Flexible Ramping Product Refinements

Stakeholder Call
3/23/20
## Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 – 10:10</td>
<td>Welcome</td>
<td>Kristina Osborne</td>
</tr>
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</table>
| 10:10 – 10:35 | • Proxy Demand Response Default Setting  
                • Full Network Model Buffer Interval  
                • Scaling Flexible Ramping Product (FRP) Requirement  
                • 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

PROPOSAL DEVELOPMENT

Issue paper
Straw proposal
Draft proposal
Draft business requirement specification
Draft tariff
Stakeholder input

DECISION

Final proposal
Board EIM Governing Body
Final tariff
FERC

IMPLEMENTATION

Business practice manual revisions
Market simulation
Go Live

We are here

This represents the typical process, and often stages of the process run in parallel.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Change from issue paper/straw proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proxy demand response eligibility</td>
<td>Tariff change to set default at 60-minute dispatchable</td>
</tr>
<tr>
<td>Ramp management between FMM and RTD</td>
<td>None</td>
</tr>
<tr>
<td>Minimum FRP requirement</td>
<td>Describes method to calculate minimum requirement. Applicable to all BAAs in the EIM.</td>
</tr>
<tr>
<td>Deliverability enhancement</td>
<td>Selected nodal procurement</td>
</tr>
<tr>
<td>FRP demand curve and scarcity pricing</td>
<td>New. Describes how FRP demand curve results in energy prices gradually rising prior to relaxing the power balance constraint.</td>
</tr>
<tr>
<td>Scaling FRP requirement</td>
<td>New. Describes methodology to incorporate load, wind and solar forecasts into requirement</td>
</tr>
</tbody>
</table>
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)

<table>
<thead>
<tr>
<th></th>
<th>HE 07</th>
<th>HE 08</th>
<th>HE 09</th>
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<tbody>
<tr>
<td>Buffer</td>
<td>FMM</td>
<td>Advisory</td>
<td>Advisory</td>
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</tbody>
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HASP for HE08

- Starts at T-37.5 (6:22:30)
- Ends at T-22.5 (6:37:30)

HASP for HE09

- Buffer | FMM | Advisory | Advisory | Advisory | Advisory | Advisory |

- Buffer | FMM | Advisory | Advisory | Advisory | Advisory | Advisory |

- Buffer | FMM | Advisory | Advisory | Advisory | Advisory | Advisory |

ISO Public
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
  – $P_{\text{min}} = 100 \text{ MW}$, $P_{\text{max}} = 200 \text{ MW}$, $5 \text{ MW/Min}$ ramp rate

• Current implementation

<table>
<thead>
<tr>
<th>Buffer</th>
<th>FMM</th>
<th>A1</th>
<th>Advisory</th>
<th>Advisory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A1 Energy = 100 MW, FMM FRU 75 MW</td>
<td></td>
</tr>
</tbody>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>FMM Energy = 175 MW, Buffer FRU 0 MW</td>
<td></td>
</tr>
</tbody>
</table>

• Assume maintain 100% of FRP up award in buffer

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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

<table>
<thead>
<tr>
<th>Relax Qty</th>
<th>Relax Price</th>
<th>Marginal Energy</th>
<th>Marginal Energy Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 MW</td>
<td>$40</td>
<td>$45</td>
<td>$85</td>
</tr>
<tr>
<td>100 MW</td>
<td>$110</td>
<td>$120</td>
<td>$230</td>
</tr>
<tr>
<td>150 MW</td>
<td>$200</td>
<td>$230</td>
<td>$430</td>
</tr>
<tr>
<td>9999 MW</td>
<td>$247</td>
<td>$250</td>
<td>$497</td>
</tr>
</tbody>
</table>

- 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:
  – 1\textsuperscript{st} 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
  – 2\textsuperscript{nd} 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

