MARKET SURVEILLANCE COMMITTEE

Zonal and Nodal Delivery Tests for Imbalance Reserves and Flexiramp

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Overview

The CAISO organized an extended discussion of nodal and zonal delivery test options, as well as potential advantages and disadvantages of the designs, over the past two weeks.

It is also important to have in mind that the problem we are seeking to address is a current mixed zonal/regional design that has been shown to:

- Procure a substantial amount of flexiramp in regions in which it cannot be delivered;
- Undermines price formation and price signals by setting a zero price of flexiramp in regions which are very short of flexiramp;
- Sets a zero price for flexiramp in the Western EIM outside California even when there is a large overall shortfall in flexiramp procurement.

Overview

Much of the discussion has focused on potential concerns if the nodal dispatch design binds too tightly in particular ways, or if there are adverse solution time impacts.

- At present the nodal dispatch design has rarely bound over the past month;
- The CAISO has explained that it is implementing the design in stages, which likely accounts for this pattern.
- Modifications to the design can and should be based on the issues the CAISO and stakeholders identify as the CAISO adds constraints to the design.
- To date we are not aware of adverse solution time impacts from the design, but these could emerge as changes are implemented or under particular system conditions.
- To date we have also not identified anomalous outcomes involving the distribution of net load uncertainty.

Overview

We have tried to outline a few zonal designs based on last weeks discussion. Three of these options involve designs that would not be based on the CAISO's nodal dispatch engine. Based on our understanding of these designs they appear to involve various combinations of:

- Serious market power issues;
- Continued deliverability issues and the potential for a continued lack of an efficient price signal;
- Great implementation and ongoing operational complexity;
- Potentially forgoing a material portion of EDAM and Western EIM benefits from regional procurement of imbalance reserves

We outline a number of other variations on zonal and nodal designs in this presentation. It is important that because of the flexibility the CAISO has built into the nodal dispatch engine, these options all fall within the capabilities of the CAISO nodal software, or slight modifications to that design.

Flexiramp/IBR Delivery Tests

We agree with some of the discussion of potential weaknesses in the proposed nodal dispatch implementation.

- We outline a number of variations on zonal and nodal designs in this presentation that could address those limitations.
- It is important that because of the flexibility the CAISO has built into the nodal dispatch engine, these options fall within the capabilities of the CAISO nodal design, or slight elaborations on that design.

Some of the potential issues do not actually relate to the nodal dispatch design but to the shape of the demand curve, which Jim will discuss later this afternoon.

Flexiramp/IBR Delivery Tests

There are eleven core choices in designing Flexiramp and Imbalance Reserves delivery tests. In addition, there is a continuum of variations between several of the core design choices as discussed below.

- Option 1: Nodal Requirement with one up and one down nodal deployment test – Zonal requirement allocated to nodes with a deployment test applied to all resources against all constraints
- Option 2: Zonal Requirement and Procurement Design – Zonal requirement met with resources located within the zone. No deployment scenarios.
- Option 3: Zonal Requirement with Contract Path Delivery Test (my take of WPTF proposal) – Zonal requirement that can be met with external resources based on a contract path similar to AS. No deployment scenarios
- Option 4: Zonal Requirement with one up and one down zonal deployment test – Zonal requirement that can be met with external resources subject to a deployment test against zonal constraints.

Flexiramp/IBR Delivery Tests

- Option 5: Nodal requirement with one up and one down nodal delivery test with nodal delivery test using a different set of transmission constraint penalty prices
- Options 6, 7 and 8 – Corresponding to options 1, 4 and 5 but applying a distinct up and down deployment scenario for each balancing area.
- Options 9 and 10 – Corresponding to options 1 and 4 but with zonal slack variables not included in Western EIM imbalance reserve constraint
- Option11: Load Conformance Design: Nodal Requirement allocated to load nodes with a full delivery test in the energy market dispatch.

In practice, there are a number of variations between options 1 and 4 in which particular constraints are modeled or not modeled. There are also a number of variations between options 1, 4 and 5 and options 6, 7 and 8 with varying numbers of deployment scenarios based on groups of balancing areas.

