GHG regulation area.
- During the binding market run resources only receive GHG attributions above their baseline dispatch level.

GHG Processes: GHG Model

- EDAM allows utilities and other market participants to bid on energy for the next day, facilitating efficient resource allocation.
- Emissions from the identified resources are considered in market optimization processes
- GHG regulation area boundaries are determined by state mandates rather than BAs
- Model is scalable to allow for future non-overlapping GHG regulation areas

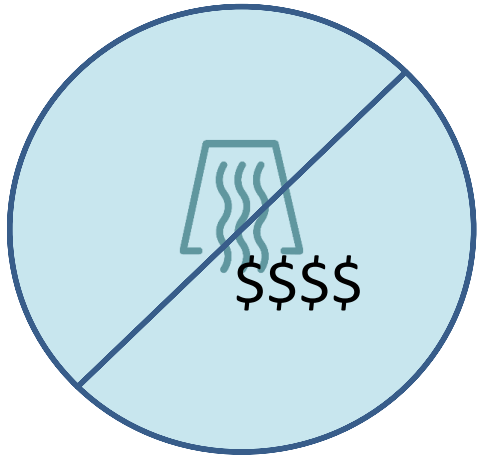
Market Process: Market Power Mitigation for Integrated Forward Market



Let’s review Market Power Mitigation for the Integrated Forward Market!

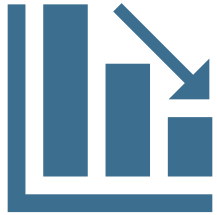
Market Power Mitigation (MPM) for Integrated Forward Market (IFM)

- At times there can be localized congestion that can result in market power being exercised.
- MPM detects and mitigates (lowers) the bids in those localized cases to ensure prices remain competitive throughout the system.



Market Power Mitigation (MPM) for Integrated Forward Market (IFM)

- If the potential for market power in a location is determined, the market analyzes the related bids and, if necessary, will replace the bids based on the following criteria:
  - **Energy bid** with the higher of the **default energy bid** or the **competitive LMP**
  - **Imbalance reserve** bid with the higher of the competitive Imbalance Reserve Up Marginal Price (IRUMP) or the **default availability bid**



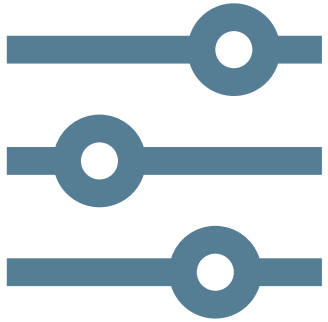
- There are no schedules or dispatches as a result of this process.
- The output of the MPM process is referred to as the clean bid set that is used in the next process.

Default Energy Bids

- The ISO calculates Default Energy Bids (DEBs) for resources to be used when Market Power Mitigation is triggered

- There are 5 calculation options for DEBs:
  - Variable Cost DEB
  - LMP-Based DEB
  - Negotiated DEB
  - Hydro DEB
  - Storage DEB*

Additional registration required



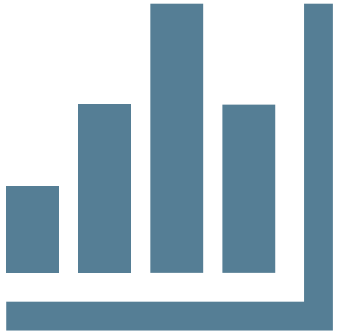
For more information, refer to the BPM for Market Instruments, Attachment D.

*Note: Storage DEB in WEIM for CAISO only, Storage DEB in EDAM for CAISO and EDAM entities.

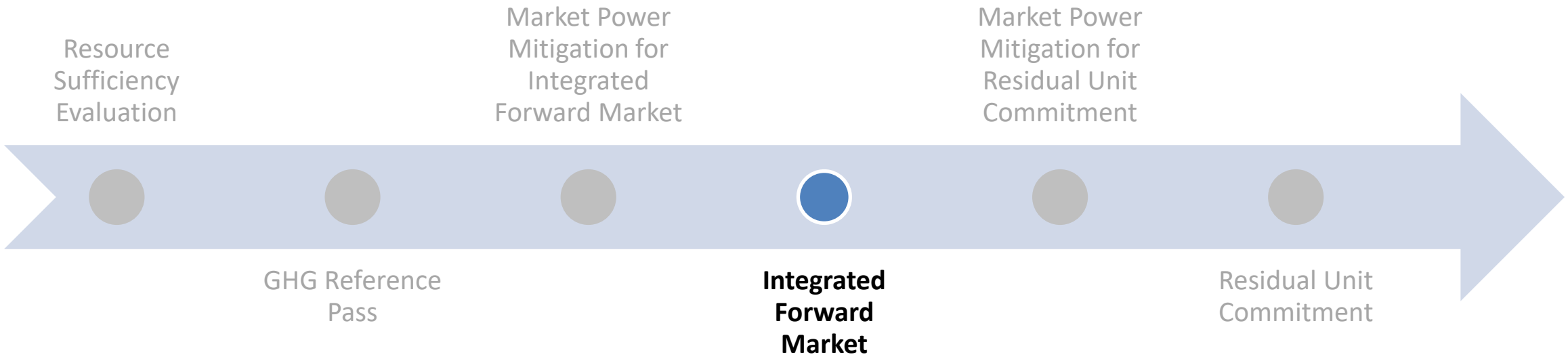
Example: LMP-Based Default Energy Bid

- A weighted-average of LMPs based on the lowest quartile (25%) of the set of validated and/or corrected LMPs at the resource's location during Trading Hours in the last 90 days when the resource was dispatched.

- Resource must pass feasibility test to determine whether it is eligible for LMP-Based DEB
  - Ensures there is sufficient LMP data to perform calculation

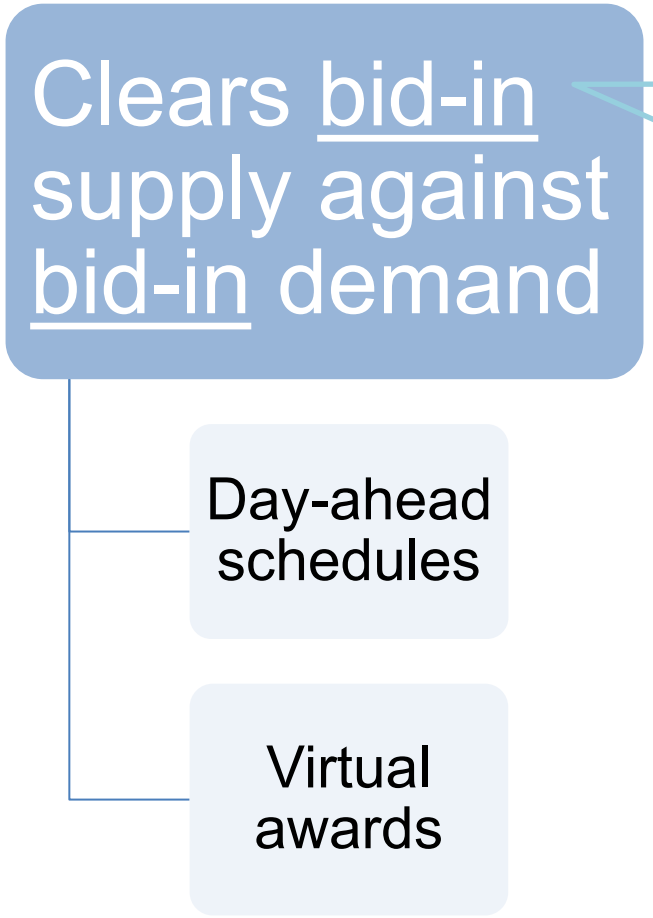


Market Process: Integrated Forward Market



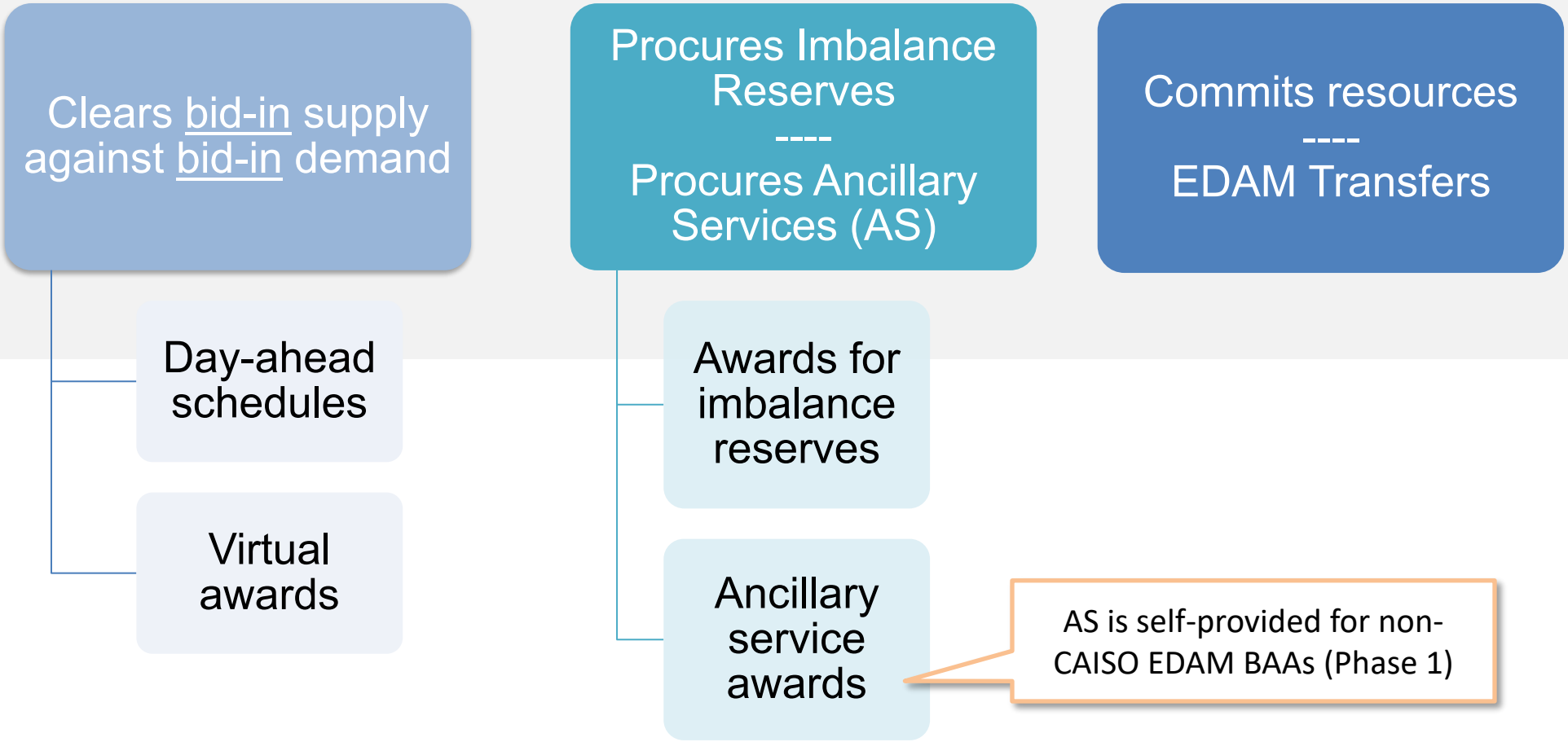
Let’s review the Integrated Forward Market!

