EIM 101 Workshop

September 13, 2018

BPA Rates Hearing Room

V2.1

Non Decisional and for Educational Purposes Only

Agenda

- Housekeeping
- What is the California ISO
- What is BPA
- What is a Balancing Authority
- What is the EIM
- Governance
- Transmission
- Roles and Definitions
- Market Activities
- Base Schedules + Bids + Market Timing
- Resource Sufficiency Tests
- Settlements

WebEx and Phone Participants

- We have muted all calls on entry, if you have a question, you will need to unmute by using *6, then please identify yourself by name and organization.
- Please do not put this call on hold OR take other calls while you are dialed into this one.
- Noisy lines may be disconnected from the meeting.

Format of EIM 101 Workshop

- There is a lot of material to present today
- We plan to leave time at the end for an open Q&A
- After each topic we will provide an opportunity to ask clarifying questions, as time permits
- We welcome feedback on the workshop – please send any to techforum@bpa.gov and reference “EIM 101 Workshop” in the subject

Upcoming EIM Stakeholder Meetings

- Oct. 11, 2018, 9 a.m.-12 noon, BPA Rates Hearing Room and by WebEx
- Nov. 20, 2018, time TBD, BPA Rates Hearing Room and by WebEx
- For more information please visit www.bpa.gov/goto/EIM

Purpose of EIM 101 Workshop

- Provide a common understanding of how the EIM currently works so that all stakeholders can engage in future meetings/workshops
- Help identify policies and business practices that may impact BPA's potential EIM participation

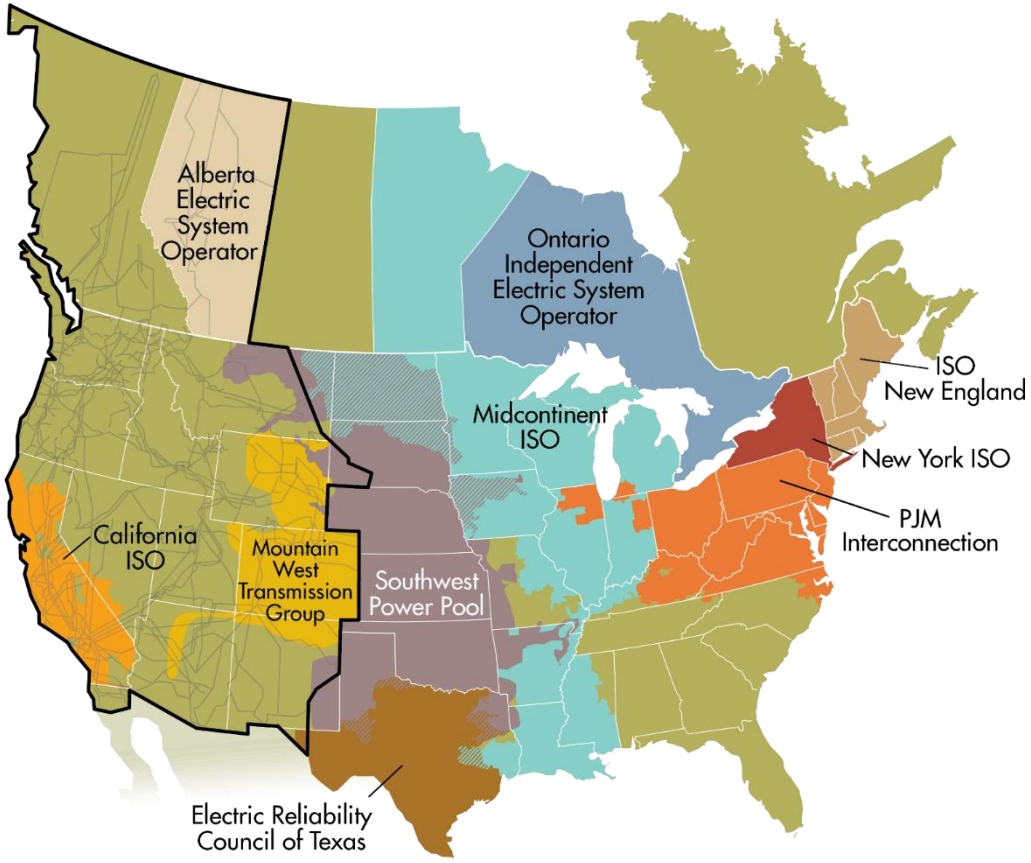
Credits & Disclaimers

- Several slides in this presentation have been reproduced *(occasionally with modifications)* with permission from the CAISO and Utilicast
- Information provided is believed to be accurate as of the publication date of this presentation
- The CAISO market rules and processes are under continual development
- Additional resources and information are available in the appendix of this presentation

What is the California ISO?

The California ISO (CAISO, CISO, ISO)

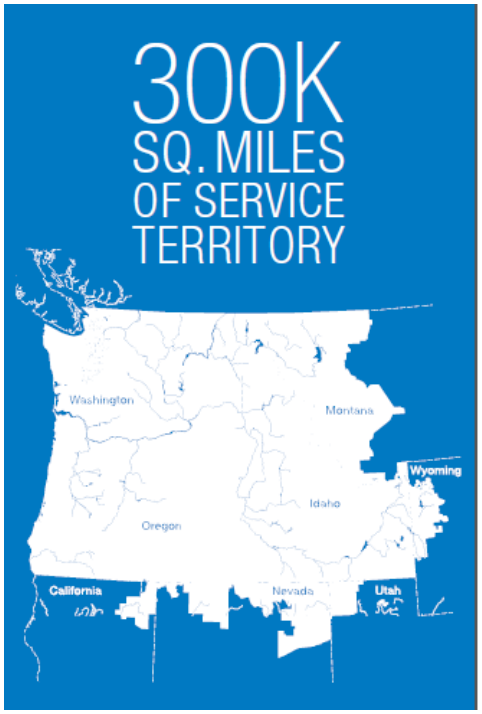
- One of nine independent grid operators in North America
- One of 39 balancing authorities in the western interconnection
- Operates markets for wholesale electricity – Day Ahead and Real Time
- Manages the California transmission system
- Manages new power plant interconnections in California
- Plans grid expansions in California
- Operates the Western Energy Imbalance Market (EIM)



What is the Bonneville Power Administration?

Bonneville Power Administration

- BPA is a Federal Power Marketing Agency located in the Pacific Northwest.



General Information

BPA established	1937
Service area size (square miles)	300,000
Pacific Northwest population	13,712,171
Transmission line (circuit miles)	15,238
BPA substations	260
Employees (FTE)	2,891 1/

1/ FTE for fiscal year 2017 from the FY 2017 Congressional Budget.

Customers

Cooperatives	54
Municipalities	42
Public utility districts	28
Federal agencies	7
Investor-owned utilities	6
Direct-service industries	2
Port districts	1
Tribal utilities	3
Total	143
Marketers (power and transmission) 2/	200
Transmission customers	532

2/ As of February 2018.

Transmission System

Operating voltage	Circuit miles
1,100 kV	1
1,000 kV	264 8/
500 kV	4,869
345 kV	570
287 kV	229
230 kV	5,328
161 kV	119
138 kV	56
115 kV	3,520
below 115 kV	282
Total 9/	15,238

8/ BPA's portion of the PNW/PSW direct-current intertie. The total length of this line from The Dalles, Oregon, to Los Angeles is 846 miles.
9/ Total circuit miles as of February 2018.

Federal Hydro Projects

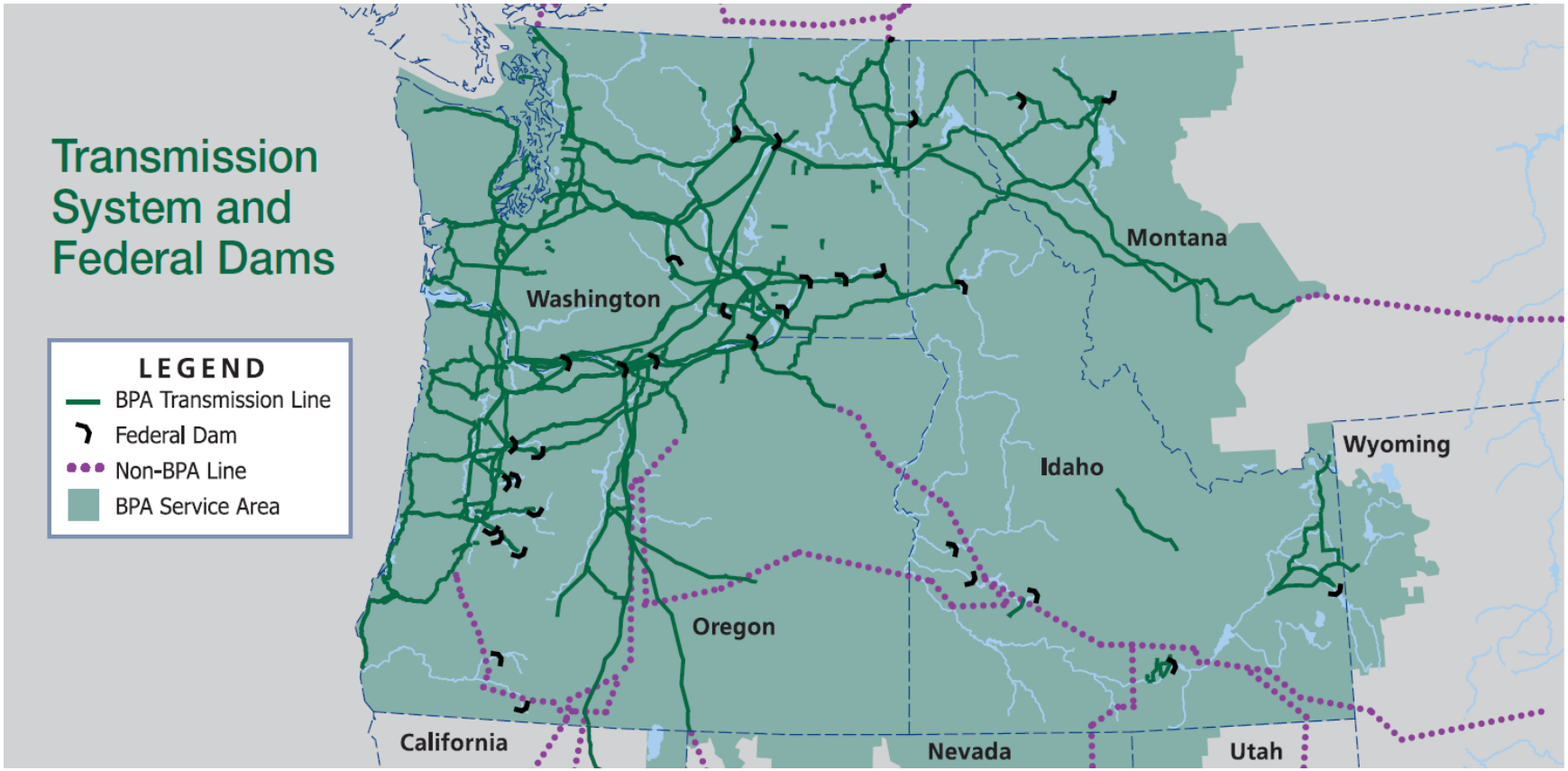
31 federal dams (max. capacity) ..... 22,458 MW

Projects owned and operated by:
U.S. Army Corps of Engineers (14,651 MW) 21 dams
Bureau of Reclamation (7,807 MW) ..... 10 dams

Federal Generation

Hydro generation	9,377 aMW
Total generation	10,313 aMW
60-min. hydro peak generation	14,192 MW
60-min. total peak generation	14,600 MW
All-time 60-min. total peak generation record (June 2002)	18,139 MW

Bonneville Power Administration



What is a Balancing Authority?

What is a Balancing Authority?

- A Balancing Authority (BA) is the entity that integrates resource plans ahead of time, maintains Demand and resource balance within one or more Balancing Authority Areas, and supports Interconnection frequency in real time.
- A Balancing Authority Area (BAA) is the collection of generation, transmission and loads within the metered boundaries (interchanges or tie-lines) of the balancing authority where load/resource balance is maintained
- 39 BAAs in the Western Interconnection
- While interconnected, each BAA operates independently

What is AGC

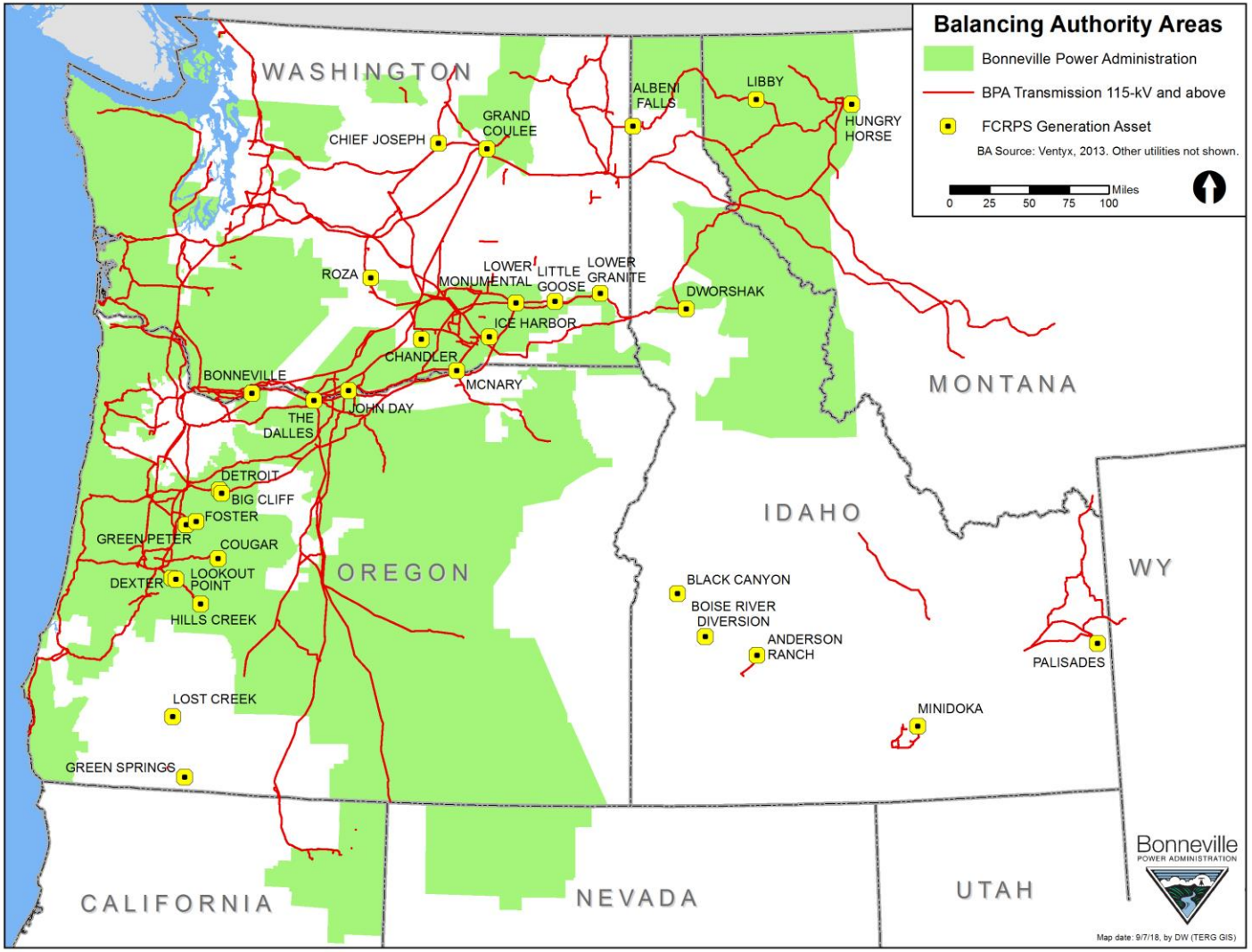
- Automatic Generation Control (AGC) is used to manage the BAA's Area Control Error (ACE) per the following basic equation (deemphasizing tie-line meter error, and ATEC):