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Option 1 – CAISO Proposed Design

Nodal dispatch with one up, and one down, deployment scenario

- Imbalance reserves scheduled across Western EIM/EDAM subject to nodal deployment test.
- Enables benefits from efficient scheduling of imbalance reserves across Western EIM/EDAM.
- Allows competition from external imbalance reserves.
- Design should be consistent with implementing zonal demand curve for imbalance reserves.
- Reduced potential for scheduling of imbalance reserves where they cannot be dispatched to balance net load uncertainty relative to zonal designs (options 2, 3 and 4).
- Possible increase in the potential for the exercise of locational market power within zones/balancing areas. This could be attributable to excluding undeliverable capacity, which is not a concern, but it could also arise from unexpected impacts of nodal allocation of net load uncertainty.

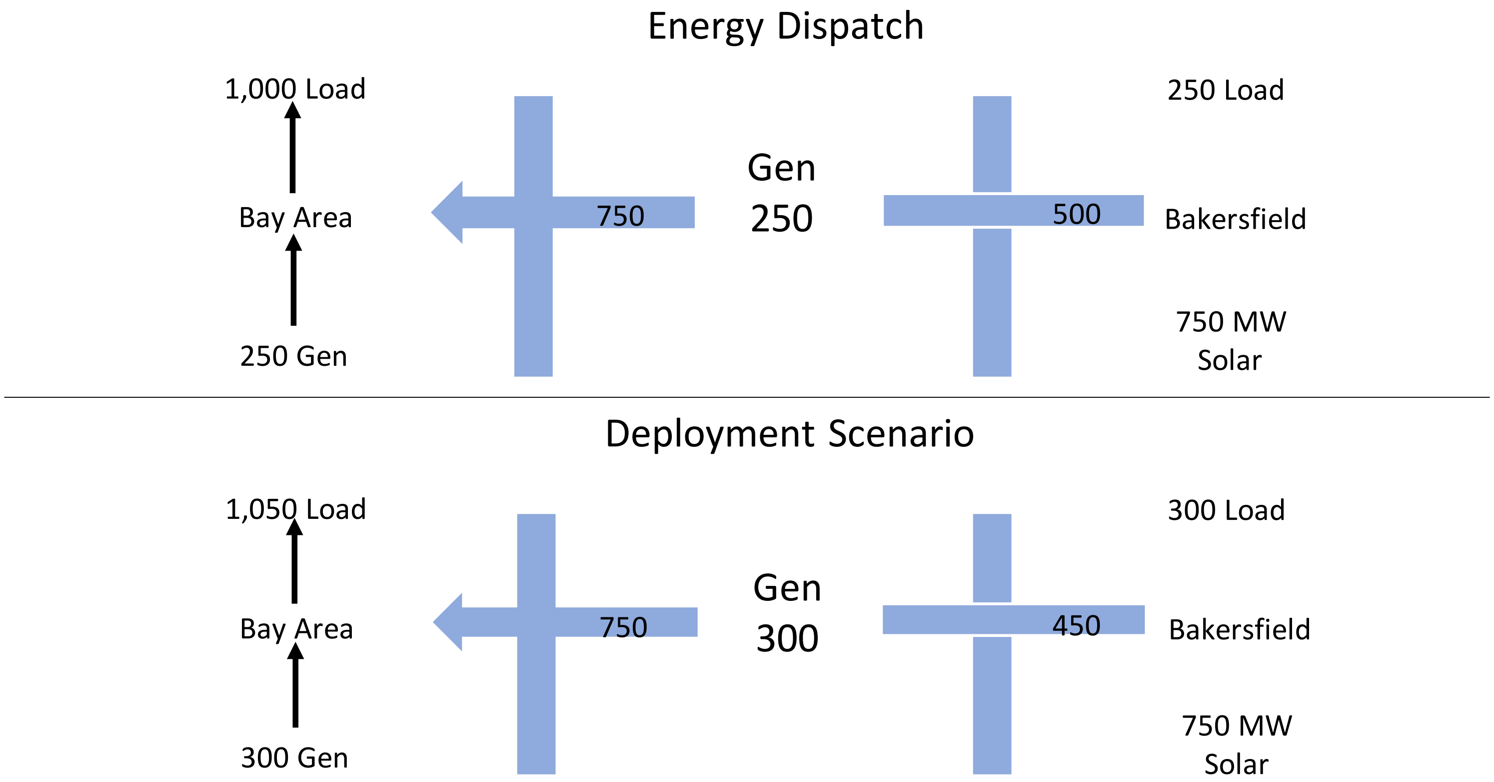
Option 1- Proposed CAISO Design (Cont)

