Flexible ramping product enhancements demand curve implementation error

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1 Summary

The flexible ramping product demand curves were implemented incorrectly as part of the other enhancements on February 1, 2023. The result is that the prices on the demand curve are too low relative to the expected cost of a power balance constraint relaxation for the level of flexible capacity procured. This made it appear inappropriately cheap for the market optimization to forgo flexible ramping capacity.

The implementation error had a relatively small impact on system-wide flexible capacity procurement and prices. The frequency of forgone flexible capacity (utilization of the demand curves) for the wider system has been relatively low. This reflects that flexible capacity within the footprint of balancing areas that passed the resource sufficiency evaluation has largely been readily available at no cost. In these cases, the incorrect demand curves are not utilized and the implementation error has no impact on flexible capacity procurement and prices. As system-wide load increases in the summer and flexible capacity becomes less available, the implementation error would be more likely to have a greater impact as the demand curves become more likely to be used.

2 Background

The flexible ramping product is designed to enhance reliability and market performance by procuring upward and downward flexible ramping capacity in the real-time market to help manage volatility and uncertainty surrounding net load forecasts.[1] The amount of flexible capacity the product procures is derived from a demand curve, which reflects a calculation of the optimal willingness-to-pay for that flexible capacity. The demand curves allow the market optimization to consider the trade-off between the cost of procuring additional flexible ramping capacity and the expected reduction in power balance violation costs.

The end of the demand curve is implemented in the California ISO market optimization as a soft requirement that can be relaxed in order to balance the cost and benefit of procuring more or less flexible ramping capacity. This requirement for rampable capacity reflects the upper end of uncertainty in each direction that might materialize.[2] Therefore, it is sometimes referred to as the *flex ramp requirement* or *uncertainty requirement*.

The prices on the demand curves should reflect the expected cost of a power balance constraint relaxation for the level of flexible ramping capacity procured. When the uncertainty requirement is met and flexible capacity is readily available, the price is zero. However, as this requirement (based on the upper end of uncertainty that might materialize) is relaxed and less flexible capacity is procured, the likelihood of a power balance constraint relaxation — and therefore the expected cost of this outcome — both increase.

1 The flexible ramping product procures both upward and downward flexible capacity, in both the 15-minute and 5-minute markets. Procurement in the 15-minute market is intended to ensure that enough ramping capacity is available to meet the needs of both the upcoming 15-minute market run and the three corresponding 5-minute market runs. Procurement in the 5-minute market is aimed at ensuring that enough ramping capacity is available to manage differences between consecutive 5-minute market intervals.

2 Based on a 95 percent confidence interval.

On February 1, 2023, the ISO implemented enhancements to the flexible ramping product. This introduced two significant changes. The first of these improves the deliverability by procuring and pricing flexible ramping capacity at a nodal level to ensure that these awards are transmission feasible. The second significant change adjusted the calculation of the uncertainty requirement by incorporating current load, solar, and wind forecast information using a method called mosaic quantile regression.[3]

3 Flexible ramping product enhancements implementation error

As part of the implementation of the February enhancements, the demand curves were calculated incorrectly. The result is that the prices on the demand curve were implemented too low relative to the expected cost of a power balance constraint relaxation for the level of flexible capacity procured. This pattern is true across all balancing areas, markets, and for both upward and downward flexible capacity.

As an example, Figure 3.1 summaries how the prices on the demand curve were implemented for upward flexible ramping capacity. The *zero percentile* (p_0) is the percentile in which the calculated net load uncertainty is zero.[4] In this example, the zero percentile is exactly at the 50th percentile of calculated net load uncertainty. Also, the demand curve is constructed with 10 segments. The segment length is calculated such that each segment has increasing size in terms of distance between two percentiles. So, the lowest priced segment (from p_{10} to p_9) covers the least distance between two percentiles (Δp) and each higher segment covers a greater distance — up to the highest priced segment at $10\times\Delta p$.[5] The total length of all segments on the demand curve is therefore $55\times\Delta p$ — between the 50th and 97.5th percentiles.[6] Δp in this example is therefore (97.5-50)/55 = 0.8636.

