EIM Stakeholder Meeting Appendix: How the EIM Works

July 24, 2018

Rates Hearing Room

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- Links to additional resources are available at the end of this presentation

Overview

- What is the EIM
- Roles and Definitions
- Market Activities
- Base Schedules + Bids + Market Timing
- BAA Sufficiency Tests
- Settlements

What is the EIM?

What is the EIM?

- The EIM is a **real-time** centralized **energy** market used to **economically** and **securely** dispatch **participating resources** to **efficiently** balance supply, transfers between participating balancing authority areas (**EIM Entities**), and load across the market's footprint (**EIM Area**).

- The EIM does this **every 5-minutes**!

What is the EIM?

- EIM's priority is to serve load at the lowest possible cost (**Economic Dispatch**).

- It does so while simultaneously ensuring generation, and transmission limitations are respected (**Security Constrained**).

- It utilizes **Bid Ranges** (INC/DEC) from voluntarily offered **participating resources** to come up with the most economical and **reliable/secure** solution of generation to meet load and interchange demands.

- Reliability actions are not penalized (if communicated correctly)

What is the EIM?

- Extension of the CAISO's Real-Time Market (**RTM**) to participating Balancing Authority Areas (**EIM Entities**)
- What is included in EIM?
  - Unit commitment for short start resources
  - Congestion management
  - 15min market (RTPD or FMM)
  - 5min dispatch (RTD)
- What is not included in EIM?
  - Capacity Ancillary Services (regulation, spin, non-spin)
  - Contingency Dispatch

What is the EIM?

- The EIM uses a **State Estimator** solution of the Western Interconnection in addition to information provided by EIM Entities and Participating Resources
- A **S**ecurity **C**onstrained **E**conomic **D**ispatch (SCED) computational software engine determines locational prices and resource dispatches based on all of the underlying data
- **Forward looking** congestion management
- Will respond to forced and planned outages
- Critical that the market has accurate information (network model, outages, forecasts, base schedules, etc.)
- 15 minute advisory market awards published for 8+ intervals (2 hours)
- 5 minute advisory market awards published for 12 + intervals (1 hour)

EIM Summary

What an EIM IS:	What an EIM is NOT:

What an EIM IS:

- An intra-hour **real-time** energy market to serve load and imbalance across participating Balancing Authorities (EIM Entities) and the CAISO (a.k.a. the EIM Area)

- A tool for centralized 5-minute dispatch of generators that have been **voluntarily** offered to the market (at a price)

- **Economically dispatches** offered resources

- **Security-constrained**, meaning transmission and reliability constraints are not exceeded, improving grid reliability, reducing energy supply cost and enhancing integration of renewable resources
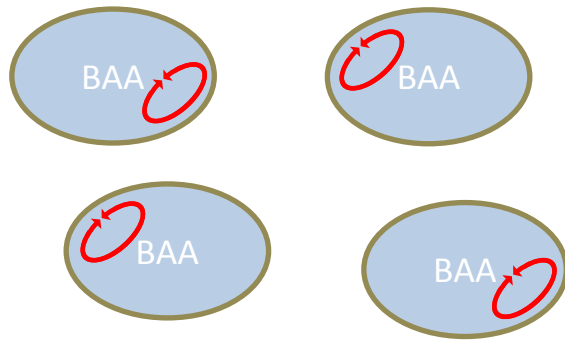
What an EIM is NOT:

- An RTO (with planning, day-ahead markets, BA consolidation)

- A centralized unit commitment tool

- A capacity market

- A replacement for the current contractual bi-lateral business structure
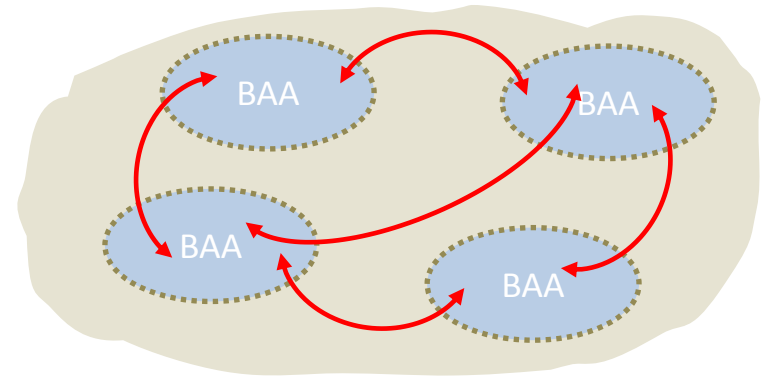
EIM Summary

Without EIM:
Each BA must balance loads and resources within its borders.

With EIM:
The market dispatches resources across BAAs to balance demand


EIM Benefits

- Reduce costs by serving imbalance and load from most economic resources

- Enhances reliability by improving system visibility and responsiveness to planned and unplanned events

- Results in more efficient dispatch of resources within/between BAAs

- Leverages geographical diversity of loads and resources in the market footprint

- Congestion Management

Are these EIM things new?

- Nope! They've been around for years. They aren't always called an EIM, but most organized energy markets (RTOs/ISOs) run a regional SCED based 5-minute market
  - PJM (RT SCED)
  - MISO (Real-Time and Operating Reserves Market)
  - SPP (Energy Imbalance Service)
  - NYISO (Real-Time Market)
  - ISO-NE (Real-Time Energy Market)
  - ERCOT (Real-Time Market)
  - CAISO (Real-Time Market)
- WECC is one of the last regions
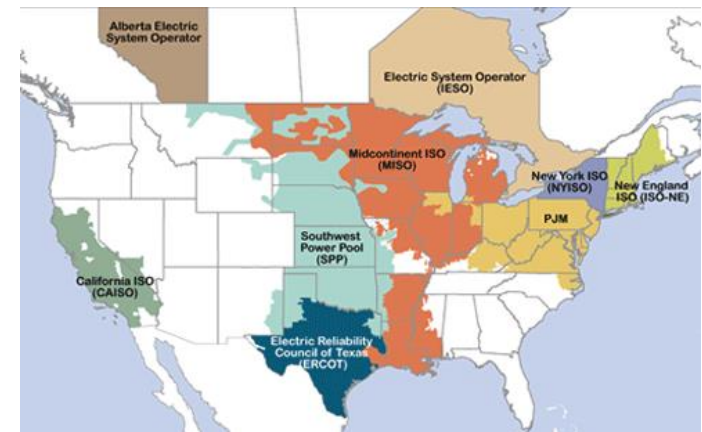
EIM Area

- Currently includes the CAISO plus **eight** EIM Entities (PACE, PACW, NVE, PSE, APS, PGE, IPCO, PWX/BCHA)

- SMUD – April 2019

- SCL/SRP/LDWP – April 2020
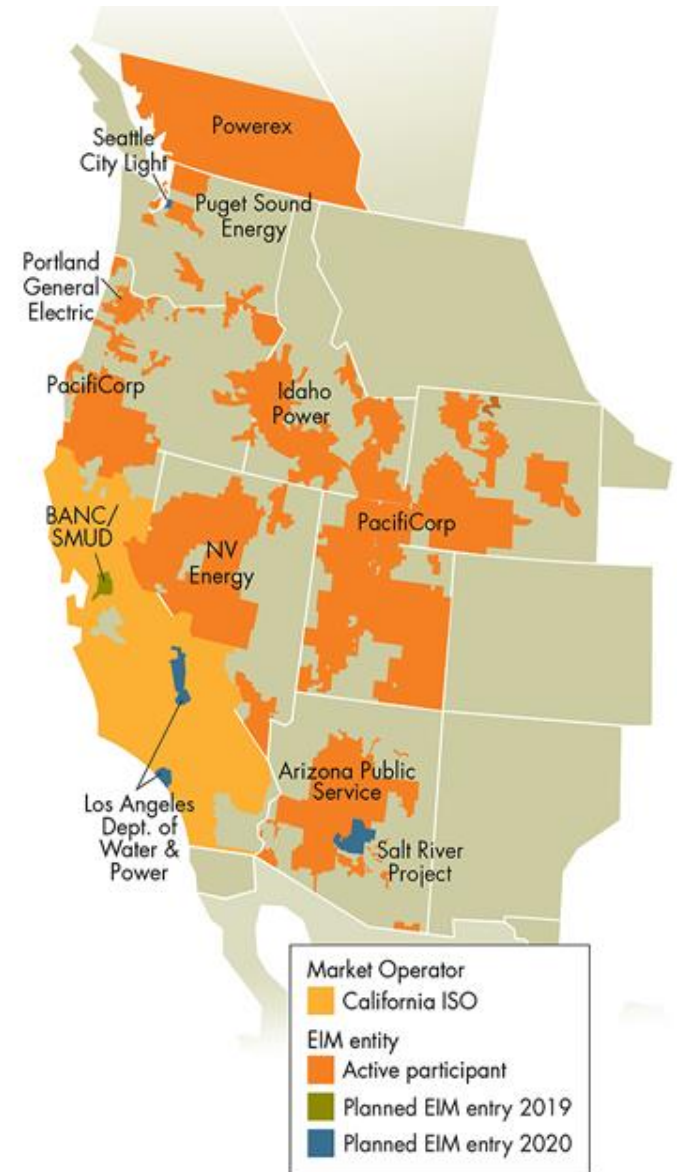
Transmission

EIM Transfer Schedules

- The EIM uses **dynamic schedules** to transfer energy between EIM BAAs

  – One exception is on the COI where separate 15-minute normal schedules and 5-minute dynamic schedules are used due to DTC issues

- The EIM Transfer for an EIM BAA is an algebraic quantity (positive for export and negative for import) for the *NET* energy exchange between a given BAA and the remaining BAAs in the EIM Area facilitated by the EIM

https://www.caiso.com/Documents/TechnicalPaper-EnergyImbalanceMarket-EnergyTransferScheduling.pdf

Energy Transfer System Resources (ETSR)

- System Resources are defined in each EIM BAA to anchor the Energy Transfer schedules from that BAA to other BAAs in the EIM Area for tracking, tagging, and settlement.
  - Analogous to a Source or Sink on an e-Tag
- ETSRs are defined as aggregate resources at the EIM BAA Default Generation Aggregation Point (DGAP), which is an aggregation of all supply resources in the BAA.
- Each ETSR is defined as either an import or an export resource, and it is associated with an EIM intertie with another EIM BAA, or a CISO intertie with the CISO.