Nodal Dispatch with one up, and one down, deployment scenario

- Potential adverse solution time impact from enforcing full constraint set in deployment scenarios
- Nodal and zonal imbalance reserve shortfalls cascade into Western EIM imbalance reserve shortfalls.
- Single up deployment scenario means that imbalance reserves may not be dispatchable to meet zonal 97.5% outcomes and diversity benefit may be overstated.
- Dispatch solution sensitive to assumed distribution of net load uncertainty within the zone, which can result in under procurement of imbalance reserves.

Option 1- Proposed CAISO Design (Cont)

Distributing some net load uncertainty to VER nodes reduces the amount of imbalance reserves that is procured within constrained load regions, compared to placing it all at the location of load (as would load conformance).



Option 1- Proposed CAISO Design (Cont)

There should not be a potential for virtual supply bids to unwind the impacts of scheduling imbalance reserves.

- Clearing virtual supply bids within constrained areas to displace imbalance reserves will be risky if the assessment of imbalance reserve needs is accurate.
- If there is not enough imbalance reserves, the price will go to the power balance violation price in FMM.
- That is a risky position for a virtual trader to take unless the expected returns are very large.
- If the penalty price is set at appropriate levels, the nodal design will not procure high cost imbalance reserves within a constrained region to meet a 2.5% probability outcome, because the demand curve will be relaxed.

Option 1- Proposed CAISO Design (Cont)

There should not be a potential for virtual supply bids to unwind the impacts of scheduling imbalance reserves.

- The CAISO nodal deployment test does not assess if the overall imbalance reserves within the EDAM or Western EIM can be dispatched to meet the 2.5% probability CAISO outcome. It only tests if they can be dispatched to meet the 97.5% CAISO outcome reduced by the diversity benefit. It does not test if the full diversity benefit is deliverable.
- Hence, there is a potential for shortfalls and high prices even if the imbalance reserves pass the deployment test.
- Moreover, the deployment scenarios do not ensure that the high net load cases can be met at low cost.

Placing virtual supply bids within transmission constrained regions will remain risky.

Option 1- Proposed CAISO Design (Cont)

Nodal dispatch will provide a better price signal for investment and operation.

- We have struggled for 6 years with designs that set imbalances reserve prices that are almost always zero. That is not an efficient price signal.
- In practice, because flexiramp delivery tests have not worked. operators, appear to test deliverability using load conformance adjustments.
- We will discuss later the limitations of using load conformance to secure deliverable flexiramp.

Option 1- Proposed CAISO Design (Cont)

Nodal dispatch does not derate the transmission system.

- Imbalance reserves will only displace energy transfers on congested transmission when that is a low cost option. This could be the case when the congestion in the energy dispatch is very slight because energy market prices are very similar inside and outside the constrained area.
- In general, nodal dispatch will not cause imbalance reserves schedules to displace energy on congested transmission but will instead ensure that imbalance reserves are scheduled where they can be dispatched without creating transmission congestion, i.e. where the transmission system is not fully loaded in the energy dispatch.

