Day-Ahead Market Enhancements

Stakeholder Technical Workshop

June 20, 2019

Agenda

Item	Time	Presenter
Welcome	10:00 – 10:10 AM	Kristina Osborne
Defining the Problem Statement	10:10 – 11:00 AM	Megan Poage
Market Formulations	11:00 AM – 12:00 PM	George Angelidis
Lunch	12:00 – 1:00 PM	
Discussion	1:00 – 2:00 PM	Don Tretheway
Deliverability	2:00 – 2:30 PM	George Angelidis
Data Analysis	2:30 – 3:00 PM	Megan Poage
Next Steps	3:00 – 3:15 PM	Megan Poage

Day-Ahead Market Enhancements

DEFINING THE PROBLEM STATEMENT

Megan Poage
Sr. Market Design Policy Developer
Market Design Policy

Previous stakeholder call announced cancellation of 15-minute scheduling

- CAISO has ceased work on 15-minute scheduling granularity
  - Cost/benefit ratio minimized due to:
    - hourly unit commitment, and
    - uncertainty of scheduling 15-minute external resources

- DAME will proceed (without phases) for implementation in Fall 2021

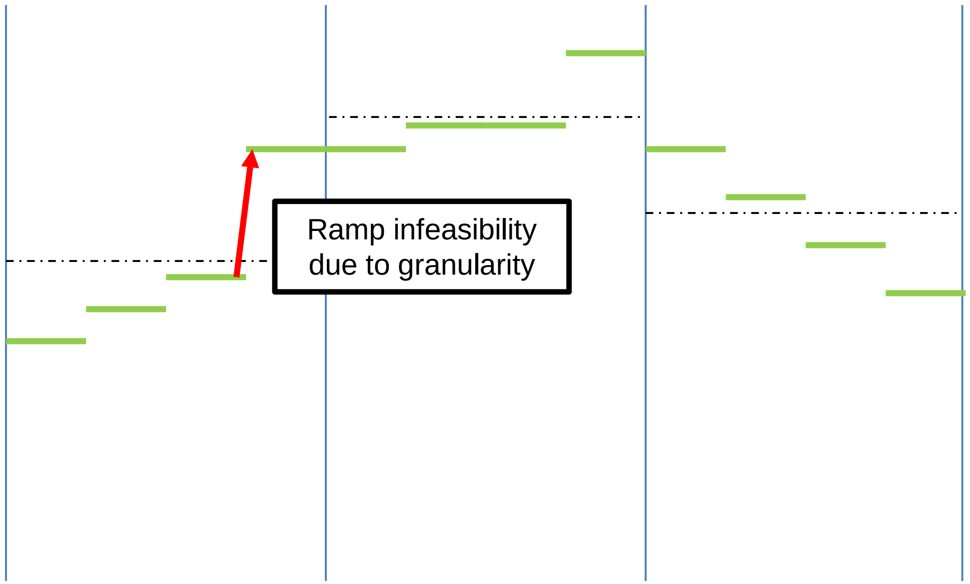
Workshop will inform market formulation development

- Two market formulations will be presented
- Requesting stakeholder feedback to identify pros and cons of each formulation
- Policy white paper (i.e. product requirements) will be published once the market formulation approach has been finalized
- Technical material posted to CAISO website

DAME solution needs to address the following operational needs

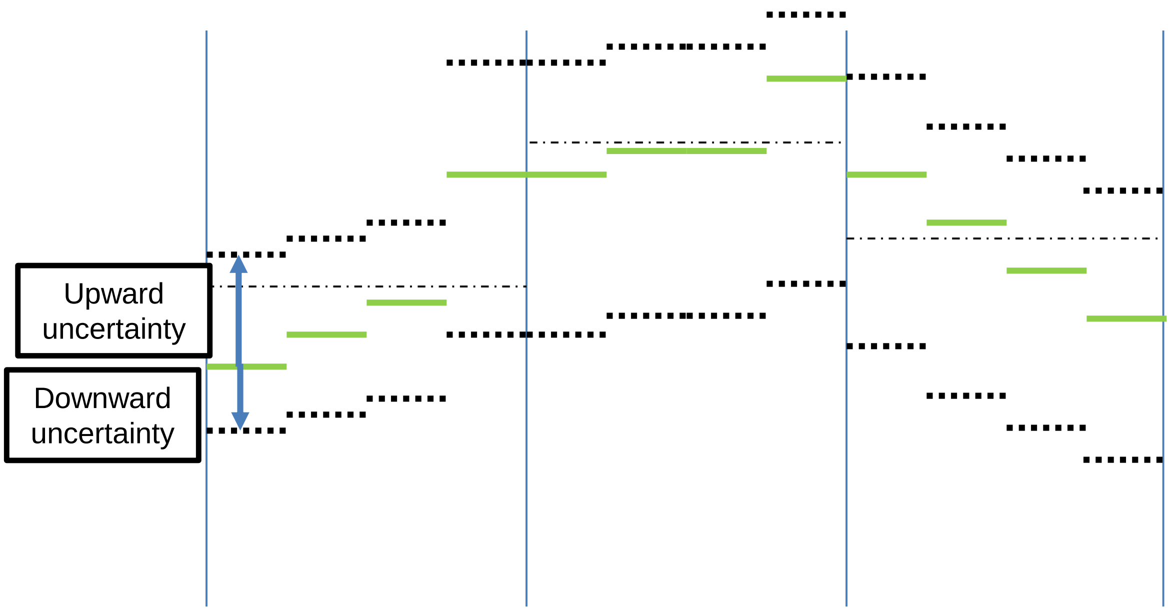
1. RAMPING NEEDS - Steep differences between 15-minute intervals (granularity differences) may result in 15-minute ramp infeasibilities due to mid-point to mid-point hourly schedules
2. NET LOAD UNCERTAINTY – The need for dispatchable generation to meet changes in the net load forecast (deviations due to load and renewables)
3. DELIVERABILITY – New product must be deliverable where it is needed