The prices on the demand curves were incorrectly calculated based on the likelihood of exactly that segment of net load uncertainty materializing times the cost of a power balance constraint relaxation. For upward flexible capacity, that is $(p_k - p_{k-1}) \times \$1{,}000/MWh$ for $k = 1$ to 10.[7] So, instead of the prices reflecting the likelihood that the net load uncertainty will materialize *greater* than a particular percentile of net load error, the prices were implemented to instead reflect the likelihood that the net load uncertainty will materialize exactly within a particular percentile range. In the example below, the highest-priced segment of the demand curve (the segment that would price forgoing all upward flexible capacity) is priced at $10 \times \Delta p \times \$1{,}000/MWh = \$86.36$. However, the expected cost of shortage with zero upward flexible ramping capacity and 50 percent likelihood that net unload uncertainty will materialize upward should approach $500/MWh.

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3 For further information on the mosaic quantile regression uncertainty calculation, see DMM's report, *Western Energy Imbalance Market Resource Sufficiency Evaluation Metrics Report covering February 2023,* May 3, 2023: http://www.caiso.com/Documents/Feb-2023-Metrics-Report-on-Resource-Sufficiency-Evaluation-in-WEIM-May-3-2023.pdf

4 The mosaic quantile regression approach calculates net load uncertainty for every 0.5 percent step between the 2.5th and 97.5th percentiles. The *zero percentile* is determined from the percentile step in which the calculated net load uncertainty switches from negative to positive. The zero percentile is derived from linear interpolation between these percentiles.

5 This approach is intended to offset a greater concentration of forecast error around the zero percentile. For example, the demand curve segment covering the 97th to 97.5th percentiles of forecast error may have a similar MW range as the demand curve segment covering the 50th to 59th percentiles of error because of a greater concentration of forecast errors around the center of the distribution.

6 55 is the triangular number of 10 (10 + 9 + … + 2 + 1 = 55).

7 The penalty price for a power balance constraint shortage can exceed $1,000/MWh (up to $2,000/MWh) based on the highest cost-verified bid. The prices on the flexible ramping capacity demand curves scale accordingly.