Integrated forward market (IFM)



- As a result, sufficient capacity may not be committed to meet forecast demand
- More on this during Step 6 (RUC)

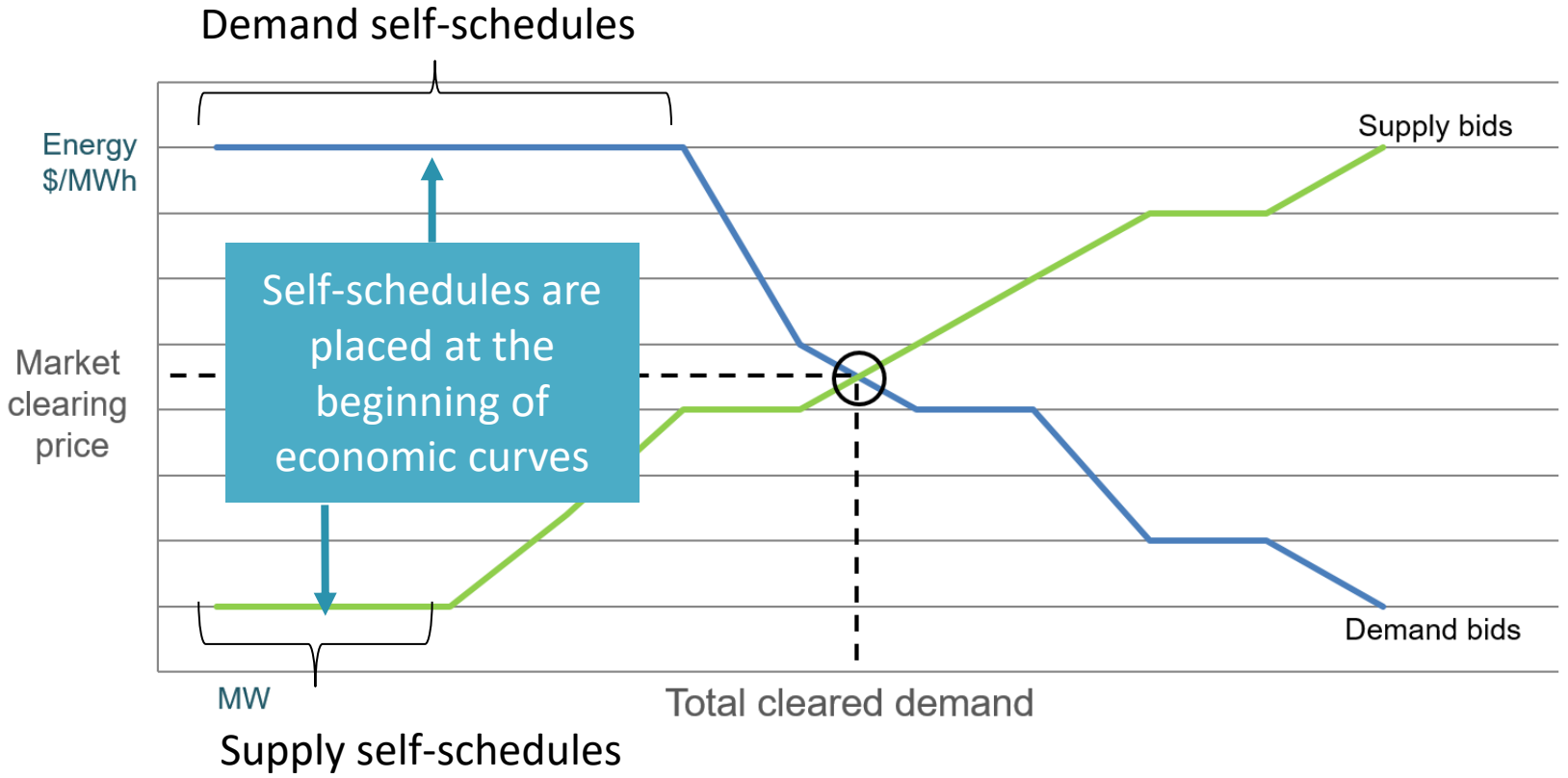
What is procured in the Integrated forward market (IFM)?



How does the IFM clear supply bids against demand bids?

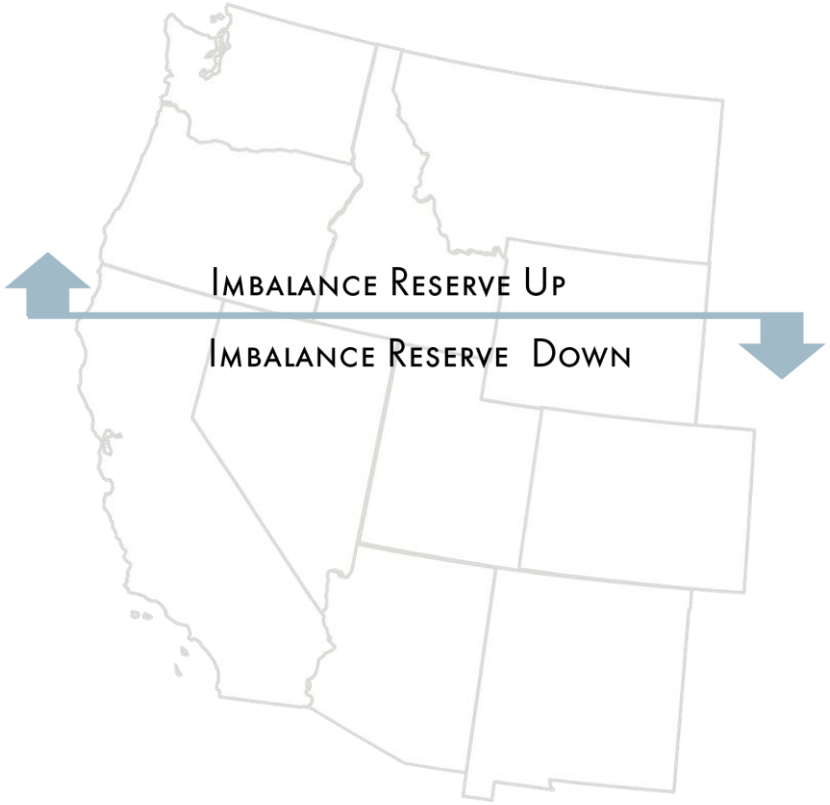
Day-ahead supply bids clear against demand bids.

Real-time supply clears against load forecast.



Note that accepted bids are paid the LMP which incorporates the market clearing price, not the bid price.

Imbalance Reserves provide consistent method for evaluating & addressing uncertainty needs in each BA

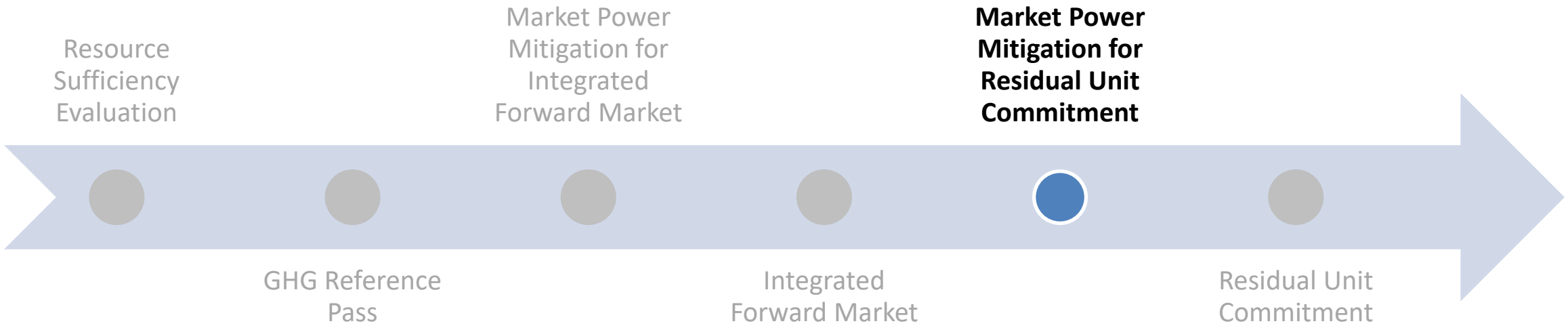


Imbalance reserve products provide the market with a mechanism to address each BAA's expected range of uncertainty when comparing the day-ahead load forecast to real-time consumption and comparing solar and wind forecasts to their real-time outputs.

Procurement of reserves will be done on an hourly basis for each BA from the bids that are submitted by SCs across the EDAM footprint.

SCs submit bids for **imbalance reserve up** and **imbalance reserve down** and may receive hourly awards for **one or both** products.

Market Process: Market Power Mitigation for Residual Unit Commitment



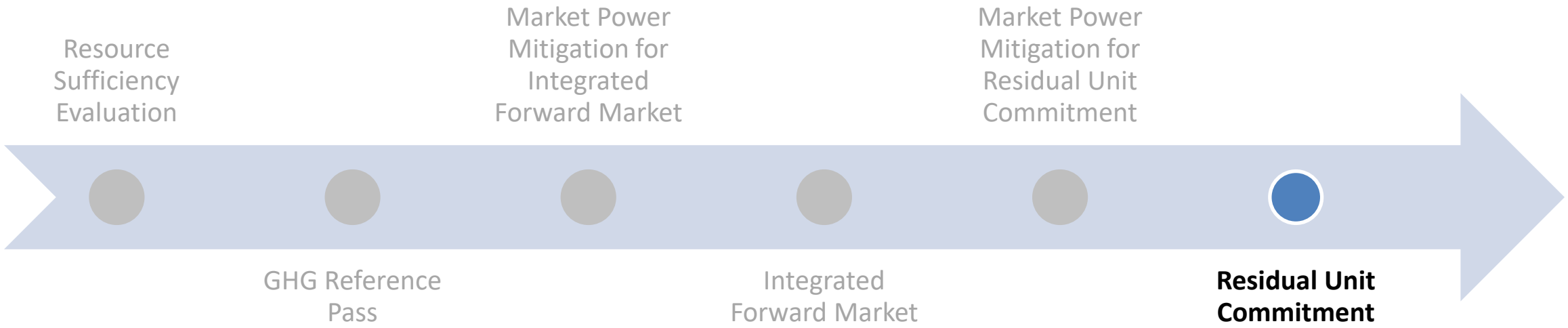
Let’s review Market Power Mitigation for Residual Unit Commitment!

Market Power Mitigation (MPM) for Residual Unit Commitment (RUC)

Prior to the Residual Unit Commitment process, there is a second Market Power Mitigation run that analyzes the bids submitted for reliability capacity and mitigates these bids, if necessary, to the **default availability bid**.

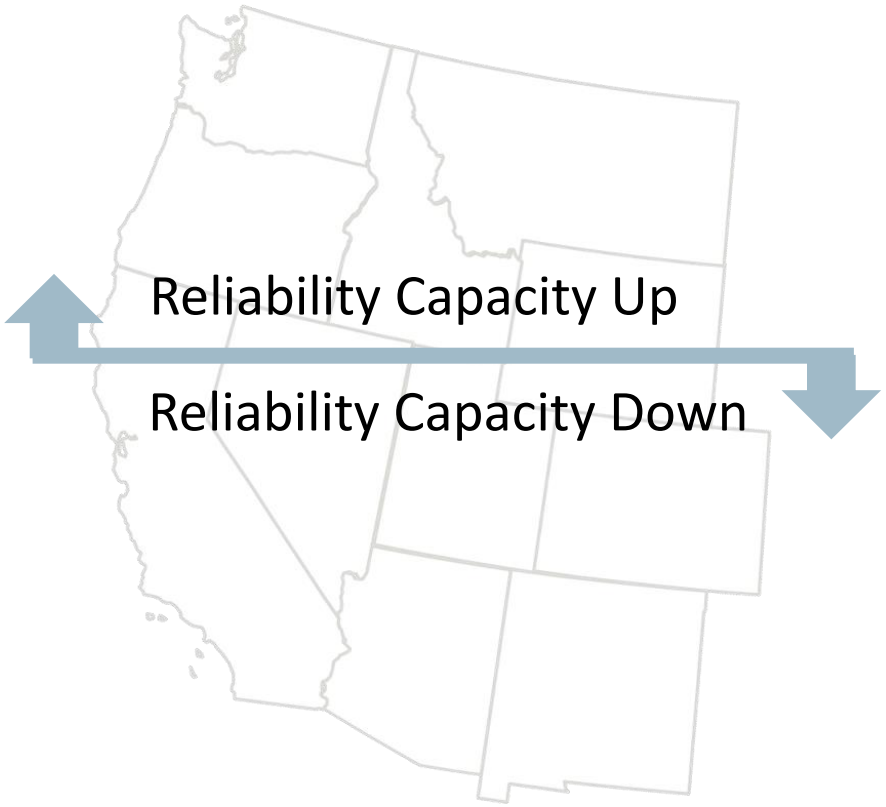
Default availability bid approximates the costs related to a resource's ability to provide reserve products.