RAMPING NEEDS - Steep differences between 15-minute intervals (granularity differences) may result in 15-minute ramp infeasibility due to mid-point to mid-point hourly scheduling



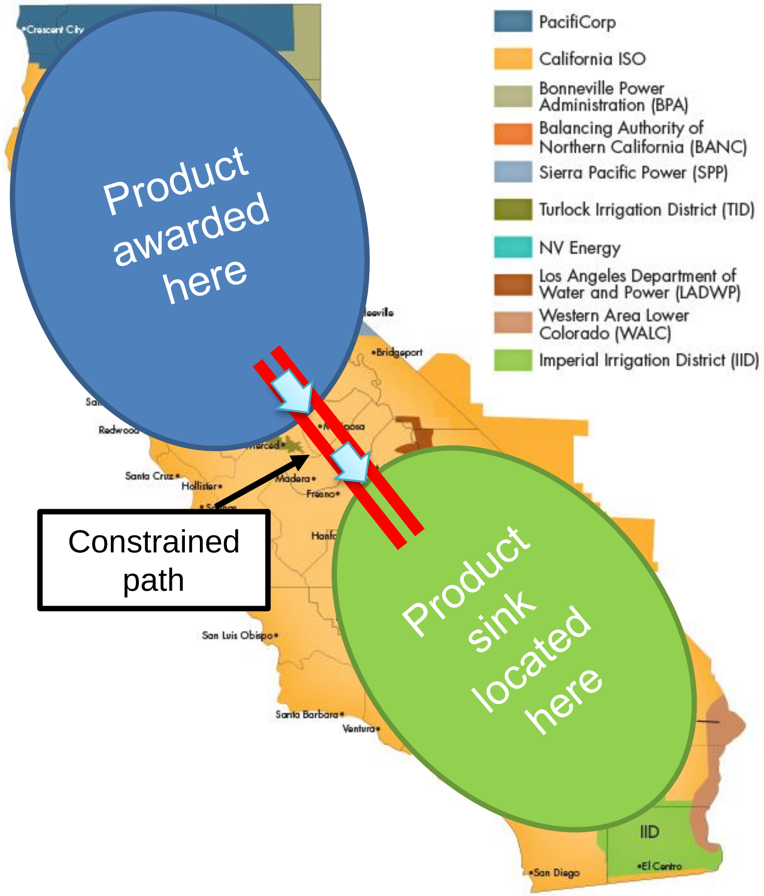
Even assuming we have perfect knowledge, the market still produces a schedule that cannot meet a single 15-minute interval ramping need due to hourly scheduling granularity.

NET LOAD UNCERTAINTY – The need for dispatchable generation to meet changes in the net load forecast (deviations due to load and renewables)



Even assuming we produce a 15-minute forecast in the day-ahead timeframe, there will be uncertainty in how much dispatchable generation is needed to meet net load.

