



## Software and Model Enhancements in CAISO's Markets

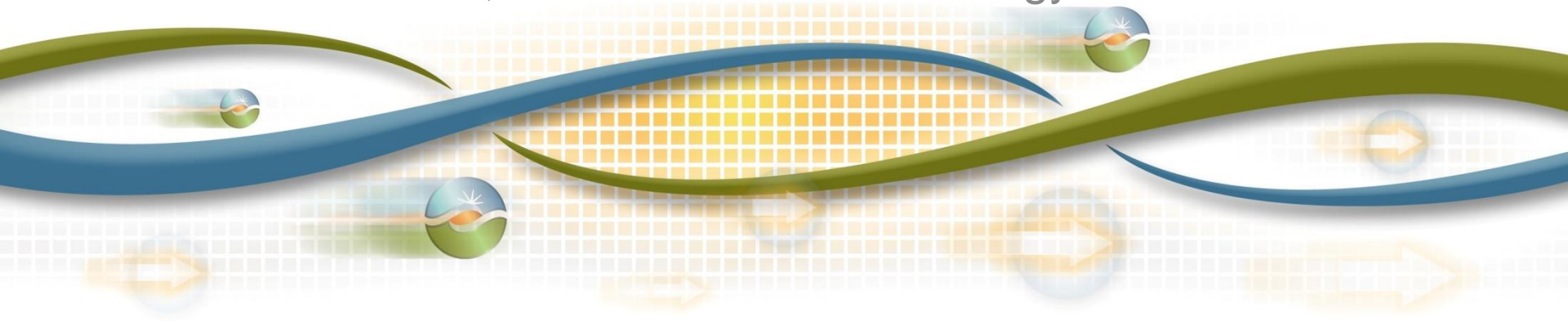
FERC Technical Conference:

Increasing Real-Time and Day-Ahead Market Efficiency  
through Improved Software - June 26, 2017

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# Agenda

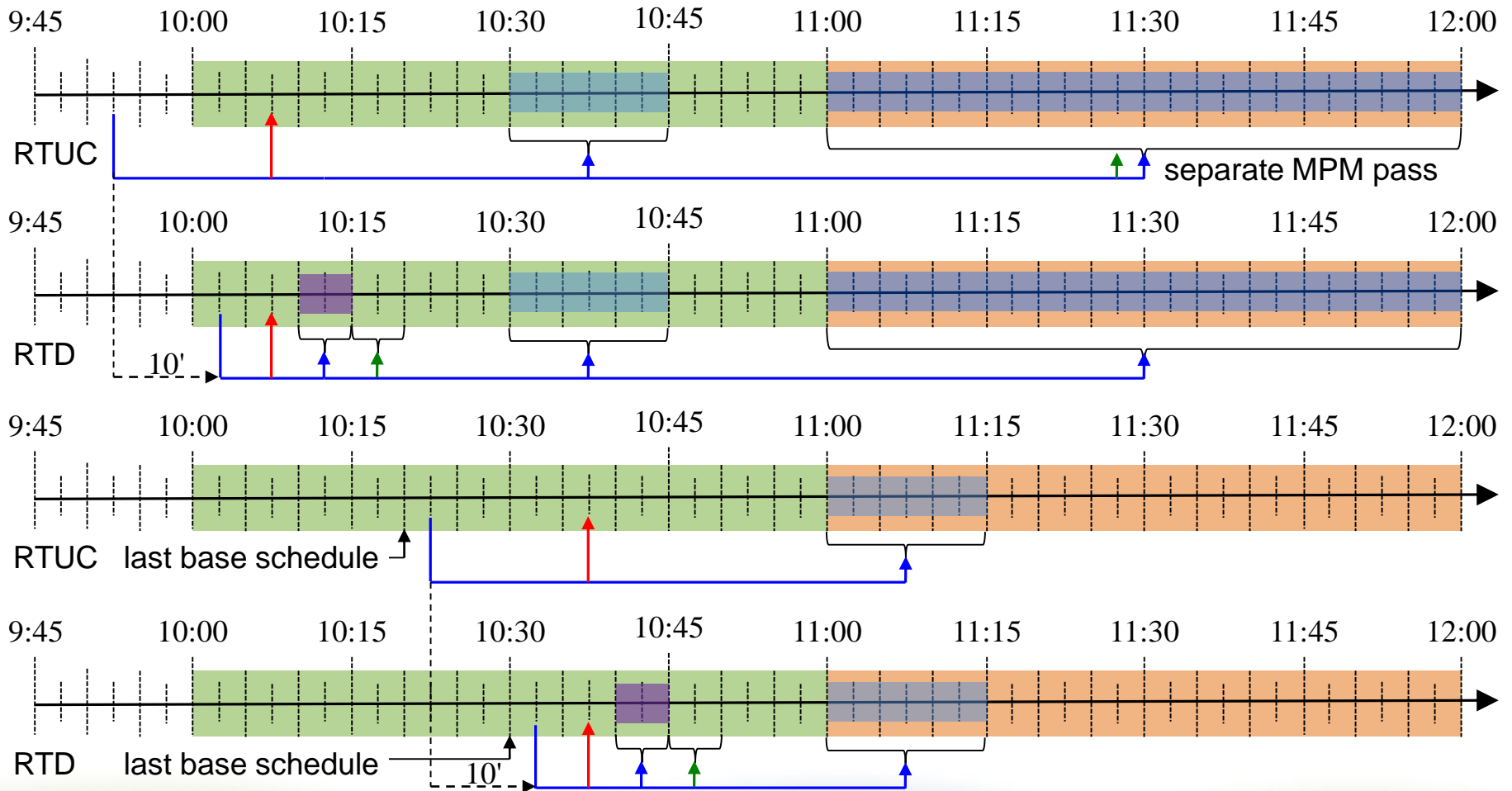
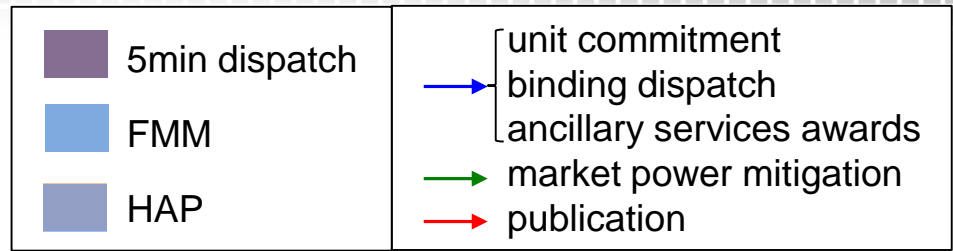
- Real-Time Market Software Restructuring
- Outage Evaluation and Approval
- Flexible Ramp Product
- Green House Gas Allocation Improvement
- Market Software Performance Requirements