Market Process: Residual Unit Commitment



Let’s review Residual Unit Commitment!

Residual Unit Commitment (RUC) process procures reliability capacity products to ensure sufficient physical supply scheduled in day-ahead



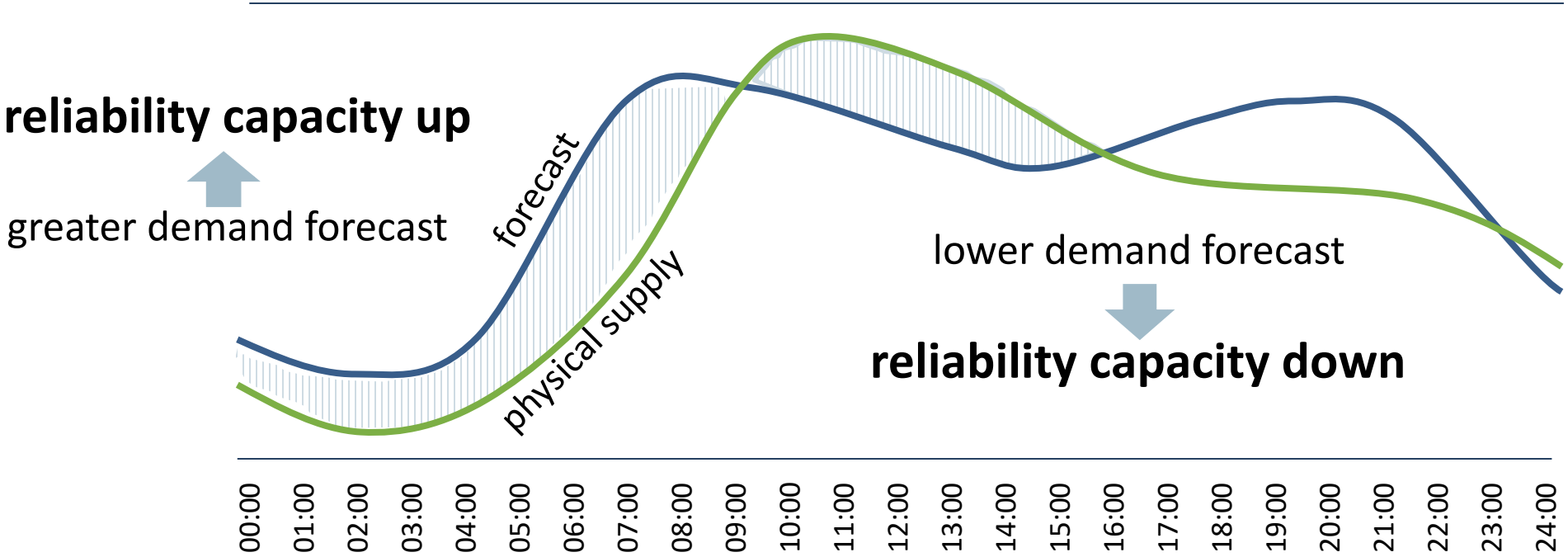
Today's RUC process procures additional capacity to meet forecasted demand.

With EDAM, reliability capacity provides BAs with upward **or** downward dispatch capability, ensuring sufficient physical supply scheduled in day-ahead.

Procurement of reliability capacity will be done on an hourly basis for each BA from the bids that are submitted by SCs across the EDAM footprint.

SCs submit bids for **reliability capacity up** and **reliability capacity down** and may receive hourly awards for **only one** of the products.

Reliability Capacity is procured in RUC, which compares the demand forecast to physical supply that clears the market



Comparison of Ancillary Services, Imbalance Reserves, and Reliability Capacity

Feature	Ancillary Services (AS)	Imbalance Reserves (IR)	Reliability Capacity (RC)
Purpose	Maintain grid reliability through frequency regulation and spinning/non-spinning reserves.	Address net load uncertainty and real-time ramping needs not covered by hourly day-ahead schedules.	Ensure sufficient physical supply to meet differences between cleared supply and net load forecast.
Market Timing	**CAISO BAA:** Procured in both Day-Ahead and Real-Time Markets. **EDAM BAA:** self-provided in Day-Ahead Market.	Procured in the Day-Ahead Market, co-optimized with energy and ancillary services (CAISO BA).	Procured in the Day-Ahead Market via enhanced Residual Unit Commitment (RUC) process.
Dispatchability Requirement	Must be able to respond within seconds to minutes depending on service type.	Must be dispatchable within 15 minutes; awards capped at 15-minute ramping capability.	Must be dispatchable within 60 minutes; awards capped at 60-minute ramping capability.
Bid Structure	Price and quantity bids for each service type.	Separate bids for upward and downward IR.	Separate bids for upward and downward RC.
Eligibility	Typically includes fast-responding resources like batteries, gas turbines, and demand response.	Resources capable of 15-minute ramping; excludes self-scheduled resources.	Resources capable of 60-minute ramping; includes multi-stage generating units.
Obligations	Must offer into real-time market if awarded (economic bid or self-schedule bid).	Must submit economic energy bids in real-time for awarded capacity.	Must submit economic energy bids in real-time for awarded capacity.

Comparison of Ancillary Services, Imbalance Reserves, and Reliability Capacity

Feature	Ancillary Services (AS)
Purpose	Maintain grid reliability through frequency regulation and spinning/non-spinning reserves.
Market Timing	**CAISO BAA:** Procured in both Day-Ahead and Real-Time Markets. **EDAM BAA:** self-provided in Day-Ahead Market.
Dispatchability Requirement	Must be able to respond within seconds to minutes depending on service type.
Bid Structure	Price and quantity bids for each service type.
Eligibility	Typically includes fast-responding resources like batteries, gas turbines, and demand response.
Obligations	Must offer into real-time market if awarded (economic bid or self-schedule bid).

We'll cover Ancillary Services during the final agenda topic, where we'll review aspects of CAISO's current market design that could be considered for future EDAM enhancements.

Bidding and Settlements

Intro & ISO Overview | Market Pricing | WEIM Overview | EDAM Overview | Day-Ahead Processes & Timelines | **Bidding & Settlements** | Examples | Convergence Bidding | Ancillary Services | Congestion Revenue Rights

Economic bids and self-schedules for physical energy can be submitted in the Day-Ahead Market by SCs for supply or demand

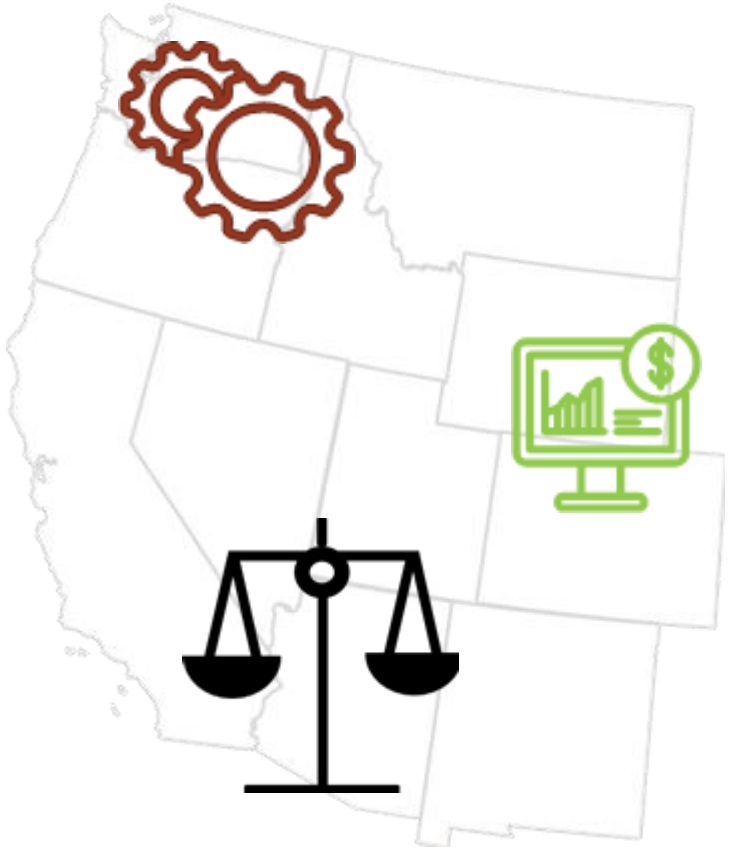
Economic Bids

- An economic bid includes both a specific **quantity** of MW and a specific **price** or **price range**. Economic bids tell the market how many additional MW SCs are willing to **buy** or **sell** when the price reaches a certain level.
- SCs for **supply** can also submit economic bids or self-schedules for physical energy in the Real-Time Market.
- SCs for **demand** do not submit bids in the Real-Time Market as the market clears supply against the load forecast.

Self-Schedule Bids

- In contrast to an economic bid, a self-schedule is an offer to **generate** or **consume** energy regardless of price. These offers only specify a **quantity**.
- Self-schedules are also known as “price takers” because they agree to take the market clearing price for the MW offered, foregoing start-up and minimum load costs.

Market Optimization and Results



SCs bid their resources into a variety of market products and the market processes run to determine the optimal solution for the trade date.

The methodology used to determine market awards is called **Security Constrained Unit Commitment (SCUC)**. The SCUC methodology maximizes economic efficiency, relieves network congestion, and considers physical constraints to achieve least-cost resource commitment and scheduling across the full 24-hours of the trade date.

Market results are published to provide **demand** and **supply** with their day-ahead schedules and awards.

What are the bidding parameters for the different products?

See Tariff section 39.6 for more bidding rules

Energy

- Maximum of 10 segments
- Supply bids ($/MWh) have a monotonically increasing bid curve
- Demand bids ($/MWh) have a monotonically decreasing bid curve
- Subject to energy soft bid cap of $1000/hard cap of $2000 and floor of -$150
- Default Energy Bid used for Market Power Mitigation

Imbalance Reserves

- One segment curve, bid + MW
- Default Availability Bid used for Market Power Mitigation

Reliability Capacity

- One segment curve, bid + MW
- Default Availability Bid used for Market Power Mitigation
- Automatic RCU bid insertion for certified resources

Note that there is a bid cap, not a price cap.

How does the Market decide which resources to commit?

Security Constrained Unit Commitment

Three-part energy bid includes:

- SUC: Start-Up cost (one time)
- MLC: Minimum Load Cost (hourly)
- Energy bid curve above minimum load ($/MWh)

(These are example values meant for educational purposes and do not reflect actual market bids.)