DELIVERABILITY – New product must be deliverable where it is needed



Even if the system-wide requirement is procured, product must be deliverable (export one region and import to another) where it is needed

Operations needs the ability to address the following in the day-ahead timeframe:

1. 15-minute ramp needs due to granularity differences
   - Currently not explicitly modeled

2. Uncertainty in how much dispatchable generation is needed to meet net load
   - Currently modeled approximately by RUC net short
   - Current RT must-offer-obligation for RA resources may be changing with RA Enhancements initiative

3. Need to ensure product deliverability
   - Currently addressed at a BAA system level with net import/export constraints

Day-Ahead Market Enhancements

MARKET FORMULATIONS

George Angelidis
Principal
Power Systems Technology Development

The ISO is proposing two day-ahead market formulations

- **Option 1:** Integrated Forward Market (IFM) followed by an after-market Reliability and Deliverability Assessment (RDA)
  - Maintains financial day-ahead market constructs
  - FRP requirement driven by market participant error

- **Option 2:** Integrated IFM & Residual Unit Commitment (RUC)
  - Shifts away from financial market, moves towards day-ahead reliability market
  - FRP requirement driven by CAISO forecast error
  - *Note: This formulation is a new approach and differs from what was previously proposed in Q3 2018*

*The ISO is contemplating using the term “imbalance reserves” instead of “day-ahead flexible ramping product”. This change is not reflected in this presentation.

Day-Ahead Market Enhancements Design Options

- Sequential IFM-RDA
  - 2 Passes: (MPM, IFM) and post-DAM RDA
  - Hourly intervals
  - Energy, AS, FRP
  - Regional deliverability constraints
  - Additional RDA unit commitment with Exceptional Dispatch
- Integrated IFM-RUC
  - 2 Passes: MPM, IFM-RUC
  - Hourly intervals
  - Energy, AS, FRP
  - Regional deliverability constraints
  - Reliability Capacity Up/Down (RCU/RCD) priced at FRP bids

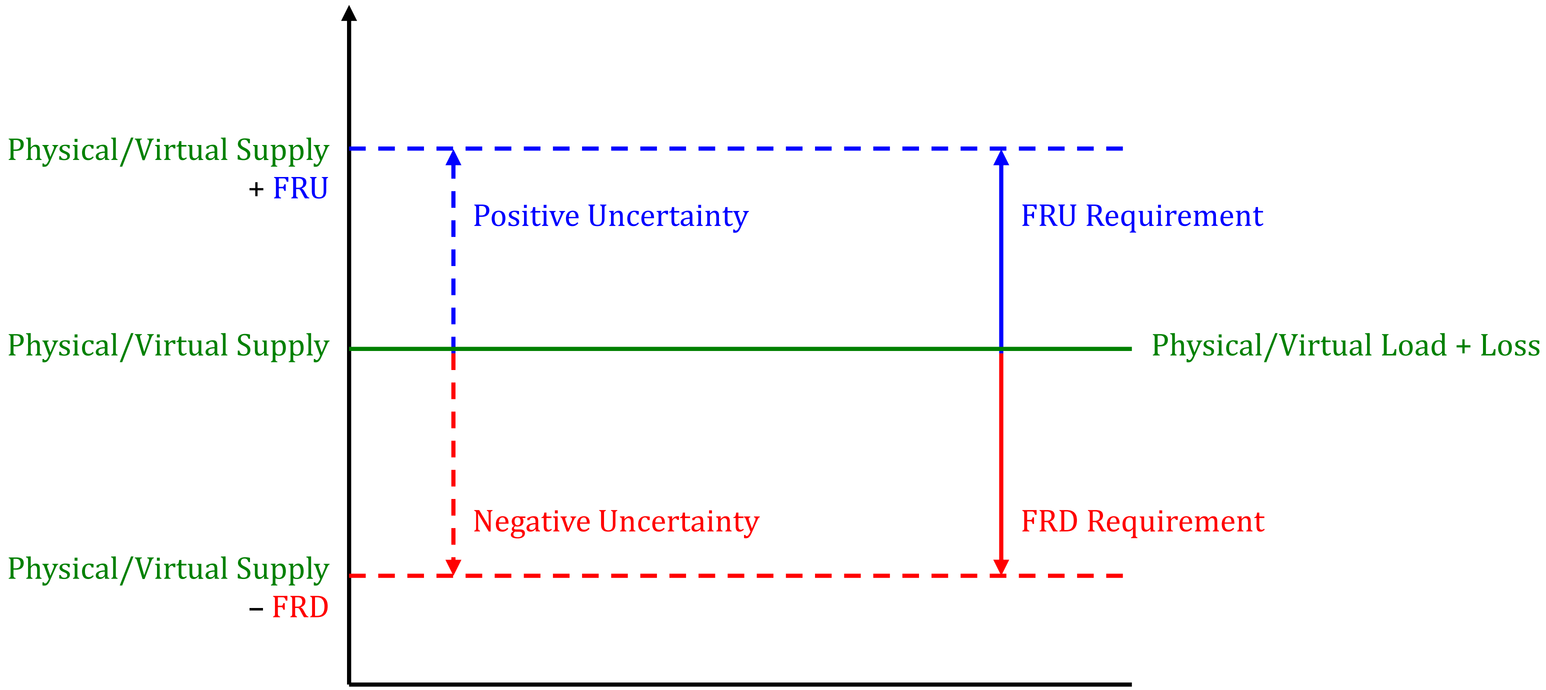
FRP in Sequential IFM-RDA

- Reserved up/down ramp capability between hourly day-ahead energy schedules
  - For granularity differences between DAME and FMM
  - For up/down uncertainty between physical/virtual supply schedules in DAME and the FMM demand forecast
- 15min product procured hourly in DAME
- Has a Must Offer Obligation for FMM
- Expires in FMM (no deviation to RTM FRP)

