Challenges of Estimating Opportunity Costs of Energy-Limited Resources and Implications for Efficient Local Market Power Mitigation

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Local market power mitigation procedures in the CAISO Energy Imbalance Market allow participant-submitted bids and offer prices to be replaced with a CAISO-administered calculation of a mitigated resource's marginal cost. Central to the current approach is the ability of the CAISO to accurately and reliably approximate marginal costs through the application of administrative formulas. For energy-limited resources, such as the large storage hydro systems in the Northwest, marginal costs are driven largely by opportunity costs, which can be very challenging to estimate. The CAISO's estimates of these opportunity costs are likely to differ from an EIM participant's own estimates, with important implications for the use of the CAISO's estimates as the offer price for energy-limited resources when mitigation is applied. A material risk of being mitigated to an offer price below an EIM participant's estimate of its resource's marginal costs is likely to discourage participation in the EIM, reducing the efficiency benefits that could be achieved by the EIM's security-constrained economic dispatch. This reduced efficiency could manifest as fewer EIM participating resources being available for economic dispatch, especially when they may be most valuable in managing variability of load and renewable resource output, ultimately leading to higher prices to consumers. An approach to reducing this risk could be to define a bandwidth above the CAISO's estimated reference price level to account for the increased uncertainty of such estimates; EIM participants' bids and offers within this bandwidth would not be deemed to reflect an exercise of market power, and would not be mitigated. Experience in other ISO and RTO organized markets that only apply mitigation to bids and offers that exceed certain price bandwidths supports exploring such an approach in the EIM to reduce the risk of over-mitigation of energy-limited resources while protecting against the exercise of local market power.

I. Introduction

This paper explores challenges that are likely to arise from applying the existing local market power mitigation ("LMPM") procedures of the CAISO Energy Imbalance Market ("EIM") to energy-limited resources—especially storage hydro resources—located outside of the California organized market footprint. These procedures are evaluated in light of basic economic principles relevant to the design of efficient market power mitigation mechanisms:

- Market outcomes should be consistent with those that would arise under competitive conditions;

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- Competition between and among suppliers more effectively disciplines market behavior than administrative interventions;
- The market design, including bid mitigation procedures, should offer efficient incentives for market participation;
- Intervention in the market should be no greater than what is necessary to protect against the material exercise of market power; and
- Bid mitigation procedures must not be unduly burdensome to administer.

Participants in the EIM are subject to the LMPM procedures under the CAISO's tariff. For each market interval, the CAISO employs a "structural test" to evaluate transmission constraints and determine which will be deemed non-competitive. Each participating resource that is able to relieve a non-competitive constraint is subject to bid mitigation, and may have its submitted offer prices reduced down to the default energy bid ("DEB") for the resource.[4] Entities that choose to participate in the voluntary EIM therefore face the possibility that, when such mitigation occurs, their resources will be dispatched based on the DEB rather than at the bid price submitted by the EIM participant (if the DEB is lower). Resources that experience bid mitigation may also be the marginal resource for meeting local demand, since mitigation should occur when there are few, if any, resources offered by competing suppliers that can relieve the non-competitive constraint. If a resource's offer price is mitigated and it becomes the marginal supplier, the DEB will not only determine the resource's dispatch, but will also likely to determine the market-clearing price at which sales in the constrained area are financially settled. Thus, the mitigated resource may end up producing energy at a price that is lower than its offer and also foregoing profits from later sales and/or reducing the availability of the resource to cost-effectively serve native load obligations in subsequent periods.

Importantly, even when an energy-limited resource is not marginal in the EIM following mitigation, the application of the DEBs may increase its dispatch relative to other resources, such as a thermal resource without an energy limit, requiring greater dispatch of more expensive units later. This will directly impact efficiency if the DEB is a materially inaccurate estimate of the energy-limited resource's marginal costs.

This places great importance on the accuracy of DEBs, and on how closely they estimate a resource's marginal costs. Properly defined, a resource's marginal costs include not only the direct costs of producing an increment of energy—such as the cost of purchasing fuel—but also any opportunity costs associated with alternative sales transactions or other uses of the resource that must be foregone in order to produce and sell an increment of energy during a specific interval of time.[5] For example, a hydro resource may only have sufficient water to operate for four hours during a particular day. The marginal cost of selling the output from this resource consists not only of any direct costs of production, but must also include costs arising from the fact that the production and sale of energy in one hour requires reducing production in one or more hours later in the day, thereby foregoing later sales and/or reducing the availability of the resource to serve native load obligations. For instance, if market prices in the four highest-price hours of the day are expected to be $30/MWh, then the marginal cost of selling limited energy in any of the other hours of the day is $30/MWh (assuming there are no other variable costs), since that is the value of the economic opportunity that must be foregone.

[4] For further discussion of how the mitigated price is determined, see Section II.

[5] The inclusion of opportunity costs in the definition of marginal costs is widely accepted. *See,* e.g., Federal Energy Regulatory Commission *Staff Analysis of Energy Offer Mitigation in RTO and ISO Markets*, Docket No. AD14-14-000, October 2014, at 3. ("...in a competitive wholesale electricity market, a resource's offer will be approximately equal to its short-run marginal cost (including opportunity costs)."

