# Flexible Ramping Product Refinements

Stakeholder Call

3/23/20

# Agenda

| Time | Topic | Presenter |
|---|---|---|
| 10:00 – 10:10 | Welcome | Kristina Osborne |
| 10:10 – 10:35 | • Proxy Demand Response Default Setting<br>• Full Network Model Buffer Interval<br>• Scaling Flexible Ramping Product (FRP) Requirement<br>• Scarcity Pricing with FRP Demand Curve | Don Tretheway |
| 10:35 – 11:00 | Minimum BAA Requirement | Robert Fischer |
| 11:00 – 11:50 | Nodal Delivery of FRP | George Angelidis |
| 11:50 – 12:00 | Next Steps | Kristina Osborne |

# ISO Policy Initiative Stakeholder Process

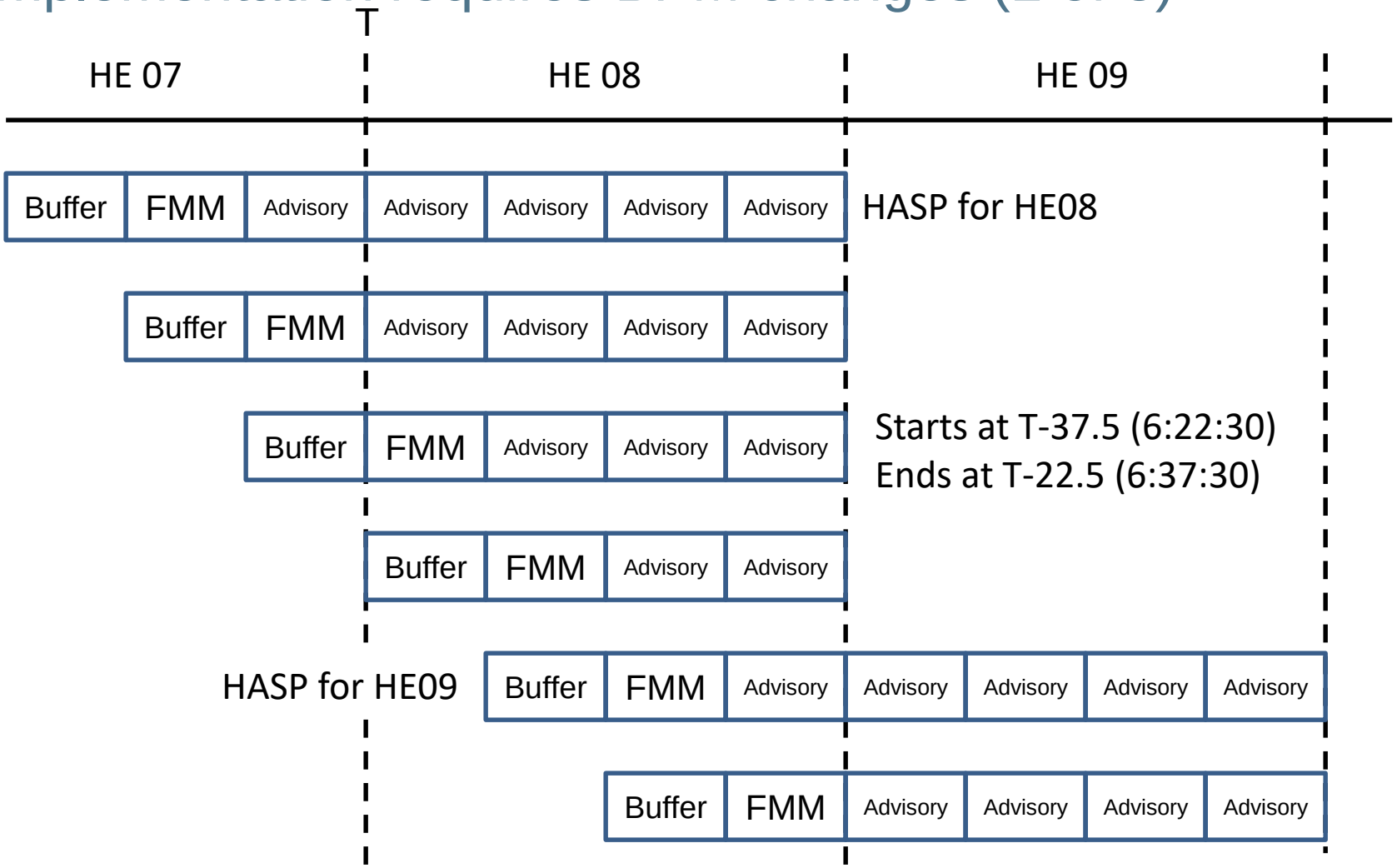
# Changes from Issue Paper/Straw Proposal