Figure 3.1 Example — implemented upward ramping capacity demand curve

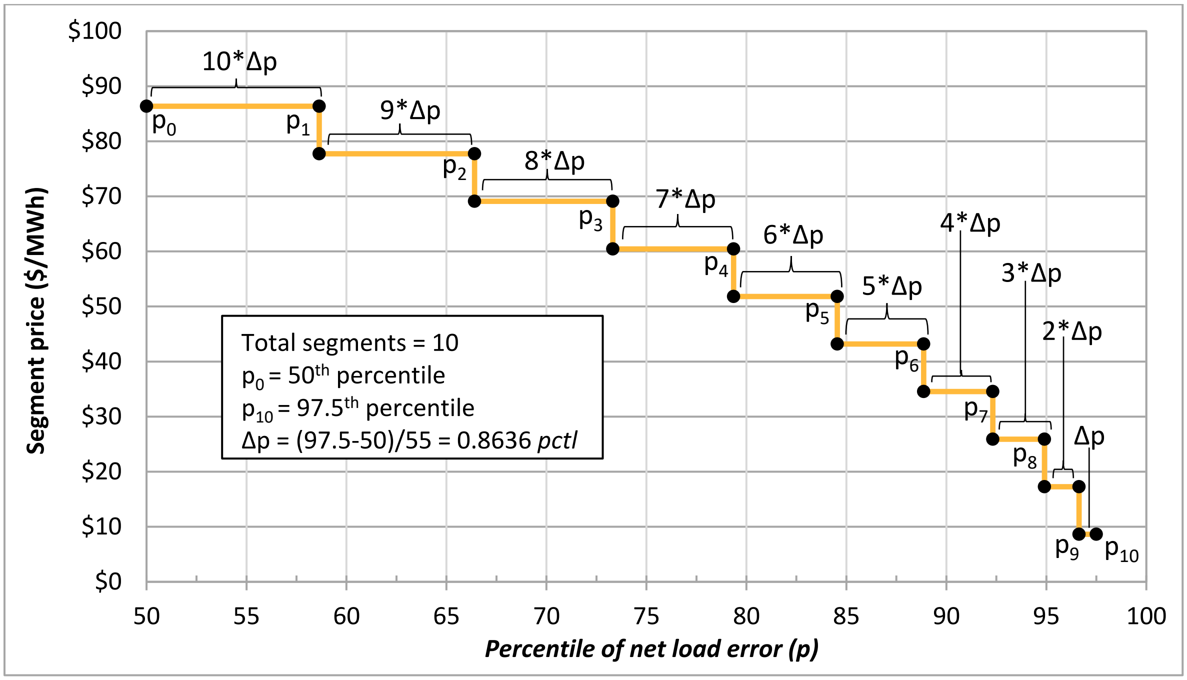

Figure 3.2 Example — corrected upward ramping capacity demand curve

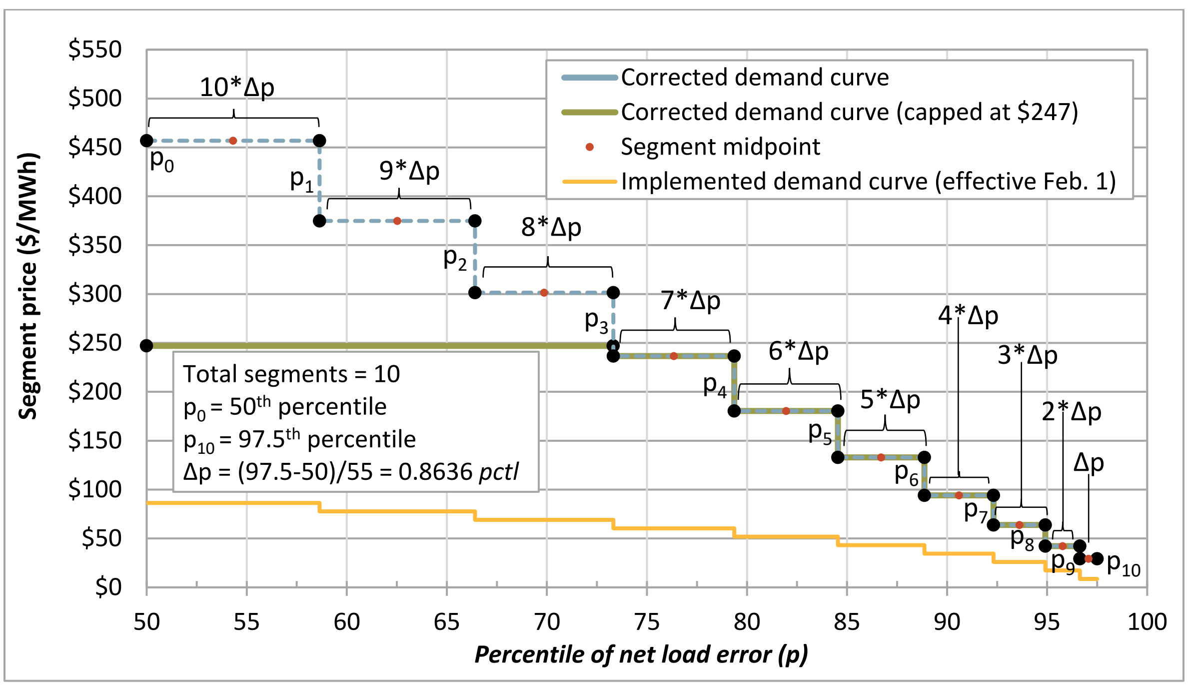

Figure 3.2 instead shows what the demand curves might look like if they were corrected to better reflect the expected cost of a shortage for the level of flexible capacity procured (or flexible capacity forgone). Here, 10 segments are again used to construct the demand curve and the segment lengths are of increasing percentile size from the 97.5th percentile (p_{10}) to the zero percentile (p_0). In this example, the zero percentile is again at the 50th percentile. The prices are derived from the likelihood that net load realizes above the *midpoint* of each segment (shown in red). This is consistent with how the demand curves were priced prior to February 1. In practice, the demand curves are capped at $247/MWh (shown by the green line). In Figure 3.2, this is compared against the implemented demand curve segments, shown by the yellow line. The prices on the demand curves were implemented lower than expected.

The California ISO has recognized the issue and will implement a correction to the calculation of the flexible ramping product demand curves.[8] This enhancement is underway.

4 Impact of implementation error

The prices on the flexible ramping product demand curves were implemented in a way that underprices the value of flexible ramping capacity relative to the expected cost of a power balance constraint relaxation. This effectively makes it appear cheaper for the market optimization to forgo flexible ramping capacity. However, the frequency of forgone flexible capacity (relaxation of the uncertainty requirement) has been relatively low, particularly for the wider-system.

The real-time market enforces an area-specific uncertainty requirement for balancing areas that fail the resources sufficiency evaluation, which can only be met by flexible capacity within that area. Flexible capacity for instead the group of balancing areas that pass the resources sufficiency evaluation are pooled together to meet the uncertainty requirement for the rest of the system. This is known as the pass-group.