# Real-Time Market: Current Design

- RTM market functions are divided between the 15' Real-Time Unit Commitment (RTUC), the 15' Short-Term Unit Commitment (STUC), and the 5' Real-Time Dispatch (RTD) as follows:

RTM Application	Time Horizon	Market Function
RTUC (15min intervals)	Up to 1:45'	<ul style="list-style-type: none"><li>Network Analysis</li><li>Market Power Mitigation (MPM)</li><li>Short-Term Unit Commitment</li><li>Hour-Ahead Processing (HAP)</li><li>Fifteen-Minute Market (FMM)</li><li>Ancillary Services procurement</li><li>Flexible Ramping Product</li></ul>
STUC (15min intervals)	Up to 4:30'	<ul style="list-style-type: none"><li>Short-Term Unit Commitment</li></ul>
RTD (5min intervals)	Up to 1:05'	<ul style="list-style-type: none"><li>Market Power Mitigation (MPM)</li><li>5min Dispatch</li><li>Flexible Ramping Product</li></ul>

# Old RTUC and New RTD Timeline



# Real-Time Market Software Restructuring

- Consolidate potentially all RTM functions into RTD to:
  - Streamline RTM and simplify operations and result publication
  - Eliminate pricing discrepancies between the 15' and the 5' dispatch due to structural differences between RTUC and RTD
  - Reduce data communications and dependencies between RTM applications improving robustness
  - Provide opportunities for timeline compression with input data submitted and decisions taken closer to real time
  - Improve load, VER and flexi ramp forecasts accuracy by pulling 15' market to real-time dispatch interval
  - Reduce financial imbalance energy exposure of bilateral transactions due to EIM

# Real-Time Market Software Restructuring

- Challenges size and complexity:
  - Multi-period RTD Time horizon increase from 12 up to 24 5' intervals
  - Unit startups/shutdowns, startup/shutdown MW profiles, minimum up and dn times, MSG transitions
  - Co-optimization of energy and AS on 5' basis, dynamic ramp sharing (5' energy versus 10' AS)
  - Ramping, hourly blocks, and 15-min block constraints
  - How to iterate between market optimization and power flow for RTD optimization
- MIP is already used in RTD

# Outage Evaluation and Approval

- Typical outage approval process relies on large number of power flow/contingency analysis runs
- Covers peak hours and/or other hours of interest
- Number of parallel independent serial evaluations
- Does not consider dispatch capabilities to accommodate outages unless OPF is used
- Does not consider inter-temporal constraints nor commitment of additional resources
- Outages rejected in early stages of any calculation sequence may be approved in a different evaluation sequence
- High demand for man power to complete evaluation and approval process