FRP in Integrated IFM-RUC

- Reserved up/down ramp capability between hourly reliability energy schedules
  - For granularity differences between DAME and FMM
  - For up/down uncertainty between the DAME demand forecast and the FMM demand forecast
- 15min product procured hourly in DAME
- Has a Must Offer Obligation for FMM
- Expires in FMM (no deviation to RTM FRP)

Sequential IFM-RDA Targets



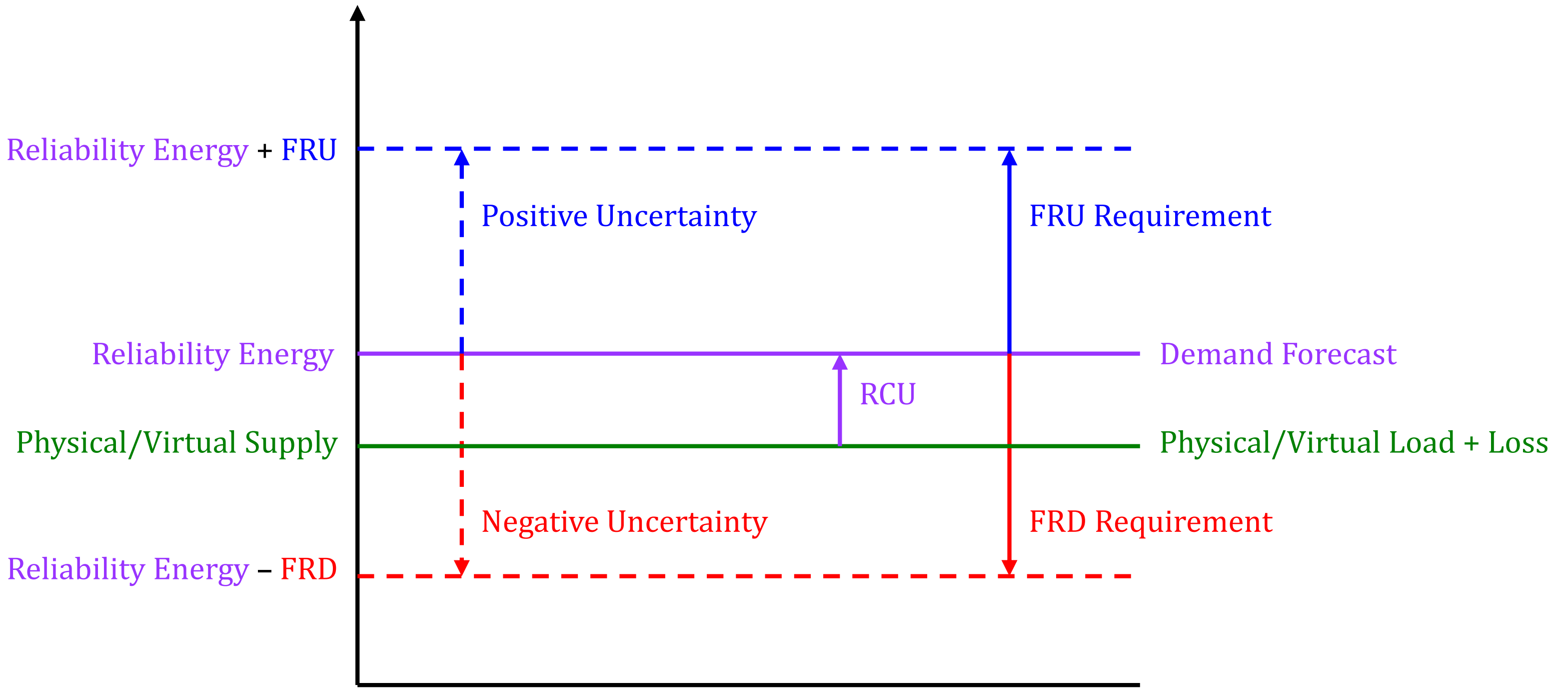
Sequential IFM-RDA Constraints

$$\sum_i EN_{i,t} + \sum_j EN_{j,t} = \sum_i L_{i,t} + \sum_j L_{j,t} + Loss_t \quad \lambda_t$$