Option 2 - Zonal Version A

Zonal Requirement and Procurement Design

- Zonal requirement must be met with resources located within the zone.
- No deployment scenarios -- reduces solution time impact.
- Consistent with zonal demand curve for imbalance reserves.
- Low implementation cost and risk
- Forgoes benefits from efficient scheduling of imbalance reserves across Western EIM.
- Substantial market power issues because imbalance reserves must be procured in each balancing area with no external competition.
- Potential for scheduling of imbalance reserves where they cannot be dispatched to balance net load uncertainty when intra-zonal constraints bind.
- Zonal imbalance reserve shortfalls cascade into Western EIM imbalance reserve shortfalls

Option 2 Zonal Version A

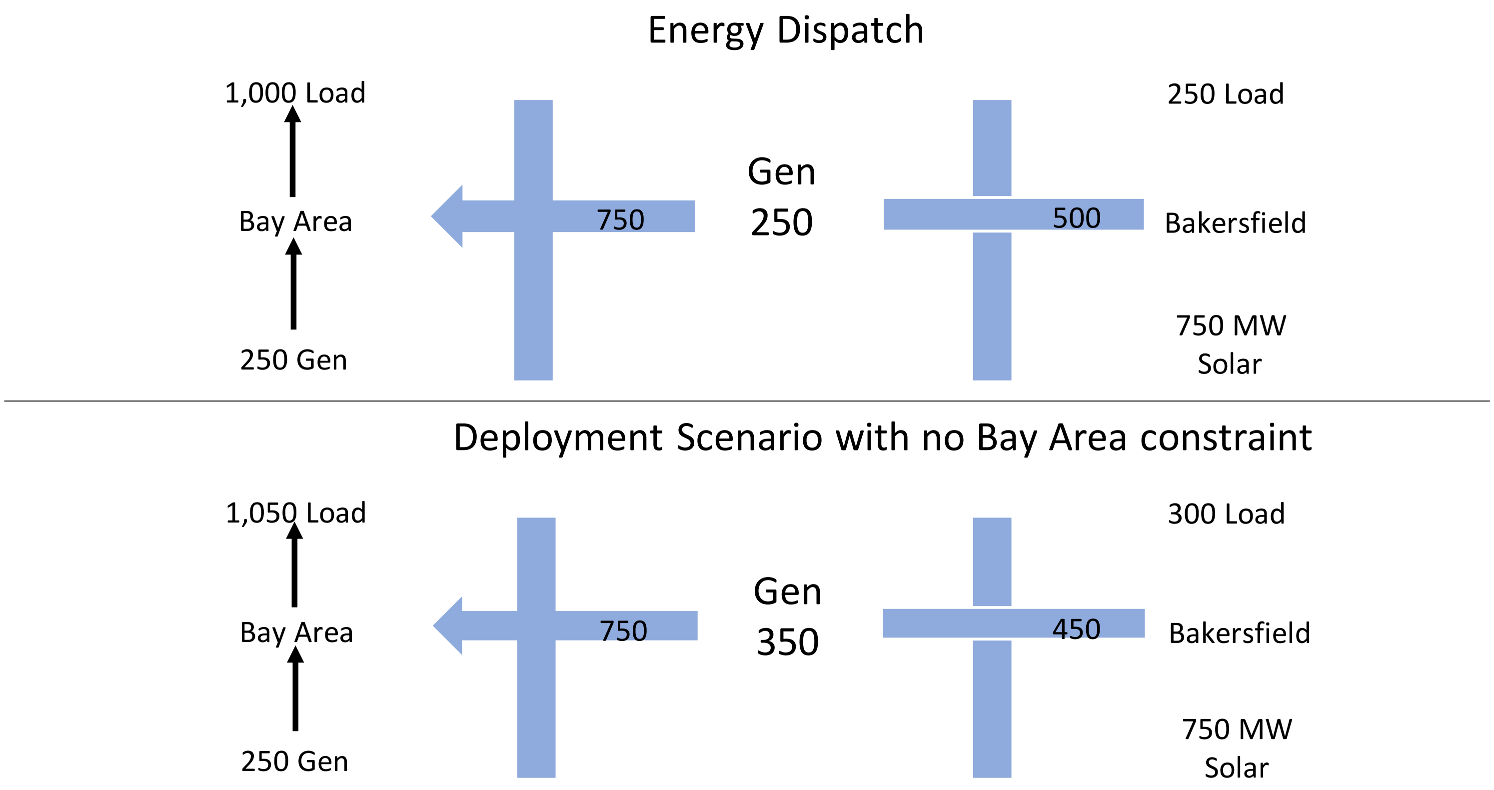
Zonal Requirement and Procurement Design

