Day-Ahead Market Design Options

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Critical thinking at the critical time™

TOPICS

- Potential Benefits of a Combined IFM RUC Design
- Potential Implementation Challenges and Concerns with Combined IFM RUC Design
- Discussion of Alternative Sequential IFM RUC Designs

The CAISO presentation from the working group meeting on 8/13 refers to the *Sequential IFM RUC Design* as “Financial, Option 1” and the *Combined IFM RUC Design* as “Financial + Forecast, Option 2”

POTENTIAL BENEFITS OF A COMBINED IFM RUC DESIGN

The essence of the option two design is that instead of first clearing the IFM against bid load, then evaluating the system's ability to meet forecast load, and potentially committing and scheduling additional resources in a separate RUC process, the combined design commits and schedules resources to minimize the combined cost of both meeting bid load and having available the resources that would be needed to meet forecast load.

- The combined solution therefore must solve two distinct powerflows to analyze transmission constraints and enforces two distinct load balance equations.
- The option 2 market engine will solve for a single unit commitment of long start physical resources to meet these two net load levels. As the CAISO develops this design it may identify other links between the dispatch of physical resources to meet bid load and/or forecast load that will need to enforced in the option 2 solution in order to meet reliability needs.

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POTENTIAL BENEFITS OF A COMBINED IFM RUC DESIGN

The option two design will provide a framework that will enable both traditional regulated utilities and load serving entities subject to limited state regulation to meet their load at least cost in a manner consistent with past practice.

- This includes the ability of utilities and load serving entities to rely on their own judgement as to the expected intermittent resource output or expected real-time economy energy purchases they wish to factor into their day-ahead market purchases, while ensuring that enough capacity is available to meet the CAISO's load forecast.

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

There are five potential benefits from implementation of a combined IFM RUC design relative to the current RUC design and relative to some sequential designs.

- More efficient commitment of long start resources.
- Binding day-ahead market financial schedules (and compensation) for all resources needed to reliably meet the CAISO load forecast.
- Consistent and efficient prices across resources scheduled in the IFM to meet bid load, and to meet the CAISO's load forecast.
- Assurance that resources committed to meet the CAISO's load forecast can be dispatched to meet that load.
- More efficient pricing for virtual supply bids that require the scheduling of incremental reliability capacity.

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POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

More Efficient Commitment of Long Start Resources

- Sequential IFM RUC designs have the inherent potential for the inefficient commitment of long start resources when additional long start resources are committed in the RUC pass.
- This potential inefficiency only exists to the extent that long start resources are committed in a RUC load pass in order to meet forecast load.
  - There is only a limited amount of long-start capacity committed in the RUC.
  - It is not clear how much of the capacity currently being committed in RUC is committed to meet forecast load or if it is committed to meet other reliability needs that are not modeled in the IFM.
  - If these resources are being committed to meet other reliability needs, that could continue to be the case following implementation of a combined IFM RUC.

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

More Efficient Commitment of Long Start Resources

- RUC commitments that are made to provide flexible capacity would be shifted into the IFM under both option 1 and 2 designs by the scheduling of imbalance reserves.

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

More Efficient Commitment of Long Start Resources

- This potential efficiency will likely become less material as the remaining once through cooling resources exit the market and there are few remaining resources that need to be committed day-ahead.
  - The CAISO may continue to have thermal resources that have notification plus start up plus minimum run times that are too long to be evaluated in STUC.
  - The efficient commitment of these thermal resources will continue to be a challenge even with a combined IFM RUC because these units would most efficiently be committed during the operating day when it is clear whether their operation is needed and/or economic.

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

More Efficient Commitment of Long Start Resources

- There may also be benefits under option 2 from more efficient scheduling between energy, imbalance reserves and reliability capacity of other resources that need to be notified in the day-ahead time frame.
- These other resources could include demand response with day-ahead notification requirements, cascade hydro, and gas fired generation that needs to schedule gas day-ahead.
- These resources may not be efficiently scheduled between energy and imbalance reserves in the IFM and reliability capacity in the forecast load pass under some sequential IFM designs.

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

Binding financial schedules for all resources needed to reliably meet CAISO load forecast

- This will be an important benefit from implementation of a combined IFM RUC as it will ensure that resources needed to meet the CAISO's load forecast will have a financially binding day-ahead market schedule that would receive compensation to cover the cost of scheduling fuel or taking other actions to ensure that they will be able to operate during the operating day.

- This goal could also be achieved with some the sequential IFM RUC designs.

