Flexible Ramping Product Refinements discussion

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Market Surveillance Committee Meeting
General Session
September 25, 2023
FRP Enhancements implemented on February 2023

• Enhanced methodology to calculate FRP requirement as a function of demand, solar, and wind forecast
  – Change from histogram calculation to quantile regression
  – Recognize the current operating condition by using forecasts as inputs

• Remove features of NIC/NEC, FRU/FRD credit from uncertainty requirement in market optimization

• Enforce transmission constraints and EIM transfer constraints
  – Assume full uncertainty realization -> FRP deployment scenario
  – FRP nodal pricing
FRP requirements may change across the three test passes

For the flex test, there are three passes at T-75, T-55 and T-40

Changes happen only from T-75 to T-55

With inputs fixed for the last pass, there are no changes from T-55 to T-40

If T-55 > T-75 then requirements increased and the value of change is positive
The majority of the FRP requirement changes (in percent) between the test passes are relatively small for CISO area.
The changes from the first to the second test is generally small across all WEIM areas for both directions of requirements.
The frequency of flexible ramping test failures may appear to increase during the months of transitioning seasons.

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Percentage of failures remain relatively low.
The frequency of flexible ramping test failures may appear to increase during the months of transitioning seasons.

Percentage of failures remain relatively low.
FRP Up Requirement for CAISO area remain within typical ranges

This is in part because of caps imposed on the naturally-produced requirements.

Zero requirements are being now observed.

The final requirements produced by the Mosaic approach are bounded by
- a histogram-based cap
- a higher-percentile mosaic cap
- a 0.1MW lower bound to disregard negative requirements
FRP Down Requirement for CAISO area remain within typical ranges
The hourly profile of upward FRP tends to follow a pattern of morning and evening peaks.
The hourly profile of downward FRP tends to follow a complementary pattern to the upward FRP, with higher values in midday hours.
Methodology to calculate FRP requirements

• Previous methodology relied only on historical data of net load errors
  – a histogram calculation with the use of 97.5th and 2.5th percentiles to define the upward and downward requirement
  – Requirement were hourly

• New quantile calculation is used mainly to account also for current system conditions
  – Based on historical data
  – Based also on prevailing load, wind and solar forecasts
  – Use a type of quadratic regression methodology, with forecasts being the regressors
  – Because forecasts are on 15-minute basis, FRP requirements are now on 15 minute basis
  – Therefore, it is expected and by design that new methodology will produce more variability in the requirements
As expected, the variability of requirements is higher with new methodology. CISO area

\[
\text{Coefficient of variation} = 100 \frac{\text{Standard deviation}}{\text{mean}}
\]

This coefficient is useful to compare degree of dispersion of different data sets. The higher the index the more variability in the data set.
The level of variability among areas is more spread in the WEIM market areas, with some areas exhibiting larger variations with the new methodology.
With the new methodology, FRP requirements are expected to exhibit more variability. CISO area only.

Inter-hourly variability:
- Use of different regression model among hours
- Use 15-minute forecasts

Intra-hour variability
- Use 15-minute forecasts

Variation = current interval req – previous interval req
A positive value means the requirement increase relative to previous interval
FRP requirement between adjacent intervals exhibits larger variability since February. CISO area only.

Inter-hourly variability:
- Use of different regression model among hours
- Use 15-minute forecasts

Intra-hour variability
- Use 15-minute forecasts

The most significant volume of variability is contained within a tight range between -50 MW to +50 MW

Variation = current interval req – previous interval req
A positive value means the requirement increase relative to previous interval
The requirement changes within ±25 percent of the value from previous interval account for over 80%. CISO area

The percentage of each group is estimated: \[ \frac{\text{current interval} - \text{previous interval}}{\text{previous interval}} \]
Across all WEIM areas, over 90 percent of the requirement changes are within 25 percent of the previous requirement.
Although the majority of the variability is in a tight range, there are more extreme changes as reflected at the tails of the distributions.
Although the majority of the variability is in a tight range, there are more extreme changes as reflected at the tails of the distributions.
The largest changes of FRP requirements with the new methodology happen between hours.

Changes from interval 4 to interval 1 means a change between hours.

In addition to 15-minute changes of forecasts, the regression model changes between hours.