EIM Transfers (Today)

- Transfers between EIM Entities are currently limited to these transfer paths

- EIM will facilitate **wheeling** of EIM energy through EIM Entities (e.g., CAISO → NVE → PACE → PACW) when more efficient transmission paths are constrained
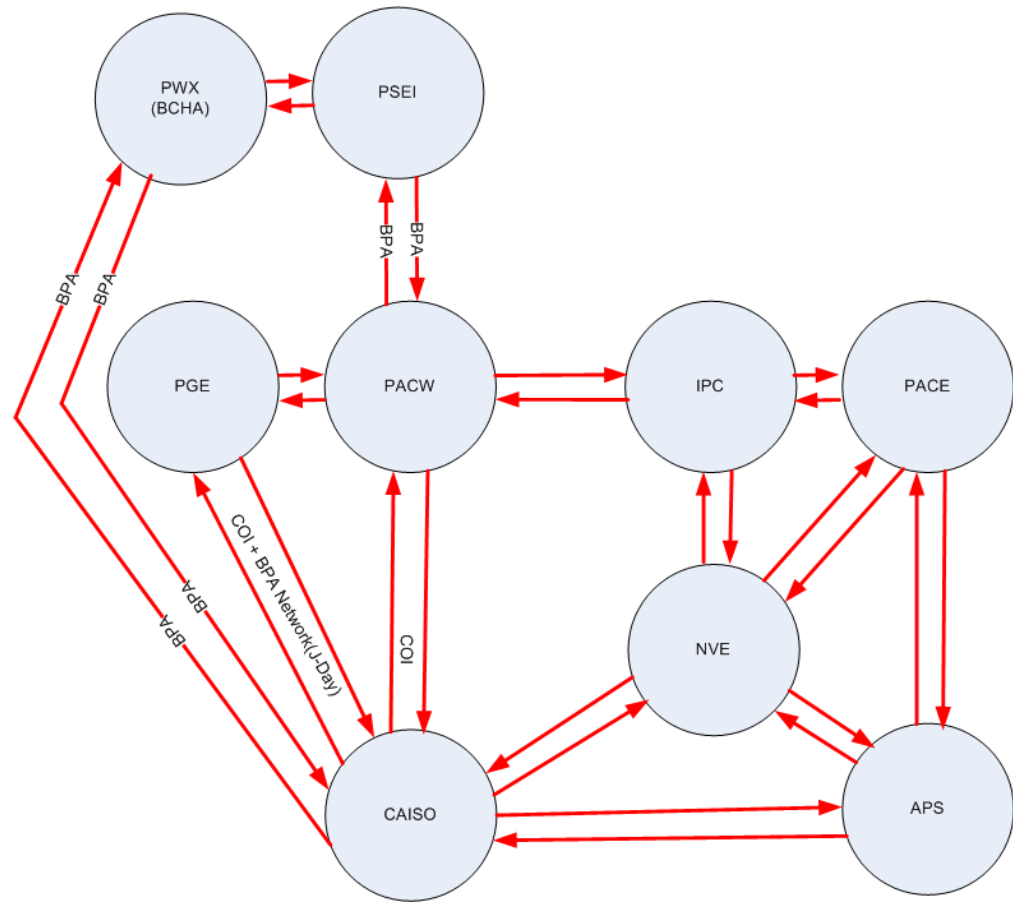
Roles and Definitions

Roles and Definitions

- **Energy Imbalance Market (EIM)** is operation of the ISO's real-time market to manage transmission congestion and optimize procurement of energy to balance supply and demand for the CISO and EIM BAAs combined (EIM Area)

- **Market Operator** is the CAISO

Roles and Definitions

- **EIM Entity** is a BAA that

  - Represents one or more Transmission Service Providers that make transmission available for EIM

  - Enters into the pro forma EIM Implementation Agreement to enable the EIM in its BAA

  - Determines the resources and the transmission service required for eligibility to participate in the EIM

  - By enabling the EIM, real-time load and generation imbalances within the EIM BAA will be settled through the EIM

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Roles and Definitions

- **EIM Participating Resource (EIMPR)** is a resource located within the EIM Entity BAA that
  - Is eligible and elects to participate in the EIM
  - Enters into the pro forma EIM Participating Resource Agreement
  - Receives 15-minute schedule and 5-minute dispatch
- **EIM Non-Participating Resource (EIMNPR)** is a resource that elects to not participate in the EIM
  - Hourly resource and import/export schedules

Roles and Definitions

- **EIM Entity Scheduling Coordinator** is the EIM Entity (or a designated third-party) that
  - Is certified by the ISO
  - Enters into the pro forma EIM Entity Scheduling Coordinator Agreement, under which it is responsible for
    - Approving resource plans for the EIM Entity BAA
    - Uninstructed imbalance energy settlement of resources not participating in EIM
    - Distributing costs or revenues from uplift allocations to the EIM Entity BAA

Roles and Definitions

- **EIM Participating Resource Scheduling Coordinator** is the participating resource (or a designated third-party) that
  - Is certified by the ISO
  - Enters into the pro forma EIM Participating Resource Scheduling Coordinator Agreement
  - Interfaces with the Market Operator to
    - Submit resource plans
    - Receive dispatch instructions and market awards
    - Receive settlement statements and bills

Roles and Definitions

- **EIM Transmission Service Provider** is a transmission owner or customer (may be a 3rd party separate from the EIM Entity) that
  - Controls transmission in the EIM Entity BAA
  - Can voluntarily inform the EIM Entity that it is making its transmission available for EIM
- **EIM Transfer** is an exchange of real-time energy between a BAA in the EIM Area and the rest of the EIM Area using transmission capacity made available for the EIM
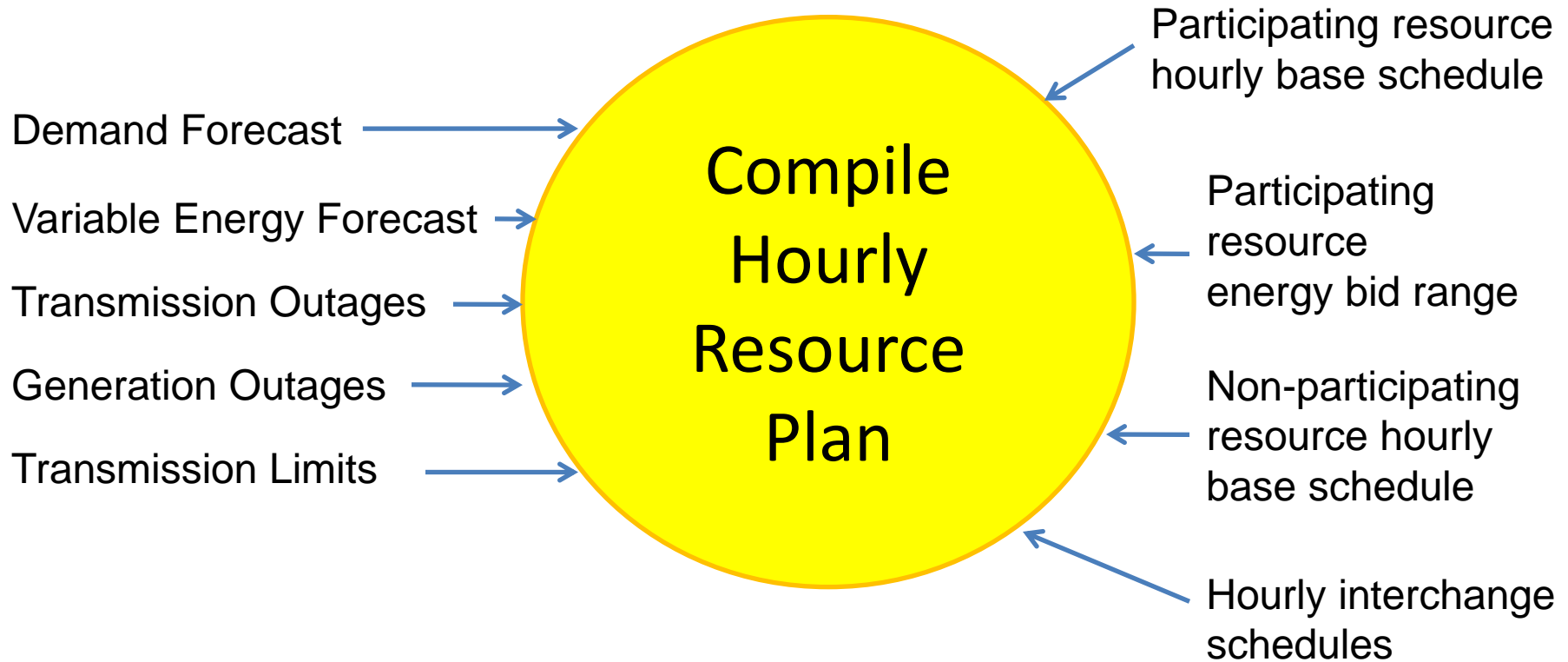
Roles and Definitions