| Issue | Change from issue paper/straw proposal |
|---|---|
| **Proxy demand response eligibility** | Tariff change to set default at 60-minute dispatchable |
| **Ramp management between FMM and RTD** | None |
| **Minimum FRP requirement** | Describes method to calculate minimum requirement. Applicable to all BAAs in the EIM. |
| **Deliverability enhancement** | Selected nodal procurement |
| **FRP demand curve and scarcity pricing** | **New.** Describes how FRP demand curve results in energy prices gradually rising prior to relaxing the power balance constraint. |
| **Scaling FRP requirement** | **New.** Describes methodology to incorporate load, wind and solar forecasts into requirement |

# Proxy Demand Response (PDR) eligibility can be addressed through BPM and Tariff changes

- ESDER 3A implemented additional scheduling options for PDR
- In Master File, can elect 60-minute, 15-minute, or 5-minute dispatchable
- 60-minute and 15-minute options are ineligible to receive FRP award
- Proposal to modify default setting in Tariff to 60-minute dispatchable, as opposed to 5-minute dispatchable
  - SC must ensure their PDR resource can be dispatched in either 15-minute or 5-minute intervals

# Maintaining FRP awards in buffer interval for Fall 2020 implementation requires BPM changes (1 of 3)

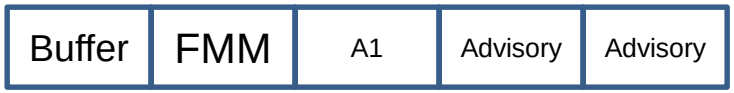


# Maintaining FRP awards in buffer interval for Fall 2020 implementation requires BPM changes (2 of 3)

- FMM requirement is 1st advisory FMM interval to binding RTD intervals in same time period
- Not enforcing FRP requirement in buffer interval can release FRP intended for RTD
  - Ramp capability is used to meet FMM schedule
  - Ramp capability leads to different unit commitment
- Propose maintaining FRP awards in the buffer interval
  - Up to 100% of the award

# Maintaining FRP awards in buffer interval for Fall 2020 implementation requires BPM changes (3 of 3)

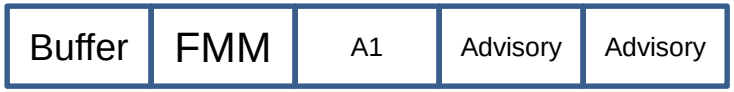
- Resource
  - Pmin = 100 MW, Pmax = 200 MW, 5 MW/Min ramp rate
- Current implementation




A1 Energy = 100 MW, FMM FRU 75 MW


FMM Energy = 175 MW, Buffer FRU 0 MW

- Assume maintain 100% of FRP up award in buffer




A1 Energy = 100 MW, FMM FRU 75 MW


FMM Energy = 100 MW, Buffer FRU 75 MW

# Enhancing methodology for setting real-time FRP requirements to incorporate load, wind, and solar forecasts into formulation

- Existing histogram methodology is a simplistic approach that only utilizes historical data in the calculation
- Proposing to adopt a quantile regression approach to provide more informed requirements based on multiple sets of predictors
- Specific results and formulation of regression model will be outlined in the BPM for Market Operations
  - Determine approach to calculate demand curve

# FRP demand curve results in energy prices gradually rising prior to relaxing power balance constraint (1 of 2)

- FRP design includes a procurement demand curve that was intended to provide scarcity pricing signals in the real-time market
  - But, FRP requirement is not always relaxed prior to the power balance constraint due to congestion

- Nodal procurement will ensure the FRP requirement is fully relaxed prior to the power balance constraint being relaxed
  - Market will no longer make FRP awards to transmission infeasible capacity
  - Produces stepped scarcity pricing up to $1,000/MWh