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

Consistent and efficient prices for resources scheduled in the IFM or RUC to meet the CAISO's load forecast.

- Most of the sequential IFM RUC designs that determine financially binding schedules for reliability capacity will yield prices for energy, imbalance reserves, and reliability capacity that are roughly consistent and fairly similar to those determined by option 2, if the market clearing price of reliability capacity is low.
- However, the sequential designs will not yield efficient prices that are even roughly internally consistent nor roughly consistent with system conditions if the cost of reliability capacity is not low, potentially leading to inefficient bidding incentives under stressed system conditions if reliability capacity needs to be scheduled in the forecast load pass.
- On the other hand, as discussed below, the prices determined by the combined IFM RUC design would also have some features that need to be carefully considered before adopting such a design.

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

Assurance that resources committed to meet the CAISO’s load forecast can be dispatched to meet that load.

- This goal can also be achieved by two or three pass sequential designs (such as 1D and 1E), but would not be achieved by one pass designs (such as Option 1B and Option 1C).

POTENTIAL BENEFITS OF COMBINED IFM RUC DESIGN

More efficient pricing for virtual supply bids that require, or conversely do not require, the scheduling of incremental reliability capacity.

- If the CAISO is scheduling reliability capacity up at the margin, virtual supply bids will clear at a lower price than physical supply by an amount equal to the incremental cost of reliability capacity up.

- Conversely, if the CAISO is not scheduling reliability capacity up at the margin, virtual supply bids will not clear at a lower price than physical supply and there would be no need to allocate uplift costs to virtual supply.

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POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

There are four core potential implementation challenges and concerns with a combined IFM RUC design.

- Can the design be implemented in a manner that achieves sufficiently optimal solutions within an acceptable time frame?
- Can a workable market power mitigation design be developed and implemented?
- Can the basic combined IFM RUC pricing design be refined to eliminate the potential for anomalous outcomes involving intermittent resource output?
- Can a market design and framework for CAISO implementation be developed that will produce efficient outcomes and be consistent with the potential impact of the CAISO's net load forecast on energy, imbalance reserves capacity, and reliability capacity prices.

POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

Can the design be implemented in a manner that achieves sufficiently optimal solutions within an acceptable time frame?

- The efficiency benefits of an option 2 from more optimal scheduling of resources between the bid load and RUC solution require that there is no loss of optimality in the bid load solution due to solution time impacts or the introduction of modeling approximations.
- Whether this can be achieved is a core question that needs to be answered before moving forward with the option 2 design.

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POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

Can a workable locational market power mitigation design for reliability capacity be developed and implemented?

- The potential for the exercise of locational market power in reliability capacity is an issue under options 1D and 1E [1] as well as under option 2. However, the optimization of energy, imbalance reserves and reliability capacity prices under option 2 will increase the incentive to exercise locational market power and magnify the price impacts.
- Offer price caps for imbalance reserves capacity and reliability capacity could in principle be implemented that would prevent offer prices from setting high prices for either imbalance reserves or reliability capacity in the day-ahead market, while providing a margin that would generally be sufficient to cover the cost of scheduling gas or incurring other costs in the day-ahead time frame in order to supply imbalance reserves or reliability capacity.

1. This will likely not be an issue under options 1B and 1C because they do not take account of congestion in scheduling reliability capacity.

POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

Can a workable locational market power mitigation design for reliability capacity be developed and implemented?

- There may also be more subtle potential impacts of the option 2 combined IFM RUC design on the potential for the exercise of market power depending on the way the CAISO's load forecast is developed and penalty prices applied to meeting the load forecast in the load balance equation for forecast load.

POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

Can the basic combined IFM RUC pricing design be refined to eliminate the potential for anomalous outcomes involving intermittent resource output?

- The design for energy and reliability capacity outlined by the CAISO imposes constraints on the energy balance in the IFM and forecast load pass.
- Energy cleared in the IFM appears in the load balance equation for both the IFM and the forecast load dispatch.
- The CAISO formulation, however, does not consider the modeling and pricing of intermittent resource output which is cleared in the IFM but is represented by a California ISO forecast in the forecast load dispatch.

POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

TEN = day-ahead market schedule of non-intermittent resources

IEN = day-ahead market schedule of intermittent resources

FIEN = RUC output forecast of intermittent resource output.