  $ACE = (NI_A - NI_S) - 10B\,(FA - FS) - I_{ME} + I_{ATEC}$

  Where:

  - **NI_A** = Net Actual Interchange - The algebraic sum of **actual** megawatt transfers across all Tie Lines, including Pseudo-Ties, with all Adjacent BAAs within the same Interconnection
  - **NI_S** = Net Scheduled Interchange - The algebraic sum of all **scheduled** megawatt transfers, including Dynamic Schedules, with all Adjacent BAAs within the same Interconnection, including the effect of scheduled ramps
  - **B** = Frequency Bias Setting (MW/0.1Hz).
  - **FA** = Actual Frequency.
  - **FS** = Scheduled Frequency.
  - I_{ME} = Interchange Meter Error.
  - I_{ATEC} = Automatic Time Error Correction

BPA's Balancing Authority Area



BPA Has 253 points of interchange (tie-lines) with 18 adjacent BAAs

What is the EIM?

What is the EIM?

- An **intra-hour** centralized **energy** market used to **economically** and **securely** dispatch **participating resources** to **efficiently** balance supply, transfers between participating Balancing Authority Areas (**EIM Entity BAAs**), and load across the market's footprint (**EIM Area**).
  - The EIM does this **every 5-minutes**!
- An extension of the CAISO's Real-Time Market (**RTM**) in response to the efforts of the Western Interstate Energy Board (WIEB) and the PUC EIM group

What is the EIM?

- EIM's priority is to serve load and imbalance 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.
- No penalty for promptly communicated reliability actions (Manual Dispatch); imbalance settlements still apply

What is the EIM?

- What is Included in EIM?
  - Unit commitment for short start resources
  - Forward looking congestion management - will respond to forced and planned outages
  - 15min market (FMM or RTPD)
    - Advisory market awards published for 4-7 FMM intervals
  - 5min dispatch (RTD)
    - Advisory market awards published for 9-13 RTD intervals
- What is NOT included in EIM?
  - Capacity Ancillary Services (regulation, spin, non-spin)
    - Ancillary Services Base Schedules are supported
  - Optimal Contingency Dispatch
    - Manual Dispatch of Contingency Reserves is supported

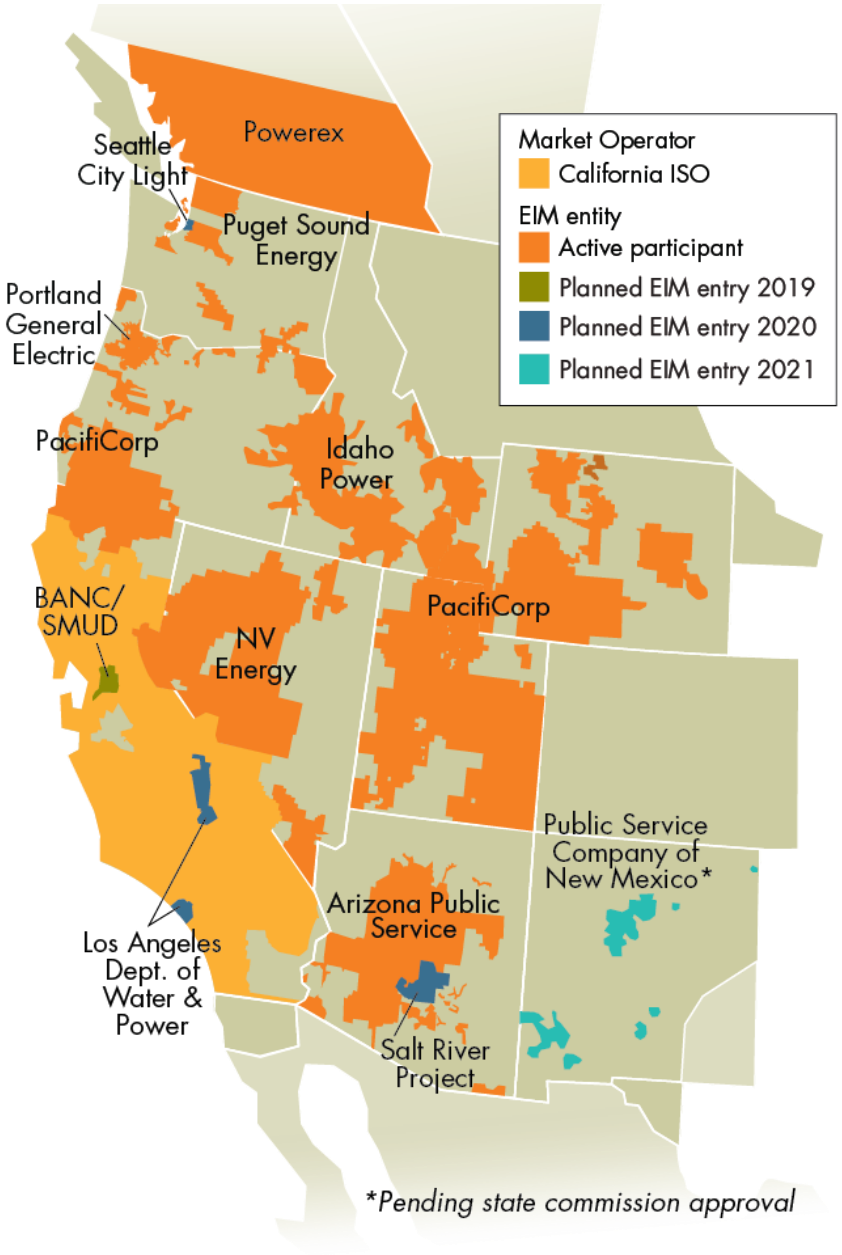
EIM Area Map

Existing Entities:

- PAC
- NVE
- APS
- PSE
- PGE
- PWX
- IDP

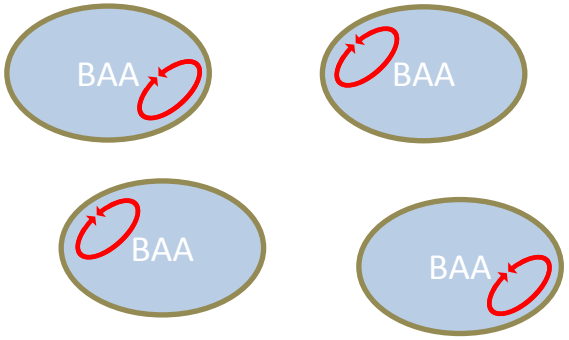
Upcoming Entities:

- BANC/SMUD (2019)
- LADWP (2020)
- SCL (2020)
- SRP (2020)
- PNM (2021)

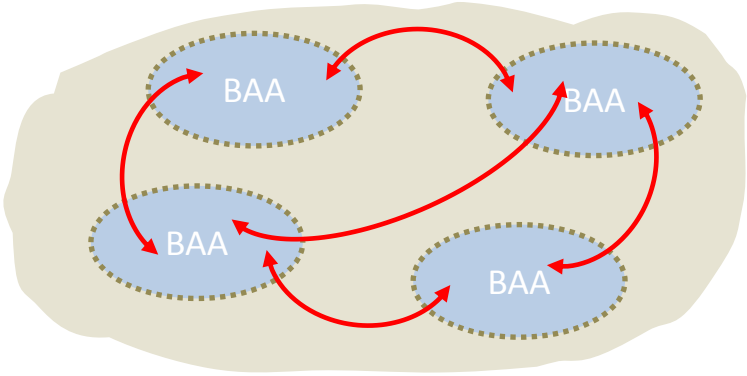


EIM Summary

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

EIM Summary

What an EIM IS:

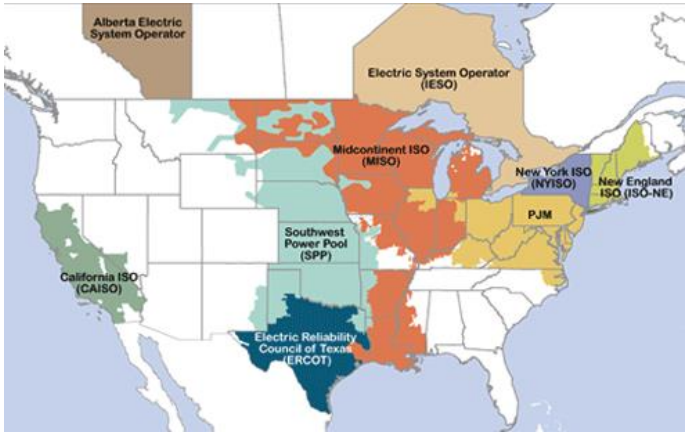
- An intra-hour **real-time** energy market to serve load and imbalance across participating Balancing Authorities (EIM Entities) and the CAISO (a.k.a. the EIM Area)
- A tool for centralized 5-minute dispatch of generators that have been **voluntarily** offered to the market (at a price)
- **Economically 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

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 (Real-Time Balancing Market)
  - NYISO (Real-Time Market)
  - ISO-NE (Real-Time Energy Market)
  - ERCOT (Real-Time Market)
  - CAISO (Real-Time Market)



EIM Governance

EIM governance structure designed by transitional committee of western stakeholders

EIM Governing Body (GB)

- 5 independent (non-stakeholder) members
- delegated authority over EIM-related market rules
- selected by S/H nominating committee, confirmed by ISO Board
- provides western entities a decision-making voice

EIM Body of state regulators (BOSR)

- advises EIM Governing Body and ISO Board on matters of interest
- currently 8 state officials from EIM states
- provides a state regulatory perspective

Regional Issues Forum (RIF)

- public vehicle for discussion of EIM-related issues, including impacts to neighboring balancing authority areas
- organized by ten self-selected sector liaisons
- may produce opinions for EIM governing body or ISO Board of Governors

Transmission

Transmission Access

- Transmission is provided in the EIM consistent with non-discriminatory Open Access principles.
- There is no explicit charge for transmission usage in the EIM.
- Transmission is currently provided in two ways:
  - Unused transmission provided directly by Transmission Service Providers (TSP) at no charge
  - Reserved transmission donated by Merchants

EIM Transfer Schedules

- The EIM primarily 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

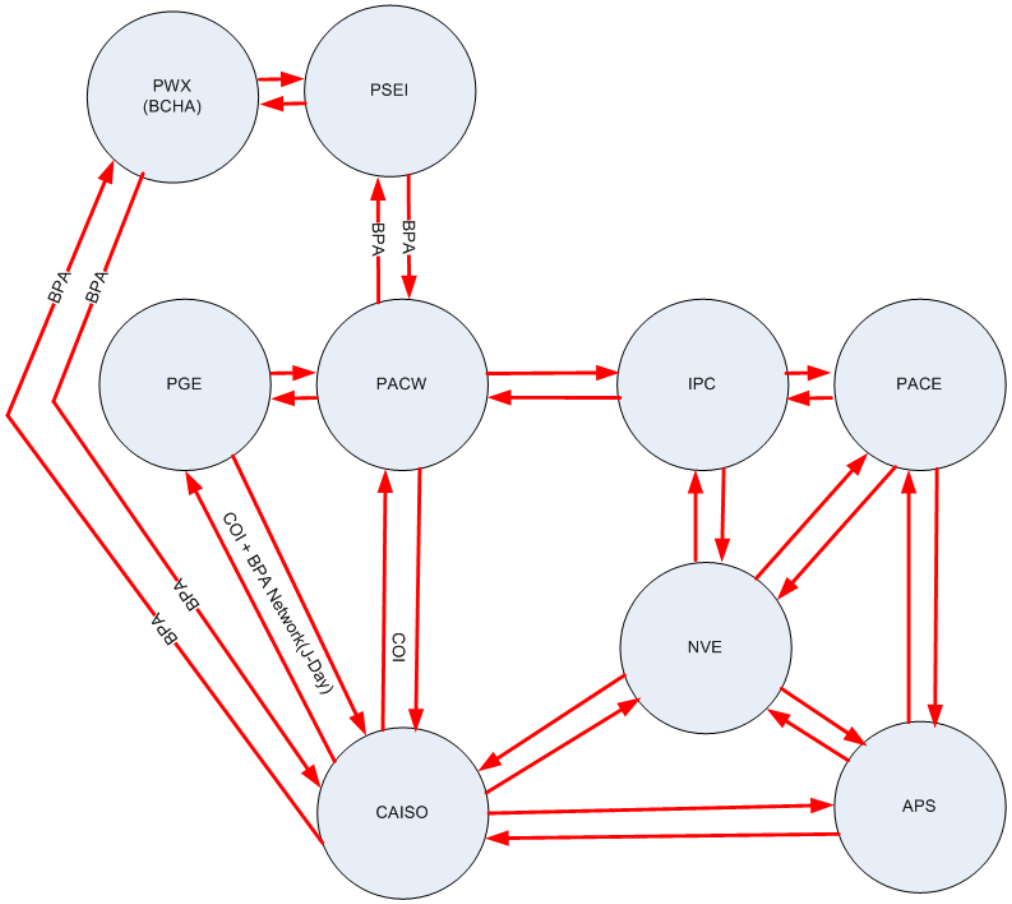
https://www.caiso.com/Documents/TechnicalPaper-EnergyImbalanceMarket-EnergyTransferScheduling.pdf

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 system 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 CAISO intertie with the CAISO.