- **Base Schedule** is a forward hourly energy schedule
  - It is the **reference for measuring imbalance deviations** for EIM settlement
  - It includes generation and interchange schedules, and load forecast
- **Resource Plan** is the combination of
  - Base schedules
  - Energy bids
  - Ancillary services schedules
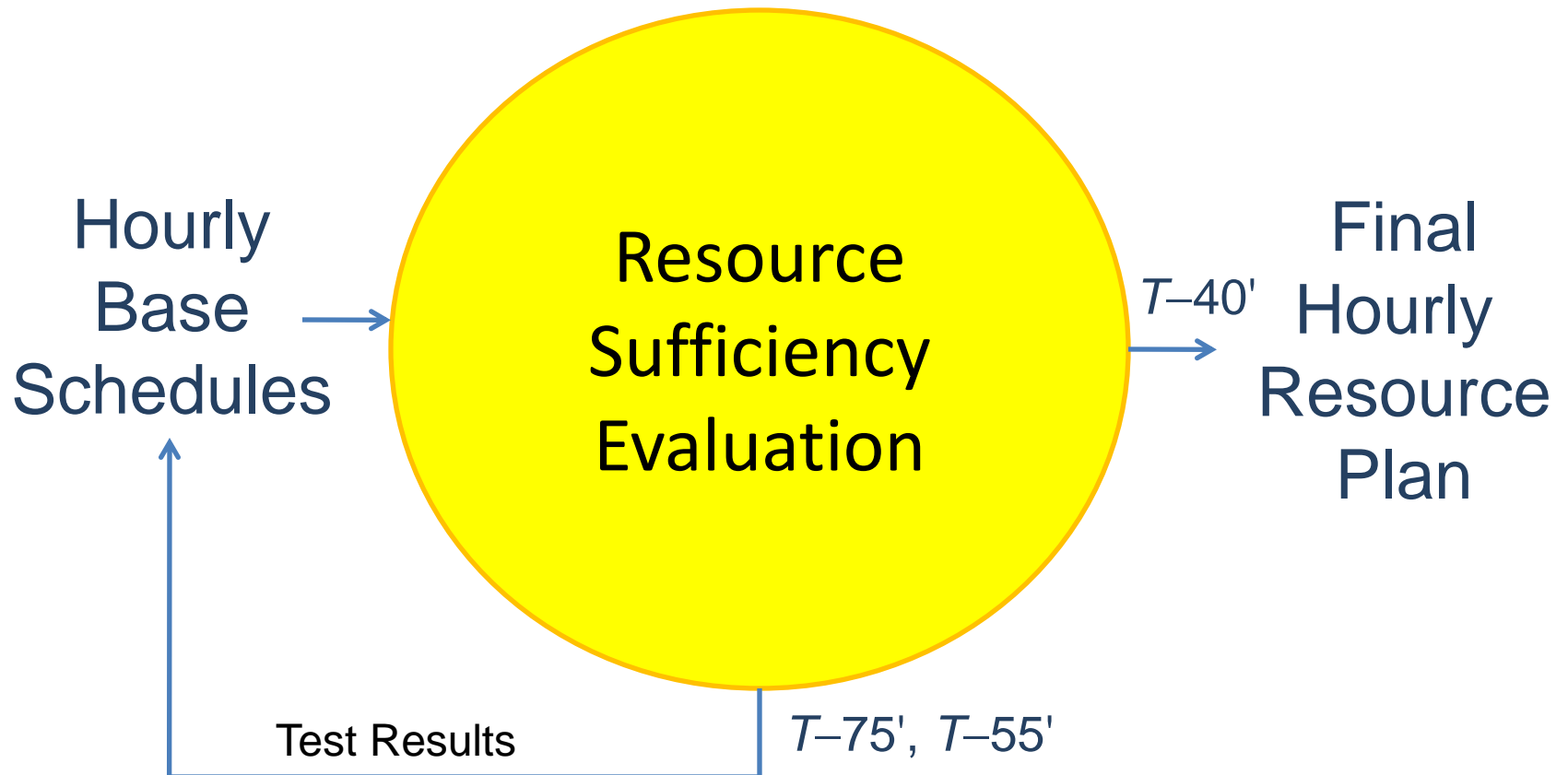
Roles and Definitions

- **Base Schedule Coordinator** is the participating or non-participating resource (or a designated third-party) that submits base schedules and ancillary services schedules

- **EIM Entity Base Schedule Coordinator** is the EIM Entity (or a designated third-party) that submits base schedules and ancillary services for EIM non-participating resources, and all EIM resources after T–55'
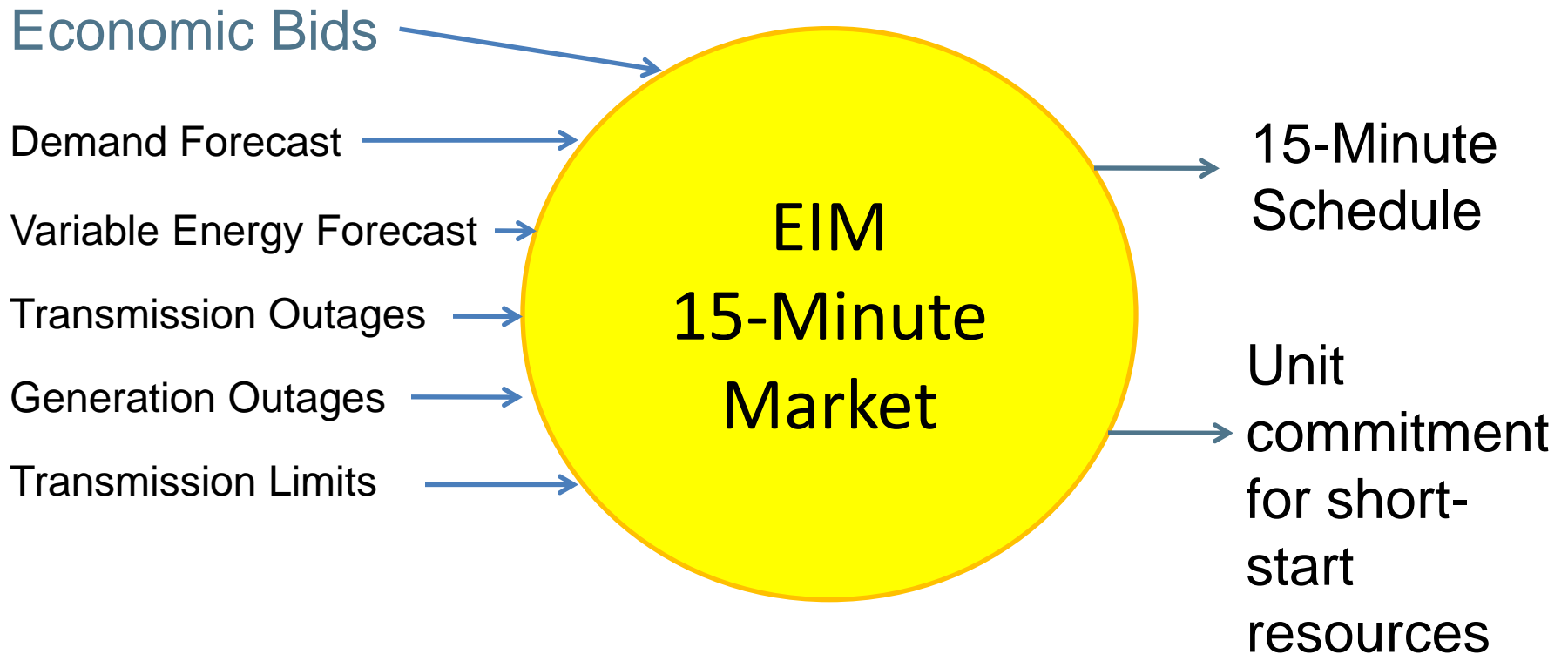
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Market Activities

Energy Imbalance Market Overview

Demand Forecast →

Variable Energy Forecast →

Transmission Outages →

Generation Outages →

Transmission Limits →

Compile Hourly Resource Plan

Participating resource hourly base schedule

Participating resource energy bid range

Non-participating resource hourly base schedule

Hourly interchange schedules

Energy Imbalance Market Overview

Hourly Base Schedules → Resource Sufficiency Evaluation → $T{-}40'$ Final Hourly Resource Plan