# FRP demand curve results in energy prices gradually rising prior to relaxing power balance constraint (2 of 2)

- Example demand curve

| Relax Qty | Relax Price | Marginal Energy | Marginal Energy Price |
|---|---|---|---|
| 50 MW | $40 | $45 | $85 |
| 100 MW | $110 | $120 | $230 |
| 150 MW | $200 | $230 | $430 |
| 9999 MW | $247 | $250 | $497 |

- For EIM entities, FRP is relaxed prior to calling on Available Balancing Capacity
  - PBC violation only after both FRP and ABC exhausted

# Minimum BAA requirement for CAISO for Fall 2020 implementation requires BPM changes (1 of 3)

- Import/export capabilities reduce a BAA's FRU/FRD requirement
  - Only considers transfer capability with adjacent BAAs
  - Therefore, cannot assume access to resources in non-adjacent BAAs
- Generally, all BAAs have import/export capability above their BAA FRP requirement
- Therefore, FRP procurement is driven by the system-wide requirement

# Minimum BAA requirement for CAISO for Fall 2020 implementation requires BPM changes (2 of 3)

- CAISO is the largest driver of the FRP requirement
- Enforce a minimum requirement that results in more local awards than system-wide constraint provides
- Reduces amount of FRP potentially unavailable to CAISO
- Evaluate historical FRP procurement to adjust minimum requirement
  - Also, determine if other BAAs need minimum requirement
- With nodal FRP, there is no need for minimum requirement

# Minimum BAA requirement for CAISO for Fall 2020 implementation requires BPM changes (3 of 3)

- Proposal to set EIM procurement targets in two tiers:
  - 1st Tier: sets a min requirement for EIM BAAs when their requirement is a pivotal share of the entire systems or EIM areas requirement
    - Calculated based on existing FRP requirements
    - Pivotal areas requirement based on:
      - Uncertainty calculations
      - Historical percentages comparison of area to EIM footprint
      - Diversity benefit factors
  - 2nd Tier: ensures that when a min requirement is imposed or when a BAA is separated due to lack of transfer capability or failed sufficiency test, the EIM level requirement is properly balanced due to the increased procurement in that area

# Example: minimum requirement calculation with no resource sufficiency failures

| BAA Group | BAA Requirement | Diversity Benefit Factor | BAA Percentage of EIM Requirement | Min Requirement Applied | DB MW amount per BAA | BAA Min Requirement |
|---|---|---|---|---|---|---|
| | MW | EIM REQ/BAA TOT | BAA/EIM | If BAA>60% => TRUE | DB Factor x BAA Requirement | Max (DB, BAA Req-DB) |
| | BAA REQ | DBF | DBP | | DB BAA | MIN REQ BAA |
| CISO | 539.00 | 0.37 | 90.74% | TRUE | 200.48 | 338.52 |
| PACE | 185.00 | 0.37 | 31.14% | FALSE | 68.81 | |
| PACW | 116.00 | 0.37 | 19.53% | FALSE | 43.15 | |
| PGE | 121.00 | 0.37 | 20.37% | FALSE | 45.01 | |
| BCHA | 206.00 | 0.37 | 34.68% | FALSE | 76.62 | |
| PSEI | 113.00 | 0.37 | 19.02% | FALSE | 42.03 | |
| IPCO | 98.00 | 0.37 | 16.50% | FALSE | 36.45 | |
| NEVP | 57.00 | 0.37 | 9.60% | FALSE | 21.20 | |
| AZPS | 147.00 | 0.37 | 24.75% | FALSE | 54.68 | |
| BANCSMUD | 15.00 | 0.37 | 2.53% | FALSE | 5.58 | |

| EIM Area Requiremen | Sum of BAA Requirement | Diversity Benefit Factor | Proposed EIM Requirement |
|---|---|---|---|
| MW | MW | EIM/Total | EIM REQ+Min(MIN REQ BAA, BAA REQ x DBF) |
| EIM REQ | BAA TOT | DBF | EIM REQ PROPOSED |
| 594.00 | 1,597.0 | 0.37 | 794.48 |