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 →PSEI) when more efficient transmission paths are constrained



Roles and Definitions

Roles and Definitions

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

Roles and Definitions

- **EIM Entity** is a Balancing Authority 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

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
    - Submits Settlement Quality Meter Data (SQMD)
    - 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

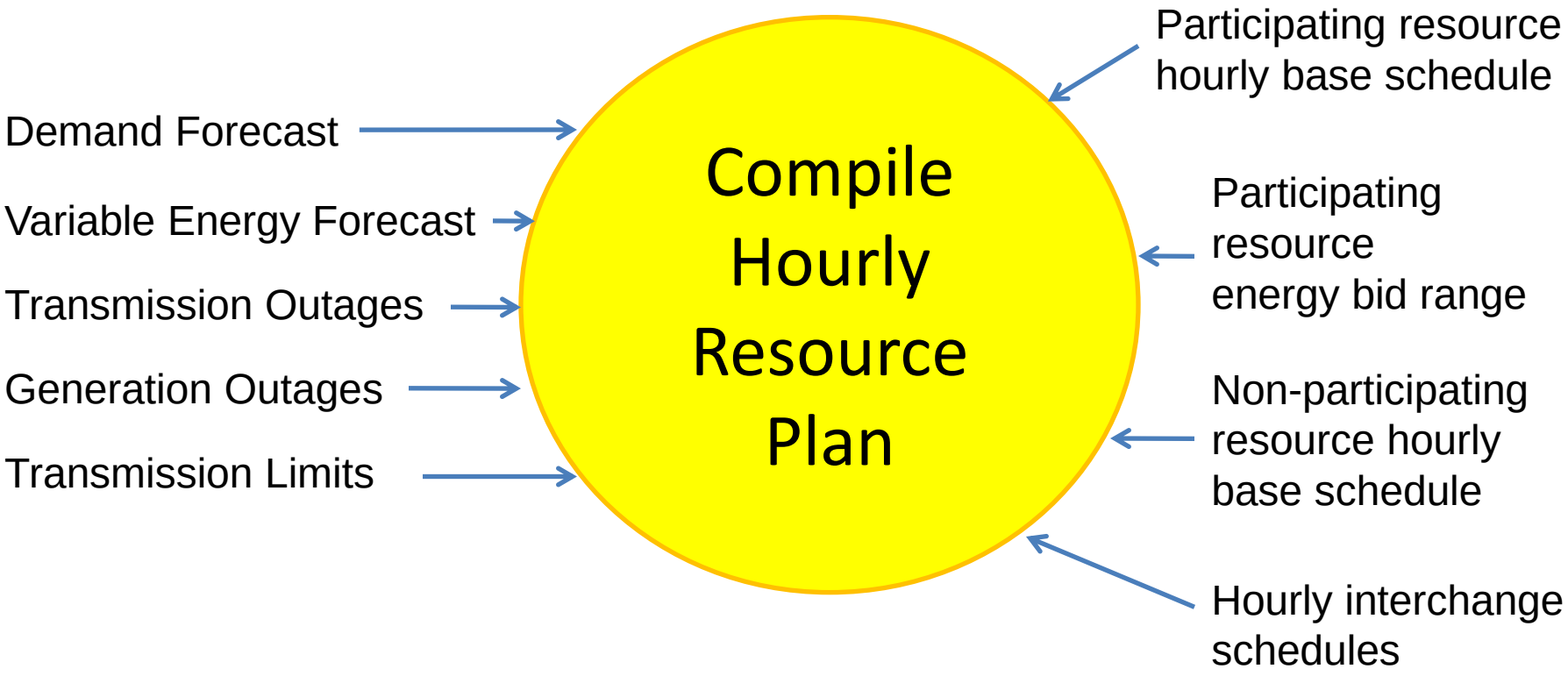
Roles and Definitions

- **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'