Test Results $T{-}75'$, $T{-}55'$

Energy Imbalance Market Overview

Economic Bids

Demand Forecast

Variable Energy Forecast

Transmission Outages

Generation Outages

Transmission Limits

EIM
15-Minute
Market

15-Minute Schedule

Unit commitment for short-start resources

Energy Imbalance Market Overview

Economic Bids →

Demand Forecast →

Variable Energy Forecast →

Transmission Outages →

Generation Outages →

Transmission Limits →

State Estimator →

**EIM
5-Minute
Dispatch**

→ Dispatch
Instructions

Energy Imbalance Market Overview

Hourly Base Schedule →

15-Minute Schedule →

5-Minute Dispatch →

Meter →

EIM Settlement

→ EIMPR SC Settlement Statement

→ EIM Entity SC Settlement Statement for EIMNPR

→ EIM Entity SC Settlement Statement for EIM BAA Neutrality

Base Schedules + Bids + Timing

Base Schedule
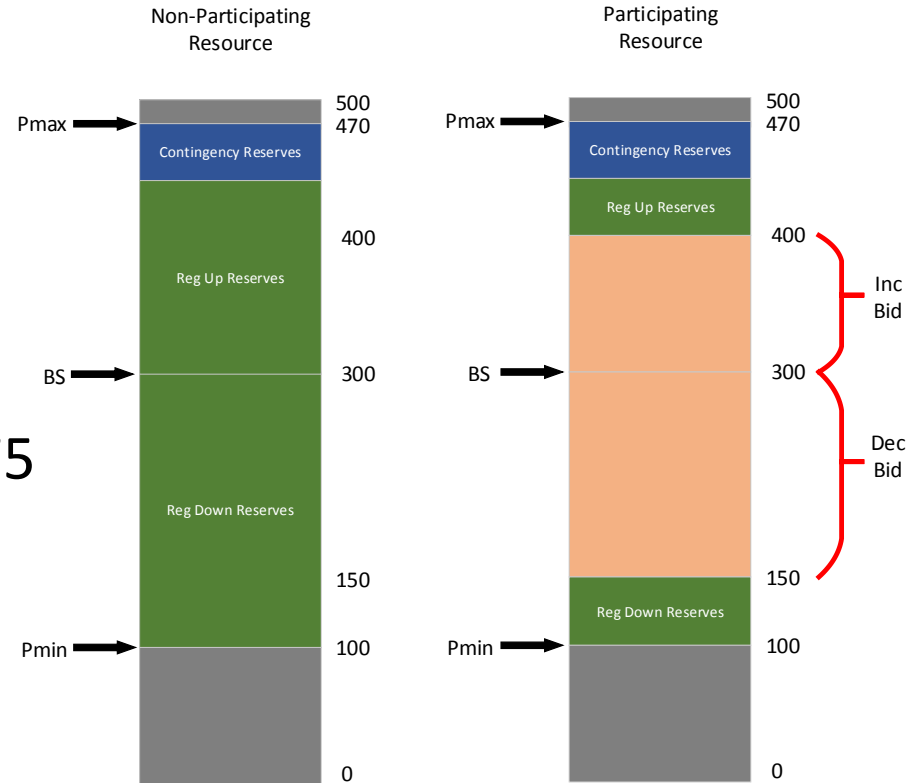
- Generation and Interchange must equal Load.

  $$G + I = L$$

- Submitted T-75, T-55, and T-40 ahead of the hour.

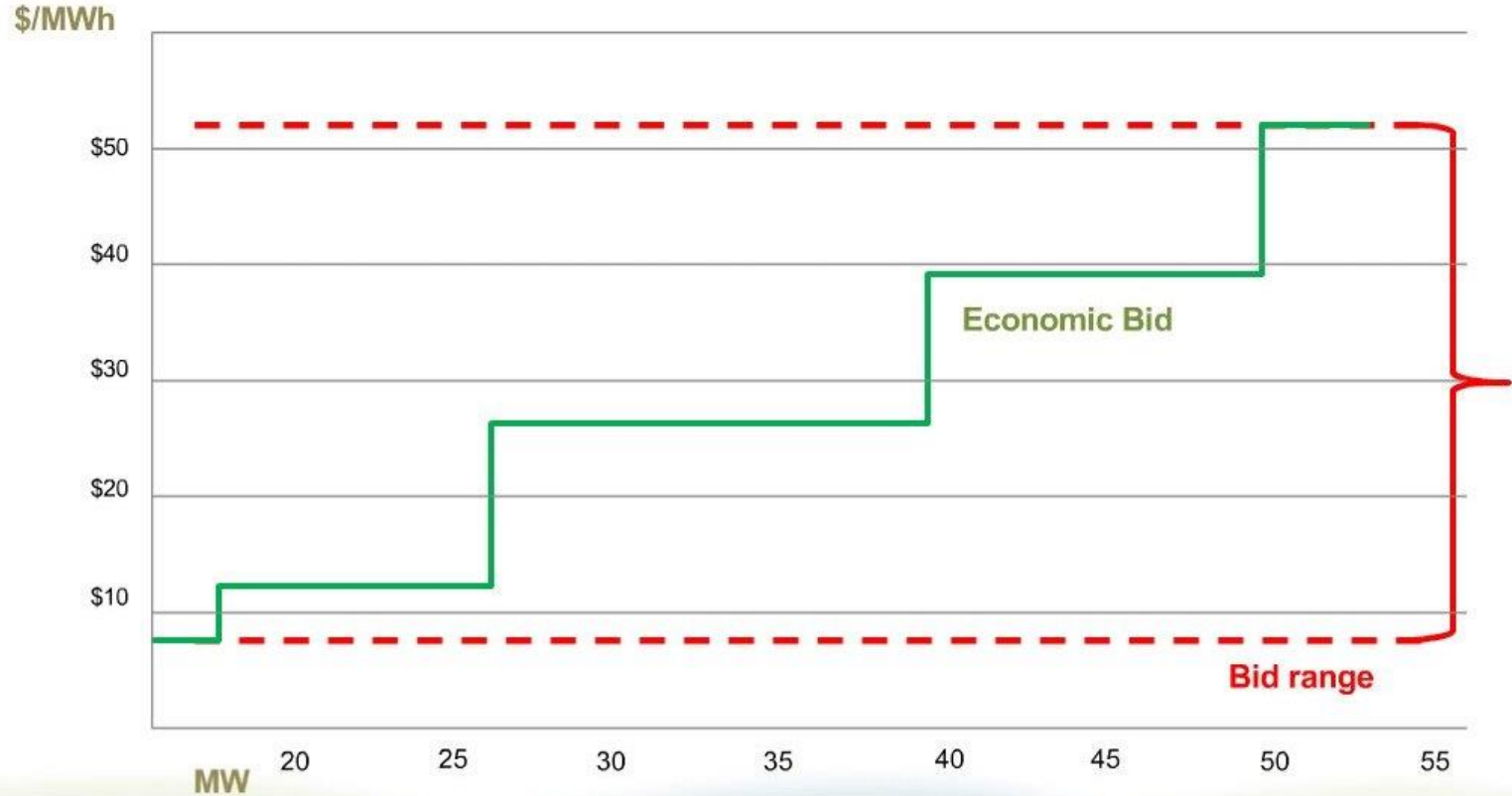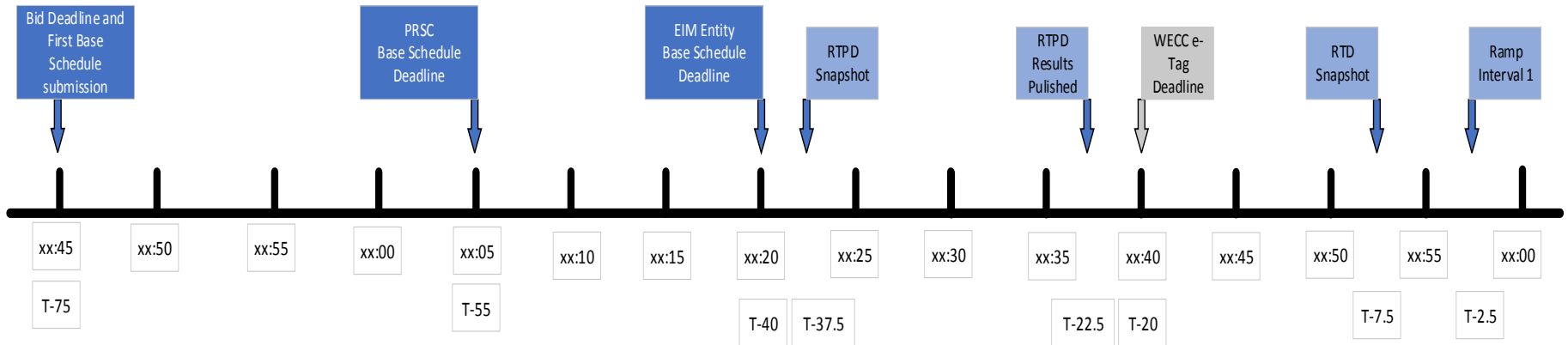- Solely used as initial starting points of units and to pass hourly sufficiency tests.