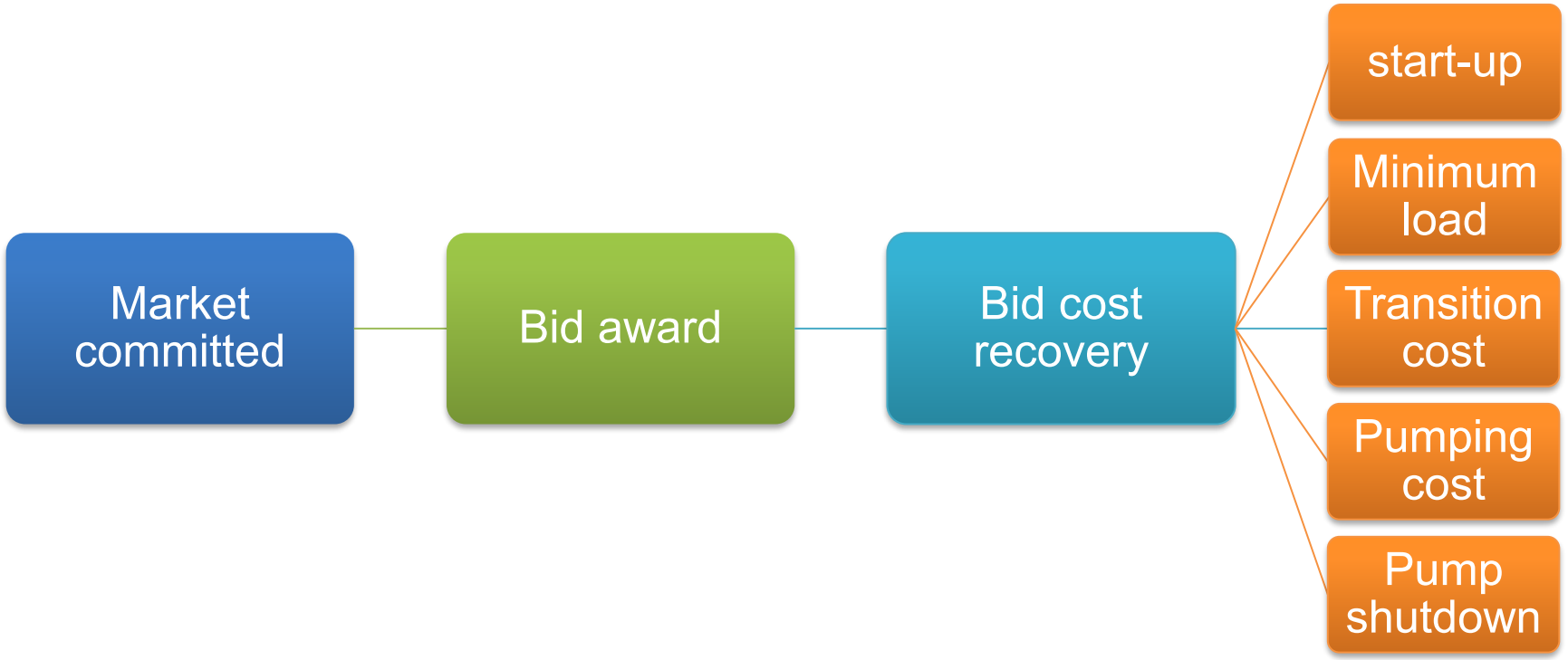
Bid Cost Recovery Overview

- Acts as a financial safeguard to prevent market participants from incurring losses when they follow dispatch instructions.
- Provides compensation when a resource's total market revenue for the operating day is less than its submitted bid costs.
- SCs can submit **self-schedule bids** and/or **economic bids**, which influence a resource's commitment status and eligibility for cost recovery.
- Resources that are **self-scheduled** are **not eligible** for bid cost recovery, since the SC has voluntarily chosen to start up the resource.

*** If a resource submits economic bids on top of a self-schedule they could be eligible to recover the energy bid amount, but they would not recover start-up and minimum load costs**

Bid Cost Recovery Overview (cont.)

If a resource submits **economic bids** and receives a market award, it becomes eligible for bid cost recovery because the market has chosen to start-up the resource. These SCs may receive a payment for bid cost recovery if they have a revenue shortfall.

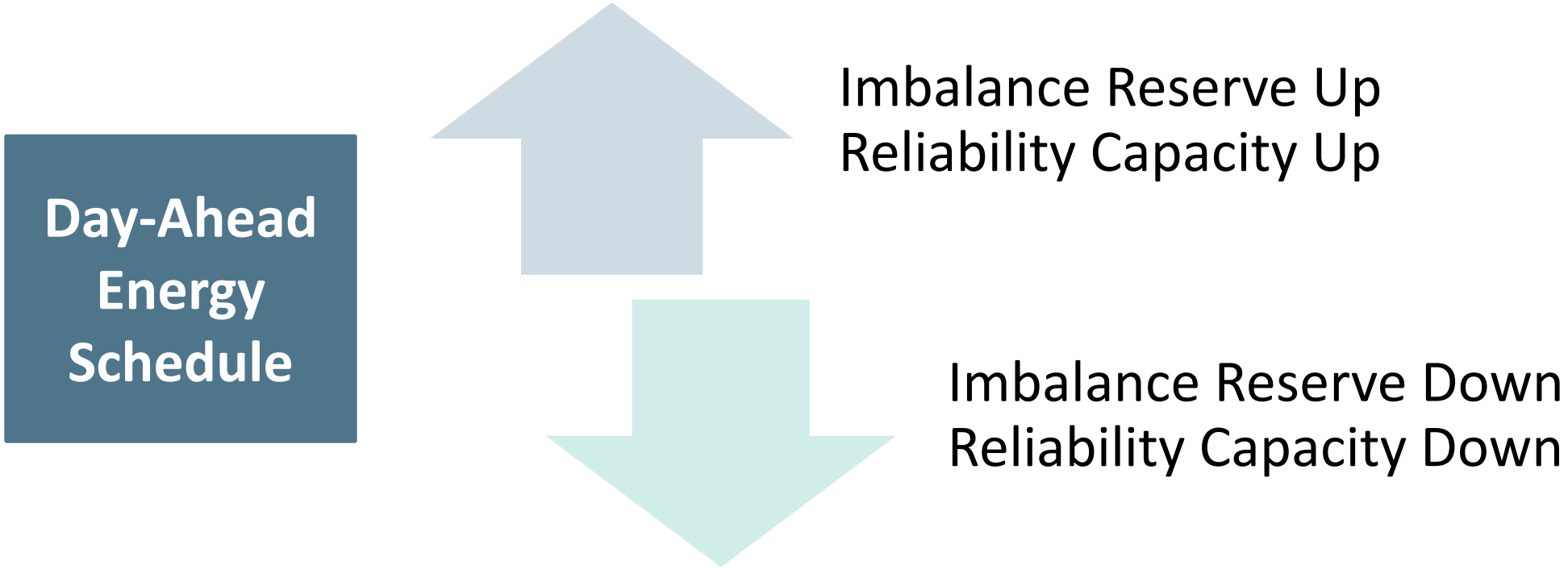


Nuances re: Self-provision of Ancillary Services (for EDAM BAAs)

- EDAM Entity determines amount and types of AS it requires for each hour of the trade date.
- EDAM SCs submit self-provided AS to meet EDAM Entity AS requirement.
  - Submissions contain MW quantity only, no price.
- No payment to resources for self-provision of AS.
- Used to ensure EDAM Entity has enough resources committed to meet AS requirements and pass the EDAM Resource Sufficiency Evaluation.

Impact of Capacity Awards on Day-Ahead Energy Schedules

A resource's awards in the day-ahead (EDAM) timeframe have a **must offer obligation** to submit bids for energy in real-time (WEIM) to cover the range of market awards. If the SC does not submit bids, the market will insert bids to ensure the resource meets its must offer obligation.



How does the day-ahead award affect a resource's real-time position?

- The Day-Ahead Market is a financial position only.
- Day-ahead awards directly affects the real-time position.
- Scheduling Coordinators are expected to deliver their day-ahead award in real-time or bid something else.
- Day-ahead awards for energy becomes a resource's day-ahead schedule. These MWs can be:
  1. Re-bid economically
  2. Bid as a self-schedule, or
  3. Submitted as a combination of self-schedule bids and economic bids.

EDAM Products and Services

Financial and physical resource capabilities determine how customers can participate in the Extended Day-Ahead Market.

Energy

- Physical supply and demand
- Virtual supply and demand (optional feature of EDAM)

Transmission

- Transfer Capacity Limit made available by EDAM Entities and EDAM SCs (transmission customers)

Capacity

- Ancillary Services (self-provided)
  - Regulation up & down
  - Spin & non-spin operating reserves
- Imbalance Reserves
- Reliability Capacity
- Flexible ramping product (Real-Time Market)

Awarded from Energy bids

Day-Ahead and Real-Time Market: Potential market outcomes

Day-ahead awards can be for:

- Energy
- Ancillary Services (self-provided for non-CAISO EDAM BAA)
- Imbalance Reserves
- Reliability Capacity

Real-time awards can be for:

- Energy
- Flexible Ramping Product

Changes that occur post day-ahead and pre real-time may trigger redispatch in the Real-Time Market.

Things to Keep in Mind

The **Security Constrained Unit Commitment** methodology maximizes economic efficiency, relieves network congestion, and considers physical constraints to achieve least-cost resource commitment and scheduling across the full 24-hours of the trade date.

A resource's awards in the day-ahead (EDAM) timeframe have a **must offer obligation** to submit bids for energy in real-time (WEIM) to cover the range of market awards. If the SC does not submit bids, the market will insert bids to ensure the resource meets its must offer obligation.

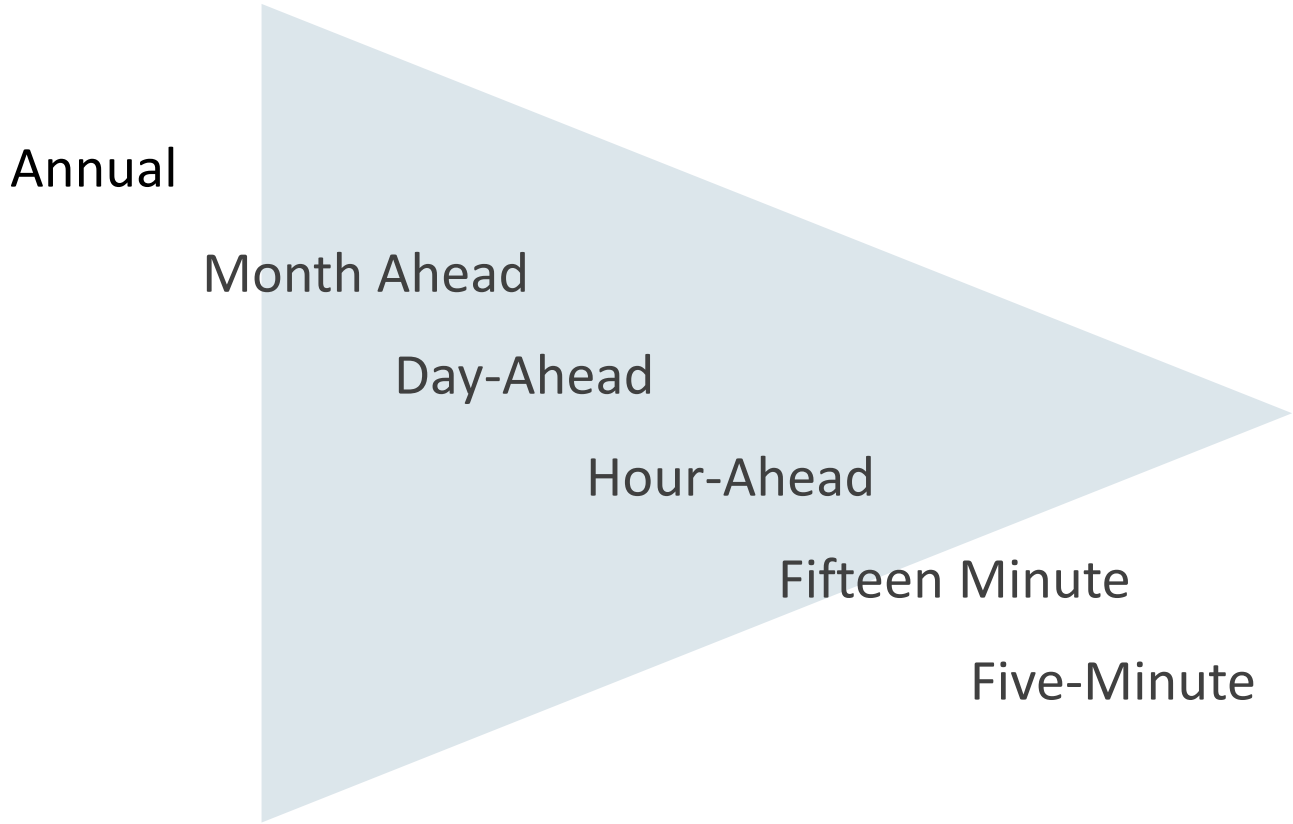
A unique aspect of **ancillary services** is that although they are included in the economic bid curve, the market will protect this capacity to be used as operating reserves for the EDAM Balancing Authority Area should the need arise.