<table>
<thead>
<tr>
<th>BAA Group</th>
<th>BAA Requirement</th>
<th>Diversity Benefit Factor</th>
<th>BAA Percentage of EIM Requirement</th>
<th>Min Requirement Applied</th>
<th>DB MW amount per BAA</th>
<th>BAA Min Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW</td>
<td>EIM REQ/BAA TOT</td>
<td>BAA/EIM</td>
<td></td>
<td>DB Factor x BAA Requirement</td>
<td>Max (DB, BAA Req-DB)</td>
</tr>
<tr>
<td>BAA Req</td>
<td>DBF</td>
<td>DBF</td>
<td></td>
<td></td>
<td>DB BAA</td>
<td>MIN REQ BAA</td>
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<tr>
<td>CISO</td>
<td>539.00</td>
<td>0.37</td>
<td>90.74%</td>
<td>TRUE</td>
<td>200.48</td>
<td>338.52</td>
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<tr>
<td>PACE</td>
<td>185.00</td>
<td>0.37</td>
<td>31.14%</td>
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<td>68.81</td>
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<tr>
<td>PACW</td>
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<td>0.37</td>
<td>19.53%</td>
<td>FALSE</td>
<td>43.15</td>
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<tr>
<td>PGE</td>
<td>121.00</td>
<td>0.37</td>
<td>20.37%</td>
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<td>45.01</td>
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<tr>
<td>BCHA</td>
<td>206.00</td>
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<td>34.68%</td>
<td>FALSE</td>
<td>76.62</td>
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<tr>
<td>PSREI</td>
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<td>42.03</td>
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<tr>
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<tr>
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<td>0.37</td>
<td>2.53%</td>
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<td>5.58</td>
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<table>
<thead>
<tr>
<th>EIM Area Requirement</th>
<th>Sum of BAA Requirement</th>
<th>Diversity Benefit Factor</th>
<th>Proposed EIM Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>MW</td>
<td>EIM/Total</td>
<td>EIM REQ + Min(MIN REQ BAA, BAA REQ x DBF)</td>
</tr>
<tr>
<td>EIM REQ</td>
<td>BAA TOT</td>
<td>DBF</td>
<td>EIM REQ PROPOSED</td>
</tr>
<tr>
<td>594.00</td>
<td>1,597.0</td>
<td>0.37</td>
<td>794.48</td>
</tr>
</tbody>
</table>
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

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<td>DBF</td>
<td>DBP</td>
<td>EIM REQ W/Min</td>
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<td>DB BAA MIN REQ BAA</td>
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<tr>
<td>CISO</td>
<td>539</td>
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<tr>
<td>BANCSMUD</td>
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<td>3%</td>
<td>FALSE</td>
<td>5.58</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>EIM Area Requirement (Original)</th>
<th>Sum of BAA Requirement (Total EIM)</th>
<th>Diversity Benefit Factor</th>
<th>Proposed EIM Requirement from Min</th>
<th>Proposed EIM Requirement from Min and Failed Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>MW</td>
<td>EIM/Total</td>
<td>EIM REQ x Min (EIM REQ, BAA, BAA REQ x DBF)</td>
<td>EIM REQ W/Min (MIN = MIN(EFF REQ - DB BAA, EFF REQ))</td>
</tr>
<tr>
<td>EIM REQ</td>
<td>BAA TOT</td>
<td>DBF</td>
<td>EIM REQ W/Min</td>
<td></td>
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<td>910.67</td>
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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

- Energy Dispatch + FRU
- Energy Dispatch
- Energy Dispatch – FRD
- Positive Uncertainty
- Negative Uncertainty
- FRU Deployment Scenario
- FRU Requirement
- Demand Forecast
- FRD Requirement
- FRD Deployment Scenario
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

\[
\begin{align*}
\min \left( \sum_i C_i \ EN_i \right) \\
\sum_{i \in BAA_j} EN_i - D_j &= T_j, \forall j \\
\sum_j T_j &= 0 \\
T_j &= \sum_{j \neq k} T_{j,k}, \forall j \\
T_{j,k} &\leq T_{j,k} = -T_{k,j} \leq \overline{T}_{j,k}, \forall j \neq k
\end{align*}
\]

\(i: \) node index, \(j: \) BAA index
Flexible Ramp Sufficiency Test

\[ T_0 = T - 7.5' \]

\[ T \]

\[ T + 15' \]

\[ T + 30' \]

\[ T + 45' \]

\[ T + 60' \]

FRUR

FRDR

MW
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

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

\[
\sum_{i \in BAA_j} FRU_i + FRUS_j = FRUR_j \quad \forall j \notin PU
\]

\[
T_j \geq \bar{T}_j
\]

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

\[
\sum_{i \in BAA_j} FRD_i + FRDS_j = FRDR_j \quad \forall j \notin PD
\]

\[
T_j \leq \bar{T}_j
\]
FRU/FRD Deployment Transfer Constraints

\[
T_{j}^{(u)} = T_j, \forall j \notin PU
\]