Bids

- **Non-Participating vs Participating Resources**

- **Bids submitted by T-75**
  - Cannot change bid after T-75
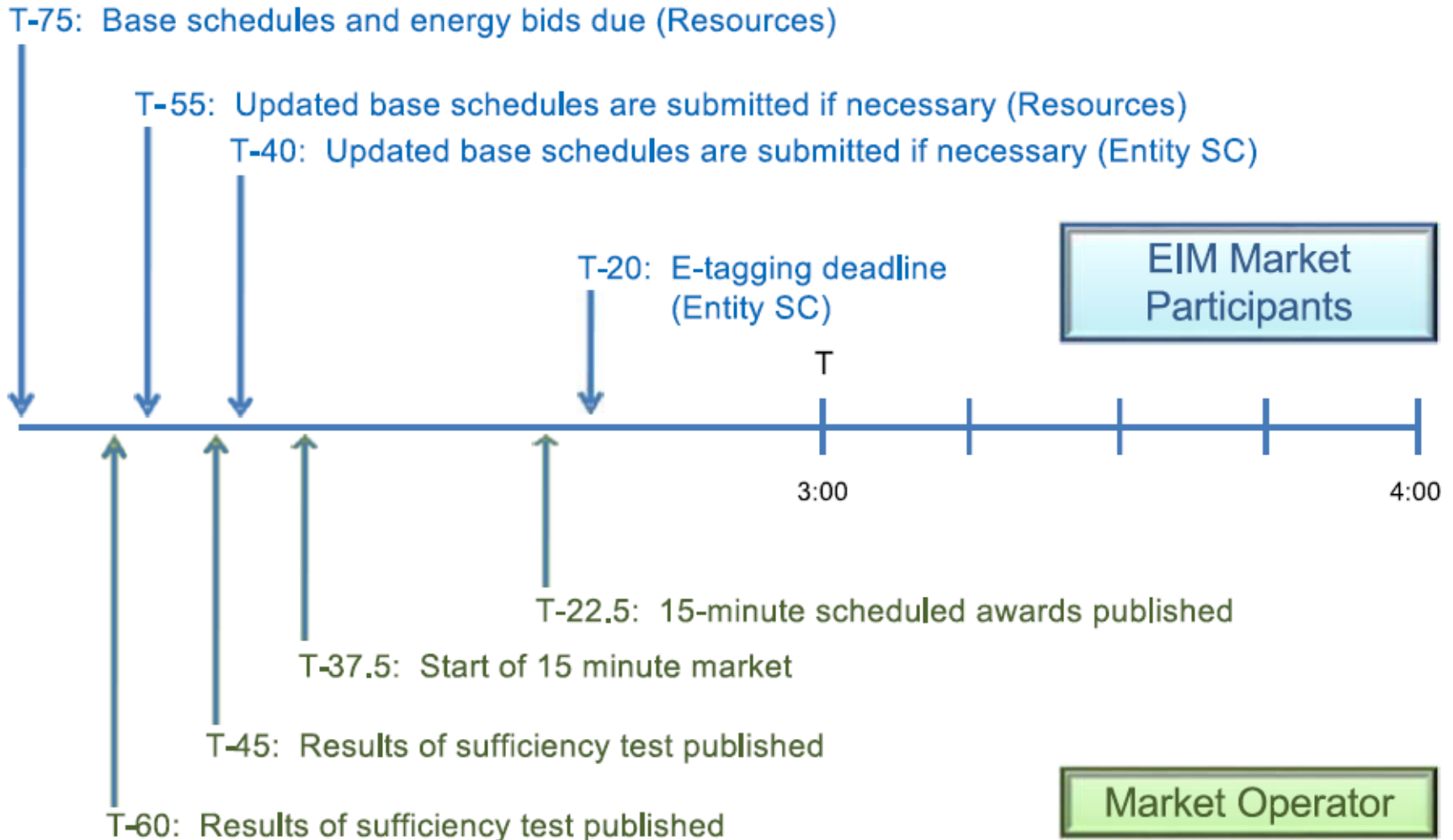 - Locked for 135 minutes
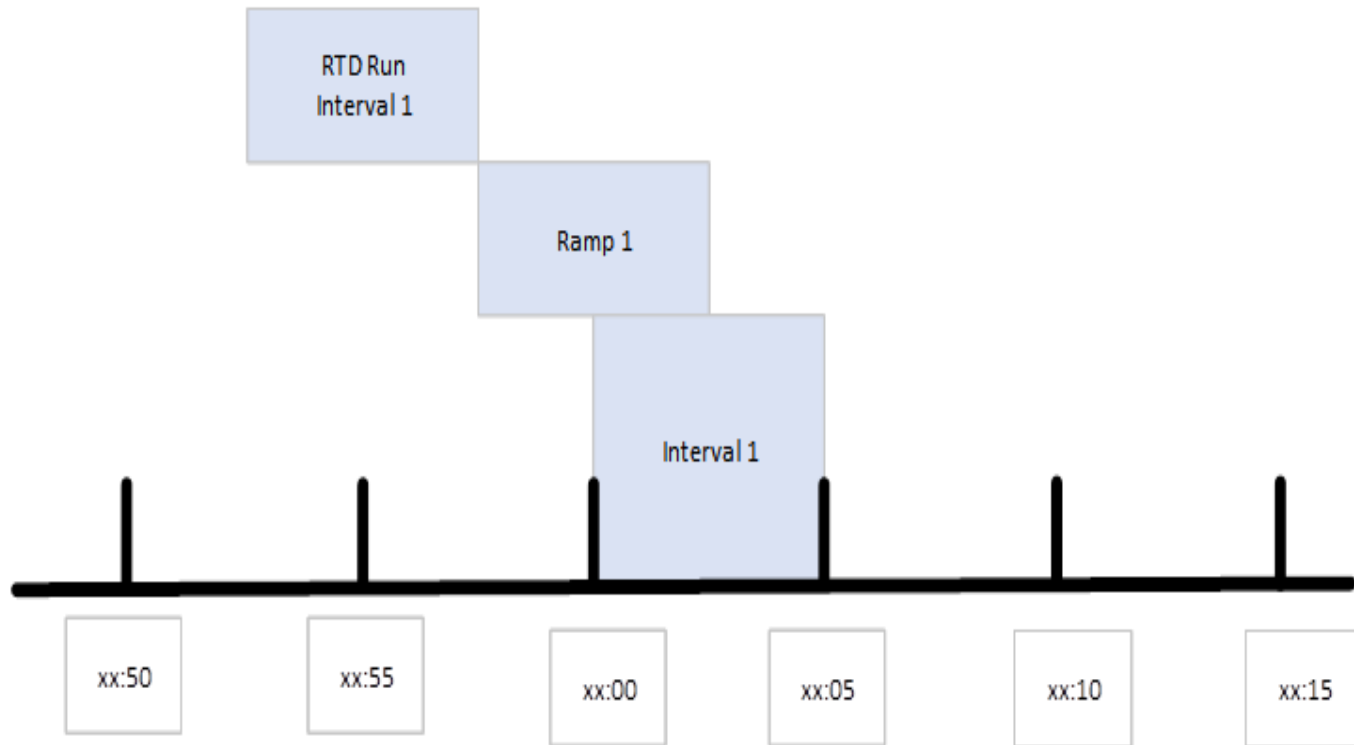
Bids

Base Schedule Timing

- Bids are locked in 75 minutes before the hour
- Participants' Base Schedules (BS) deadline 55 minutes before the hour
- EIM Entity's BS deadline 40 minutes before the hour

Used for proof that market is not performing BAL compliance for the Entity BA

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Base Schedule Timing

T-75: Base schedules and energy bids due (Resources)

T-55: Updated base schedules are submitted if necessary (Resources)

T-40: Updated base schedules are submitted if necessary (Entity SC)

T-20: E-tagging deadline (Entity SC)