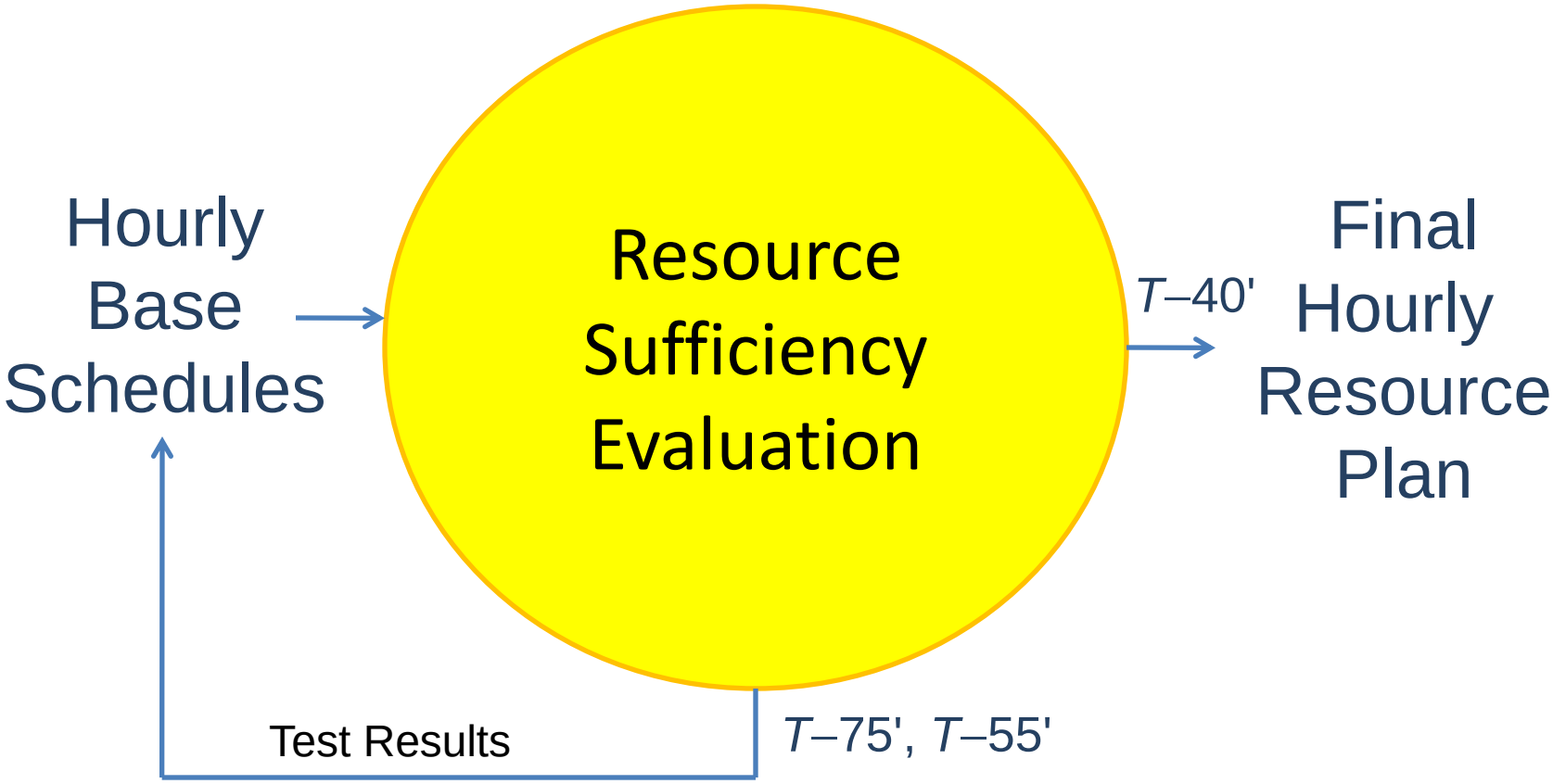
Break

Market Activities

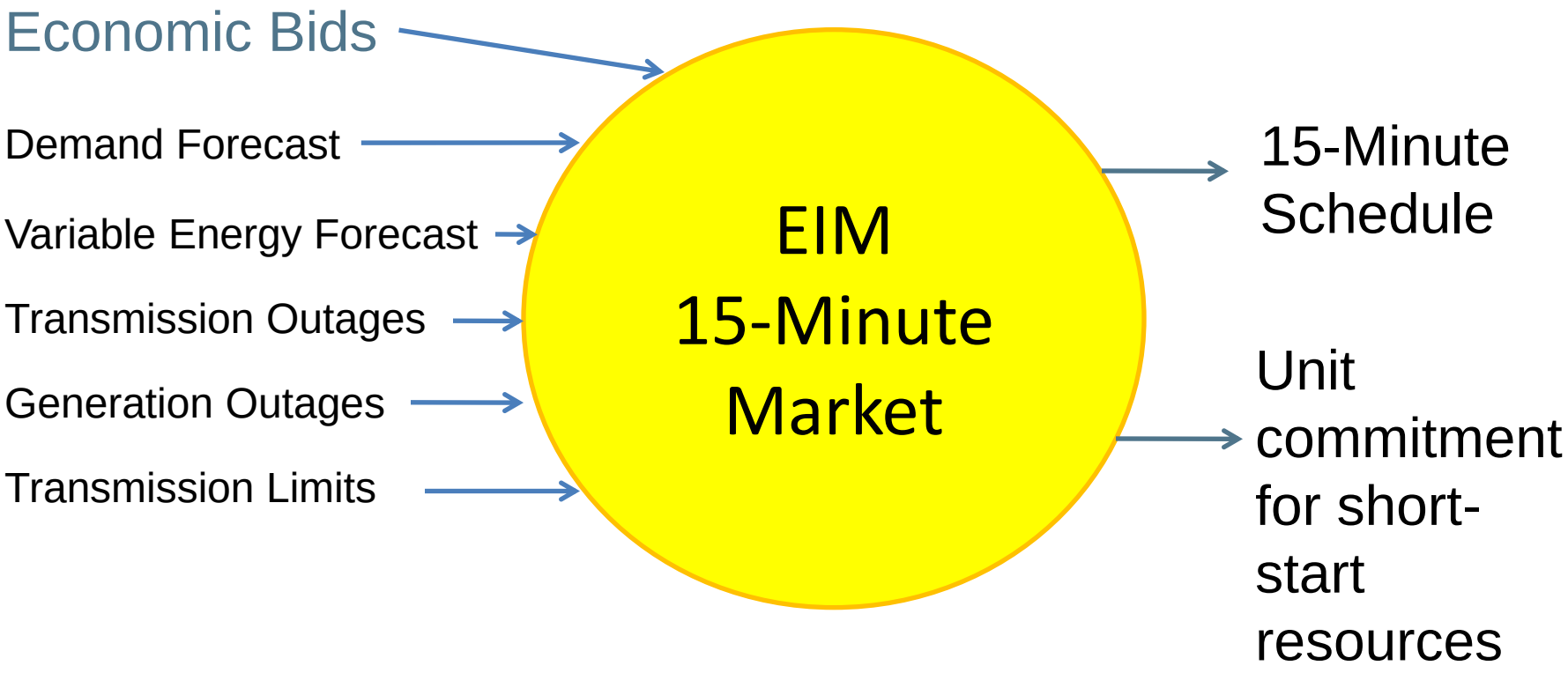
Market Activities



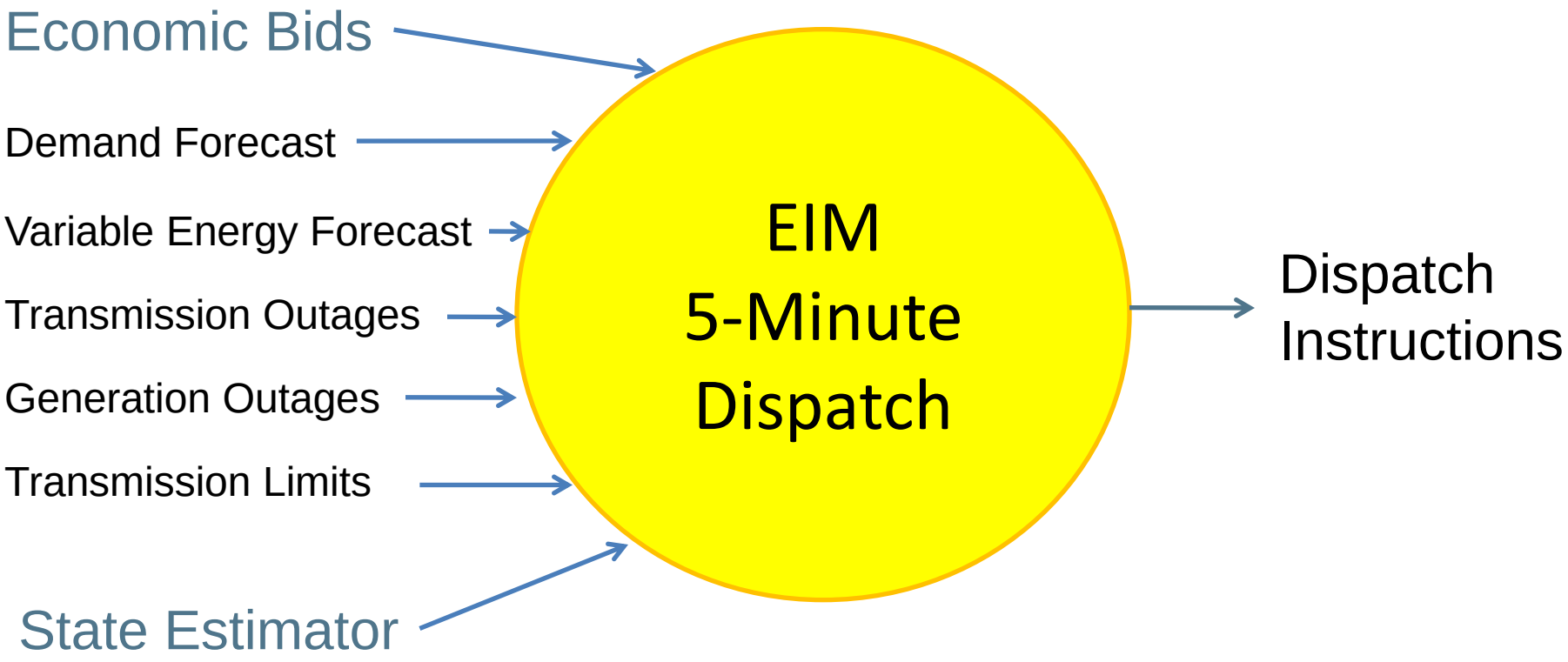
Market Activities



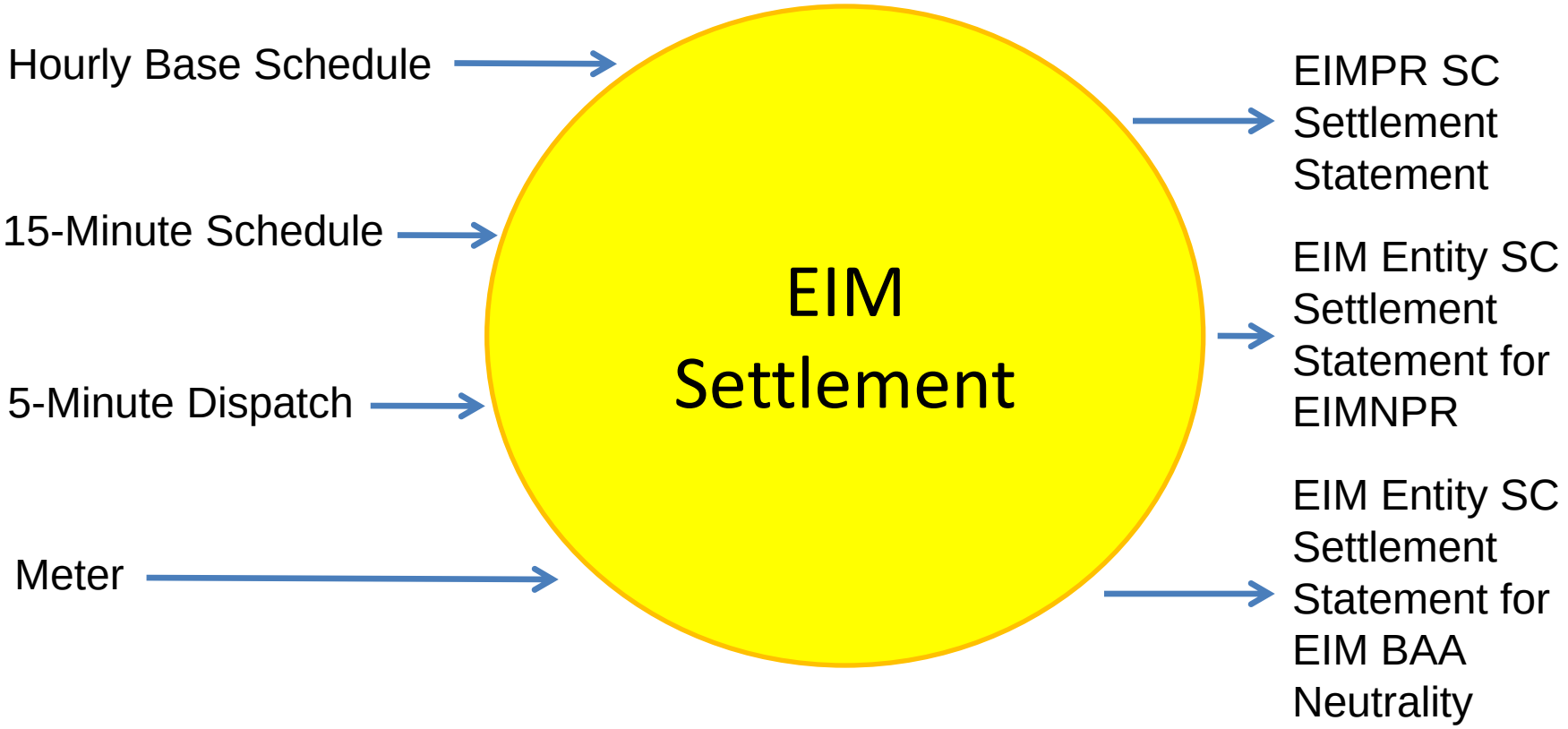
Market Activities



Market Activities



Market Activities



Base Schedules + Bids + Timing

Base Schedule

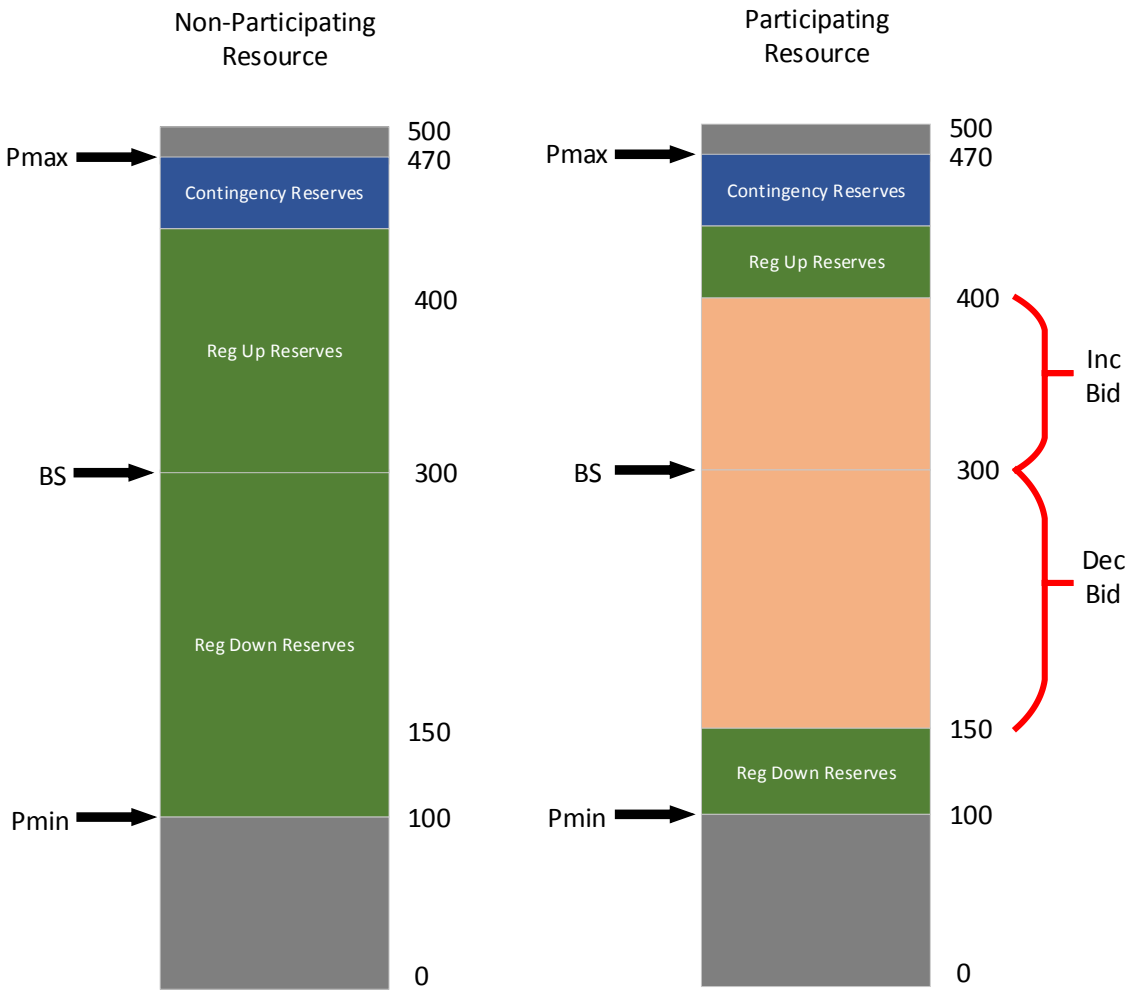
- Generation and Interchange must equal Load.

$$G + I = L$$

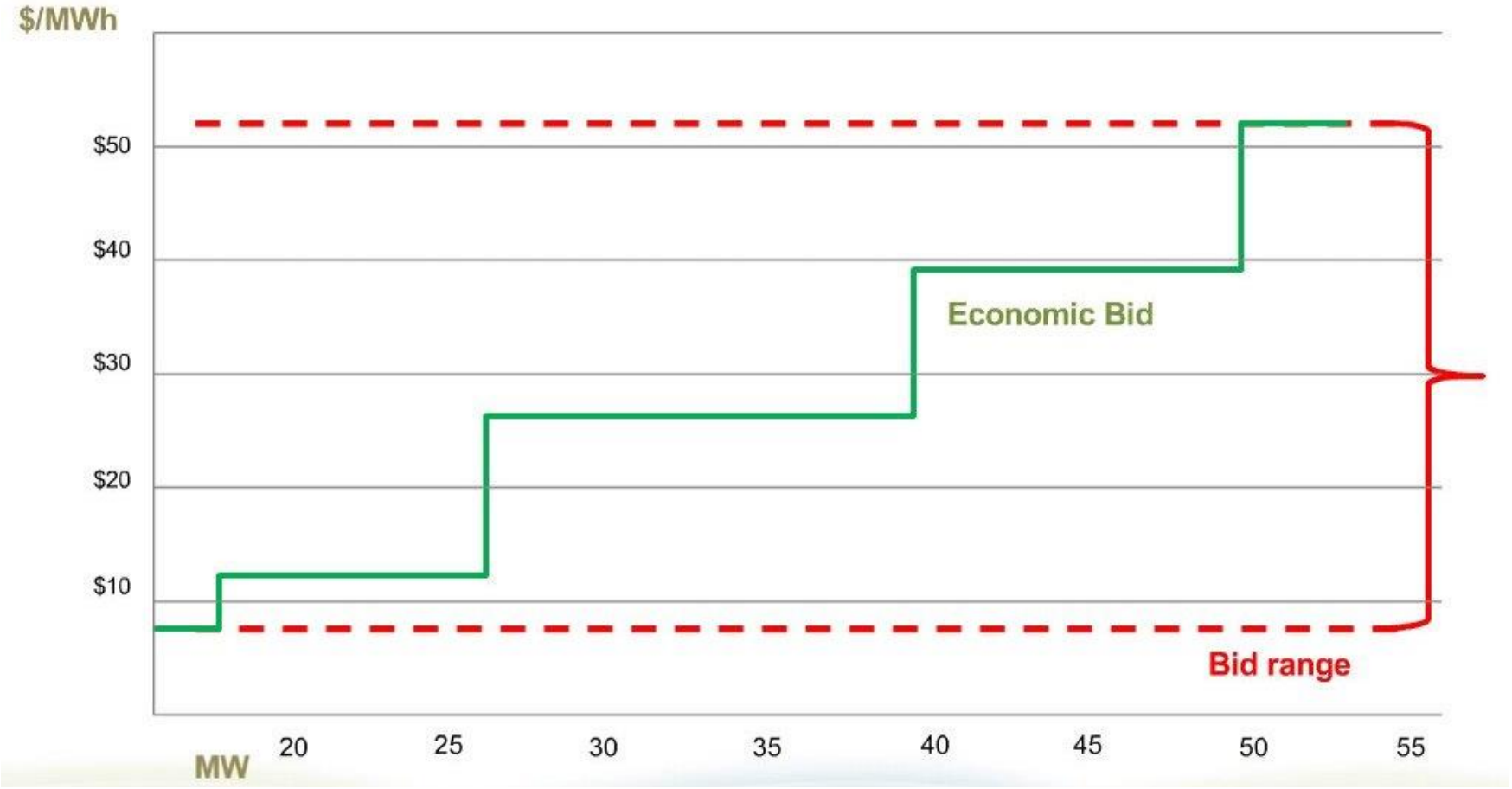
- Submitted T-75, T-55, and T-40 ahead of the hour.
- Solely used as initial starting points of units and to pass hourly sufficiency tests.

Bids

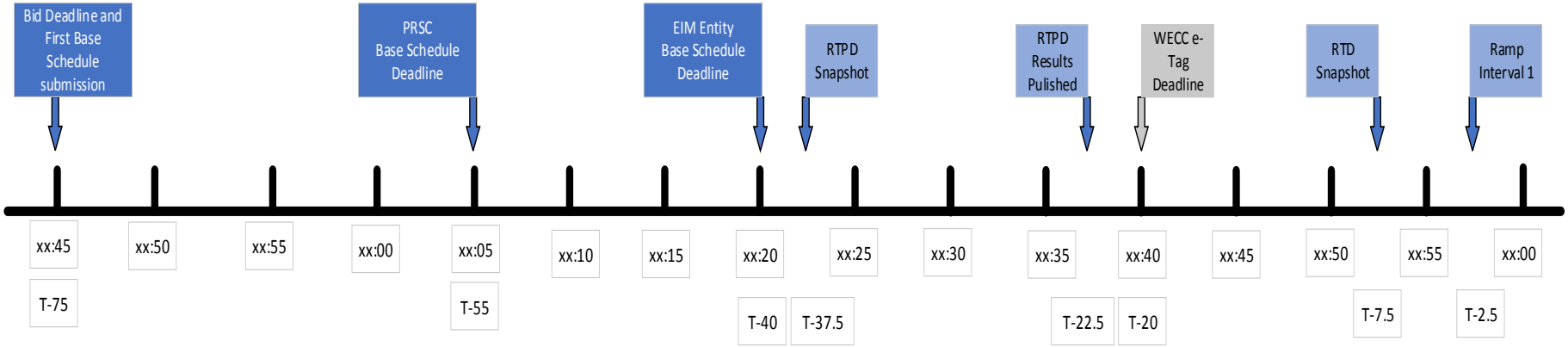
- Non-Participating vs Participating Resources
- Bids submitted by T-75
  - Cannot change bid after T-75
  - Locked for 135 minutes