Hypothesis: Since intra-hour changes show to be smaller for other intervals, the extreme changes of requirements (red dots) clustered at intervals 1 seem to be driven by the regression coefficient changes.
Visualization of one of the outlier of FRP changes for CISO area

Change from 1,600 MW to (floor) 0 MW
It did track the actual uncertainty properly

Actual uncertainty of ~1,200 MW greater than requirement of 300 MW

Zigzag changes
Visualization of one of the outlier of FRP changes for an area in the Pacific Northwest

Steep reduction of FRD even tough uncertainty is in reducing in the opposite direction

Actual uncertainty greater than FRP procurement

Zigzag changes even when uncertainty is in the opposite direction

Steep changes in the requirements pose a challenge for entities to assess conditions to pass the test
Nodal procurement of FRP

- Previous market formulation did not consider transmission feasibility when awarding FRP

- Previous CAISO analysis showed deliverability to be one of the main issues impacting FRP efficacy

- FRP enhanced formulation relies on nodal procurement to tackle FRP deliverability

- New formulation enforce transmission constraints and EIM transfer constraints in FRP deployment scenarios
Considerations for enforcement of transmission constraints

- Flow-based transmission constraints in CAISO’s markets can be
  - Base flowgates
  - Contingency flowgates
  - Nomograms

- There are also scheduling and transfer limits

- FRP nodal model introduced with a limited set of constraints while gaining operational experience and settling systems

- With the go-live on Feb 2023, only base flowgates constraints were enforced for FRP nodal procurement

- On September 13, nomograms started to be enforced for FRP
Nodal FRP has direct computational implications for the real-time market due to needing to solve for additional constraints.

The inclusion of flowgate constraints for FRP increase run time by about 100 seconds.

The real-time market runs need to be completed within specific pre-determined timelines.
Nomograms started to be enforced for FRP on September 13; this added to the existing enforcement of base flowgates.

The level of congestion observed in real-time for energy has been relatively modest for the base flowgates, which is the type of constraints enforced for FRP for the first six months of nodal FRP.
Base Flowgate constraints have been binding at relatively low frequency for FRU in CAISO area.

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Values are shown in percent of intervals binding for FRU per constraint. Majority of constraints binding are lower voltage and more local in nature.
Base Flowgate constraints have been binding at relatively low frequency for FRD in CAISO area.

Values are shown in percent of intervals binding for FRU per constraint. Majority of constraints binding are lower voltage and more local in nature.
Congestion on flowgate constraints in other WEIM areas has been sporadic and *de minimis*

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**Values are shown in percent of intervals binding for FRU per constraint**

ISO PUBLIC
Most of the time the majority of areas pass the test and are part of the passing group, which is the only requirement enforced in the real-time market.
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Downward FRP
With the introduction of nodal formulation, upward FRP procurement from CAISO area reduced significantly.

Prior to February 2023, CAISO area had a minimum FRP requirement, which forced FRP procurement from internal resources. With the nodal implementation, this minimum requirement is no longer in place. Procurement from CAISO area is driven by overall economics.
Upward FRP procurement is largely supported by areas from the Pacific Northwest
With the introduction of nodal procurement, downward FRP is largely procured from areas in the southwest and California.
Downward FRP procurement from CAISO area is largely occurring in midday hours when solar production is plentiful and months with modest demand level.

[Bar chart showing monthly FRP procurement from Dec-22 to Aug-23, with different regions colored differently: California, Central/Mountain, Pacific Northwest, Southwest.]

ISO PUBLIC
Upward FRP procurement is supported by various types of technologies
With nodal formulation, storage resources tend to support upward FRP procurement for evening ramping hours.
Downward FRP procurement is supported by various types of technologies
With nodal formulation, storage resources tend to support downward FRP procurement for evening ramping hours.
Frequency of intervals with non-zero FMM prices for upward FMM continues to be low after nodal implementation.
Frequency of intervals with non-zero RTD prices for upward FRP continues to be low after nodal implementation.
Why FRP clears at $0?

- FRP procurement is from a larger area (passing area), in which there is plenty of capacity available from a diverse generation mix.

- A small subset of transmission constraints have been enforced so far for deployment scenarios as the ISO gains experience with the new model.

- FRP (nodal, zonal or system wide) is based on opportunity costs instead of bids.
Example of $0 FRP prices

- February 24, HE18. FMM market
- Passing group: all WEIM areas except BPA
- Uncertainty requirement: 1019.8 MW
- Total resource awards matches the requirement. Procurement was met from 18 units from 5 out of the 19 balancing areas in the group
- Therefore, there is no relaxation (surplus variable) to trigger the demand curve.
- No resource experienced an opportunity cost to procure FRP

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With nodal approach, the nodal FRP prices have more than the FRP procurement shadow prices defining the price

02/24/2023 18:35 hrs, FRP RTD binding
Passing group FRP req shadow price: -$100.4
Passing group total FRU award: 305.5 MW
All FRP requirement is met with 7 resources
There are nodal prices!