# Example: minimum requirement calculation with a resource sufficiency failure

Assume Pace Failed Flex Test and 0 MW Credit therefore Effective requirement (EFF REQ) is 185 MW

| BAA Group | BAA Requirement | Diversity Benefit Factor | BAA Percentage of EIM Requirement | Min Requirement Applied | DB MW amount per BAA | BAA Min Requirement |
|---|---|---|---|---|---|---|
| | MW | EIM REQ/BAA TOT | BAA/EIM | If BAA>60% => TRUE | DB Factor x BAA Requirement | Max (DB, BAA Req-DB) |
| | BAA REQ | DBF | DBP | | DB BAA | MIN REQ BAA |
| CISO | 539 | 0.37 | 91% | TRUE | 200.48 | 338.52 |
| PACE | 185 | 0.37 | 31% | FALSE | 68.81 | |
| PACW | 116 | 0.37 | 20% | FALSE | 43.15 | |
| PGE | 121 | 0.37 | 20% | FALSE | 45.01 | |
| BCHA | 206 | 0.37 | 35% | FALSE | 76.62 | |
| PSEI | 113 | 0.37 | 19% | FALSE | 42.03 | |
| IPCO | 98 | 0.37 | 16% | FALSE | 36.45 | |
| NEVP | 57 | 0.37 | 10% | FALSE | 21.20 | |
| AZPS | 147 | 0.37 | 25% | FALSE | 54.68 | |
| BANCSMUD | 15 | 0.37 | 3% | FALSE | 5.58 | |

| EIM Area Requirement (Original) | Sum of BAA Requirement (Total EIM) | Diversity Benefit Factor | Proposed EIM Requirement from Min | Proposed EIM Requirement from Min and Failed Test |
|---|---|---|---|---|
| MW | MW | EIM/Total | EIM REQ+Min(MIN REQ BAA, BAA REQ x DBF) | EIM REQ W/MIN+ Min(EFF REQ-DB BAA,EFF REQ) |
| EIM REQ | BAA TOT | DBF | EIM REQ W/MIN | |
| 594.00 | 1597.00 | 0.37 | 794.48 | 910.67 |

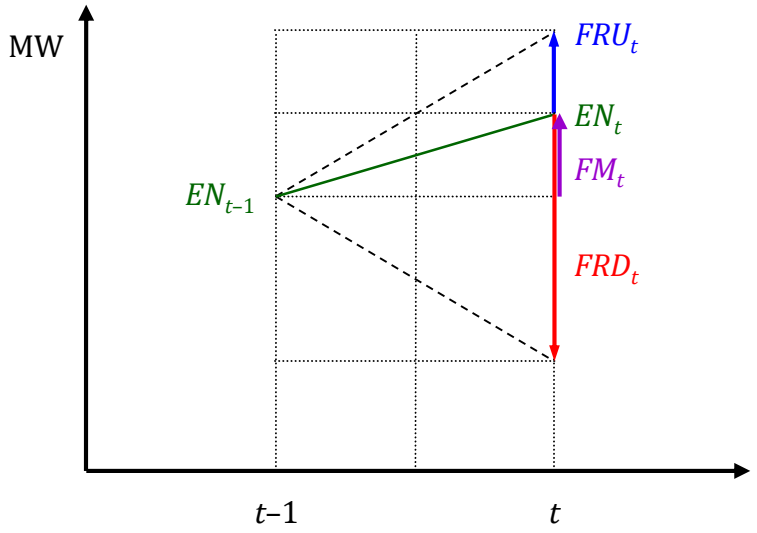
# Improve deliverability by not awarding FRP to resources that have a zero opportunity cost because of congestion. Target implementation Fall 2021

- Flexible ramping up awarded to resource behind constraint
  - Next market run unable to dispatch higher than current output
- Flexible ramping down awarded to resource providing counterflow
  - Next market run unable to dispatch lower than current output