$$\sum_i FRU_{i,t} \geq FRUR_t \quad \rho_t$$

$$\sum_i FRD_{i,t} \geq FRDR_t \quad \sigma_t$$

Integrated IFM-RUC Targets



Integrated IFM-RUC Constraints

$$\sum_i EN_{i,t} + \sum_j EN_{j,t} = \sum_i L_{i,t} + \sum_j L_{j,t} + Loss_t \qquad \lambda_t$$

$$\sum_i REN_{i,t} = \sum_i \left(EN_{i,t} + RCU_{i,t} - RCD_{i,t}\right) = D_t \qquad \xi_t$$

$$\sum_i FRU_{i,t} \geq FRUR_t \qquad \rho_t$$

$$\sum_i FRD_{i,t} \geq FRDR_t \qquad \sigma_t$$

Objective Function for Sequential IFM-RDA vs. Integrated IFM-RUC

- Unit Commitment costs
  - Start-Up, Minimum Load, State Transition costs
- Incremental energy costs for Energy schedules
- Ancillary Services costs at AS bids
- Flexible Ramp Up/Down costs at FRP bids

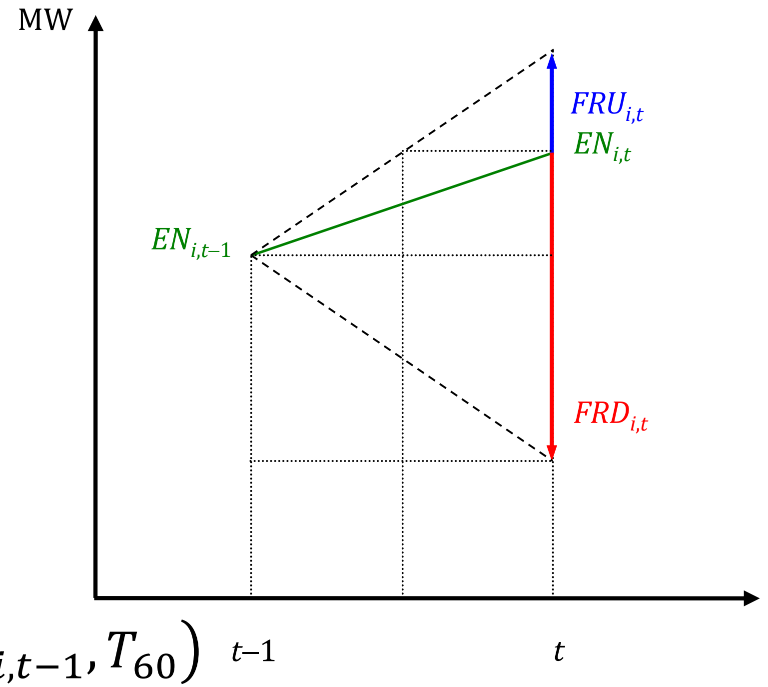
  $\sum_t \sum_i \left(FRU_{i,t}\, FRUP_{i,t} + FRD_{i,t}\, FRDP_{i,t} \right)$
- Reliability Capacity Up/Down costs at FRP bids

  $\sum_t \sum_i \left(RCU_{i,t}\, FRUP_{i,t} + RCD_{i,t}\, FRDP_{i,t} \right)$

  $REN_{i,t} - EN_{i,t} \le RCU_{i,t}$

  $EN_{i,t} - REN_{i,t} \le RCD_{i,t}$

Capacity and shared ramping constraints for Sequential IFM-RDA vs. Integrated IFM-RUC



- FRU/FRD feasible with both Energy/Reliability schedules
- Capacity Constraints

$$EN_{i,t} + FRU_{i,t} \le UEL_{i,t}$$
$$EN_{i,t} - FRD_{i,t} \ge LEL_{i,t}$$
$$REN_{i,t} + FRU_{i,t} \le UEL_{i,t}$$
$$REN_{i,t} - FRD_{i,t} \ge LEL_{i,t}$$

- Shared Ramping constraints

$$EN_{i,t} + FRU_{i,t} \le EN_{i,t-1} + RRU_i\left(EN_{i,t-1}, T_{60}\right)$$
$$EN_{i,t} - FRD_{i,t} \ge EN_{i,t-1} - RRD_i\left(EN_{i,t-1}, T_{60}\right)$$
$$REN_{i,t} + FRU_{i,t} \le REN_{i,t-1} + RRU_i\left(REN_{i,t-1}, T_{60}\right)$$
$$REN_{i,t} - FRD_{i,t} \ge REN_{i,t-1} - RRD_i\left(REN_{i,t-1}, T_{60}\right)$$