<table>
<thead>
<tr>
<th>Resource</th>
<th>Fuel Type</th>
<th>FRU MW</th>
<th>FRU Nodal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WATER</td>
<td>3.3</td>
<td>7.7</td>
</tr>
<tr>
<td>2</td>
<td>GAS</td>
<td>26</td>
<td>3.8</td>
</tr>
<tr>
<td>3</td>
<td>LESR</td>
<td>26.8</td>
<td>19.3</td>
</tr>
<tr>
<td>4</td>
<td>LESR</td>
<td>0.08</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>LESR</td>
<td>32.3</td>
<td>19.3</td>
</tr>
<tr>
<td>6</td>
<td>LESR</td>
<td>178.3</td>
<td>19.3</td>
</tr>
<tr>
<td>7</td>
<td>LESR</td>
<td>38.6</td>
<td>0</td>
</tr>
</tbody>
</table>
FRP nodal price is composed of both FRP req shadow price and congestion component

Resource 5 FRU award: 32.3MW
FRU nodal price: $19.3

Nodal pricing components:
• Shadow price for Passing group FRU: −$100.4
• Binding constraint $3861.6
• Shift factor: −0.031
• Congestion component FRU deployment:
  −$119.7 = $3861.6 * (−0.031)

• FRU LMP = -$100.4+$119.7=$19.3
On average, the upward FRP requirements tend to be fully procured, which in turns may result in a zero price
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The frequency of FRP procurement relaxation is low and tends to be concentrated for peak hours.
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The effectiveness of the FRP product can be assessed with how FRP is utilized when uncertainty realizes

- Estimate utilization

\[
Utilized \ FRU = \min \left\{ FRU \ \text{Award}, \ \max(Rеаlized \ uncertainty, 0) \right\}
\]

- There are three main reasons for which FRP may not be utilized
  - Economics. Capacity is available but not dispatched because it is not in merit
  - Congestion. Capacity is not deliverable due to being stranded behind transmission constraints. This led to the nodal approach
  - Resource constraints. Any resource limitation that may prevent the deployment or availability of FRP
In pursue of an estimation of FRP utilization

- There should not be an expectation that FRP will be fully utilized all the time
- If no uncertainty realizes then FRP does not need to be utilized
- If uncertainty realizes, it may be at lower levels than FRP was procured for, so FRP may not need to be fully utilized
- If uncertainty realizes in one direction (i.e., downward), then FRP will not need to be utilized for the opposite direction (i.e., upward),
- If uncertainty realizes, FRP may not be utilized if prices are not high enough to make the FRP capacity in merit
- Nothing prevents FRP to be utilized, even when no uncertainty realizes, to absorb other system changes
HE20 example of FRP utilization showcases a variety of scenarios

- Cases where FRP utilization is greater than actual uncertainty.
- Cases where actual uncertainty is in the downward direction but FRU is utilized.
- Cases where FRP is utilized below the level of actual uncertainty and requirement.
- Cases where actual uncertainty is higher than FRP requirements.
The main reason for not using FRP is economics, while there is still a portion related to non deliverability.
How did FRP perform during the July 2023 events?

- Actual uncertainty on July 20 of 2,024 slightly greater than FRP procured of 1,957 WM.
- In contrast, actual uncertainty on July 25 was under the FRP requirement of 1905 MW.
FRP was procured mainly from the Pacific Northwest

Hydro resources procured a large share

Storage resources in CAISO got FRP awarded for peak hours
FRP had mixed performance during the July events

- On July 20 during the critical time, FRP had a good level of utilization

- On July 25 during the critical time, FRP showed a poor level of utilization

- This was due to congestion on nomograms stranding FRP

- Nomograms not enforced at that time; however, if nomogram were enforced, FRP would be relaxed by 1,000MW
Areas for improvement and further assessment

• The results of the T-55 test are now used to determine if an entity pass or not the test for consideration in the run of the first interval of the hour in the real-time market. Tariff language has been revised

• Treatment of negative but negligible FRP requirement shadow prices

• Consideration of energy limits in the FRP procurement for certain energy-limited resources

• FRP demand curve erroneous calculation
Areas for improvement and further assessment

• Enhance logic to account for exceptional dispatches of storage resources in the FRP procurement.

• Further assessment of storage resources supporting FRP due to complexities in managing its state of charge, mainly for resources on regulation. FRP procurement does not project SOC utilization if deployed.

• July events show that non-FRP-related variability (non-VER deviations, outages/derates, imports/exports underperformance) can realize concurrent with FRP-related uncertainty and thus FRP is not designed to absorb this type and level of variability.

• Further assessment of variability in the requirements and its trade-offs. In the end, the uncertainty is inherently variable as measured by error of net loads between FMM and RTD markets.