# Outage Evaluation and Approval

- Optimal transmission switching for congestion management in CAISO not effective for real-time market timeline
- Use of optimal switching for outage evaluation and approval process is very effective as part of Integrated Optimal Outage Coordination
  - Integrated single pass evaluation and approval of all candidate outages for the study period of up to 7 days with hourly granularity
  - Full modeling of dynamic and static capabilities of the system and resources
  - Covers all 24 hours of every day of the study period not just peak hours and/or hours of interest
  - Combined processing of generation and transmission outages
  - Optimization objective is the maximum number of outages approved
  - Support for optimal window relaxation of outage start and end time
  - Support for cost based evaluation and approval of outages
  - Full SCUC with the addition of outages modelling
  - Integrated AC power flow and contingency analysis verification



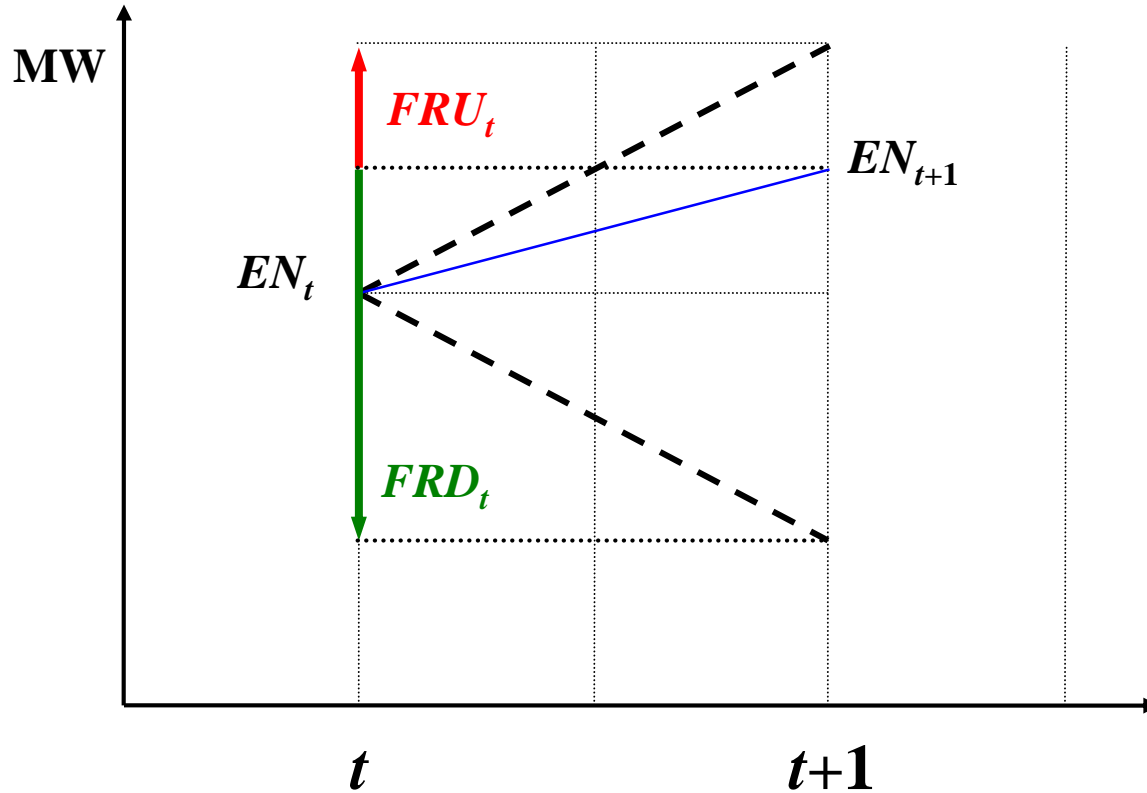
# Outage Evaluation and Approval

- Challenges:
  - Full SCUC for up to 168 hours time horizon with the addition of large number of outages approval optimization
  - Complexity beyond optimal transmission switching due to integrated transmission and generation outages evaluation
  - Complexity due to flexibility of window outage start and end time around fixed outage duration
  - Very large MIP problem combined with a very large AC power flow/contingency analysis
  - Relatively short time available for the solution (< 4 hours)

# Flexible Ramp Product (FRP)

- Composed of Flexible Ramping Up (FRU) and Flexible Ramping Down (FRD) capability
- Currently procured in RTUC and RTD market applications
- The FRP is resource ramping capability that is reserved from scheduling or dispatch in the current market to address uncertainty that may materialize in lower hierarchy real-time market
- Only 5' dispatchable resources with energy bids may provide FRP
- FRP is priced on the margin at applicable opportunity costs. No bids are submitted for FRP