T

EIM Market Participants

3:00

4:00

T-22.5: 15-minute scheduled awards published

T-37.5: Start of 15 minute market

T-45: Results of sufficiency test published

T-60: Results of sufficiency test published

Market Operator
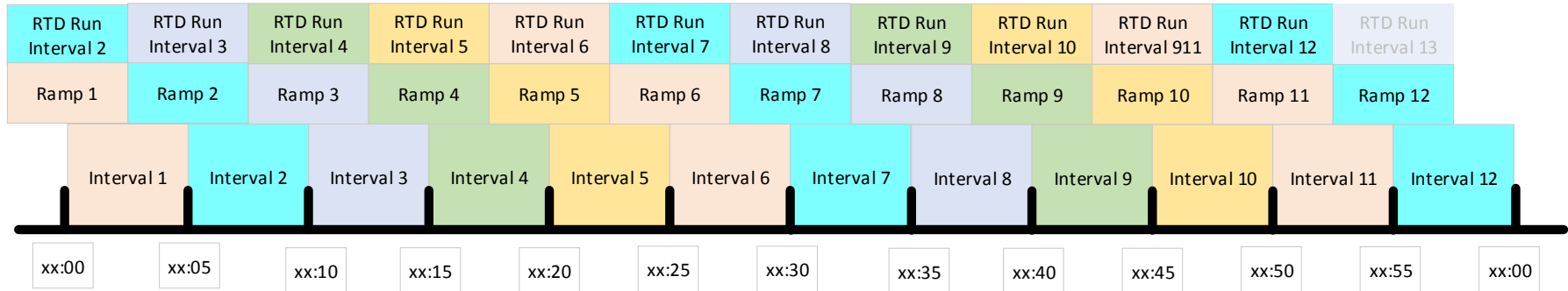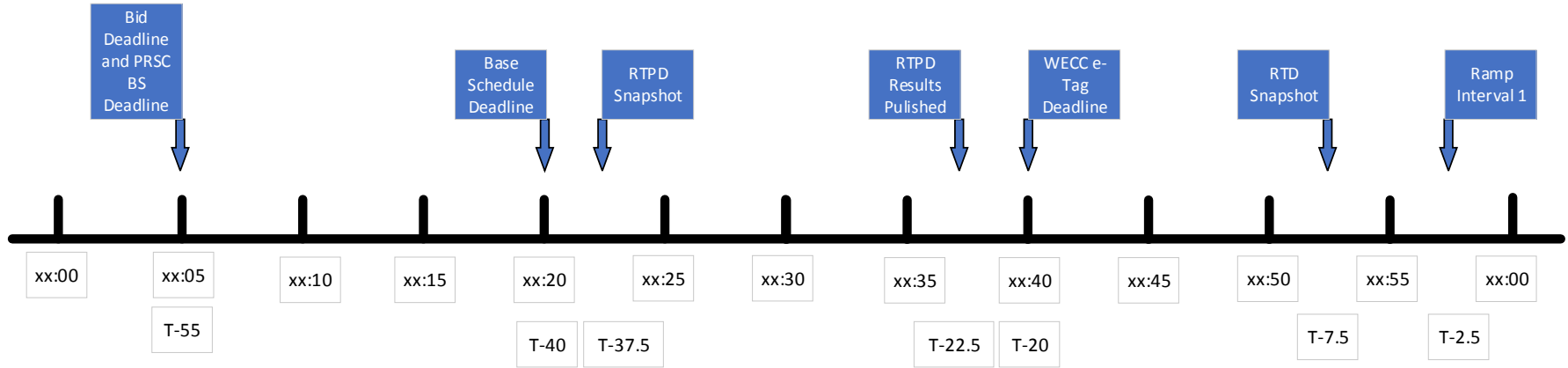
One RTD 5-Minute Run

- Market begins calculation 7.5 minutes prior to the 5-minute market interval and published results 1-2 minutes prior to ramp
- Solution provides the target for the middle of the interval that resources are expected to ramp to (i.e., Dispatch/Desired Operating Target or DOT)

Continuous RTDs
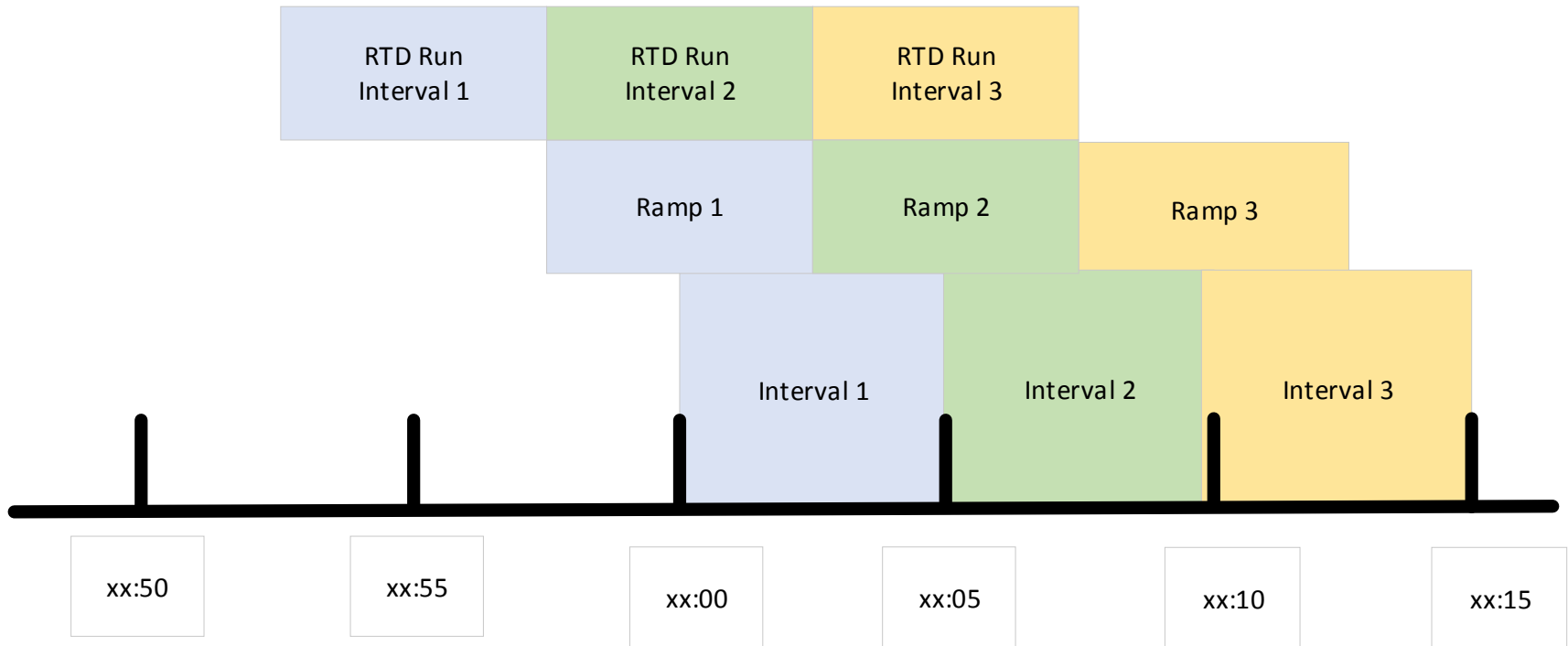
Within the Hour

Resource Sufficiency

Why Perform Resource Sufficiency Evaluation

- On an hourly basis, the CAISO performs a series of Resource Sufficiency (RS) tests to determine if an EIM Entity is leaning on the EIM for capacity, flexibility or transmission.

- Resource sufficiency helps ensure each EIM Entity can fulfill their own reliability obligations.

- If the EIM Entity passes the RS evaluation, it will have access to other EIM resources to meet its load and uncertainty for the next operating hour.

- If the EIM Entity fails the RS evaluation for the next operating hour, then incremental EIM transfers during the hour will not be allowed in the direction of the failure.
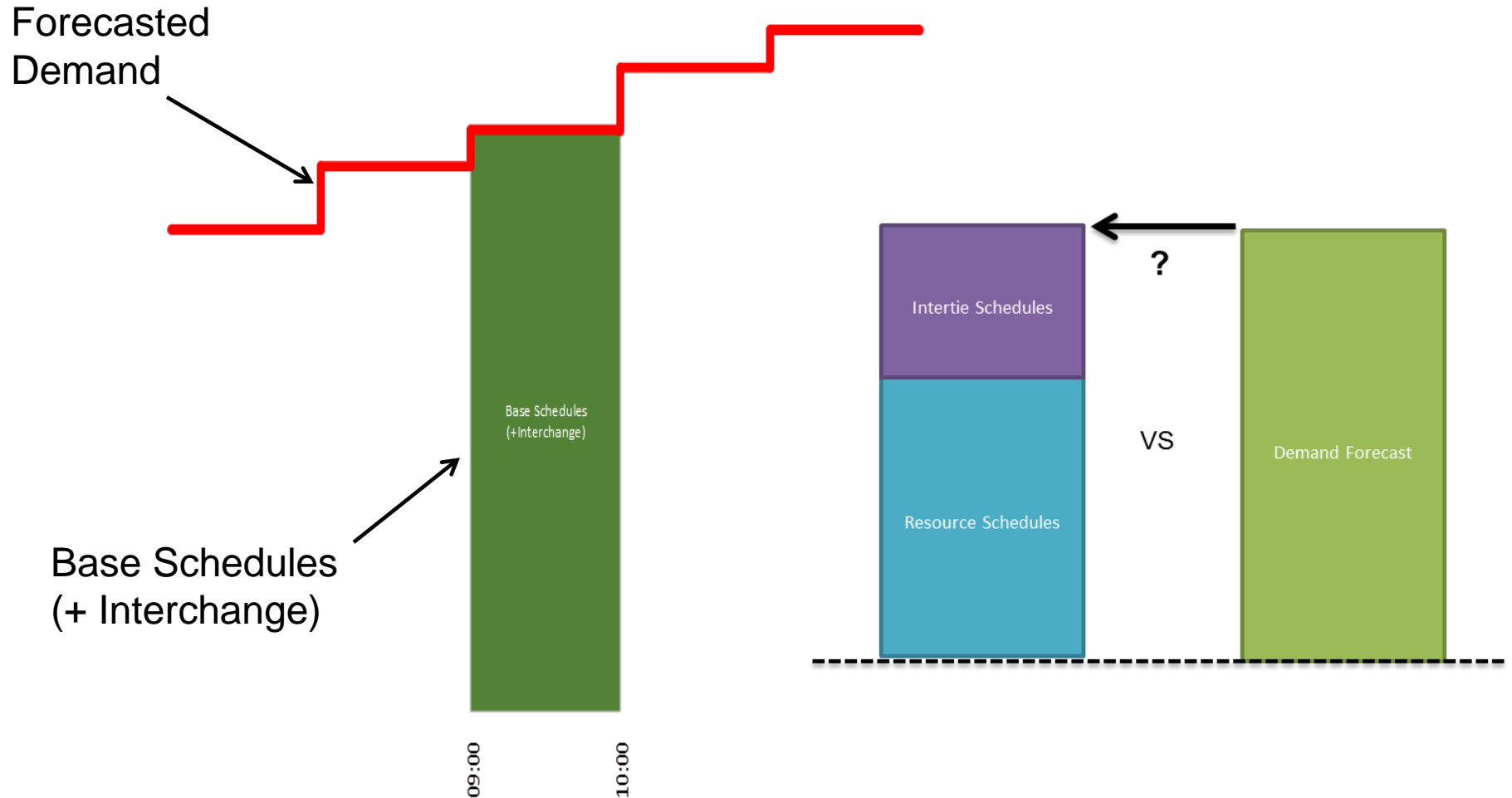
Resource Sufficiency Tests