Does ability to submit offer prices ensure that imbalance reserves will not be scheduled behind transmission constraints that are expected to bind in the market solution under a zonal design?

- There is no apparent reason to expect this to be the case.
- This would only be the case if market participants located behind constraints that prevented the resources from being dispatched higher for energy, *submitted offer prices for imbalance reserves that were materially higher than the offers of resources that would be deliverable.*
- This is not plausible. In fact, resources that know they are unlikely to be dispatchable might offer imbalance reserves at prices that are lower than their true costs to earn free margins.

Option 2- Zonal Design Version A (Cont)

Assuming that none of the net load uncertainty will located within load pockets or that no supply of imbalance reserves will be located within generation pockets, risks scheduling imbalance reserves that cannot be delivered. This will incent operators to use load conformance to compensate for these failures.



Option 2A -- WPTF Proposal? – Zonal B

Zonal Requirement and Procurement Design with ad hoc adjustments to zonal requirement.

- This option would be the same as option 2 but the zonal requirement would be adjusted hour by hour on an ad hoc basis based on expectations of whether zone or balancing area will be congested in market solution.
- These adjustments would reduce the potential for scheduling of imbalance reserves where they cannot be dispatched to balance net load uncertainty relative Zonal Version A when intra-zonal constraints bind.
- These adjustments would reduce the potential of forgoing benefits from efficient scheduling of imbalance reserves across Western EIM relative to Zonal Version A.
- There would be undefined implementation cost and risk for developing ad hoc tools, as well as long term adverse impact on reliability of the need for operators to make these ad hoc adjustments during stressed system conditions.
- Would not reduce market power issues because imbalance reserves designated for balancing area must be procured in each balancing area with no external competition. This would be very problematic if the balancing area operator were making the zonal adjustments.

Option 3 – Zonal Version C

Zonal Requirement with Contract Path Delivery Test

- This would be similar to the design the CAISO used prior to expansion of the Western EIM.
- No deployment scenarios -- reduces solution time impact.
- Enables benefits from more efficient scheduling of imbalance reserves across Western EIM.
- Allows competition from external imbalance reserves.
- Consistent with zonal demand curve for imbalance reserves.
- Zonal imbalance reserve shortfalls cascade into Western EIM imbalance reserve shortfalls.
- Substantial implementation complexity and risk, coupled with potential anomalous outcomes from overlaying contract path imbalance reserve schedules on flow based energy market dispatch.
- Potential for scheduling of imbalance reserves where they cannot be dispatched to balance net load uncertainty when omitted intra-zonal constraints bind.

Option 4 – Zonal Version D

Zonal Requirement with one up, and one down, deployment scenario

- Enables benefits from more efficient scheduling of imbalance reserves across Western EIM.
- Allows competition from external imbalance reserves.
- Consistent with zonal demand curve for imbalance reserves.
- Potential improvement in solution time relative to full nodal dispatch design from reduced transmission constraint set in deployment scenarios.
- Possible reduction in the potential for the exercise of locational market power within zones/balancing areas.
- Potential for scheduling of imbalance reserves where they cannot be dispatched to balance net load uncertainty when omitted constraints bind.

Option 4 – Zonal Version D (Cont)

Zonal Requirement with one up, and one down, deployment scenarios

- Imbalance reserve scheduling may be less sensitive to assumed distribution of net load uncertainty within the zone than with Nodal dispatch, depending on which constraints are modeled in the deployment scenarios.
- Possible anomalies from different sets of transmission constraints enforced in energy market dispatch and deployment scenarios.
- Zonal imbalance reserve shortfalls cascade into Western EIM imbalance reserve shortfalls
- Single deployment scenario means that imbalance reserves may not be dispatchable to meet zonal 97.5% outcomes, with consequence that diversity benefit may be overstated.