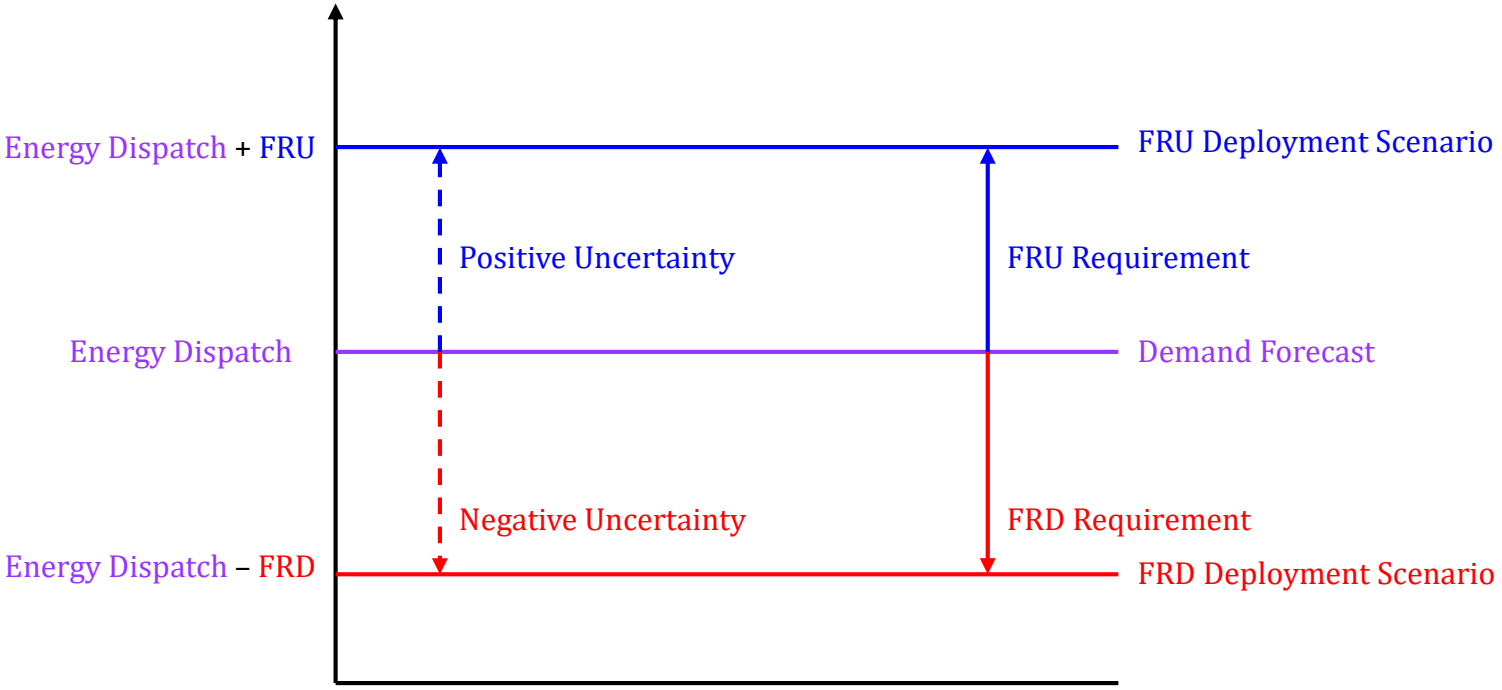
Similar issues will exist with day-ahead imbalance reserves

# What is the Flexible Ramping Product?

- Forecasted Movement (FM)
  - Energy dispatch difference from interval *t*–1 to *t*
- Flexible Ramp Award (FRU/FRD)
  - Reserved ramp capability from interval *t*–1 to *t* for uncertainty