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

\[
T_{j}^{(d)} = T_j, \forall j \notin PD
\]

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

\[
T_{j}^{(u)} = \sum_{k \in EIM} \sum_{l} \left( ET_{j,k,l}^{(u)} - IT_{j,k,l}^{(u)} \right), \forall j \in EIM
\]

\[
T_{j}^{(d)} = \sum_{k \in EIM} \sum_{l} \left( ET_{j,k,l}^{(d)} - IT_{j,k,l}^{(d)} \right), \forall j, k \in EIM
\]

\[
0 \leq ET_{j,k,l,t}^{(u)} \leq \overline{ET}_{j,k,l,t}
\]

\[
0 \leq IT_{j,k,l,t}^{(u)} \leq \overline{IT}_{j,k,l,t}
\]

\[
0 \leq ET_{j,k,l,t}^{(d)} \leq \overline{ET}_{j,k,l,t}
\]

\[
0 \leq IT_{j,k,l,t}^{(d)} \leq \overline{IT}_{j,k,l,t}
\]
Transmission Constraints

\[
LFL_m \leq \tilde{F}_m + \sum_i \Delta E N_i \ SF_{i,m} \leq UFL_m
\]

\[
LFL_m \leq \tilde{F}_m + \sum_i \Delta E N_i \ SF_{i,m} + \sum_i FRU_i \ SF_{i,m}^{(u)} \leq UFL_m \ \forall m
\]

\[
LFL_m \leq \tilde{F}_m + \sum_i \Delta E N_i \ SF_{i,m} - \sum_i FRU_i \ SF_{i,m}^{(d)} \leq UFL_m
\]
Price Formation

\[
\sum_{i \in \text{BAA}_j} EN_i - D_j = T_j, \forall j \in \text{EIM} \\
\sum_{i \in \text{BAA}_j} FRU_i + FRUS_j = FRUR_j, \forall j \notin \text{PU} \\
T_j^{(u)} = T_j + \sum_{i \in \text{BAA}_j} FRU_i - (FRUR_{PU} - FRUS_{PU}) \frac{D_j}{\sum_{j \in PU} D_j}, \forall j \in PU \\
\sum_{j \in PU} \sum_{i \in \text{BAA}_j} FRU_i + FRUS_{PU} = FRUR_{PU} \\
\sum_{i \in \text{BAA}_j} FRD_i + FRDS_j = FRDR_j, \forall j \notin \text{PD} \\
T_j^{(d)} = T_j - \sum_{i \in \text{BAA}_j} FRD_i + (FRDR_{PD} - FRDS_{PD}) \frac{D_j}{\sum_{j \in PD} D_j}, \forall j \in PD \\
\sum_{j \in PD} \sum_{i \in \text{BAA}_j} FRD_i + FRDS_{PD} = FRDR_{PD} \\
\lambda_j^{(u)} \\
\rho_{j,t}^{(u)} \\
\lambda_j^{(d)} \\
\rho_{PU} \\
\sigma_j \\
\lambda_j^{(d)} \\
\rho_{PD} \\
\sigma_{PD}
\]
Marginal Prices

\[ LMP_i = \frac{\lambda_j}{LPF_i} - \sum_m SF_{i,m} \mu_m - \sum_m SF^{(u)}_{i,m} \mu^{(u)}_m + \sum_m SF^{(d)}_{i,m} \mu^{(d)}_m, \forall i \in BAA_j \land j \in EIM \]

\[ FRUMP_i = \begin{cases} 
\rho_j - \sum_m SF^{(u)}_{i,m} \mu^{(u)}_m, \forall i \in BAA_j \land j \notin PU \\
\bar{\lambda}^{(u)}_j + \rho_{PU} - \sum_m SF^{(u)}_{i,m} \mu^{(u)}_m, \forall i \in BAA_j \land j \in PU \\
\end{cases} \]

\[ FRDMP_i = \begin{cases} 
\sigma_j + \sum_m SF^{(d)}_{i,m} \mu^{(d)}_m, \forall i \in BAA_j \land j \notin PD \\
-\bar{\lambda}^{(d)}_j + \sigma_{PD} + \sum_m SF^{(d)}_{i,m} \mu^{(d)}_m, \forall i \in BAA_j \land j \in PD \\
\end{cases} \]
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

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