SETTLEMENTS

Market Settlements

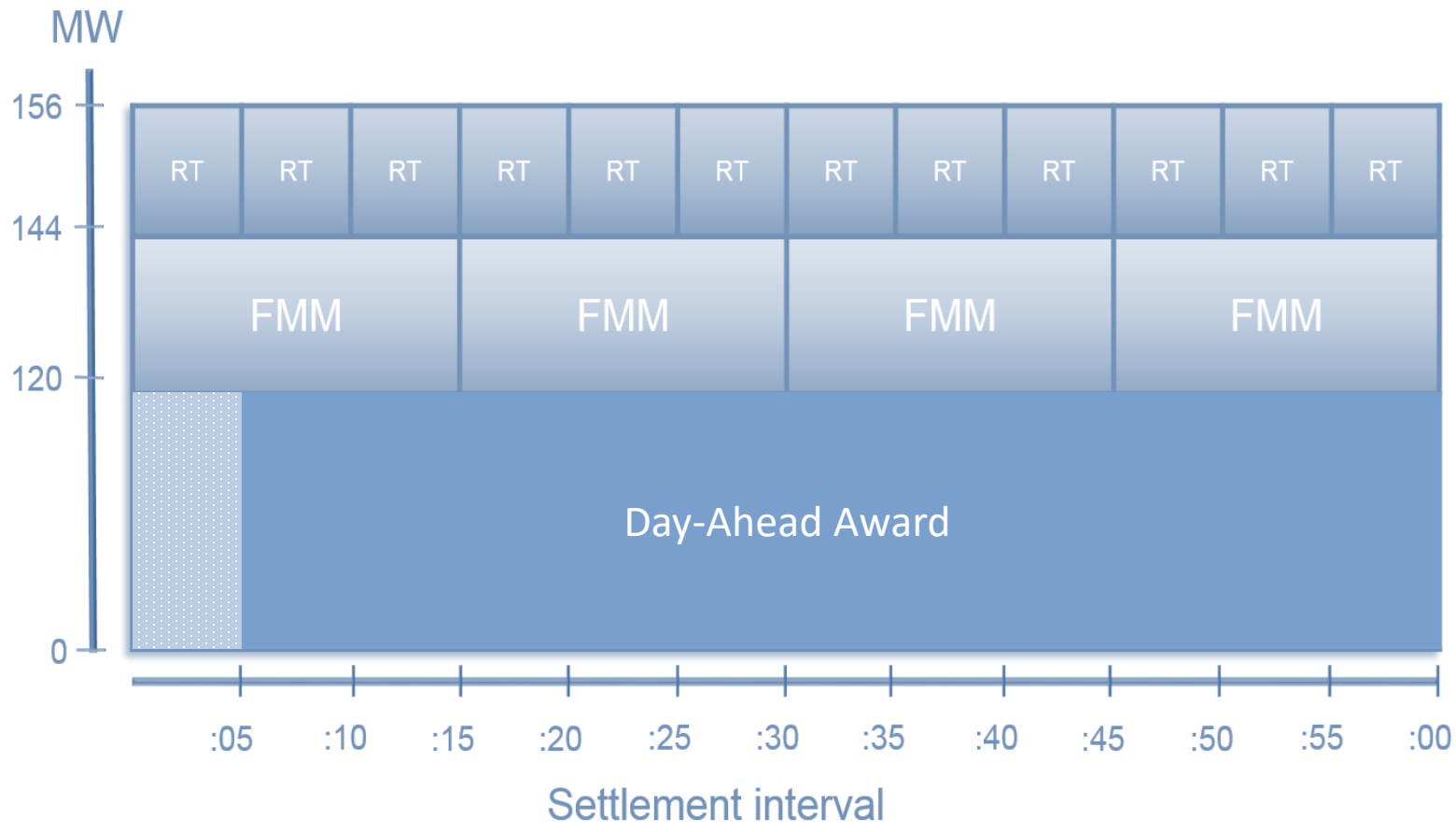
- ISO provides settlement services for both Day-Ahead and Real-Time energy markets
- Settlements are conducted with SCs representing market participants
- Applies to resources and loads that bid into and are awarded by the market
- Covers settlements for energy produced/consumed and associated charges
- ISO settles directly with EDAM entity SCs for certain transactions
- EDAM entities can allocate settlements within their own balancing area
- More details available in the EDAM entity's Tariff

Each transaction within the market is associated with a specific Scheduling Coordinator type, market activity, timeframe and charge code



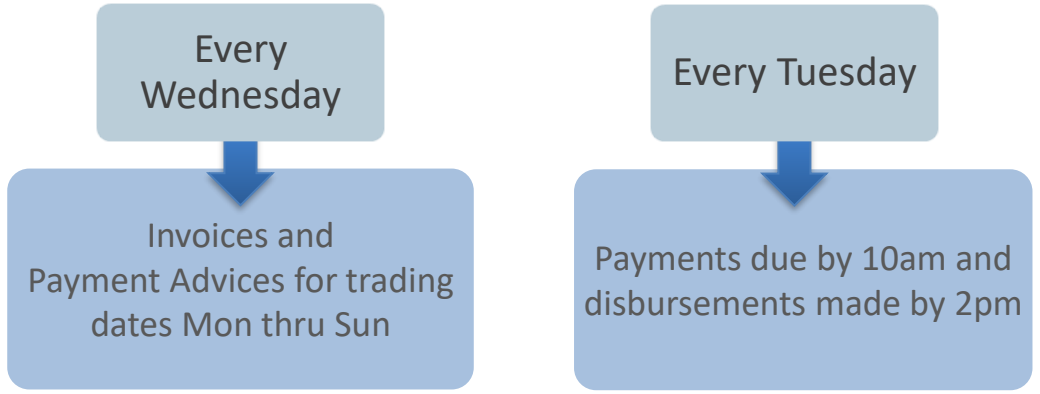
Energy settlements occur in day-ahead, the fifteen-minute and real-time markets

Energy settlements are calculated in 5-minute intervals

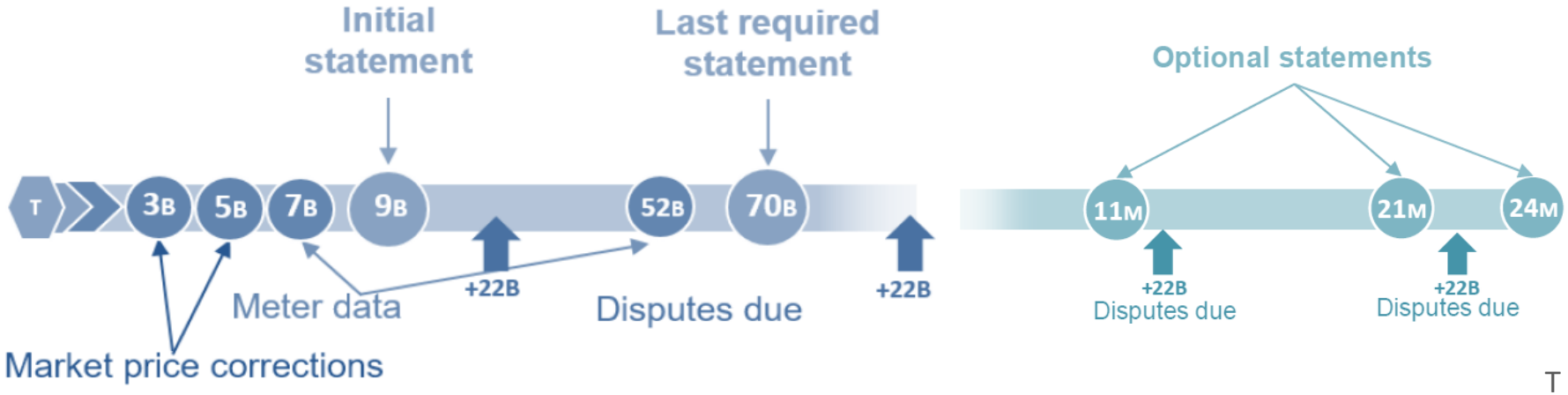


Key Settlement Dates

Invoices & payment advices



Settlement Timeline



T = Trade Date
B = Business Days
M = Months

Bidding and Settlements Examples

Simplified Bidding and Settlements Examples

Assumptions for Simplicity

- These examples assume hourly transactions and that the resource's meter data aligns with real-time dispatch instructions.

Actual Settlement Operations

- In practice, each hour is divided into 5-minute intervals.
- Market awards are compared against 5-minute meter data values for settlement accuracy.

Supply

Resources are compensated based on the Locational Marginal Price (LMP) associated with when the market award was issued:

- Day-Ahead Market (DAM)
- Real-Time Fifteen-Minute Market (FMM)
- Real-Time Five-Minute Dispatch (RTD)

Demand

Load is settled at a weighted average hourly real-time market price, based on:

- Four FMM prices
- Twelve RTD prices
- Deviations between DAM load and FMM forecast
- Deviations between FMM forecast and RTD forecast

Reminder: Accepted bids are paid the LMP not the bid price.