- Performed for each EIM BAA and the CISO
    - After $T-75'$/$T-55'$/$T-40'$ for the Trading Hour starting at T

- Consist of the following four tests:
    1. Balancing Test
    2. Bid Capacity Test
    3. Flexible Ramping Sufficiency Test
    4. Feasibility Test *(also performed in Day Ahead Market)*

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Balancing Test

- Ensures that each EIM Entity is balanced prior to the operating hour

- Compares base schedules (for EIM Generation Base Schedules plus Interchange Base Schedules) with hourly demand forecast

- EIM Entity elects ISO demand forecast option:
  - Pass: BAA imbalance within 1%
  - Fail: BAA imbalance greater than 1%
    - Over-scheduling/under-scheduling penalty if actual demands delta is above 5%

- EIM Entity elects own demand forecast option:
  - Success (always)
    - Over-scheduling/under-scheduling penalty always applies

Balancing Test

Forecasted Demand

Base Schedules (+ Interchange)

Base Schedules (+Interchange)

09:00

10:00

Intertie Schedules

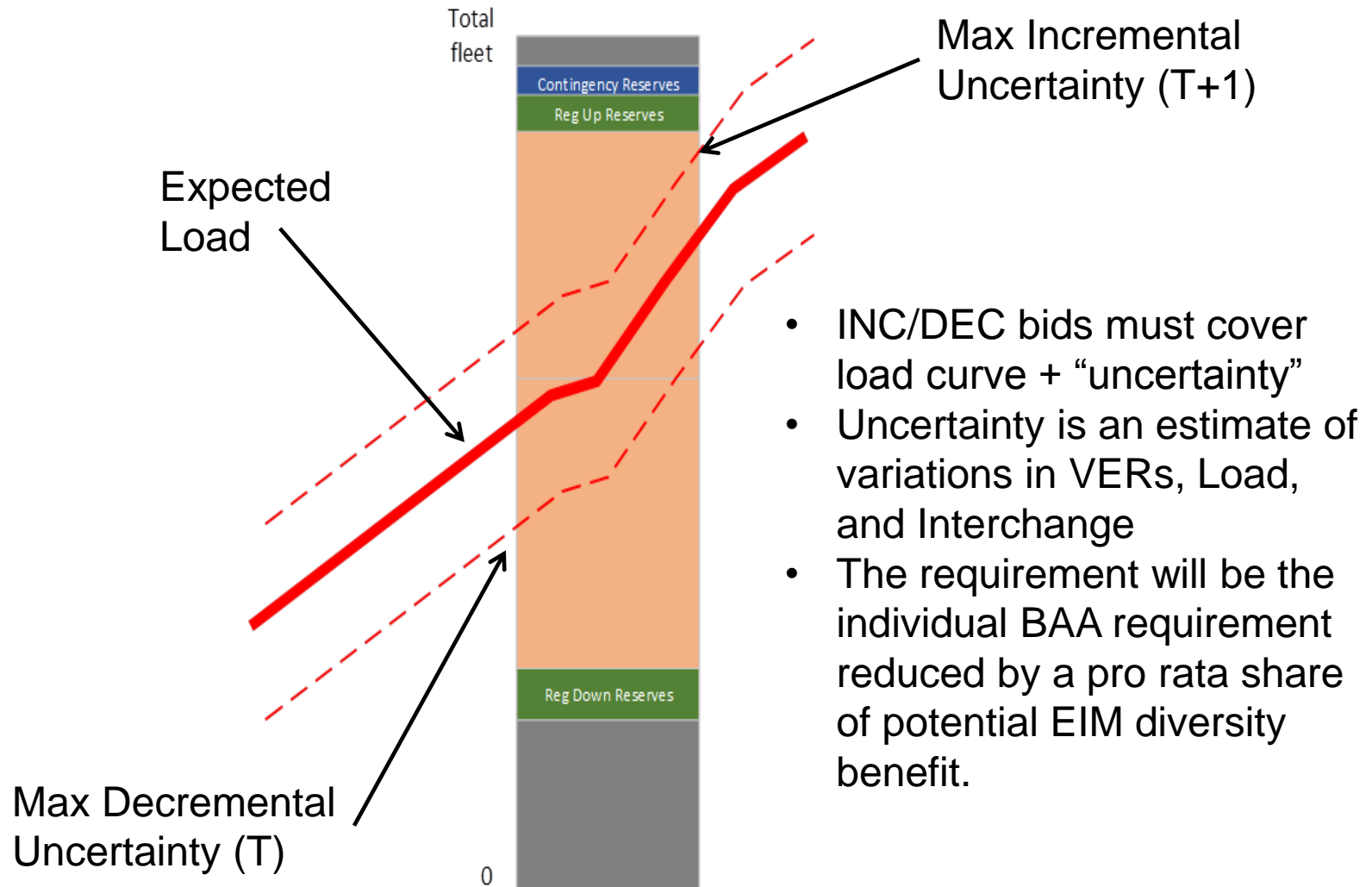Resource Schedules

?

VS

Demand Forecast

Bid Capacity Test

- Comparison of aggregate INC/DEC bid range from Participating Resources within the BAA versus the demand forecast plus historical inter-tie deviations

  – Pass: sufficient capacity

  – Fail: insufficient capacity

    - Automatically fails the Flex Ramp Sufficiency Test
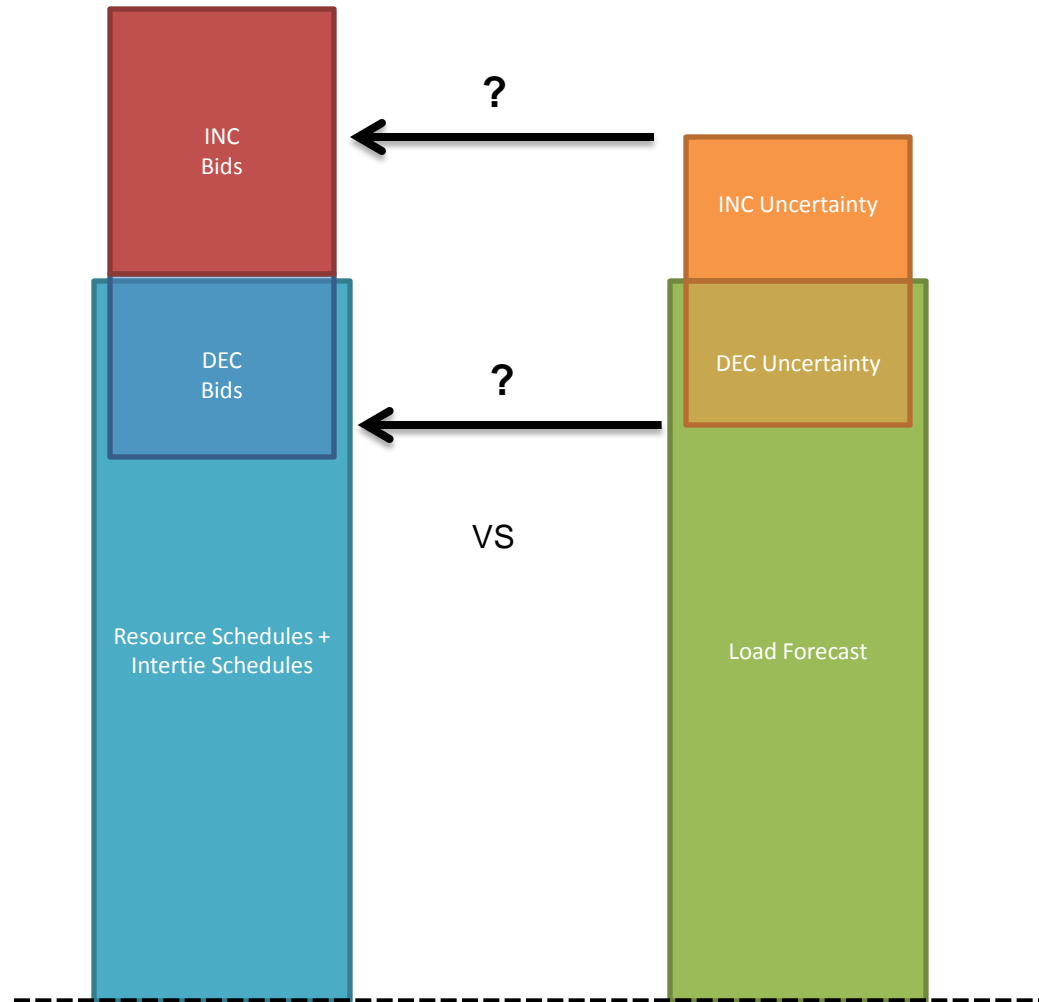   - Limited EIM transfers in direction of failure