Bids


$/MWh
$50
$40
$30
$20
$10
Economic Bid
Bid range
20
25
30
35
40
45
50
55
MW

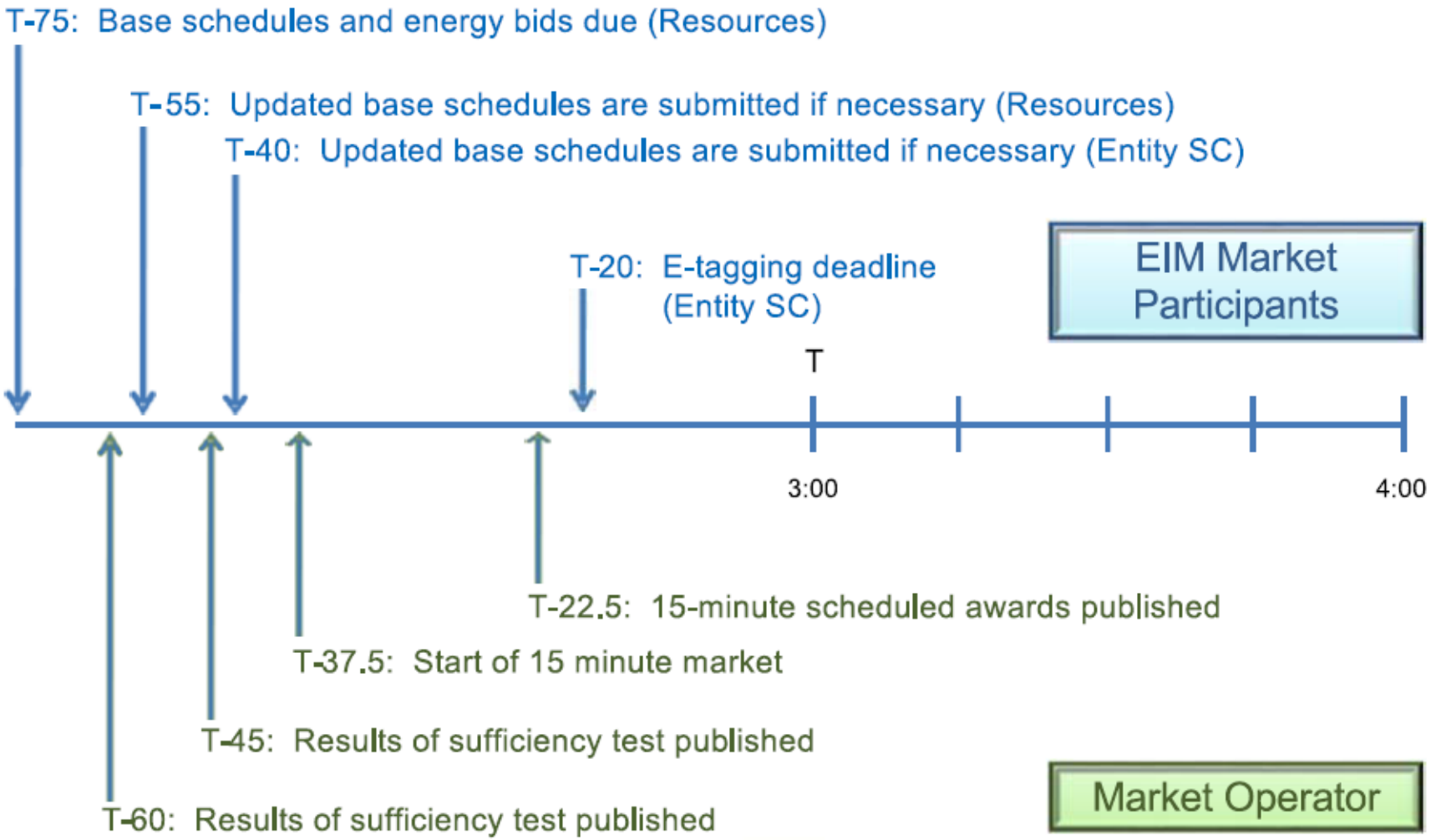
Base Schedule Timing



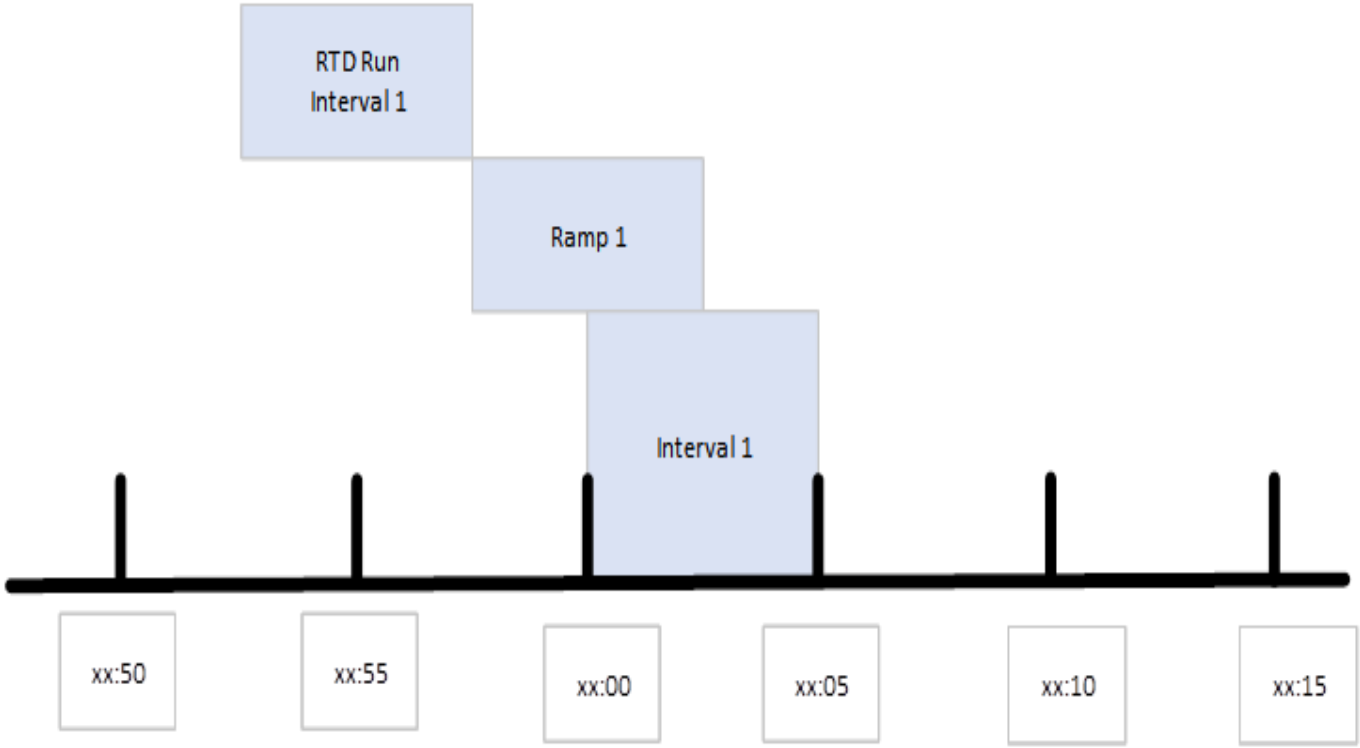
- Bids are locked 75 minutes before the hour
- Participants' Base Schedules deadline is 55 minutes before the hour
- EIM Entity's Base Schedules deadline is 40 minutes before the hour

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

Base Schedule Timing

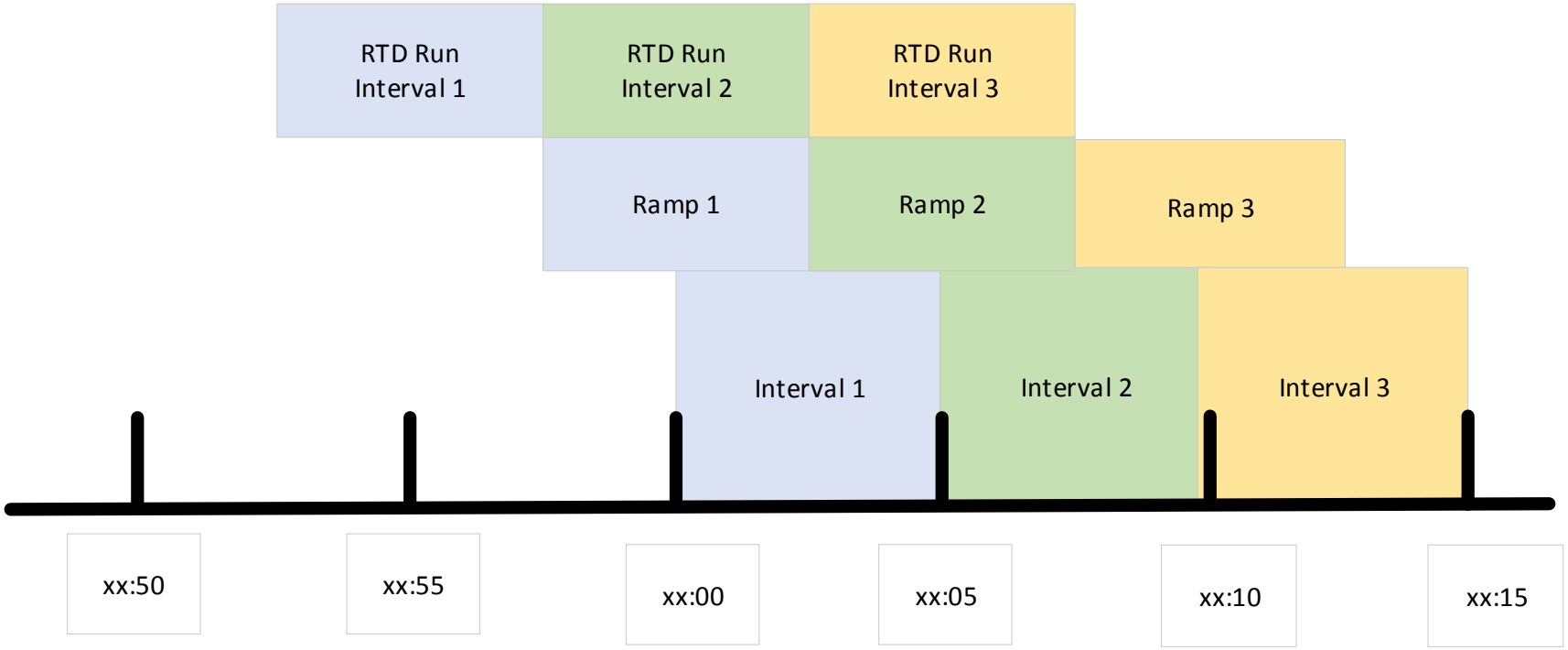


One RTD 5-Minute Run

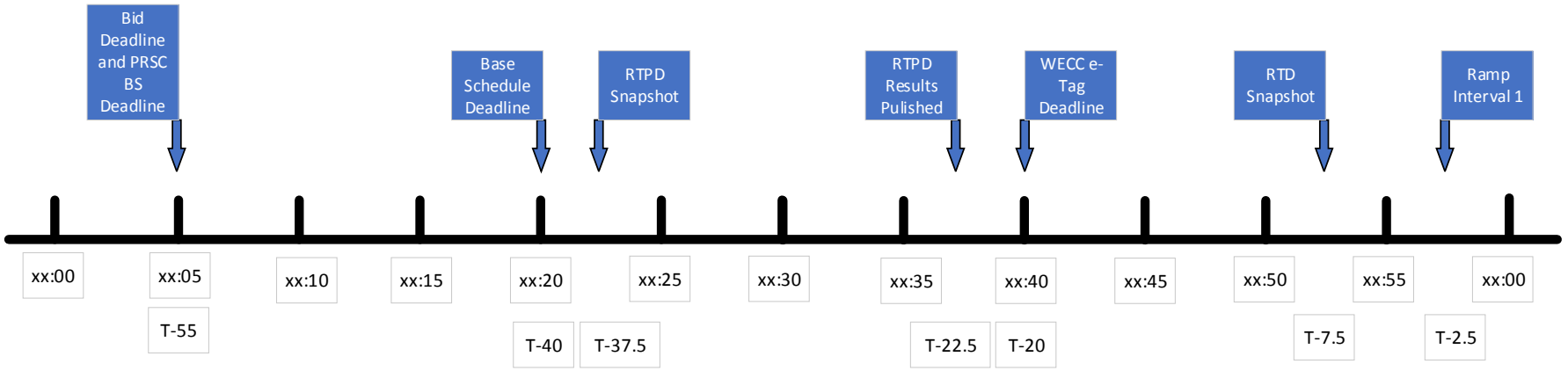


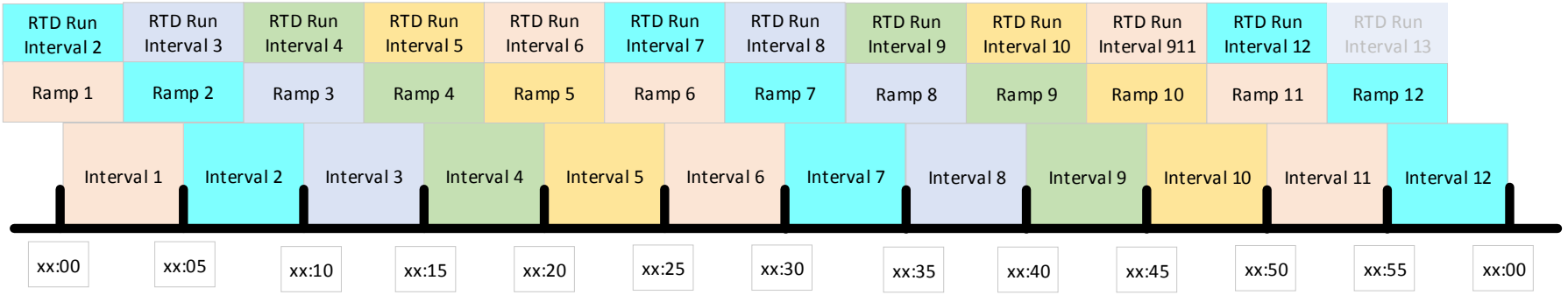
- Market begins calculation 7.5 minutes prior to the 5-minute market interval and publishes results 1-2 minutes prior to ramp
- Solution provides the target for the middle of the interval that resources are expected to ramp to (i.e., Dispatch/Desired Operating Target or DOT)

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.
  - The EIM Market will still optimize resources/bids within the EIM Entity's area.