Scenario 1: Generator receives an energy award in DA and an incremental energy award in RT

Generator Characteristics

G1
Capacity: 90 MW

DA & RT Bids

MW	Price ($/MW)
50	$10
90	$20

Market Outcomes

Day-Ahead Market (EDAM) Results

Day-Ahead LMP = $15

Energy Award: 50 MW

Demand Increases

Real-Time Market (WEIM) Results

Real-Time LMP = **$20**

Energy Award: 90 MW
G1 Produces 90 MW

Market Settlements

Market	Amount (MW)	Price ($/MW)	Revenue ($)
Day-Ahead	50	15	750
Real-Time	90 – 50 = 40	20	800
			1,550

Generator Costs

Cost	Amount (MW)	Price ($/MW)	Amount ($)
Offer Segment 1	50	10	500
Offer Segment 2	40	20	800
			1,300

Profit **$1,550 (revenue) - $1,300 (costs) = $250**

Scenario 2: Generator receives an energy award in DA and a decremental energy award in RT

Generator Characteristics

G2
Capacity: 100 MW

DA & RT Bids

MW	Price ($/MW)
70	$5
100	$15

Market Outcomes

Day-Ahead Market (EDAM) Results

Day-Ahead LMP = $15

Energy Award: 100 MW

Demand Decreases

Real-Time Market (WEIM) Results

Real-Time LMP = **$10**

Energy Award: 70 MW
G2 Produces 70 MW & "Buys" 30 MW

Market Settlements

Market	Amount (MW)	Price ($/MW)	Revenue ($)
Day-Ahead	100	15	1,500
Real-Time (buy-back)	70 – 100 = (30)	10	(300)
			1,200

Generator Costs

Cost	Amount (MW)	Price ($/MW)	Amount ($)
Offer Segment 1	70	5	350
Offer Segment 2	0	15	0
			350

Profit **$1,200 (revenue) - $350 (costs) = $850**

Scenario 3: Generator receives no energy award in DA and an incremental energy award in RT

Generator Characteristics

G3
Capacity: 200 MW

DA & RT Bids

MW	Price ($/MW)
100	$40
200	$50

Market Outcomes

Day-Ahead Market (EDAM) Results

Day-Ahead LMP = $30

Energy Award: 0 MW

Demand Increases

Real-Time Market (WEIM) Results

Real-Time LMP = **$60**

Energy Award: 200 MW
G3 Produces 200 MW

Market Settlements

Market	Amount (MW)	Price ($/MW)	Revenue ($)
Day-Ahead	0	30	0
Real-Time	200 – 0 = 200	60	12,000
			12,000

Generator Costs

Cost	Amount (MW)	Price ($/MW)	Amount ($)
Offer Segment 1	100	40	4,000
Offer Segment 2	100	50	5,000
			9,000

Profit **$12,000 (revenue)** - **$9,000 (costs)** = **$3,000**

Scenario 4: Generator receives energy award in DA and self-schedules in RT

Generator Characteristics

G4
Capacity: 250 MW

DA & RT Bids

MW	Price ($/MW)
150	self-schedule
250	$30

Market Outcomes

Day-Ahead Market (EDAM) Results

Day-Ahead LMP = $20

Energy Award: 150 MW

Real-Time Market (WEIM) Results

Real-Time LMP = $25

Energy Award: 150 MW
G4 Produces 150 MW

Market Settlements

Market	Amount (MW)	Price ($/MW)	Revenue ($)
Day-Ahead	150	20	3,000
Real-Time	150 - 150 = 0	60	0
			3,000

Generator Costs

Cost	Amount (MW)	Price ($/MW)	Amount ($)
Offer Segment 1 (SS)	150	25	3,750
Offer Segment 2	0	30	0
			3,750

Profit $3,000 (revenue) - $3,750 (costs) = $(750)

Scenario 5: Load receives energy award in DA and increments in RT

Generator Characteristics

L1

RT Load: 250 MW

DA Bids

MW	Price ($/MW)
100	$40
250	$70

Market Outcomes

Day-Ahead Market (EDAM) Results

Day-Ahead LMP = $50

Energy Award: 100 MW

Real-Time Market (WEIM) Results

Real-Time LMP = $60

L1 Meter Value 250 MW

Market Settlements

Market	Amount (MW)	Price ($/MW)	Payment ($)
Day-Ahead	(100)	50	(5,000)
Real-Time	100 - 250 = (150)	60	(9,000)
			(16,000)

Scenario 6: Load receives energy award in DA and decrements in RT

Generator Characteristics

L2

RT Load: 100 MW

DA Bids

MW	Price ($/MW)
100	$20
150	$30

Market Outcomes

Day-Ahead Market (EDAM) Results

Day-Ahead LMP = $30

Energy Award: 150 MW

Real-Time Market (WEIM) Results

Real-Time LMP = $25

L2 Meter Value 100 MW

Market Settlements

Market	Amount (MW)	Price ($/MW)	Payment ($)
Day-Ahead	(150)	30	(4,500)
Real-Time (sell-back)	150 - 100 = 50	25	1,250
			(3,250)

CAISO Market Design & Potential Future Topics

- Convergence Bidding
- Ancillary Services
- Congestion Revenue Rights

Intro & ISO Overview | Market Pricing | WEIM Overview | EDAM Overview | Day-Ahead Processes & Timelines | Bidding & Settlements | Examples | Convergence Bidding | Ancillary Services | Congestion Revenue Rights

CAISO Market Design & Potential Future Topics

This section introduces elements of the CAISO market design that currently apply to the **CAISO Balancing Authority Area only**

These design features are not part of the WEIM or EDAM frameworks today, but they may be considered as future enhancements*

Our aim is to familiarize you with these concepts so that you can recognize and understand them if they emerge in future discussions or proposals

*Convergence bidding is currently an optional feature of EDAM

CAISO Market Design & Potential Future Topics

Convergence Bidding

Convergence Bidding

Economic bids and self-schedule bids for physical energy can be submitted in the Day-Ahead Market by SCs for supply or demand. **Convergence bids** can be submitted for **virtual supply** and/or **virtual demand**.

Convergence, or virtual, bidding indicates **financial participation in the Day-Ahead Market** and is an **optional feature of EDAM**. EDAM entities can elect whether to enable convergence bidding in their areas. Only certified convergence bidders may submit virtual energy bids.

Convergence bidding SCs take a financial position in the Day-Ahead Market by submitting **virtual supply** or **virtual demand** bids based on their prediction of differences between day-ahead and real-time prices. These positions are settled in the Real-Time Market based on actual conditions.

Convergence Bidding: **financial** participation in the market

Virtual Demand

- A bidder submits a bid to buy MW in the Day-Ahead Market
- Assuming the bid clears, the bidder will pay the day-ahead price for the MW
- The Real-Time Market automatically sells the MW and the bidder will be paid at the real-time price

Virtual Supply

- A bidder submits a bid to sell MW in the Day-Ahead Market
- Assuming the bid clears, the bidder will be paid the day-ahead price for the MW
- The Real-Time Market automatically buys the MW and the bidder will pay the real-time price

Financial participation only – not associated with physical resources

Why does convergence bidding exist and what are the benefits?

Convergence bidding benefits the market as well as participants

Market

- Increases market liquidity
- Lowers costs and improved grid operations due to more efficient day-ahead commitment
- Minimizes differences between day-ahead & fifteen-minute prices

Participant

- Mitigates the risk impact of an outage that happens after the close of the day-ahead market
- Hedges against exposure to fifteen-minute market pricing for load
- Earns revenues or risk losses between the day-ahead and fifteen-minute prices

Day-Ahead Convergence Bidding Settlement

Virtual
(Convergence Bidder)

Total virtual **supply** awards =
Sum of virtual supply bid segments* X LMP

Total virtual **demand** awards =
Sum of virtual demand bid segments* X LMP

* Only segments that cleared in the IFM

Per trading hour:

Total virtual supply awards

+ Total virtual demand awards

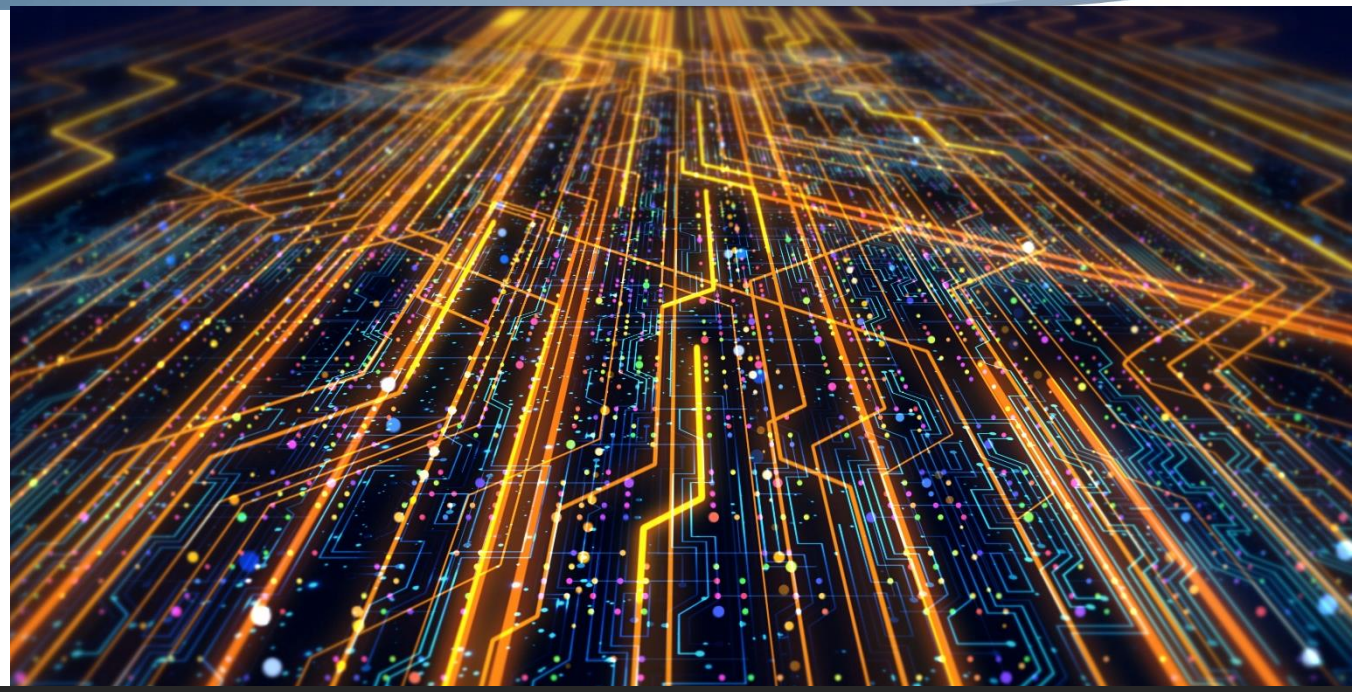
Total settlement amount for virtual awards

Example: Convergence Bidding Settlement

Virtual
(Convergence Bidder)

Day-Ahead	Quantity Bid	Bid Price	Market Clearing Price	Award	Total Virtual Award
Supply	Sell 10 MW	$30	$30	Paid $300	
Demand	Buy 15 MW	$20	$20	Charged $300	
					Paid $0
Real-Time	**Quantity Liquidated**	**Bid Price**	**Avg of FMM prices**	**Settlement**	
Supply	Buy 10 MW		$27	Charged $270	
Demand	Sell 15 MW		$20	Paid $300	
					Paid $30
					Net $30

Day-Ahead Awards are an hourly LMP, Real-Time liquidates at the average of the 4 Fifteen-Minute Market LMPs.



CAISO Market Design & Potential Future Topics

Ancillary Services

Intro & ISO Overview | Market Pricing | WEIM Overview | EDAM Overview | Day-Ahead Processes & Timelines | Bidding & Settlements | Examples | Convergence Bidding | **Ancillary Services** | Congestion Revenue Rights

Ancillary Services

Ancillary Services Responsibilities

- Each BAA is responsible for procuring and managing ancillary services.
- BAAs fulfill these needs through a combination of self-supply, bilateral contracts, and market mechanisms (varies by BAA structure).