# FRU/FRD Deployment Scenarios



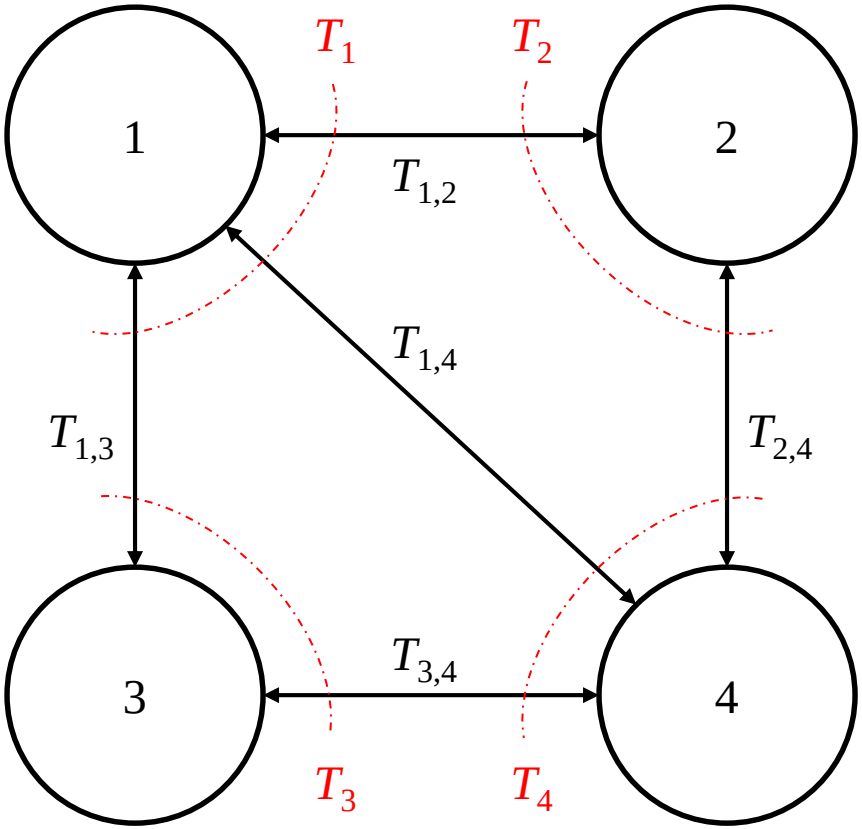
# FRU/FRD Deployment Scenario Setup

- FRU/FRD awards are deployed in all BAAs while the demand forecast in the EIM Area is increased/decreased to balance
- VERs scheduled at forecast with FRD awards
- All physical transmission constraints (base case and contingencies) enforced
- All scheduling limits (ETSR limits, ITCs/ISLs) enforced

# FRU/FRD Procurement Simplification

- Separate procurement for BAAs that fail the FRU/FRD sufficiency test; no FRU/FRD credit
- Common procurement for BAAs that pass the FRU/FRD sufficiency test
  - Common FRU/FRD requirements for the BAA group
  - Common demand price elasticity in the BAA group
  - Energy and deployed FRU/FRD awards in the deployment scenarios are subject to transfer limits
    - No need for complex and approximate FRP adjustments by net import/export capacity (NIC/NEC)