Settlement for Sequential IFM-RDA vs. Integrated IFM-RUC

- Supply
  - $-EN_{i,t}\,\lambda_t, t = 1,2,\dots,T_D$
  - $-EN_{j,t}\,\lambda_t, t = 1,2,\dots,T_D$
- Demand
  - $+L_{i,t}\,\lambda_t, t = 1,2,\dots,T_D$
  - $+L_{j,t}\,\lambda_t, t = 1,2,\dots,T_D$
- FRP
  - $-FRU_{i,t}\,\rho_t, t = 1,2,\dots,T_D$
  - $-FRD_{i,t}\,\sigma_t, t = 1,2,\dots,T_D$
- Reliability Energy
  - $-REN_{i,t}\,\xi_t = -\left(EN_{i,t} + RCU_{i,t} - RCD_{i,t}\right)\xi_t, t = 1,2,\dots,T_D$
- Marginal loss over-collection (to measured demand)
- Congestion revenue (to CRRs)

Cost Allocation

Cost	Cost Allocation	
	Tier 1	Tier 2
FRU Cost	In proportion to net negative demand deviation plus net virtual supply, if system virtual supply exceeds system virtual demand, up to an average FRU cost rate	Remaining cost in proportion to metered demand
FRD Cost	In proportion to net positive demand deviation plus net virtual demand, if system virtual demand exceeds system virtual supply, up to an average FRD cost rate	Remaining cost in proportion to metered demand
Reliability Cost	In proportion to net negative demand deviation plus net virtual supply, if system virtual supply exceeds system virtual demand, up to an average Reliability cost rate	Remaining cost in proportion to metered demand

Technical solvers available to compare and contrast market formulations

- Sequential IFM-RDA: http://www.caiso.com/Documents/SolverWorksheet-Day-AheadMarketEnhancements-IntegratedForwardMarket-FlexibleRampingProduct.xlsx

- Integrated IFM-RUC: http://www.caiso.com/Documents/SolverWorksheet-Day-AheadMarketEnhancements-IntegratedForwardMarket-ResidualUnitCommitment.xlsx

Day-Ahead Market Enhancements

DISCUSSION

Don Tretheway
Senior Advisor
Market Design Policy

Pros and cons from key differences between approaches

Sequential IFM & RDA

- Maintains construct of a financial day-ahead market with new reliability tool for operators
- Requirement driven by market participant error
- Physical generation, virtuals, load same settlement
- Other?

Integrated IFM & RUC

- Shifts away from a financial market and towards a day-ahead reliability market
- Requirement driven by CAISO forecast error
- Physical generation two part settlement, virtuals only settles energy, load settle on energy with uplift
- Other?

Day-Ahead Market Enhancements

DELIVERABILITY CONSTRAINT

George Angelidis
Principal
Power Systems Technology Development

Regional constraints will ensure deliverability for the new day-ahead product

- Day-ahead market will co-optimize procurement of energy, AS and new product

- Constraints modeled to ensure deliverability between regions

- Minimizes costs associated with procurement of the new day-ahead product

Sequential IFM-RDA
Regional Deliverability Constraints

$$
\left.
\begin{array}{c}
\max\left(0, \sum_{i \in S_r} \left(EN_{i,t} - L_{i,t}\right) + \sum_{j \in S_r} \left(EN_{j,t} - L_{j,t}\right) - Loss_{r,t}\right) + \\
\max\left(0, \sum_{i \in S_r} ASU_{i,t} - ASUR_{r,t}\right) + \\
\max\left(0, \sum_{i \in S_r} FRU_{i,t} - FRUR_{r,t}, FRDR_{r,t} - \sum_{i \in S_r} FRD_{i,t}\right) \le NEL_{r,t} \\
\max\left(0, \sum_{i \in S_r} \left(L_{i,t} - EN_{i,t}\right) + \sum_{j \in S_r} \left(L_{j,t} - EN_{j,t}\right) + Loss_{r,t}\right) + \\
\max\left(0, \sum_{i \in S_r} RD_{i,t} - RDR_{r,t}\right) + \\
\max\left(0, \sum_{i \in S_r} FRD_{i,t} - FRDR_{r,t}, FRUR_{r,t} - \sum_{i \in S_r} FRU_{i,t}\right) \le NIL_{r,t}
\end{array}
\right\} , \forall r > 0 \land t = 1, \dots, T_D
$$