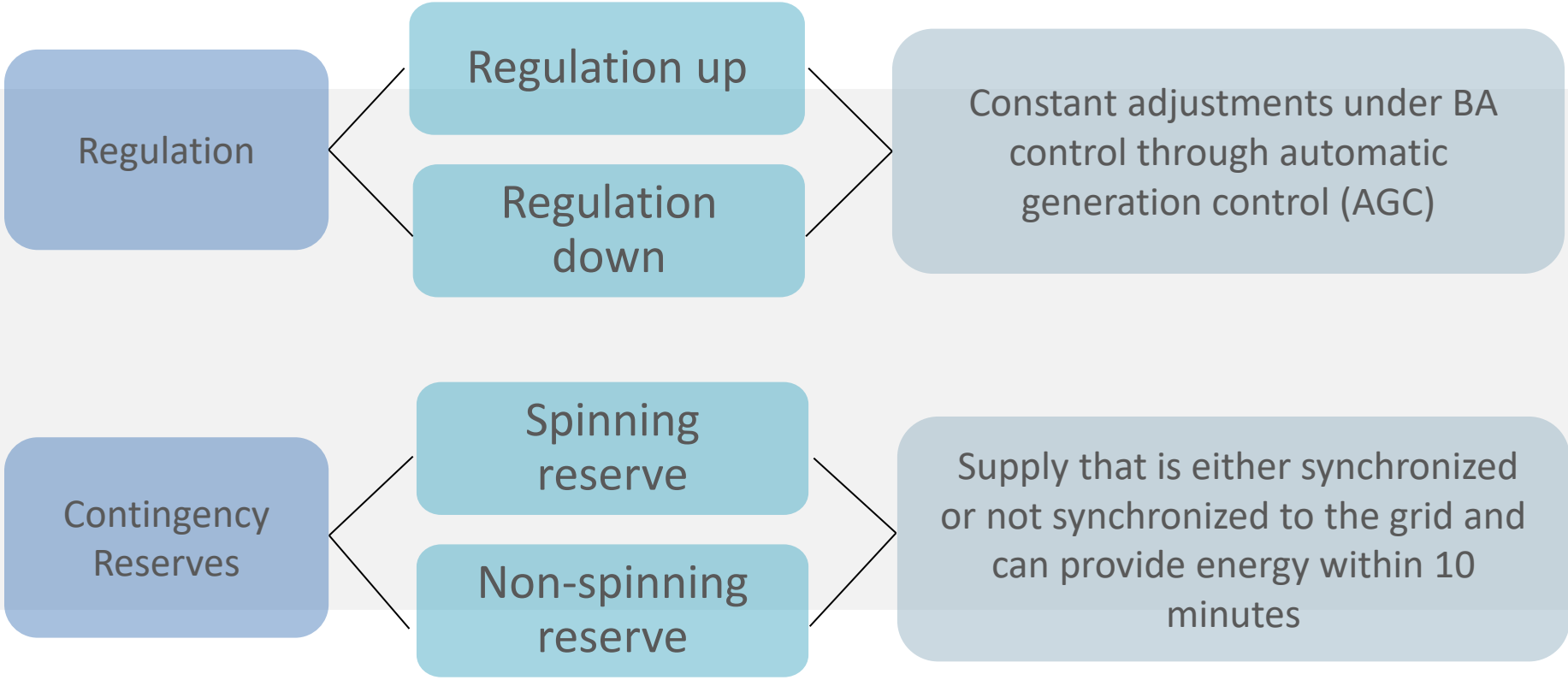
Market Participation and Coordination

- CAISO is the only WEIM BAA that procures ancillary services through a centralized market.
- Some BAAs participate in reserve sharing groups to pool resources and reduce individual reserve requirements.

Compensation for Ancillary Services in the CAISO BAA

- SCs are compensated for Day-Ahead and Real-Time ancillary services capacity at the Ancillary Services Marginal Price for each product.
- Day-Ahead awards for ancillary services are submitted as energy bids in the Real-Time Market.
- When these energy bids are awarded in Real-Time, SCs are paid the Real-Time LMP.

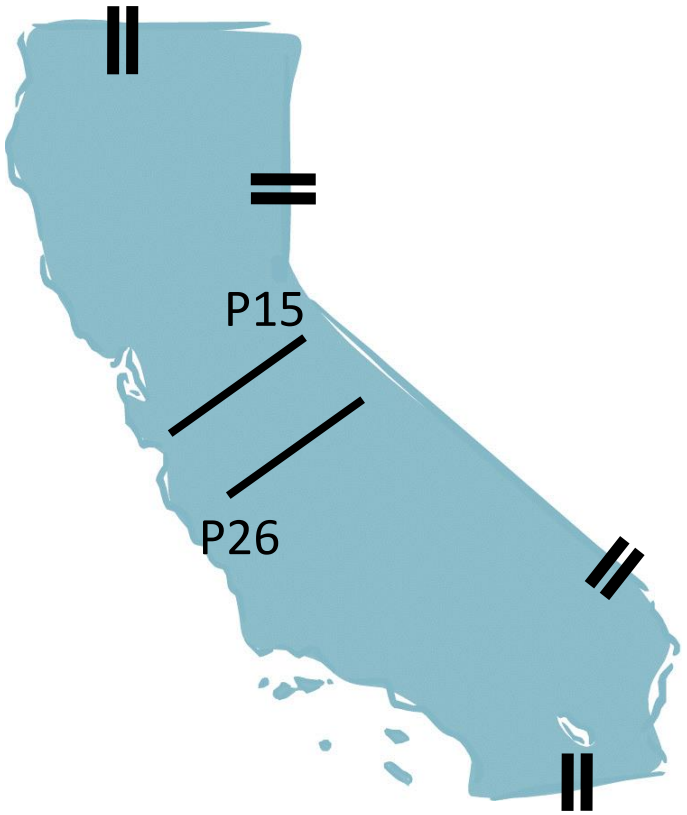
Ancillary services (AS) ensure reliability as electricity is moved from generating sources to customers



Ancillary service procurement within the CAISO BAA is regional

Two overlapping system regions to ensure reliability
- ISO system region
- ISO expanded system region

Eight sub regions
- North of Path 15 & 26 + expanded northern region
- South of Path 15 & 26 + expanded southern region



Procurement targets are set by the CAISO to meet WECC standards.

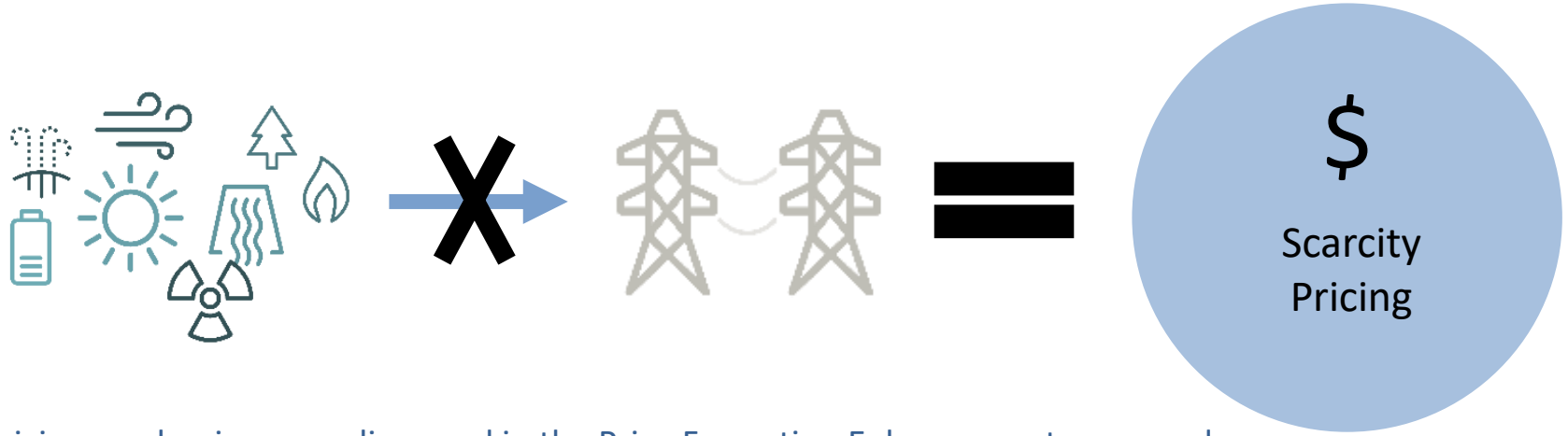
Scarcity pricing reflects the high value of electricity during times when the grid is under stress—such as during peak demand or limited supply.

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

CAISO currently employs several mechanisms related to scarcity pricing to reflect tight supply conditions and incentivize market participants to respond in ways that maintain grid reliability.

For example, the Scarcity Reserve Demand Curve adjusts ancillary service prices along several tiers*

- Automatically increases prices during shortages to reflect rising procurement costs.
- Influences energy prices through opportunity cost of reserve capacity.
- (CAISO is the only WEIM BA that procures ancillary services through the market)



*Other scarcity pricing mechanisms are discussed in the Price Formation Enhancements proposal.

CAISO Market Design & Potential Future Topics

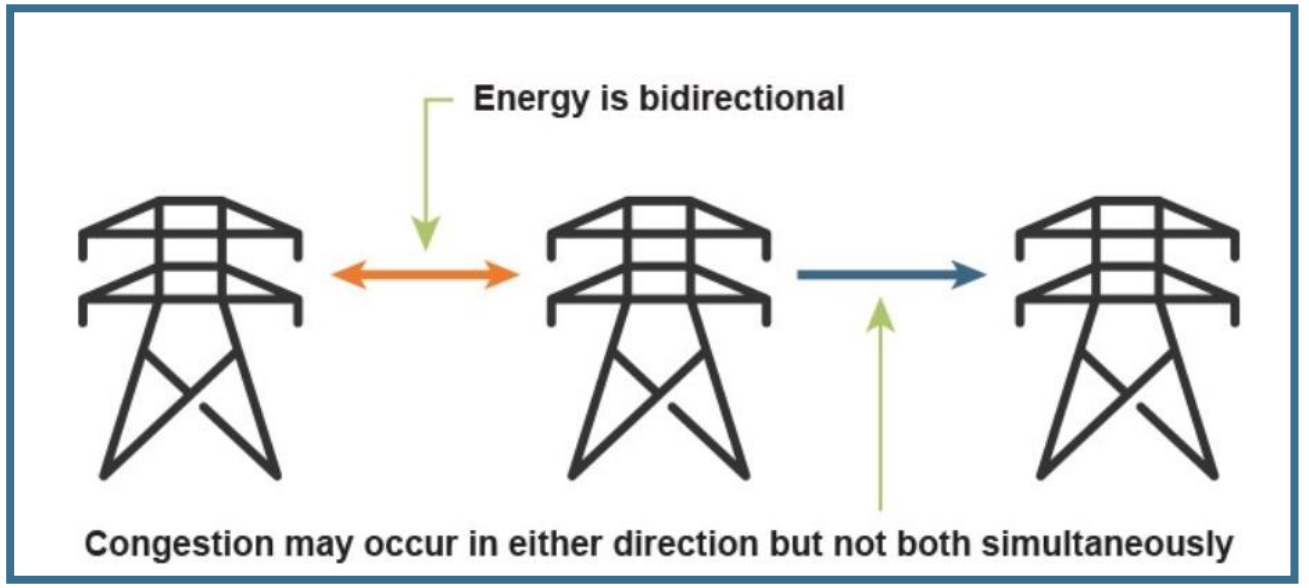
- Congestion Revenue Rights

Intro & ISO Overview | Market Pricing | WEIM Overview | EDAM Overview | Day-Ahead Processes & Timelines | Bidding & Settlements | Examples | Convergence Bidding | Ancillary Services | Congestion Revenue Rights

Let’s revisit the topic of congestion

Congestion in the Day-Ahead Market occurs when there is insufficient available transmission capacity to accommodate all energy schedules simultaneously.