Bid Capacity Test

- Comparison of aggregate INC/DEC energy bid range from Participating Resources within the BAA versus the demand forecast plus historical inter-tie deviations
  - Pass: sufficient bid capacity
  - Fail: insufficient bud capacity
    - Automatically fails Flexible Ramp Sufficiency test
    - Limited EIM transfers in direction of failure

Bid Capacity Test

Total fleet

Contingency Reserves

Reg Up Reserves

Max Incremental Uncertainty (T+1)

Expected Load

Reg Down Reserves

0

Max Decremental Uncertainty (T)

- INC/DEC bids must cover load curve + "uncertainty"
- Uncertainty is an estimate of variations in VERs, Load, and Interchange
- The requirement will be the individual BAA requirement reduced by a pro rata share of potential EIM diversity benefit.

https://www.caiso.com/Documents/BusinessRequirementsSpecification-FlexibleRampingProduct.pdf   48

Bid Capacity Test
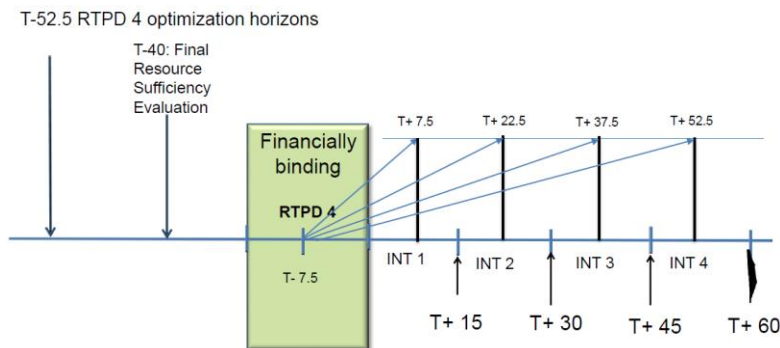
Flexible Ramping Sufficiency Test

- Ensures that each balancing area has enough ramping resources over each hour to meet expected upward and downward ramping needs
- INC and DEC ramping capability are considered separately
- Formulated for all BAAs in the EIM Area individually and for the entire EIM Area

  – Pass: resource ramp capabilities are above the requirements
  - Requirement is reduced by the available net import/export capability (diversity benefit)

  – Fail: resource ramp capabilities are below the requirements
  - EIM Transfer is limited from below/above the base at the last 15-min schedule before the hour (at T−7.5')
  - Possible to fail in only one direction (INC vs DEC), locking out of market actions only in that direction.

Flexible Ramping Sufficiency Test

- Data used:
  - Initial schedules at $T-7.5'$ for each 15' interval midpoints
    - Advisory solutions from FMM at T-75' and T-55' are used
    - Binding solution from FMM at T-40'
  - Participating Resources energy bids and ramp rates
  - 15' Flexible ramping up/down requirements
    - Change in demand forecast
    - Reduced by any prorated EIM diversity benefit
    - Reduced by any credit for net outgoing/incoming EIM transfer at $T-7.5'$
   - Reductions limited by the available net import/export capability

Flexible Ramping Sufficiency Test

- Cumulative test for meeting flexible ramping requirements for each 15' interval of the hour
    - 15' ramp from $T-7.5'$ to $T+7.5'$ (1st 15' interval)
    - 30' ramp from $T-7.5'$ to $T+22.5'$ (2nd 15' interval)
    - 45' ramp from $T-7.5'$ to $T+37.5'$ (3rd 15' interval)
    - 60' ramp from $T-7.5'$ to $T+52.5'$ (4th 15' interval)

- Test passes if <u>all</u> four cumulative tests pass
- Test fails if <u>any</u> of the four cumulative tests fail

Flexible Ramping Sufficiency Test
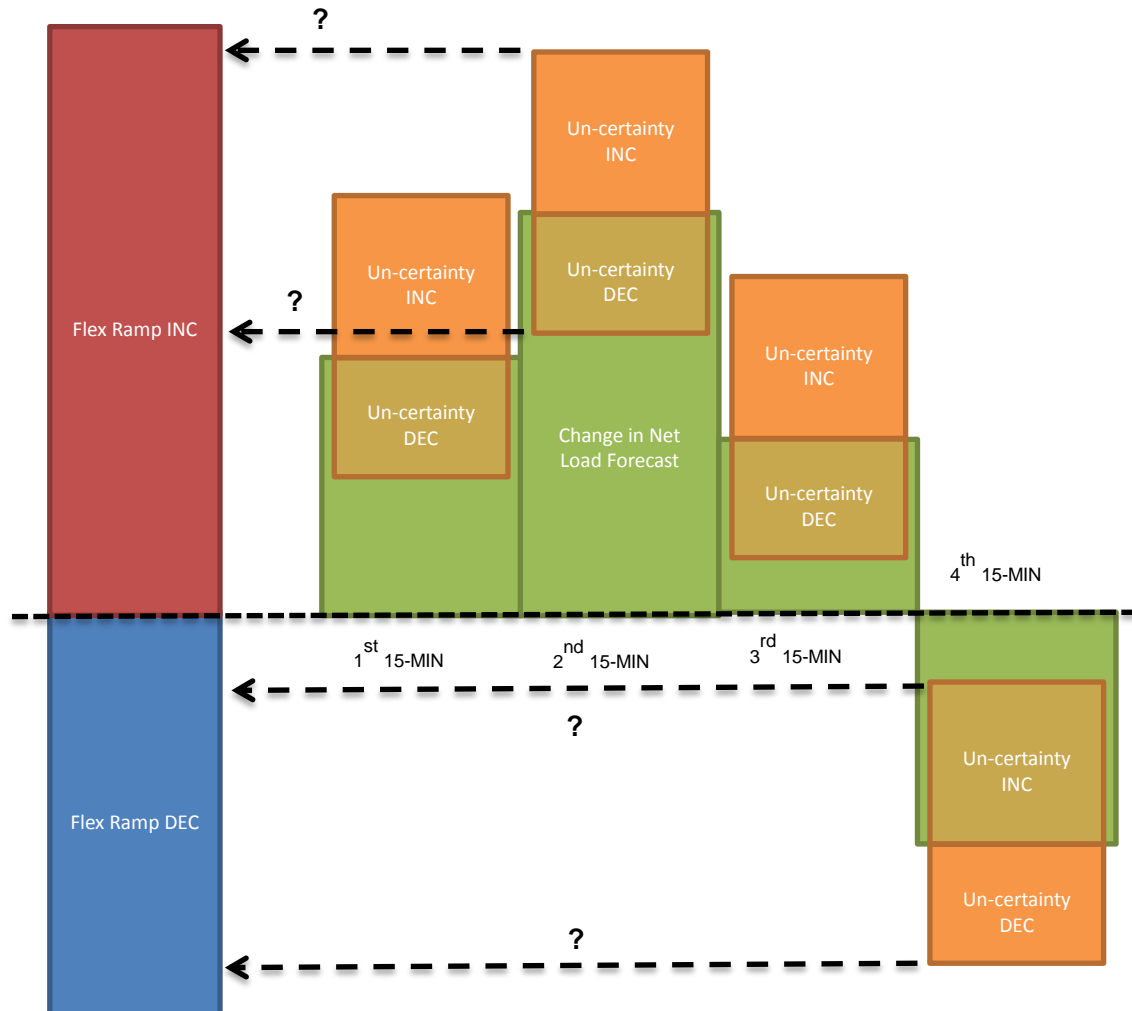
Feasibility Test

- CAISO performs a power flow feasibility test on the day before the Operating Day and using Base Schedules submitted to the Real-Time Market
  - Pass: no transmission limit violations
  - Fail: transmission limit violations identified
  - Consequences: None – informational only

Available Balancing Capacity

- Reserved capacity up/down on participating and non-participating resources

- Declared as Regulation up/down base schedules

- Conditionally dispatched to avoid power balance constraint violation when the net EIM Transfer is at its limit

- Submitted Energy Bid is used for EIMPR

- Default Energy Bid (DEB) is used for EIMNPR

Contingency Dispatch

- Contingency in CISO
  - Suspend RTD; invoke RTCD
  - Isolate CISO from the EIM Area
    - Freeze CISO EIM Transfer at last RTD advisory solution
  - Send previous advisory 5min dispatch for EIMPR
- Contingency in an EIM BAA
  - EIM BAA Operator notifies ISO of contingency status
  - Isolate EIM BAA from the EIM Area
    - Freeze EIM Transfer for EIM BAA at last RTD advisory solution
  - Incorporate Manual Dispatch instructions in RTD

On-line Resources

- [Western EIM Website](#)
- [Western EIM online training](#)
  - [Introduction to EIM (CBT)](#)
  - [How EIM Works (CBT)](#)
  - [Base Scheduling (CBT)](#)
  - [Metering (CBT)](#)
  - [Settlements (CBT)](#)
- [EIM Resource Sufficiency](#)
- [EIM Business Practice Manual](#)