VEN = Virtual supply

VL= Virtual load

L = physical bid load

D = CAISO load forecast

With this notation:

The IFM load balance equation becomes:

[1A] TEN + IEN +VEN = L +VL + losses

The load balance equation in the RUC solution is:

[2A] REN = TEN + FIEN + RCU- RCD = D

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POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

The implication of this formulation is that thermal generation that clears in the IFM (TEN) will be paid the shadow price of both the [1A] [λ in George's notation] and [2A][ξ in George's notation] load balance constraints, while intermittent resource output covered by the CAISO forecast would only be paid the shadow price of the [1A] constraint.

- This issue can likely be addressed by redefining the CAISO intermittent resource output forecast in the load balance equation as the forecast net of the portion that is cleared in the IFM, so the forecast load pass load balance equation would be:

[2B] REN = TEN + (FIEN – IEN) + IEN + RCU- RCD = D

With this approach intermittent resource output that cleared in the IFM would receive the same compensation as thermal generation.

POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

However, the use of equation [2B] as the forecast load pass load balance equation would have implications that need to be worked through.

- While the clearing of additional either intermittent or thermal output to meet load in the IFM could reduce the amount of reliability capacity the CAISO would need to schedule in the forecast load pass, this would not be the case if the intermittent output cleared from a given resource exceeded its expected output, with the offer essentially a virtual supply bid.

- This possibility could perhaps be addressed by including intermittent resource output in the [2B] load balance equation up to the amount of CAISO's output forecast for the resource, but this would need to be evaluated.

POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

Can a market design and framework for CAISO implementation be developed that will produce efficient outcomes and be consistent with the potential impact of the CAISO's net load forecast on energy, imbalance reserves, and reliability capacity prices.

- This challenge involves a number of issues, all of which also exist in the option 1 sequential designs in which they will impact production costs.
- These issues will have a much larger impact on market prices in the option 2 combined IFM RUC design.

- CAISO load forecast accuracy;
- Imbalance reserves penalty price;
- Scheduling of reliability capacity on the interties.

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POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

California ISO load forecasts that exceed the actual expected real-time net load can raise the production cost of meeting load under both the option 1 sequential designs and under the option 2 combined IFM RUC design.

- The CAISO and stakeholders need to recognize the potential under option 2 for a high CAISO load forecast to not just cause market participants to incur RUC uplift costs or high reliability capacity charges but to result in materially higher energy market prices under a combined IFM RUC design.
- This outcome is a result of core features of the option 2 design. It needs to be addressed in the way the CAISO load forecast is developed or penalty prices determined.

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POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

The choice of the imbalance reserve penalty price used in the IFM can have substantial market impacts under option 2 and some option 1 designs because the price of imbalance reserves will be determined in conjunction with the price of reliability capacity.

- This outcome is a result of core features of the option 2 design and some option 1 designs.
- The option 1 designs that do not have this interaction will have material inconsistencies in prices and schedules when the imbalance reserve penalty price impacts prices.
- These outcomes need to be addressed in the way the CAISO determines the penalty prices for various levels of imbalance reserves.

POTENTIAL CHALLENGES IN IMPLEMENTING A COMBINED IFM RUC DESIGN

The ability to meet forecast load by scheduling reliability capacity on the interties could in some circumstances have a material impact on the production cost of meeting load under both option 1 and option 2 IFM designs.

- The ability to meet forecast load by scheduling reliability capacity on the interties is more likely have a material impact in lowering energy and flexible capacity prices under option 2.
- It is therefore even more important under option 2 than under option 1 designs to allow the scheduling of reliability capacity on the interties.
- This will make it important to resolve design and operational issues with the scheduling of reliability capacity on the interties:
  - Real-time offer prices
  - Settlement of real-time deviations
  - Congestion pricing in the IFM

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OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

We have identified five alternative versions of an option 1 Sequential IFM-RUC design that we outline below. All of these designs will:

- Co-optimize the scheduling and pricing of energy and imbalance reserves;
- Provide financially binding day-ahead market schedules and compensation for resources relied upon to provide imbalance reserves;
- Provide more assurance that an appropriate amount of imbalance reserves will be available in real-time, and scheduled at least cost, than ad hoc operator adjustments in RUC;

But they will only ensure that imbalance reserves can be dispatched to meet real-time variations in net load to the extent that appropriate locational requirements are defined in the IFM;

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OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

There are five alternative versions of an option 1 Sequential IFM-RUC design.

Option 1A: Separate IFM and RUC passes with imbalance reserves scheduled in the IFM pass, and RUC capacity scheduled in a separate RUC pass. This corresponds to the status-quo design with the addition of imbalance reserves.