# EIM Optimization Model




$$\min\left(\sum_i C_i\, EN_i\right)$$

$$\sum_{i \in BAA_j} EN_i - D_j = T_j, \forall j$$

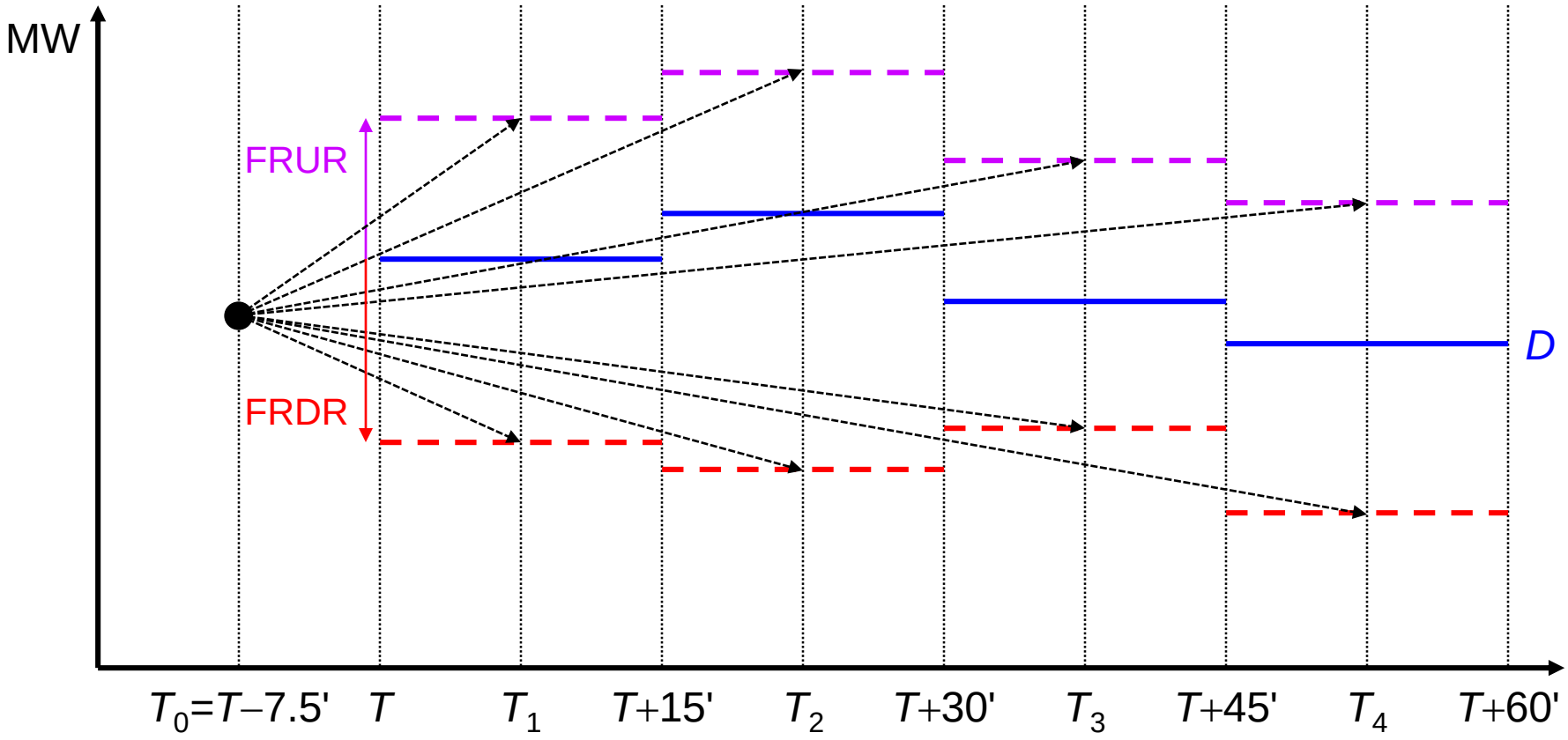
$$\sum_j T_j = 0$$

$$T_j = \sum_{j \neq k} T_{j,k}\,, \forall j$$

$$\underline{T}_{j,k} \leq T_{j,k} = -T_{k,j} \leq \overline{T}_{j,k}, \forall j \neq k$$

$i$: node index, $j$: BAA index

# Flexible Ramp Sufficiency Test



# FRU/FRD Procurement

- $PU$: set of BAAs that pass the FRU sufficiency test
- $PD$ : set of BAAs that pass the FRD sufficiency test
- $FRUS/FRDS$: FRU/FRD demand elasticity

$$\sum_{j \in PU} \sum_{i \in BAA_j} FRU_i + FRUS_{PU} = FRUR_{PU}$$

$$\left.\begin{array}{l} \sum_{i \in BAA_j} FRU_i + FRUS_j = FRUR_j \\ T_j \geq \tilde{T}_j \end{array}\right\}, \forall j \notin PU$$

$$\sum_{j \in PD} \sum_{i \in BAA_j} FRD_i + FRDS_{PD} = FRDR_{PD}$$

$$\left.\begin{array}{l} \sum_{i \in BAA_j} FRD_i + FRDS_j = FRDR_j \\ T_j \leq \tilde{T}_j \end{array}\right\}, \forall j \notin PD$$

# FRU/FRD Deployment Transfer Constraints

$$T_j^{(u)} = T_j, \forall j \notin PU$$

$$T_j^{(u)} = T_j + \sum_{i \in BAA_j} FRU_i - (FRUR_{PU} - FRUS_{PU}) \frac{D_j}{\sum_{j \in PU} D_j}, \forall j \in PU$$

$$T_j^{(d)} = T_j, \forall j \notin PD$$

$$T_j^{(d)} = T_j - \sum_{i \in BAA_j} FRD_i + (FRDR_{PD} - FRDS_{PD}) \frac{D_j}{\sum_{j \in PD} D_j}, \forall j \in PD$$

$$\left.\begin{aligned} T_j^{(u)} &= \sum_{\substack{k \in EIM \\ k \neq j}} \sum_{l} \left( ET_{j,k,l}^{(u)} - IT_{j,k,l}^{(u)} \right) \\ T_j^{(d)} &= \sum_{\substack{k \in EIM \\ k \neq j}} \sum_{l} \left( ET_{j,k,l}^{(d)} - IT_{j,k,l}^{(d)} \right) \end{aligned}\right\}, \forall j \in EIM \quad \left.\begin{aligned} 0 \leq ET_{j,k,l,t}^{(u)} &\leq \overline{ET}_{j,k,l,t} \\ 0 \leq IT_{j,k,l,t}^{(u)} &\leq \overline{IT}_{j,k,l,t} \\ 0 \leq ET_{j,k,l,t}^{(d)} &\leq \overline{ET}_{j,k,l,t} \\ 0 \leq IT_{j,k,l,t}^{(d)} &\leq \overline{IT}_{j,k,l,t} \end{aligned}\right\}, \forall j,k \in EIM$$