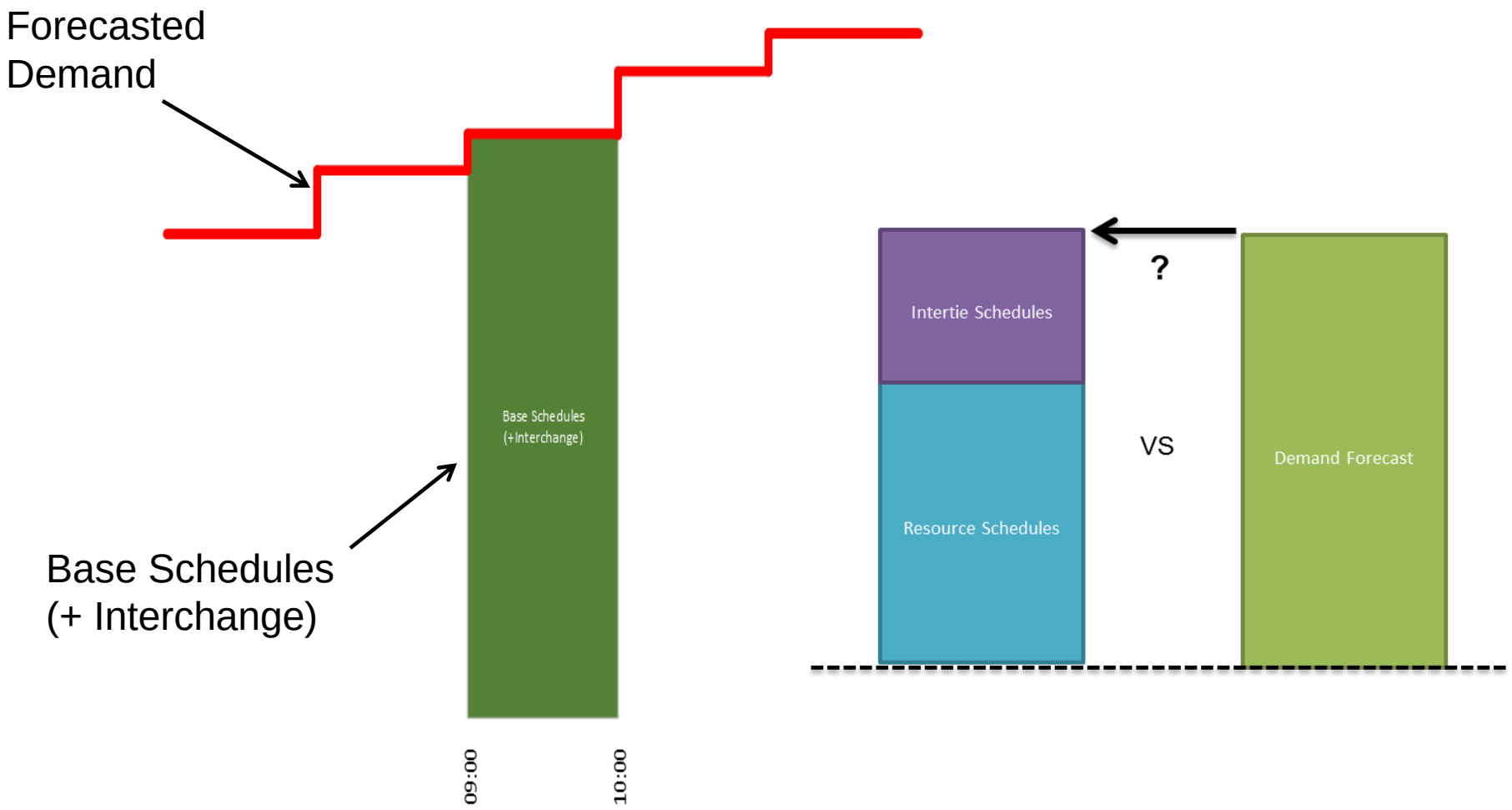
Resource Sufficiency Tests

- Performed for each EIM BAA and the CAISO
  - 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)*

Balancing Test

- Ensures that each EIM Entity is balanced prior to the operating hour
- Compares BAA base schedules (Generation Base Schedules plus Interchange Base Schedules) with hourly demand forecast
- If EIM Entity elects ISO demand forecast option:
  - Pass: BAA imbalance within 1%
  - Fail: BAA imbalance greater than 1%
    - Over-scheduling/under-scheduling penalty applies if actual demands delta is above 5%
- If EIM Entity elects own demand forecast option:
  - Success (always)
    - Over-scheduling/under-scheduling penalty always applies

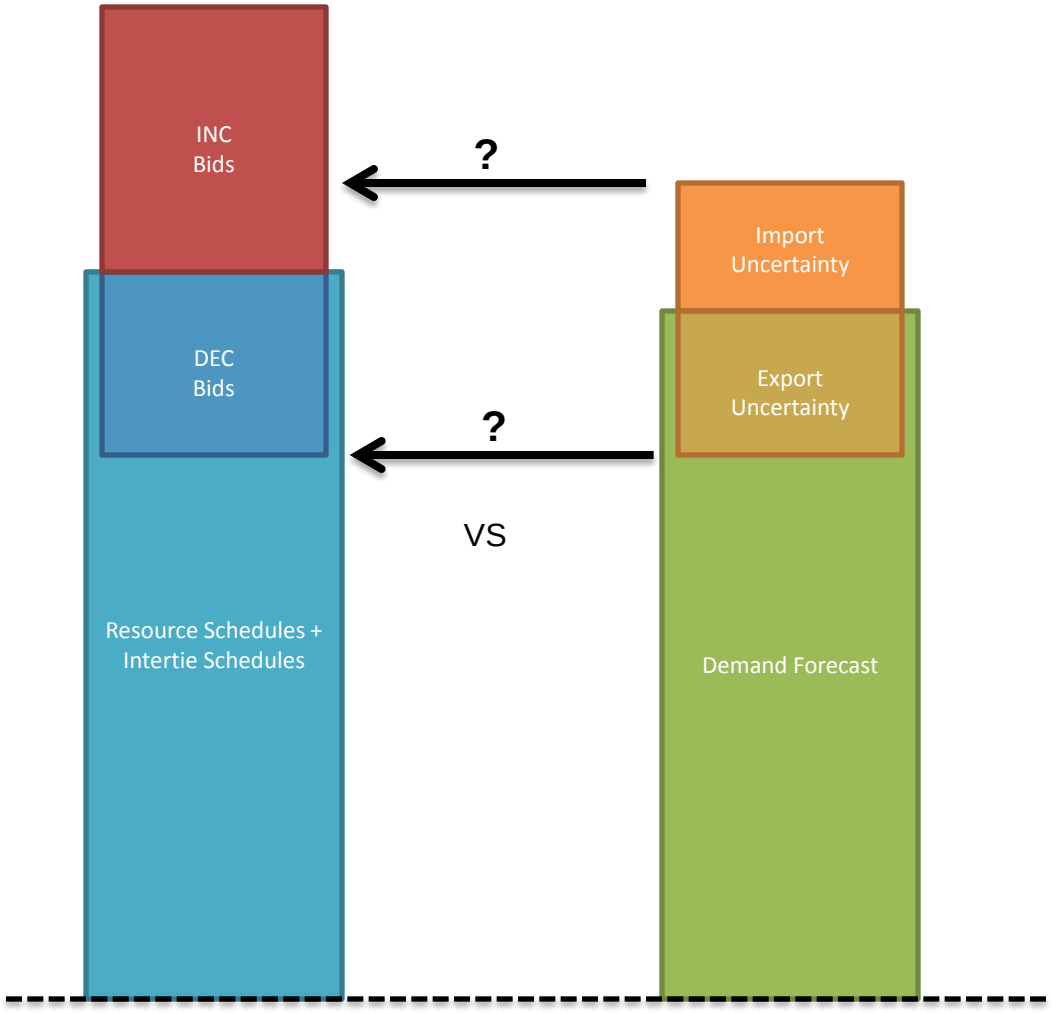
Balancing Test



Bid Capacity Test

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

Bid Capacity Test



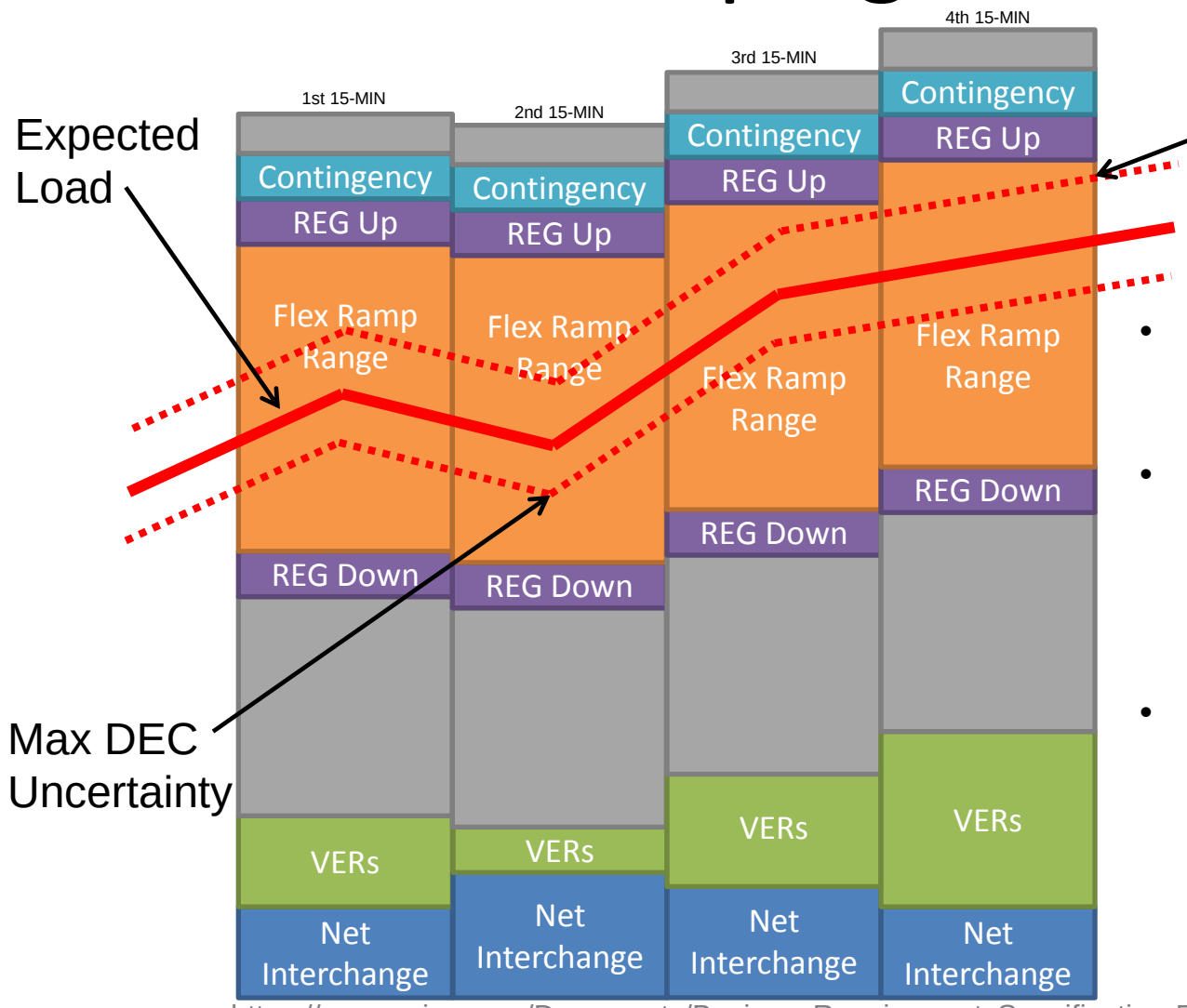
Flexible Ramping Sufficiency Test

- Ensures that each balancing area has enough ramping resources across each hour to meet expected upward and downward ramping needs
- INC and DEC ramping capability are considered separately
- Each 15' interval tested 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 diversity benefit, limited to the available net import/export capability
  - Fail: resource ramp capabilities are below the requirements
    - EIM Transfer is limited to the net import/export level from the last 15-min schedule before the hour (at *T*−7.5')
    - Possible to fail in only one direction (INC or DEC), limiting market actions only in that direction.

Flexible Ramping Sufficiency Test

- Data used:
  - Initial Participating Resource operating points used as the last FMM for the prior hour (at *T*−7.5‘)
    - 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
  - VER and Demand Forecasts at 15’ intervals
  - 15' Flexible Ramp Uncertainty up/down requirements
    - Historical Load net VER difference from last Advisory 15-min run versus Binding 5-min market runs within that Hour of the Day
    - Reduced by a 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

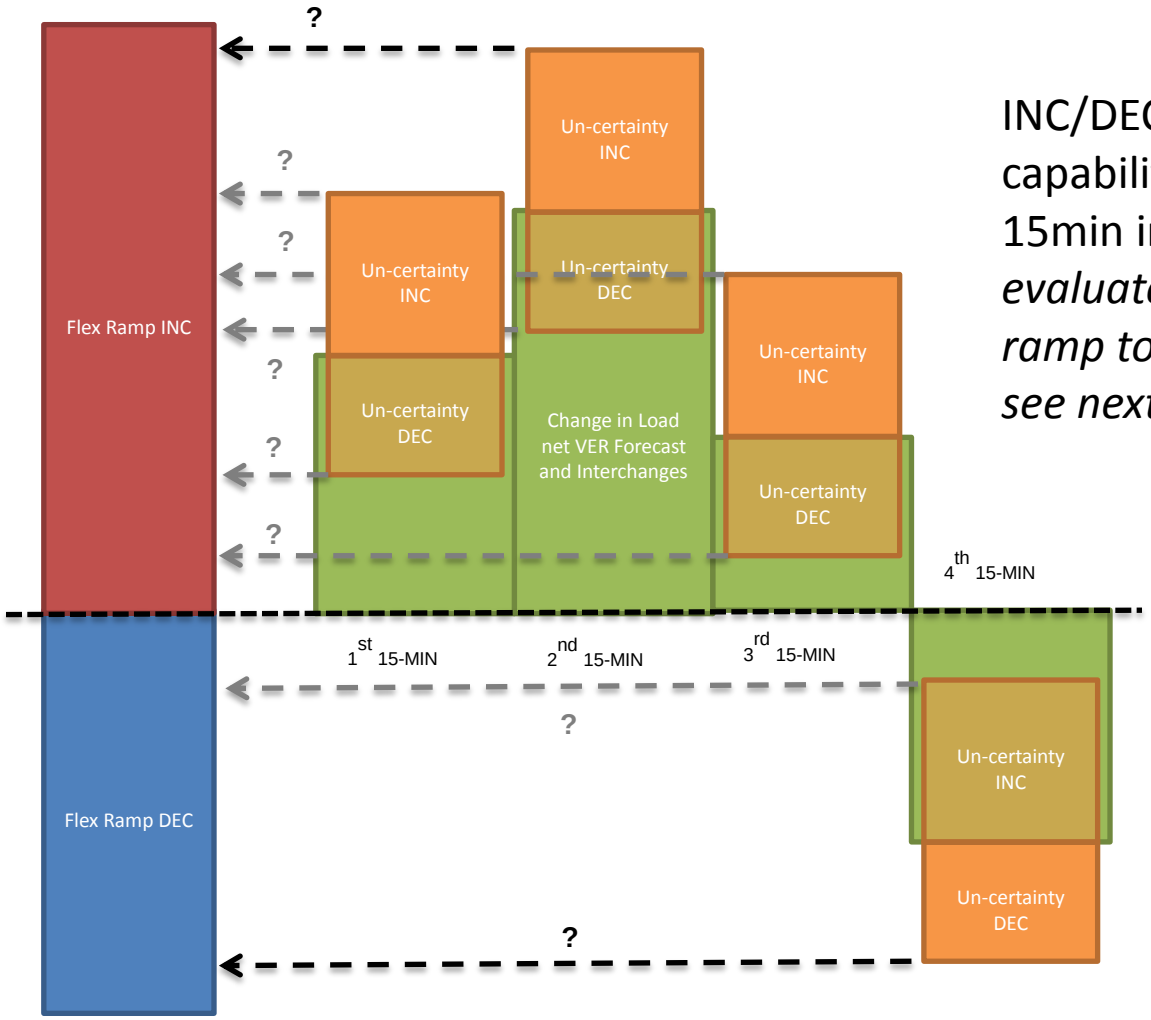
Flexible Ramping Sufficiency Test



- INC/DEC bids must cover Expected Load + "Uncertainty"
- Uncertainty is an estimate of unforeseen variations in VERs and Load *(2.5/97.5 percentiles of histogram)*
- Individual BAA requirement will be reduced by a pro rata share of overall EIM diversity benefit.