Option 1B: IFM pass which schedules imbalance reserves to meet a projected combination of RUC – FMM uncertainty and IFM to RUC uncertainty, based on the historical differences between IFM cleared generation and FMM net load forecast. There would be a separate evaluation that would test the deliverability and adequacy of the scheduled imbalance reserves in meeting the CAISO load forecast. This is the Option 1 sequential IFM design described in CAISO materials.

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OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

Option 1C: IFM pass which schedules imbalance reserves to meet a projected RUC – FMM uncertainty and the actual difference between IFM cleared generation and the RUC load net load forecast. There would be a separate RUC evaluation that would test the deliverability of the scheduled imbalance reserves in meeting the RUC load forecast.

Option 1D: The IFM would consist of separate bid load and forecast load unit commitment and dispatch passes, with imbalance reserves and energy cleared in a bid load pass and additional capacity above that dispatched in the bid load pass cleared as reliability capacity (RCU) in a forecast load pass.

OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

Option 1E: The IFM would have separate bid load and forecast load unit commitment and dispatch passes as under Option 1D.

- The forecast load pass would be followed by a final bid load dispatch pass in which any long start resources committed in the forecast load pass would be blocked on at minimum load and dispatched to meet bid load and provide imbalance reserves.

- The difference between the energy and imbalance reserves cleared in the bid load redispatch pass and the dispatch in the forecast load pass would be cleared as reliability capacity (RCU).

OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

We have eight observations regarding these alternative option 1 sequential IFM RUC designs.

1. The requirement that forecast load be met with imbalance reserves that are dispatchable in a 15 minute time frame increases the cost of meeting load and prices under option 1B.
- This requirement is not an inherent feature of Option 1B.
- Relaxing this requirement to allow forecast load be met with reliability capacity dispatchable in an hourly timeframe will lead to prices and schedules that are more consistent with the optimum and option 2.

OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

2. Because Option 1B schedules resources to meet forecast load based on imbalance reserve zones, rather than the location at which forecast load must be met, there is a potential that option 1B will schedule imbalance reserves/reliability capacity at locations where it cannot be dispatched to meet forecast load.

- This outcome would require that additional capacity be scheduled or committed in the RUC pass.

OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

3. The amount of imbalance reserves/reliability capacity scheduled to meet forecast load under option 1B is based on historical differences between IFM and FMM net load.

- This will not necessarily correspond to the amount of imbalance reserves/reliability capacity required to meet the CAISO load forecast in the sequential evaluation pass.
- It appears that this design will either schedule the same or more capacity than the current RUC process or option 2.

SEQUENTIAL IFM-RUC DESIGNS

4. Option 1C would schedule the appropriate amount of imbalance reserves or reliability capacity to meet the CAISO's load forecast but we believe that it would be as complex to implement as option 2 and would raise similar implementation challenges, while not providing assurance that reliability capacity could be dispatched to meet forecast load.
5. Option 1D would schedule the appropriate amount of reliability capacity at locations where it could be dispatched to meet forecast load.
6. Option 1D would require 2 unit commitment and dispatch passes, yet not provide energy schedules for the minimum load block of long start resources committed in the forecast load pass.

OPTION 1 - SEQUENTIAL IFM-RUC DESIGNS

7. Like Option 1D, Option 1E would schedule the appropriate amount of reliability capacity at locations where it could be dispatched to meet forecast load.

- In addition, option 1E would provide energy schedules for the minimum load block of long start resources committed in the forecast load pass, and adjust the schedules of other resources.

- On the other hand, option 1E would require 2 unit commitment and dispatch passes, plus a final bid load redispatch pass.

SEQUENTIAL IFM-RUC DESIGNS

8. If there are no long start resources that need to be committed, Option 1D will generally produce schedules for energy, imbalance reserves and reliability capacity that are very similar to option 2.

- If there are long start resources, option 1E will generally produce schedules for energy, imbalance reserves and reliability capacity that are very similar to option 2.
- However, under either option 1D or 1E there will generally be at least small inconsistencies between the prices of energy and imbalance reserves determined in the IFM pass and the price of reliability capacity determined in the forecast load pass.

SEQUENTIAL IFM-RUC DESIGNS

- Under tight high load conditions these price inconsistencies could be very large. Such large potential pricing inconsistencies would likely introduce inefficient bidding incentives during these conditions.
- It is possible that some kind of ex post pricing design could be developed to determine prices for energy, imbalance reserves and reliability capacity that would be more consistent with the forecast load pass schedules under option 1D and with the final bid load dispatch under 1E.
  - This would be a research project and it is uncertain how consistently such a design would produce reasonably efficient settlement prices.

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