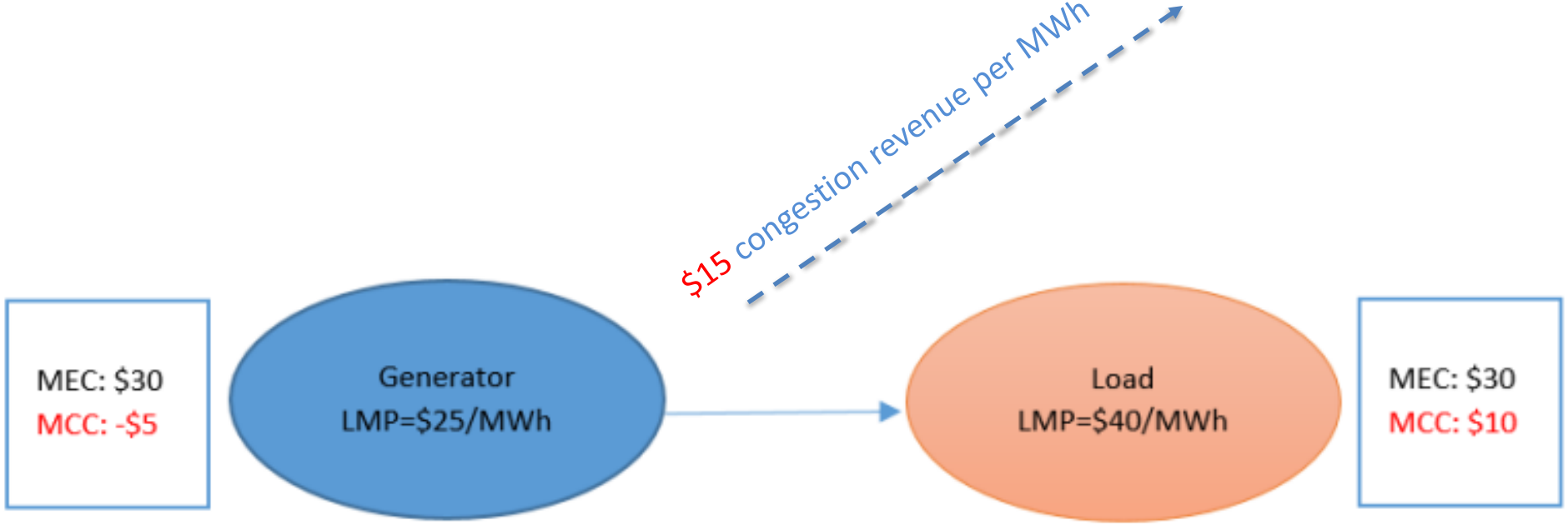
Energy exchanged in the Day-Ahead Market is not directionally dependent, but all congestion is. Insufficient transmission capacity may occur in a specific direction.



What is congestion revenue?

- Locational Marginal Price (LMP) components:
  - Marginal energy component (MEC)
  - Marginal congestion component (MCC)
  - Marginal losses component (MLC)

Congestion revenue is the money accrued when energy transactions are settled at congestion prices (MCC)



What are CRRs?

Congestion Revenue Rights (CRRs) are financial instruments used in the CAISO BA to manage variability in congestion costs that occur under day-ahead Locational Marginal Pricing (LMP).

Discussions are underway in the policy phase on whether or how to incorporate CRRs into EDAM in the future. The ISO has a collaborative stakeholder process to explore this and other topics.

CRRs are acquired by:

1. ISO allocation to Load Serving Entities (LSEs)
2. Auction to any qualified entities whose bids are awarded CRRs

CRR Types

CRR OBLIGATION

- The holder is paid if congestion is in the same direction of the CRR
- The holder is charged if congestion is in the opposite direction of the CRR
- Acquired through allocation or auction

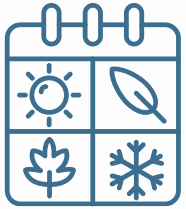
CRR OPTION

- Holder is paid if congestion is in the same direction of the CRR
- No payment or charge if congestion is in the opposite direction of the CRR
- available to project sponsors of a merchant transmission facility that do not elect some form of regulatory cost recovery, or converted merchant transmission facilities.

Four CRR Terms

Monthly CRR

A CRR acquired for one calendar month. Monthly CRRs are made available on a Time-Of-use (TOU) basis.



Seasonal CRR

A CRR acquired through the annual allocation or auction process that has a term of one season and is either on or off peak.

Seasons are defined as:

Season 1: Jan, Feb, March
Season 2: April, May, June
Season 3: July, Aug, Sept
Season 4: Oct, Nov, Dec.

Long-Term CRR

One of the tiers in the annual allocation process is the Long-Term (LT). The first year will be awarded as a seasonal CRR, the remaining 9 years will be awarded as an LT CRR.

Merchant Transmission

The Merchant Transmission CRR has a term of 30 years or the pre-specified intended life of the facility, whichever is less. The acquisition of the Merchant Transmission CRR is performed through a separate process.

Source and Sink

- A **source**, or injection occurs when available energy is added to the CAISO grid.
- A **sink** is the opposite. It is a withdrawal of energy from the CAISO grid.
- Each of the **source**/**sink** pairs creates flow on the operating constraints of the Full Network Model (FNM).
- The injection and withdrawal megawatts (MW) should be balanced in the CRR model.

Simultaneous Feasibility Test (SFT)

The SFT is used to ensure the ISO is issuing CRRs related to feasibility of flow based on network constraints.

The STF takes the CRR source(s) location, the CRR sink(s) location and MW quantity(s) of the CRR nomination (allocation) or CRR bid (auction) and applies these to the FNM as if they were generator(s) and load(s).

The FNM used is similar to the model used in the Day-ahead market including topology and constraints limits.

CRR Allocation Overview

- The ISO may allocate (give) a CRR without cost to qualified entities.
  - Qualified entities are limited to internal LSEs and qualified Out-of-Balancing Authority Area Load Serving Entities (OBAALSEs) that meet specific requirements for participation in the CRR allocation process.
  - Qualifications for LSEs are based on eligible load, while qualifications for OBAALSEs are based on eligible load and contracts.

CRR Allocation Process

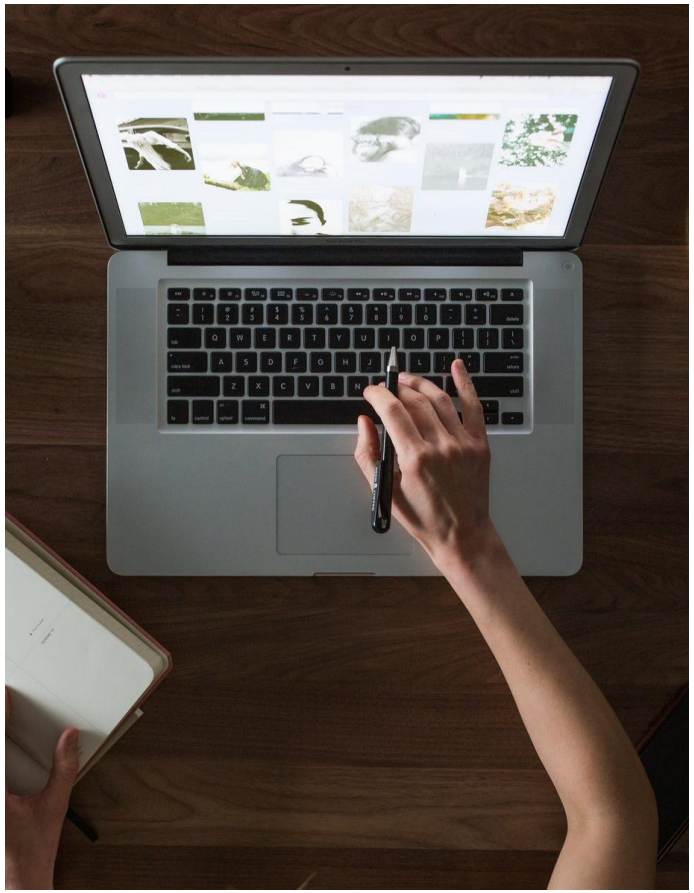
The ISO allocates CRRs through monthly and annual processes. Approximately 30 days before the start of the operational month, the monthly allocation process starts. The annual allocation/auction process begins approximately 4 months before the start of the CRR year.

In the **monthly** allocation process:

- Eligible MW quantity is based on forecasted load data
- Outages are modeled in this monthly process

In the **annual** allocation process:

- Eligible MW quantity is based on historic load data
- Outages are not modeled as all lines are assumed to be in-service unless a long-term outage is known prior to the running of the annual process



CRR Auction Overview

- CRRs that are not allocated are put up for auction. After the monthly and annual allocation processes, qualified entities interested in acquiring CRRs may submit a bid through an annual and/or monthly auction.*

- Some entities may also acquire CRRs from CRR Holders through the Secondary Registration System (SRS) where CRRs are traded bilaterally.

*The annual auction will not include Long Term CRRs

Auction Clearing Prices: **Buy** Offers

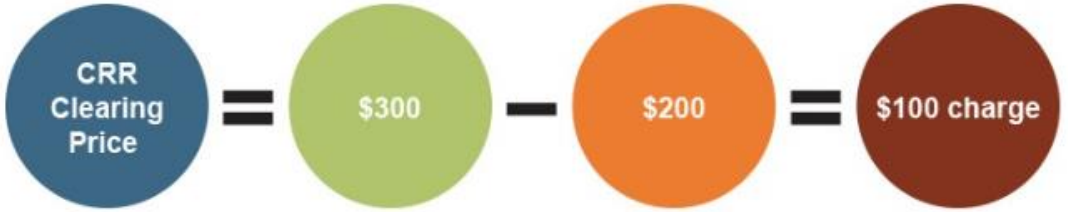
All CRR APNode Market Clearing Prices (MCPs) will be published after each market.

In general, the CRR clearing price is the MCP at the source/injection minus the MCP at the sink/withdrawal.

For Buy Offers:

- A positive value is a charge to the bidder.
- A negative value is a payment to the bidder.

A Buy Offer may look like this:



Auction Clearing Prices: **Sell** Offers

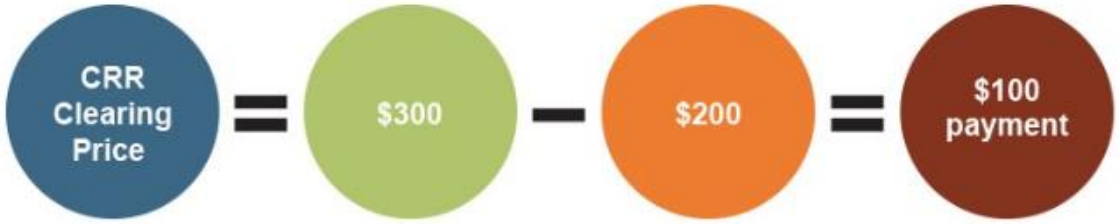
All CRR APNode Market Clearing Prices (MCPs) will be published after each market.

In general, the CRR clearing price is the MCP at the source/injection minus the MCP at the sink/withdrawal.

For Sell Offers:

- A positive value is a payment to the seller.
- A negative value is a charge to the seller.

A Sell Offer may look like this:



Conclusion

End of day summary, Q&A

Let’s revisit today’s agenda topics:

Introduction & CAISO Overview

- ✓ Safety Briefing
- ✓ Welcome and Overview of Agenda
- ✓ Group Introductions
- ✓ ISO Overview (Key Terms & Functions)

Navigating CAISO Markets

- ✓ Locational Marginal Pricing (LMP)
- ✓ WEIM Overview
- ✓ EDAM Overview
- ✓ Day-Ahead Market Processes & Timelines

Bidding & Settlements

- ✓ Resolution of Day-Ahead Positions in Real-Time
- ✓ Settlements
- ✓ Bidding Examples

Overlook Tour & Lunch

CAISO Market Design & Potential Future Topics

- ✓ Convergence Bidding
- ✓ Ancillary Services
- ✓ Congestion Revenue Rights

What questions do you have?

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