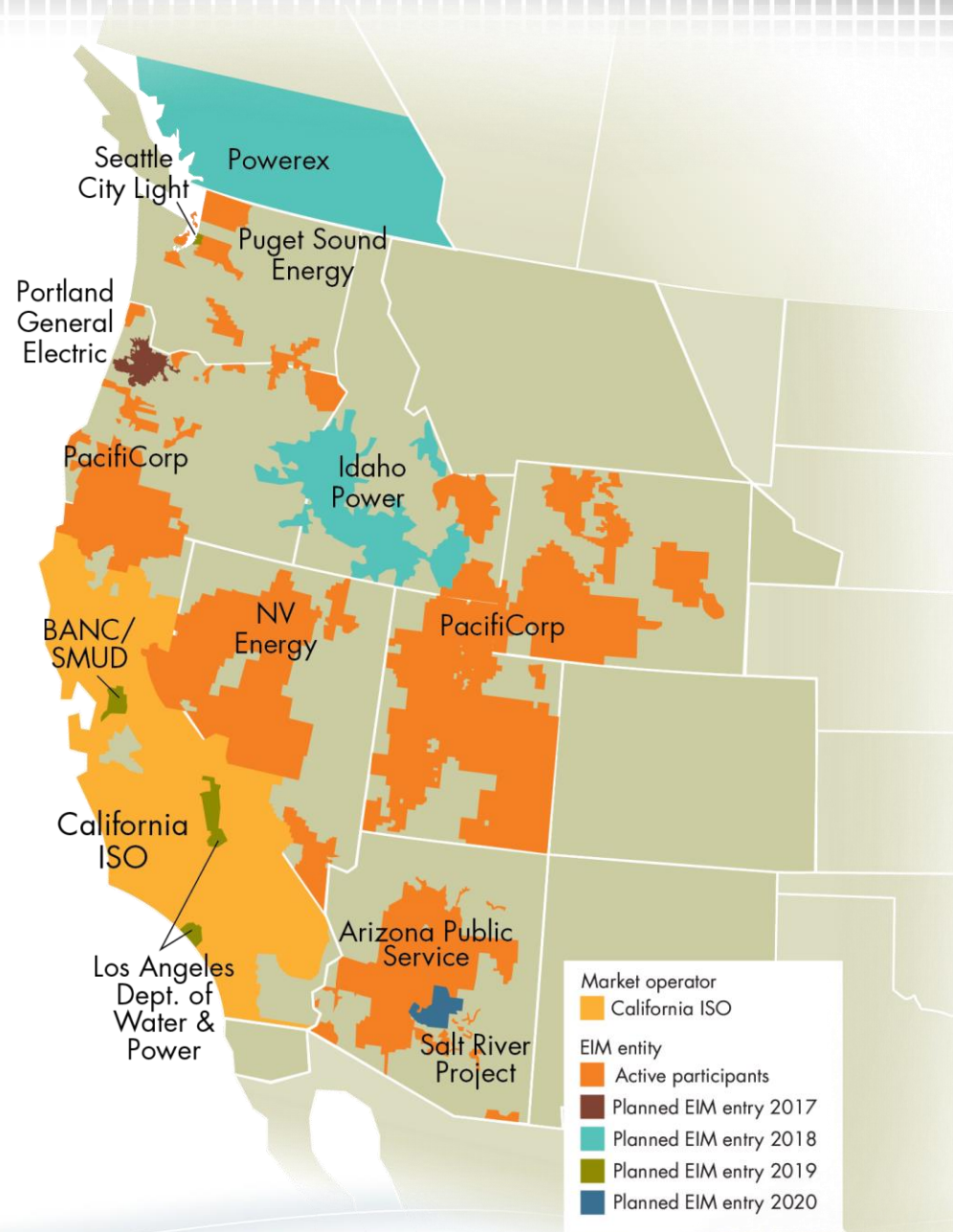
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# Flexible Ramp Product (FRP)

- Uncertainty due to forecast errors, VER intermittency, resources uninstructed deviations needs FRP
- High levels of renewable integration to the grid created steep net load ramping
- Average hourly energy from DAM does not capture accurately ramp in and ramp out during parts of steep daily net load ramping
- Move DA from hourly to 15' time increments to improve compatibility with the 15' real-time market
- DA Commitment of resources can be within the hour rather than at the hourly boundaries
- Ramping is across the hour in addition to top of the hour
- Still provide support for hourly block interchanges

# EIM entity map



# Green House Gas Allocation Improvement

- Western Energy Imbalance Market provides reliability and renewable integration benefits to the West while also providing economic benefits to participants
- Cumulative Peak Demand around 116 GW, about 2/3 of WECC
- GHG policies in CA and other states significantly impact market software
- Improvements to existing EIM GHG allocation method may require two-pass RTD solution which may pose performance challenge

# Market Software Performance Requirements

- IOOC solution in < 4 hours
- DAM solution in < 1 hour
- RTD solution in < 300 sec:
  - 60 sec data input
  - 120 sec MIP solution
  - 90 sec operator review
  - 30 sec data output and publishing

# Questions