Option 4 – Zonal Version D (Cont)

Listening to the CAISO discussion on Wednesday, this appears to be what the CAISO has actually implemented.

James Friedrich noted on slide 6 that

- "Constraints gradually being included in FRP deployment scenarios with phased approach
- Ongoing discussions and analysis will inform ultimate set of constraints enforced in FRP deployment scenarios that will guide imbalance reserve implementation"

This is exactly in the spirit of the Option 4 Zonal design.

- The flexibility to add or subtract constraints in the deployment scenarios enables the CAISO to tailor the solution to what is needed.

Option 5

Nodal Dispatch with one up, and one down, deployment scenarios and adjusted transmission penalty prices in deployment scenarios

- Design the same as Nodal dispatch (option 1), or a design such as option 4, but reduced penalty prices are used for violating some transmission constraints in deployment scenarios.
- The intent of this design is to avoid the potential for the deterministic modelling of the location of net load uncertainty in the base nodal dispatch design to lead to inefficient outcomes.
  - Net load uncertainty realizations occur across a probability cloud of locations;
  - With high demand curve prices, deterministic modeling could inflate costs by purchasing high cost imbalances reserves at a location that is only marginally better than other locations;
  - With low demand curve prices, deterministic modeling can procure too little imbalance reserves when they are expensive at particular locations
  - With lower transmission penalties on some constraints, the nodal dispatch engine will schedule imbalance reserves at another location if the cost is too high at the modeled location of net load uncertainty.

Option 5 (Continued)

Nodal Dispatch with adjusted penalty prices in deployment scenarios

- Reduced penalty prices on some constraints in deployment scenarios reduces the potential for the exercise of locational market power within zones/balancing areas and reduces sensitivity of the solution to assumed distribution of net load uncertainty within the balancing area relative to Option 1.
- Reduced potential for Nodal and Zonal imbalance reserve shortfalls to cascade into Western EIM imbalance reserve shortfalls as reserves could be procured outside the cosntrained region based on lower transmission penalty price.
- Has much the same other benefits and limitations as Option 1.

Options 6, 7 and 8

Options correspond to Options 1, 4 and 5 but with a distinct up, and down, deployment scenario for each balancing area or subgroup of balancing areas.

- Shares most benefits and limitations of Options 1, 4 and 5.
- Testing multiple deployment scenarios would reduce the potential that imbalance reserves would not be dispatchable to meet balancing area 97.5% outcomes.
- Solution time requirements are likely unworkable, even for zonal designs.
- Potentially large implementation and performance risks, likely need for extended design period.
- CAISO has noted that the nodal dispatch engine has the ability to apply more than one deployment scenario, so this direction could be an evolutionary path if it proved to be desirable based on market experience.

Options 9 and 10

Options 9 and 10 correspond to Options 1 and 4 but zonal slack variable would not be included in imbalance reserve requirement for Western EIM.

- Shares most strengths and limitations of Options 1 and 4.
- Eliminates the potential for imbalance reserve procurement shortfalls in individual balancing areas or groups of balancing areas to cascade into imbalance reserve procurement shortfalls for the Western EIM as a whole, supporting procurement of sufficient imbalance reserves to provide diversity benefit.
- Could result in scheduling of some amount of imbalance reserves at locations with low value for meeting overall Western EIM net load uncertainty.
- Only relevant to the extent that there are material shortfalls of imbalance reserve procurement within individual balancing areas.
- This is also implementable within the CAISO nodal dispatch engine by changing the cacading of slack variables.