Flexible ramping product prices for the pass-group have frequently been zero since the enhancements. When the shadow price on this constraint is zero, this reflects that flexible capacity within the wider footprint of balancing areas that passed the resource sufficiency evaluation is readily available. Here, the upper end of the uncertainty requirement can be met by resources with zero opportunity cost for providing that flexibility. In these cases, the incorrect demand curves are not utilized and the implementation error has no impact on flexible capacity procurement and prices.

Figure 4.1 shows the percent of intervals since implementation of the enhancements in which the 15-minute market price for flexible capacity was non-zero for the group of balancing areas that passed the tests.[9] The frequency of non-zero prices on the constraint for *system-wide* flexible capacity that was in place prior to the enhancements in February is also shown. Figure 4.2 shows the same information for 5-minute market prices. The frequency of non-zero prices (including any relaxation along the demand curves) were slightly higher in April and May, but remained low overall. As system-wide load conditions increase in the summer and flexible capacity becomes less available, the implementation error would be more likely to have a greater impact as the demand curves become more likely to be utilized to price

8 California ISO, Market Performance and Planning Forum, June 29, 2023 slide 81: http://www.caiso.com/Documents/Presentation-MarketPerformancePlanningForum-Jun29-2023.pdf

9 Based on the reference shadow price for meeting the uncertainty requirement. As part of the enhancements, flexible ramping product prices are now determined locationally at each node. The nodal price can be made up of two components. The first component is the reference shadow price associated with meeting the uncertainty requirement. The nodal price can also include a congestion component.

flexible capacity in the greater WEIM system. The implementation error can also impact *local* flexible capacity pricing within a balancing area that can exist because of limited transfer capacity or following a resource sufficiency evaluation failure.

Figure 4.1 Frequency of non-zero system or pass-group flexible ramping product shadow price (15-minute market)

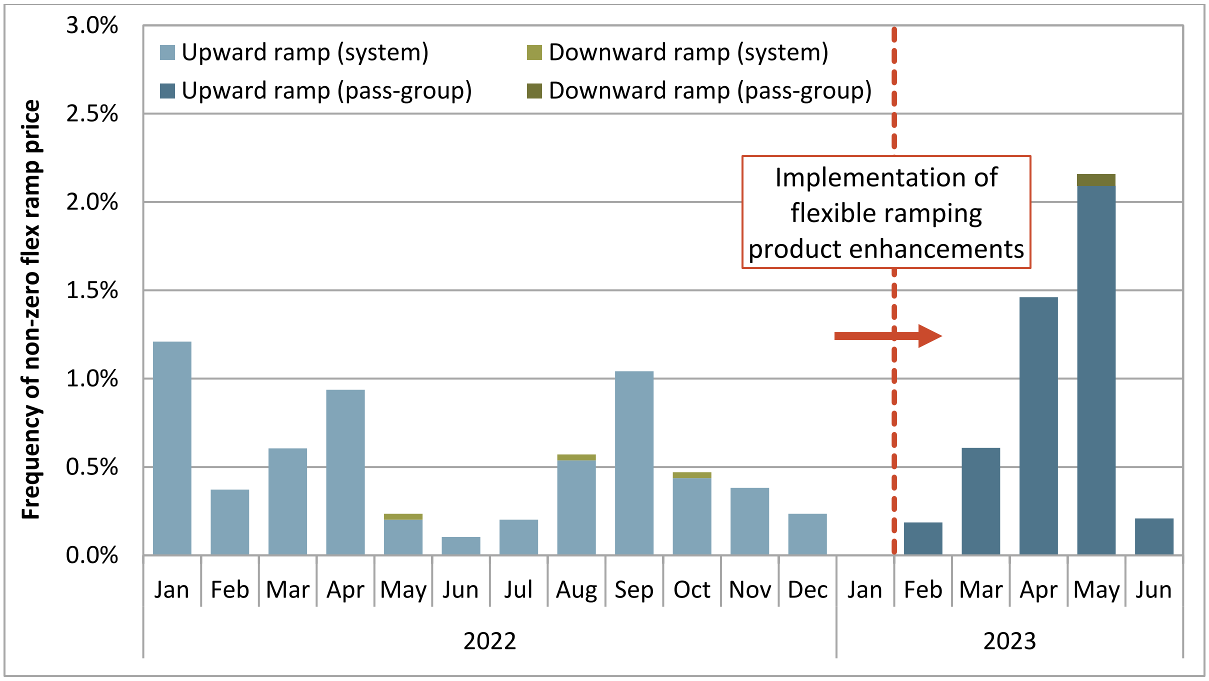

Figure 4.2 Frequency of non-zero system or pass-group flexible ramping product shadow price (15-minute market)