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

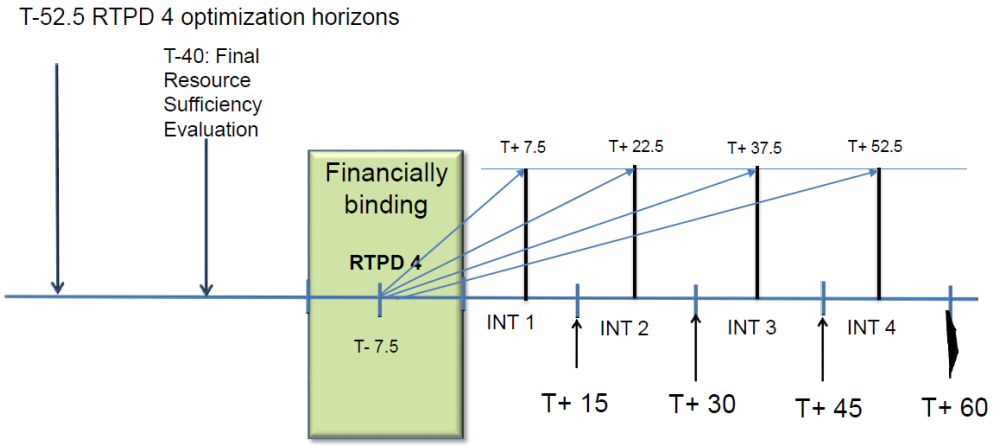
Flexible Ramping Sufficiency Test



INC/DEC flexible ramping capability is the same for all 15min intervals *(it is evaluated separately for each ramp to a 15min interval – see next slide)*

Flexible Ramping Sufficiency Test

- EIM Entity's Participating Resource ramping abilities are subject to a cumulative test 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

Feasibility Test

- Feasibility test are performed:
  - On the day before the Operating Day using Day Ahead Market (DAM) Base Schedules
  - Prior to each operating hour using the Resource Sufficiency timeline (*T*-75', *T*-55' and *T*-40')
    - Uses Base Schedules submitted to the RTM
    - DAM Base Schedules are not used in RTM
  - 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 in base schedules
- Conditionally dispatched by the EIM to avoid a power balance constraint violation within the EIM Entity's BA only when the net EIM Transfer is at its limit
  - Only available to your own BAA
- Does not contribute to Available Flexible Ramping Capacity
- Submitted Energy Bid is used for EIM Participating Resources (EIMPR)
- Default Energy Bid (DEB) is used for EIM Non-Participating Resources (EIMNPR)

Contingency Dispatch

- Contingency in CAISO
  - Suspend RTD; invoke Real-Time Contingency Dispatch(RTCD)
  - Isolate CAISO from the EIM Area
    - Freeze CAISO EIM Transfer at last RTD advisory solution
  - Send previous advisory 5min dispatch for EIMPR
- Contingency in an EIM BAA
  - CAISO does not perform Contingency Dispatch for EIM Entities
  - 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

EIM Settlements

What are EIM Settlements?

- Processes related to, and resulting in, the invoicing of charges and credits for participation in the EIM.
  - Pre-Settlements & Market Operations Feedback
  - Settlements-Related Data Submission and Collection
  - Shadow Settlements (validation)
  - Invoicing of EIM Charges/Credit to EESC and PRSC
  - Payment and Receipt of Funds for EIM Charges and Credits
  - Settlements-Related Dispute Management

EIM Settlements Basics

For Transmission Customers transacting within an EIM BAA, the financially binding base schedule, typically at T-57, forms the basis for settlement of imbalance energy charges:

- **Load:** difference between scheduled demand and metered demand is settled at the load aggregation point (LAP) price for period of deviation.
- **Non-participating generators:** difference between base schedule and metered generation is settled at Locational Marginal Price (LMP) for applicable pNode
- **Participating Resources:** settle directly with CAISO at their LMP for awards and deviations from their operating targets
- **Interchange**: The difference between e-Tag, typically at T-57, and any subsequent tag changes before/during hour are settled as instructed imbalance energy (IIE)
  - Auto-matching is a feature that can be used by EIM Entities to self-balance non-dynamic schedule deviations tag changes after *T*-40 with non-EIM BAAs

EIM Settlement Basics

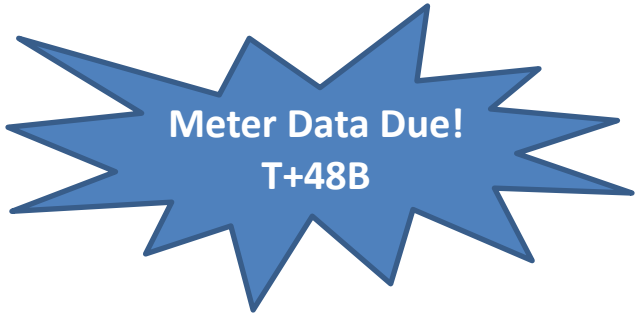
- CAISO settles on about 60 billing determinants
  - 26 with the Participating Resource Scheduling Coordinator (PRSC)
  - 34 with the EIM Entity Scheduling Coordinator (EESC)

- Approximately 70-80% of the EIM settlement dollars reside in 3 charge codes (CC)
  - Instructed Imbalance (PRs & NPRs)
    - Difference between Base Schedules and 15-min Market Schedule (FMM IIE)
      - CC 64600
    - Between 15-min Market Schedules (FMM) and 5-min Real Time Market Dispatch (RTD IIE)
      - CC 64700
  - Uninstructed Imbalance (PRs, NPRs, and Loads)
    - Difference between hourly meter and base schedule for EIM non-participating load; between meter and expected energy (i.e., RTD DOT) for other EIM resources (RTD UIE)
      - CC 64750

Charge Code Matrix: http://www.caiso.com/Documents/ISOMarketChargeCodesMatrix.xls

EIM Settlements Basics

- Settlement statements are posted daily by CAISO for at least 3, and up to 7, versions
  - **Trade Day + 3 Business Days (T+3B)**
  - **T+12B**
  - **T+55B**
  - T+9M (Months)
  - T+18M
  - T+33M
  - T+36M



- Settlement statements are included on the Invoice following the statement posting date
- CAISO has a formal dispute process whenever there are questions or discrepancies with the settlement statements or invoices

Other Settlement Categories

- **Under / Over Scheduling Load:** assigned to EIM entity
  - Could be charges or payments
  - Typically allocated by EIM Entity
  - Not charged if using CAISO load forecast
- **EIM Uplifts:** Typically allocated by EIM entities to load on basis of measured demand (metered demand plus interchange exports)
  - Market neutrality
  - Congestion offset
  - Marginal losses offset
  - Neutrality Adjustments
  - Bid Cost Recovery

Questions?

Upcoming EIM Stakeholder Meetings

- Oct. 11, 2018, 9 a.m.-12 noon, BPA Rates Hearing Room and by WebEx
- Nov. 20, 2018, time TBD, BPA Rates Hearing Room and by WebEx
- For more information please visit www.bpa.gov/goto/EIM

Thank You

- We welcome feedback on the workshop
- please send any to techforum@bpa.gov and reference “EIM 101 Workshop” in the subject

Appendix

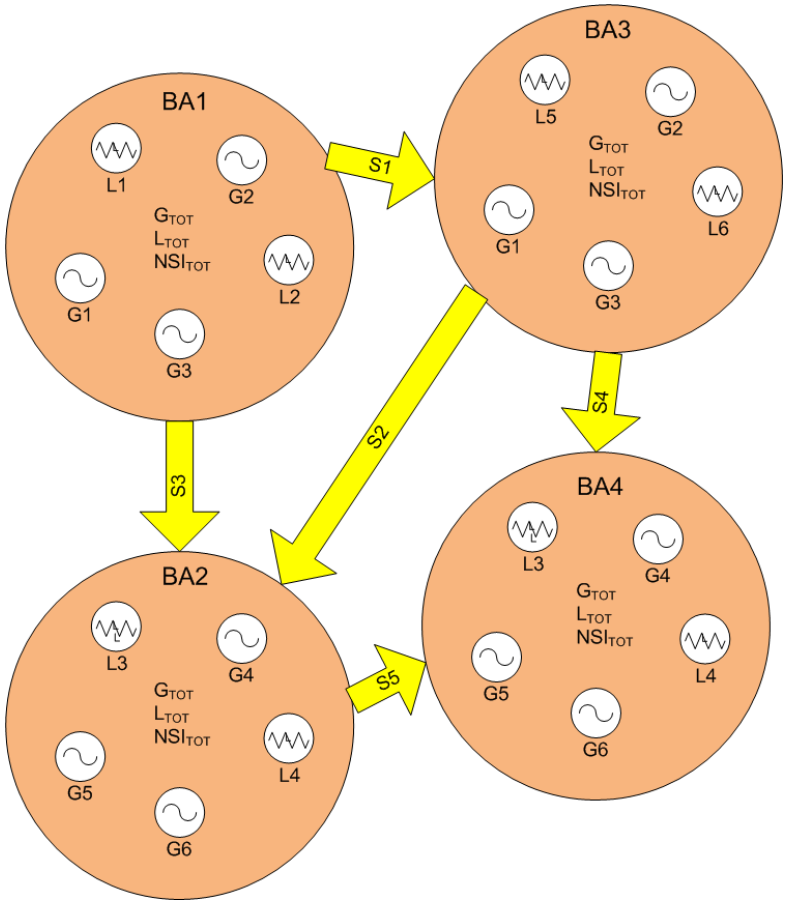
On-line Resources

- 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

With & Without an EIM

Without an EIM

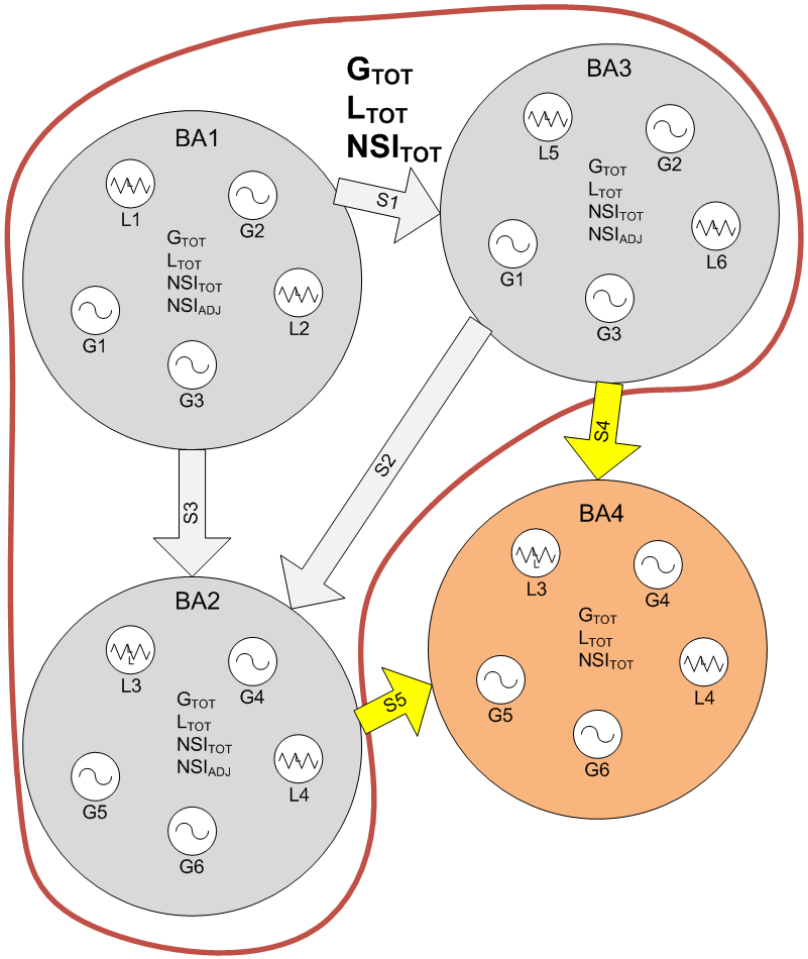
- Outside of emergency situations, each BA must balance their own area and cannot use resources and load in another area to balance or manage congestion unless pre-arranged bi-laterally ahead of time.
- *Example:* BA1 must serve its internal load (L1+L2) and scheduled export obligation (S1+S2)



BA = Balancing Authority
L = Load
G = Generator
NSI = Net Scheduled Interchange
S = Schedule

With an EIM

- The EIM economically and securely redispatches participating resources every 5 minutes across the entire market footprint (BA1+BA2+BA3) sufficient to serve the total market load and net market exports (S4+S5).
- Net Scheduled Interchange (NSI) for each Balancing Authority is dynamically adjusted to account for dispatches from the EIM and the resulting EIM Transfers.
- The dispatch of participating resources honors transmission limits and EIM energy transfers between BAAs are constrained to the amount of transmission made available to the market via dynamic schedules



What are Locational Marginal Prices?

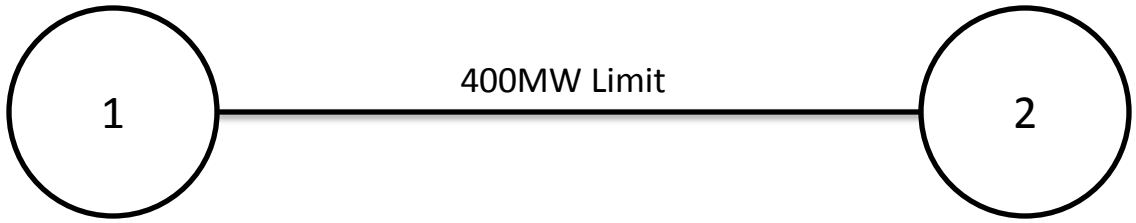
LMP

- Locational Marginal Pricing (LMP) are the result of the EIM optimization and represent the marginal cost of providing the next increment of energy demand (i.e., cost to serve the next MW of load) at thousands of pricing points, or pNodes, within the EIM Area.
- LMPs provide price signals that account for the additional costs of electricity caused by 1) congestion and 2) line loss at various points on the electricity grid and 3) Green House Gas (GHG) compliance for serving California load.
- LMPs allow the EIM to efficiently determine the interaction of energy supply and energy demand

LMPs & GHG

- GHG compliance cost component of the LMP is the rate the market uses to calculate a payment to each generator in an EIM BAA for its output that is determined to serve ISO imbalances. This payment is funded through the price paid within the ISO for imbalance energy embedded in the system marginal cost of energy.
- For resources in an EIM entity's BAA, there are no GHG compliance costs when the resources serve load outside of the ISO. The EIM design allows EIM participating resources to submit two bids: (1) an energy bid and (2) a GHG bid adder.
- To avoid charging EIM entities for GHG compliance outside of California, the LMP of nodes in the EIM footprint outside of the ISO balancing authority area will include a negative GHG component if there is an EIM transfer into the ISO; otherwise, the value is zero.