Option 11 – Current Mechanism

Load Conformance

- CAISO/Western EIM operators apparently use load conformance adjustments to ensure ramp is deliverable outside the flexiramp design. Operators schedule imbalance reserves up by applying positive load conformance adjustments and imbalance reserves down by applying negative load conformance adjustments.
- Resources that are in effect providing imbalance reserves in RTPD are paid the difference between the RTPD energy price and RTD energy price.
- This design could be extended to the EDAM, with operators scheduling imbalance reserves with adjustments to the load forecast in the IFM, selling back excess procurement in the FMM at FMM prices, and uplifting the costs.
- No adverse solution time impact from solving additional deployment scenarios.

Option 11 – Current Design (Cont)

Load Conformance Design

- Enables benefits from more efficient scheduling of imbalance reserves across Western EIM.
- Allows competition from external imbalance reserves.
- Reduced potential for scheduling of imbalance reserves where they cannot be dispatched to balance net load uncertainty relative to Zonal options 2 and 3 (because it enforces transmission constraints) and relative to option 5 (because transmission constraints are enforced at full penalty prices).
- No potential for the direct exercise of locational market power in scheduling imbalance reserves within zones/balancing areas, energy offer price mitigation would be applied.

Option 11 – Current Design (Cont)

Load Conformance Design

- Like deployment options only a single uncertainty realization is modeled.
- Lack of demand curve for imbalance reserves can result in anomalous energy and imbalance reserve prices, particularly if operators try to schedule imbalance reserves to cover large amounts of load forecast uncertainty.
- Operators can only schedule imbalance reserves/flexiramp up or imbalance reserves/flexiramp down in a particular dispatch interval. This is not a concern if shortfalls in imbalance reserves down are not an issue.
- All imbalance reserves/flexiramp is scheduled within CAISO, unnecessarily inflating cost (this could be changed if CAISO operators could adjust loads in every balancing area, but this would add even more ad hoc elements to an ad hoc apporach).
- CAISO rate payers currently bear all costs of imbalance reserves/flexiramp.
- Shortfalls in imbalance reserve/flexiramp procurement in CAISO cascade to Western EIM.

There are also variations in which some imbalance reserves could be scheduled with a demand curve using one of the imbalance deserves and some scheduled using load conformance.

Nodal Delivery Test Design Performance

A critical issue in choosing between option 1 and some of the other alternatives is how well the current nodal dispatch implementation is performing.

- Is the current implementation performing as intended?
  - It appears that the nodal dispatch design is having no impact on either the FMM or RTD dispatch.
  - This may be because the CAISO is gradually adding transmission constraints to the model.
- What compromises have been made to achieve solution time and what is their impact on the quality of the solution?
- Is the solving of intra-zonal/balancing area constraints based on a deterministic assignment of net load uncertainty contributing to anomalous solutions?
  - Not an issue at present as the nodal design is not impacting the scheduling of imbalance reserves.
- If there are implementation issues, what is the complexity level of the changes required to correct them?

Conclusions

Zonal options 2, 2A and 3, to the extent I understand what is intended, have serious weaknesses.

In practice, the CAISO implementation embraces both Options 1 and 4, with the CAISO able to find tune the transmission constraints modeled in the deployment scenarios.

The attractiveness of option 5 depends to a considerable degree on how well options 1/4 perform in practice and what adjustments are needed. In particular, if the nodal design under procures material amounts of imbalance reserves as a result of binding transmission constraints within balancing areas.

Conclusions

Options 6, 7, and 8 would better test full imbalance reserve deliverability but are unworkable near term from an implementation standpoint. It appears that the CAISO nodal dispatch software engine has the ability to accommodate evolutionary changes in this direction.

Options 9 and 10 might improve performance if there are material shortfalls in imbalance reserve procurement over the EDAM/Western EIM design as a result of shortfalls within individual balancing areas. This can be observed over time.

Refining Option 11 is an alternative if the other options prove unworkable. But option 11 has important limitations as a long-run framework for providing imbalance reserves in EDAM.

Eliminating down deployment scenarios in some or all hours could improve solution time. The engine could only run these deployment scenarios in the hours in which operators currently use downward load conformance adjustments.