Integrated IFM-RUC Regional Deliverability Constraints

$$
\left.
\begin{array}{c}
\max\left(0, \sum_{i \in S_r} REN_{i,t} - D_{r,t}\right) + \\
\max\left(0, \sum_{i \in S_r} ASU_{i,t} - ASUR_{r,t}\right) + \\
\max\left(0, \sum_{i \in S_r} FRU_{i,t} - FRUR_{r,t}, FRDR_{r,t} - \sum_{i \in S_r} FRD_{i,t}\right) \leq NEL_{r,t} \\
\max\left(0, D_{r,t} - \sum_{i \in S_r} REN_{i,t}\right) + \\
\max\left(0, \sum_{i \in S_r} RD_{i,t} - RDR_{r,t}\right) + \\
\max\left(0, \sum_{i \in S_r} FRD_{i,t} - FRDR_{r,t}, FRUR_{r,t} - \sum_{i \in S_r} FRU_{i,t}\right) \leq NIL_{r,t}
\end{array}
\right\} , \forall r > 0 \wedge t = 1, \ldots , T_D
$$

The proposed deliverability constraints are incrementally better than the current methodology

- First step towards assessing deliverability

- Can be utilized for:
  - new day-ahead product,
  - ancillary services, and
  - real-time flexible ramping product

- May eventually investigate nodal pricing in lieu of a deliverability constraint

Day-Ahead Market Enhancements

PROPOSAL FOR ANALYSIS

Megan Poage
Sr. Market Design Policy Developer
Market Design Policy

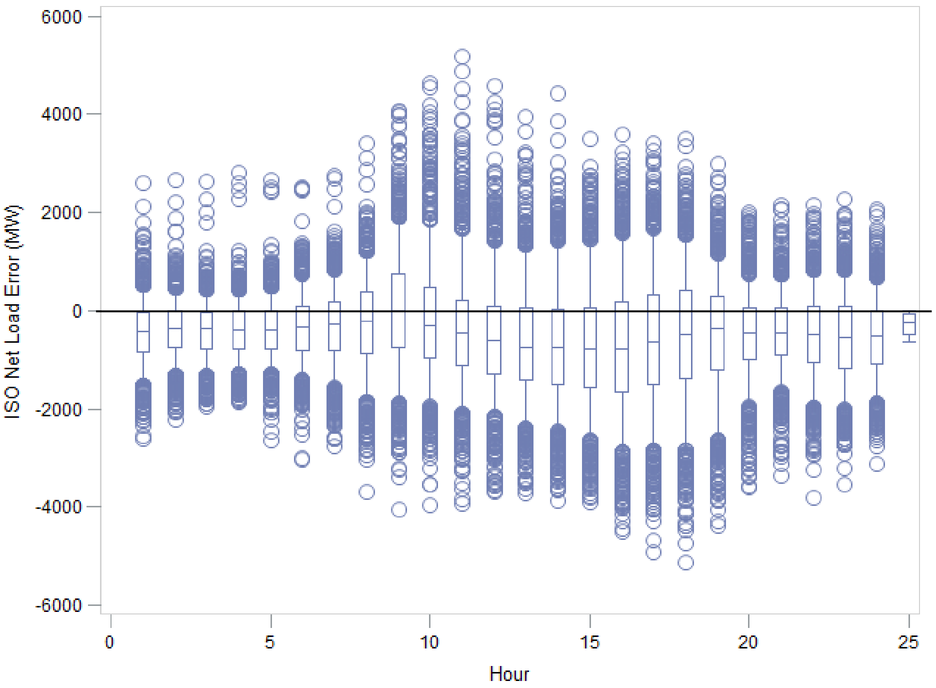
Need to analyze and understand uncertainty between day-ahead and real-time markets

- **Uncertainty**: the need for dispatchable generation to meet changes in net load (deviations due to load and renewables)