LMP Example

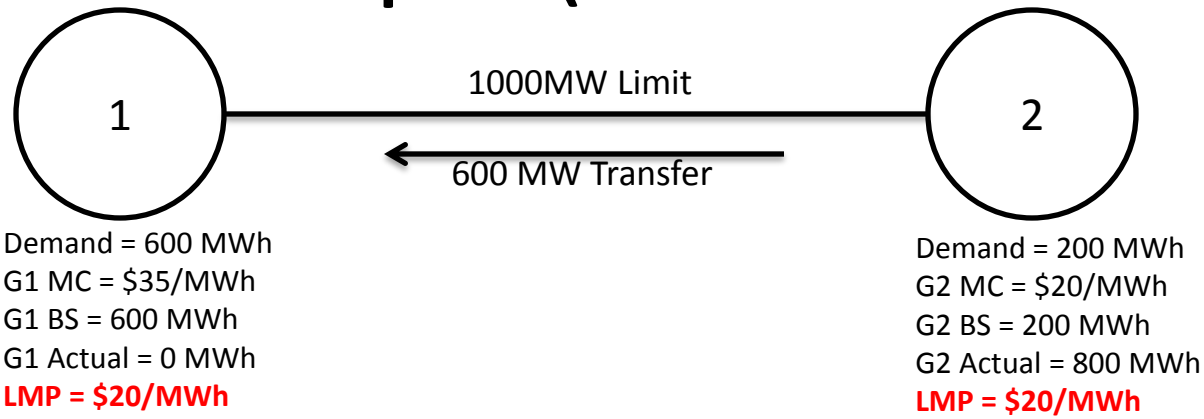


Demand = 600 MWh
Generator 1 (G1) Marginal Cost (MC) = $35/MWh
G1 Base Schedule (BS) = 600 MWh

Demand = 200 MWh
Generator 2 (G2) Marginal Cost (MC) = $20/MWh
G2 Base Schedule = 200 MWh

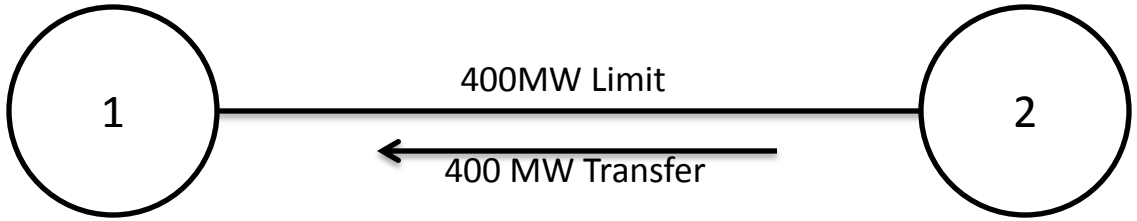
- The marginal cost of energy in zone 1 is higher ($35) than in zone 2 ($20).
- Demand is higher in zone 1 (600 MWh) than in zone 2 (200 MWh)
- There is a transmission line between the two zones & we are ignoring losses
- Assume each generator is serving their local demand
- Assume each generator, G1 and G2, has sufficient capacity to serve the total demand (800 MWh)

LMP Example (unconstrained)



- If the transfer of energy between the two zones is unconstrained
  - G2 would serve the local 200 MWh of demand and the 600 MWh of demand in zone 1
  - There would be a transfer of 600 MWh from zone 2 to zone 1
- The LMP (i.e., cost to serve the next increment of demand) at both zone 1 and zone 2 would be $20/MWh
- G1 would pay $20/MWh for the replacement energy from G2, saving $15/MWh
- G2 would be paid $20/MWh for the additional 600 MWh of energy produced to serve zone 1's demand

LMP Example (constrained)

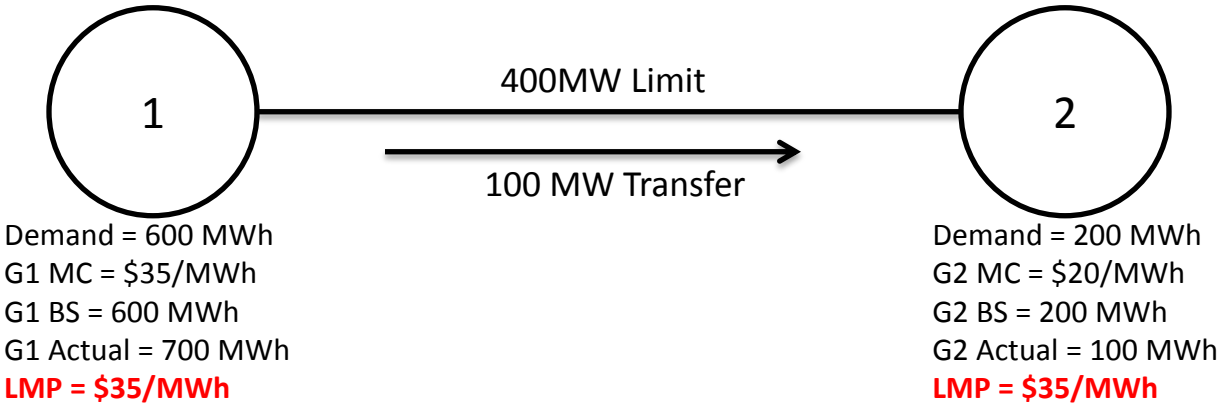


Demand = 600 MWh
G1 MC = $35/MWh
G1 BS = 600 MWh
G1 Actual = 200 MWh
LMP = $35/MWh

Demand = 200 MWh
G2 MC = $20/MWh
G2 BS = 200 MWh
G2 Actual = 600 MWh
LMP = $20/MWh

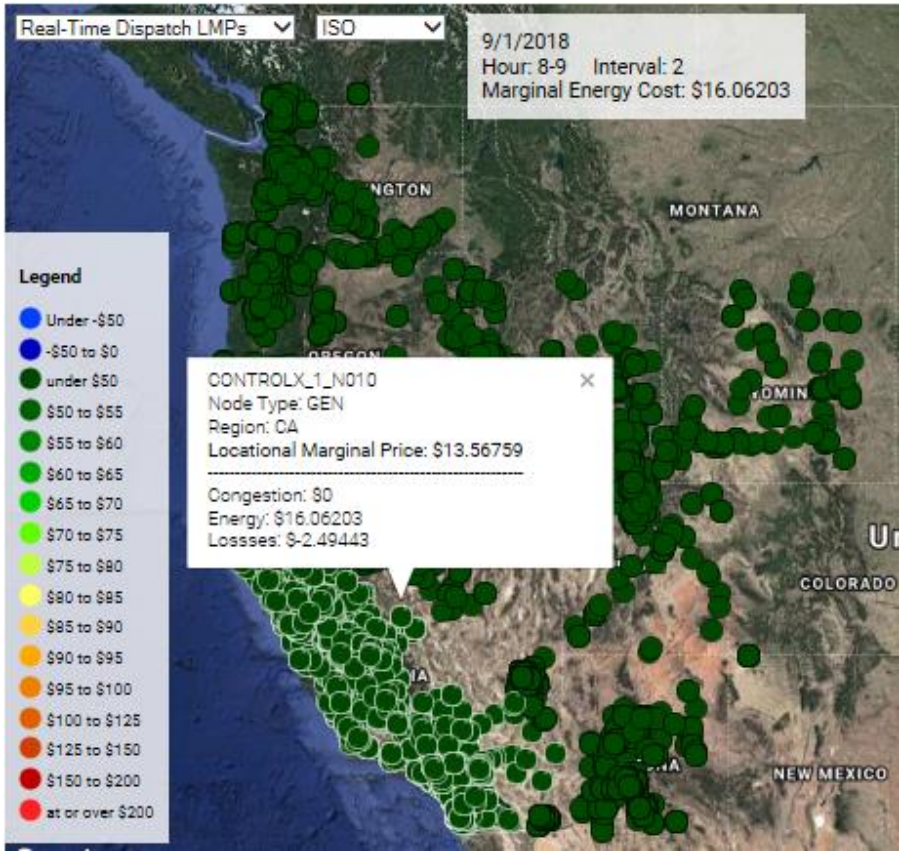
- If the transfer of energy between the two zones was limited to 400 MW
  - G2 would serve the local 200 MWh of demand, but could only transfer 400 MWh to zone 1 due to the constraint
  - G1 would have to service the remaining 200 MWh of demand in zone 1
  - The marginal cost of energy (LMP) in zone 2 would be $20/MWh
  - The marginal cost of energy (LMP) in zone 1 would be $35/MWh
- G1 would pay $35/MWh for the 400 MWh energy from G2
- G2 would be paid $20/MWh for the additional 400 MWh of energy produced to serve zone 1's demand
- EIM would collect from G1 $14,000 ($35 x 400)
- EIM would pay G2 $8,000 ($20 x 400)
- EIM collected excess revenue of $6000 ($14,000 - $8,0000) - this excess revenue is called "congestion revenue."

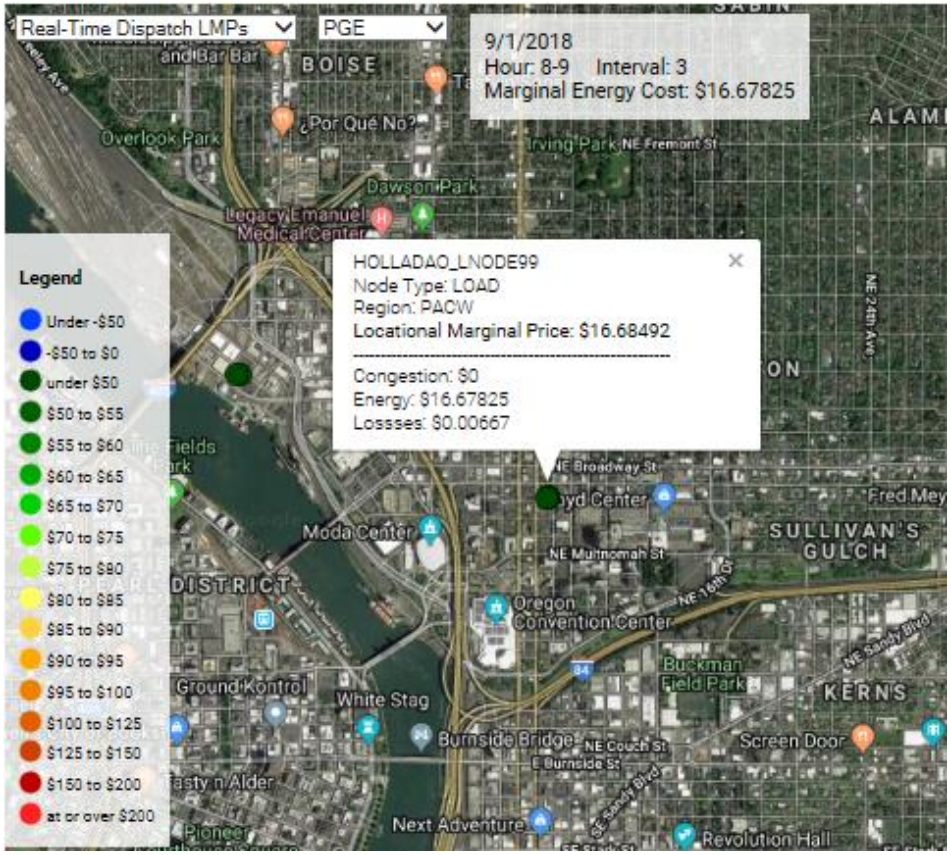
LMP Example (G2 Derate)



- What if G2 could only generate 100 MWh due to a real-time derate?
  - G1 would need to serve the last 100 MWh or load in zone 2
  - The marginal cost of energy (LMP) in zone 2 would be $35/MWh
  - The marginal cost of energy (LMP) in zone 1 would be $35/MWh
- G2 would pay $35/MWh for the 100 MWh energy from G1
- G1 would be paid $35/MWh for the additional 100 MWh of energy produced to serve zone 2's demand
- EIM would pay G1 $3,500 ($35 x 100)
- EIM would collect from G2 $3,500 ($35 x 100)
- EIM is revenue neutral ($3,500 - $3,500) – No Congestion Revenue

LMP Price Map





http://www.caiso.com/PriceMap/Pages/default.aspx

EIM Settlement Example (Participating Resource)

Settlement Example for PR (one 15-minute interval)

- Scenario:
  - Resource has an hourly Base Schedule of **350 MWh** and an hourly bid of **$20.00/MWh**
  - Resource receives an **FMM** Schedule/Award of 385 MW **(INC of 35)** for FMM interval 2 (XX:15-XX:30) with an **LMP of $22.50**
  - Resource receives an **RTD** 5-minute market dispatch of:
    - 400 MW **(INC of 15 MW)** for RTD interval 4 (XX:15-XX:20)
      - **LMP of $23.50**
    - 355 MW **(DEC of 30 MW)** for RTD interval 5 (XX:20-XX:25)
      - **LMP of $20.75**
    - 320 MW **(DEC of 65 MW)** for RTD interval 6 (XX:25-XX:30)
      - **LMP of $17.50**
  - Resource **Meter** Actuals:
    - 405 MW **(INC of 5 MW)** for RTD interval 4 (XX:15-XX:20)
    - 360 MW **(INC of 5 MW)** for RTD interval 5 (XX:20-XX:25)
    - 310 MW **(DEC of 10 MW)** for RTD interval 6 (XX:25-XX:30)

Settlement Example for PR (one 15-minute interval)

- Credits & Debits:
  - FMM 15-30 (Interval 2)
    - Credit of $196.88 (35 MW x $22.50)/4 ←FMM IIE 64600
  - RTD 15-20 (Interval 4)
    - Credit of $29.38 (15 MW x $23.50)/12 ← RTD IIE 64700
  - RTD 20-25 (Interval 5)
    - Debit of $51.88 (30 MW x $20.75)/12 ← RTD IIE 64700
  - RTD 25-30 (Interval 6)
    - Debit of $94.79 (65 x $17.50)/12 ← RTD IIE 64700
  - Meter 15-20 (Interval 4)
    - Credit of $9.79 (5 MW x $23.50)/12 ← RTD UIE 64750
  - Meter 20-25 (Interval 5)
    - Credit of $8.65 (5 MW x $20.75)/12 ← RTD UIE 64750
  - Meter 25-30 (Interval 6)
    - Debit of $14.58 (10 x $17.50)/12 ← RTD UIE 64750
- Total Settlement: $83.45 ($196.88+$29.38–$51.88-$94.79+$9.79+$8.65–$14.58)