# Transmission Constraints

$$\left.\begin{aligned} LFL_m \le \tilde{F}_m + \sum_i \Delta EN_i \, SF_{i,m} \le UFL_m \\ LFL_m \le \tilde{F}_m + \sum_i \Delta EN_i \, SF_{i,m} + \sum_i FRU_i \, SF_{i,m}^{(u)} \le UFL_m \\ LFL_m \le \tilde{F}_m + \sum_i \Delta EN_i \, SF_{i,m} - \sum_i FRU_i \, SF_{i,m}^{(d)} \le UFL_m \end{aligned}\right\}, \forall m$$

# Price Formation

$$\sum_{i \in BAA_j} EN_i - D_j = T_j, \forall j \in EIM \qquad \lambda_j$$

$$\sum_{i \in BAA_j} FRU_i + FRUS_j = FRUR_j, \forall j \notin PU \qquad \rho_{j,t}$$

$$T_j^{(u)} = T_j + \sum_{i \in BAA_j} FRU_i - (FRUR_{PU} - FRUS_{PU}) \frac{D_j}{\sum_{j \in PU} D_j}, \forall j \in PU \qquad \lambda_j^{(u)}$$

$$\sum_{j \in PU} \sum_{i \in BAA_j} FRU_i + FRUS_{PU} = FRUR_{PU} \qquad \rho_{PU}$$

$$\sum_{i \in BAA_j} FRD_i + FRDS_j = FRDR_j, \forall j \notin PD \qquad \sigma_j$$

$$T_j^{(d)} = T_j - \sum_{i \in BAA_j} FRD_i + (FRDR_{PD} - FRDS_{PD}) \frac{D_j}{\sum_{j \in PD} D_j}, \forall j \in PD \qquad \lambda_j^{(d)}$$

$$\sum_{j \in PD} \sum_{i \in BAA_j} FRD_i + FRDS_{PD} = FRDR_{PD} \qquad \sigma_{PD}$$

# Marginal Prices

$$LMP_i = \frac{\lambda_j}{LPF_i} - \sum_m SF_{i,m}\,\mu_m - \sum_m SF_{i,m}^{(u)}\,\mu_m^{(u)} + \sum_m SF_{i,m}^{(d)}\,\mu_m^{(d)}\,, \forall i \in BAA_j \wedge j \in EIM$$

$$FRUMP_i = \begin{cases} \rho_j - \sum_m SF_{i,m}^{(u)}\,\mu_m^{(u)}\,, \forall i \in BAA_j \wedge j \notin PU \\ \lambda_j^{(u)} + \rho_{PU} - \sum_m SF_{i,m}^{(u)}\,\mu_m^{(u)}\,, \forall i \in BAA_j \wedge j \in PU \end{cases}$$

$$FRDMP_i = \begin{cases} \sigma_j + \sum_m SF_{i,m}^{(d)}\,\mu_m^{(d)}\,, \forall i \in BAA_j \wedge j \notin PD \\ -\lambda_j^{(d)} + \sigma_{PD} + \sum_m SF_{i,m}^{(d)}\,\mu_m^{(d)}\,, \forall i \in BAA_j \wedge j \in PD \end{cases}$$

# FRP Settlement and Cost Allocation

- No change in Forecasted Movement or FRU/FRD award settlement
  - Locational Marginal Prices
- No change in Forecasted Movement cost allocation
- No change in FRU/FRD cost allocation
  - 2-tier cost allocation by resource category
  - Separate for each BAA that fails the FRU/FRD test
  - Common for all BAAs that pass the FRU/FRD test

# Next steps

| Item | Date |
|---|---|
| Post Revised Straw Proposal | March 16, 2020 |
| Stakeholder Conference Call | March 23, 2020 |
| Stakeholder Comments Due | April 6, 2020 |
| Draft Final Proposal | May 5, 2020 |
| BPM Language within a Proposed Revision Request – Buffer, Minimum, Requirement | Aligned with Fall 2020 release |
| Complete Business Requirement Specifications and Tariff Development | October 2020 |
| EIM Governing Body Briefing | November 4, 2020 |
| ISO Board of Governors Decision | November 18-19, 2020 |

Please send written comment using the comments template available on the initiative webpage to initiativecomments@caiso.com.