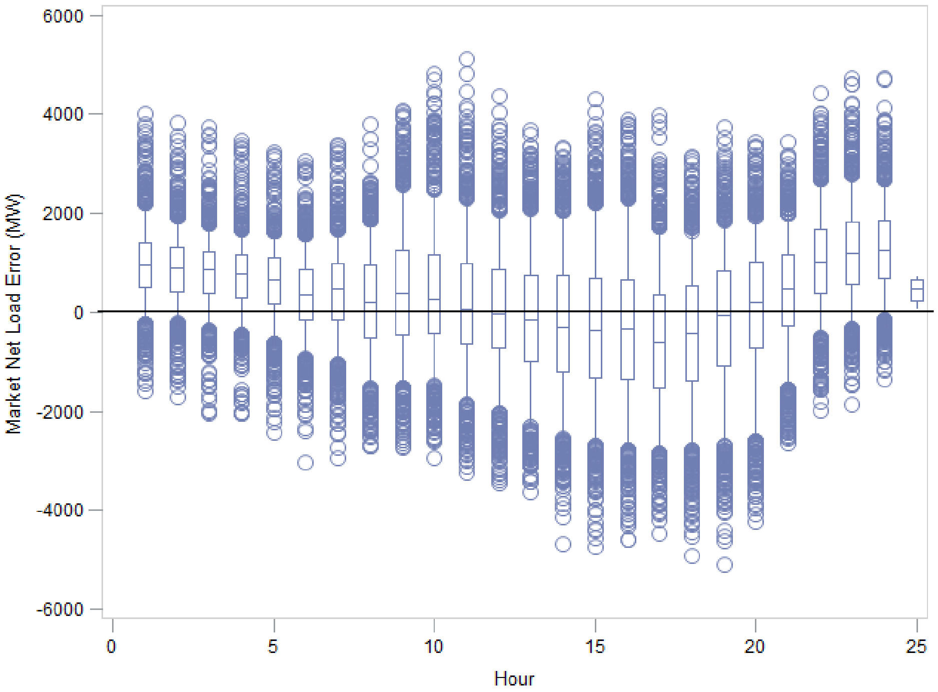
- **Two objectives for data analysis:**
  - Advise market formulation. *Is there greater uncertainty between cleared-demand (IFM) and RTM or the ISO's forecast of demand (RUC) and RTM?*
  - Determine procurement targets for new product. *Does the product need to meet FMM or RTD uncertainty?*

Preliminary analysis identified net load differences between RUC → FMM and IFM → FMM to advise market formulation determination

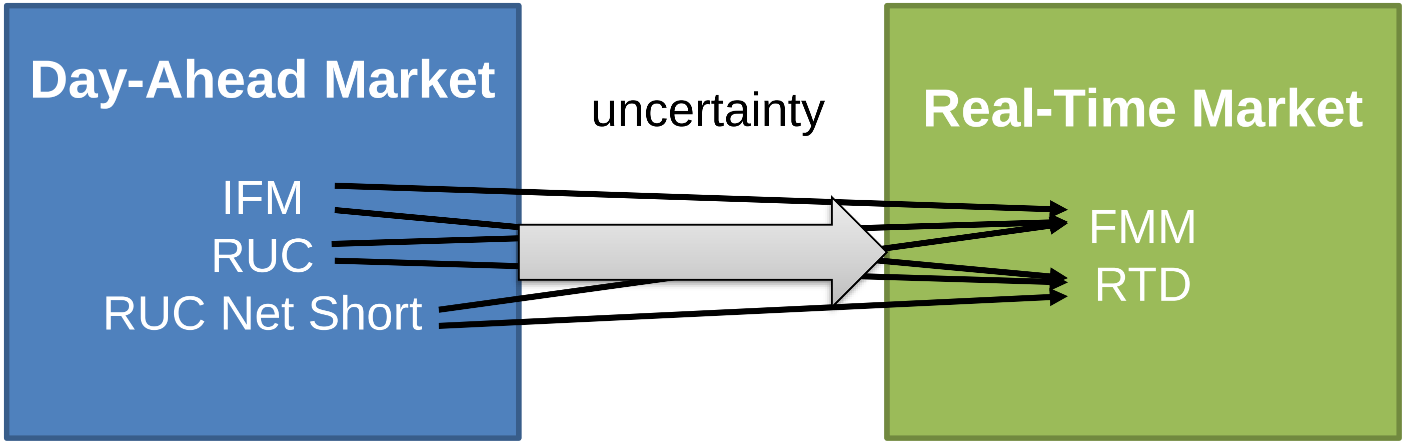
RUC to FMM:
CAISO Net Load Forecast to FMM Net Load



IFM to FMM:
Market Bid-in Demand to FMM Net Load



Proposed analysis will include statistical approach to analyze uncertainty between day-ahead and real-time markets



Identify the magnitude of uncertainty (day-ahead to FMM vs. day-ahead to RTD) to determine if other factors contribute to uncertainty (i.e. levels of wind/solar generation)

Day-Ahead Market Enhancements

NEXT STEPS

Megan Poage
Sr. Market Design Policy Developer
Market Design Policy

Planned schedule

Milestone	Date
Stakeholder Technical Workshop	June 20, 2019
*Comments Due**	July 11, 2019
Market Surveillance Committee Meeting	August 19, 2019
Straw Proposal	September 2019
Market Surveillance Committee Meeting	October 11, 2019
Revised Straw Proposal	November 2019
Draft Final Proposal	February 2020
Draft Tariff Language	Q2 & Q3 2020
BRS Development	Q2 & Q3 2020
Policy Final Proposal	Q3 2020
EIM GB & ISO BOG	Q4 2020
FERC Filing	Q1 2021
Implementation	Fall 2021

*Please send comments using the template on the initiative webpage to initiativecomments@caiso.com.