As discussed in this paper, opportunity costs can be very challenging to estimate,[6] and the estimates calculated by an external entity, such as the CAISO, may diverge from the estimates as determined by the participant that offers the resource into the market. If differences between an EIM participant's estimate of its resource's marginal costs, including opportunity costs, and the CAISO's estimates are large, significant concerns can arise. In particular, a DEB based on a CAISO estimate of marginal costs that is less than the EIM participant's estimate presents a risk of several types of inefficient outcomes.

First, the EIM participant faces a risk of being dispatched to sell energy at a price below its estimate of the resource's marginal cost, with self-evident financial harm to the seller, while market prices will no longer accurately reflect the value of energy in the given interval. Accurate price signals are critical to encouraging load response and supply resources to be available where and when they are most valuable to maintaining reliable and least-cost electricity supply.

Second, an EIM participant with an energy-limited resource faces a risk that the resource will be depleted by more than the total energy that the participant sought to make available, based on all of the considerations and constraints affecting the management of the energy-limited resource. Such outcomes diminish the efficiency of the market as a whole, as energy depleted during lower-priced hours when additional output is available from resources without energy limits may result in less energy being available from the energy-limited resource during subsequent hours when it would be more valuable to the market, resulting in higher prices during the later hours due to lack of conservation of the limited energy. None of these outcomes are consistent with the economic principle of designing bid mitigation procedures that lead to market outcomes consistent with what would arise under competitive conditions.

Over time, the risk that the EIM may dispatch a resource inconsistently with the seller's view of its marginal costs can be expected to discourage voluntary participation in the EIM. This can result in reduced EIM activity during specific hours that an EIM participant anticipates the possibility of being dispatched at a price less than its estimate of its marginal cost, or more general reductions in the resources or entities that elect to participate in the EIM. All of these outcomes reduce the amount of competitive supply offered into the EIM, which may prevent the EIM participants from fully realizing the potential efficiency benefits of coordinated, security-constrained economic dispatch.[7] Supply will be less available when needed to respond to variations in load or intermittent production, and prices will rise. Market power mitigation measures that lead to such diminished supply participation may therefore actually hinder, rather than support, the full development of competitive conditions in the EIM. This is inconsistent with the principles of providing efficient incentives for market participation, and relying on competition between and among suppliers as the primary way to discipline market behavior.

The expansion of the EIM to include resources located outside of California, and especially the inclusion of large energy-limited hydro systems in the Northwest, means that DEBs must now be calculated for a large number of resources whose marginal costs are driven primarily by opportunity costs that can be challenging to estimate in part because they are subject to considerable uncertainty regarding future conditions and constraints. For such resources, an EIM participant's estimate of marginal costs and the estimates developed by the CAISO will likely differ by a greater amount, and in more hours, than for non-EIM resources. Moreover, the challenge of estimating the opportunity costs could be heightened during periods of short-run transmission or capacity constraints, during which the marginal dispatch of these

[6] The challenge of calculating opportunity costs is also broadly recognized. *See*, e.g., FERC Staff, *op. cit.*, at 1. ("...opportunity costs for some resources can be difficult to determine with precision.")

[7] Generally, reduced supply participation would be reflected in higher prices, encouraging additional participation by other sellers, thus making participation decisions self-correcting in theory. However, this is less likely to occur if LMPM provisions increase the risk of participation and/or dampen the market prices that signal opportunities for increased supply participation.

resources is most important to the efficiency of the EIM. Because of the heightened importance of the opportunity cost component of marginal cost estimates, there is an increased possibility of inefficient outcomes—*i.e.*, a reduction in supply leading to higher prices and decreased reliability—from applying the current DEB rules, motivating an examination of whether the DEB rules should be modified in their application to energy-limited resources in the EIM.

II. Summary of Bid Mitigation of EIM Participating Resources

EIM participants submit bids and offers for all EIM participating resources, which are subject to the LMPM provisions under the CAISO tariff.[8] The LMPM mechanism applied in the EIM is largely an extension of the LMPM processes that existed prior to the EIM, which was developed for mitigation of resources within the CAISO balancing authority area ("BAA").

Conditions Triggering Bid Mitigation

Prior to each binding market run, the CAISO performs a market power mitigation ("MPM") run, using the bids and offers as submitted by the market participants. The results of this MPM run are used to identify conditions triggering bid mitigation due to (1) local transmission constraints *within* an EIM entity's area; or (2) limitations on transfers *into* an EIM entity area.

For local transmission congestion *within* an EIM entity's area, the CAISO LMPM process performs a structural test known as the three-pivotal supplier test, which is an indicator of the concentration of supply offers capable of relieving the transmission constraint (*i.e.*, capable of meeting demand in a local pocket downstream of the constraint). If supply conditions fail the structural test, all resources capable of meeting demand in that constrained area are subject to bid mitigation.

For limitations on transfers *into* an EIM entity area, however, the CAISO LMPM process does not perform a three-pivotal supplier test. Instead, the LMPM process only tests whether incremental demand within an EIM entity's area can be served by incremental supply from the CAISO BAA. Since incremental supply from the CAISO BAA is deemed to be competitive for purposes of this market rule (due to the fragmented ownership and control of resources within the CAISO footprint), when incremental demand in an EIM entity area can be served by incremental supply from the CAISO BAA, market conditions in the EIM entity area are considered to be competitive, and bid mitigation of resources within the EIM entity's area is not necessary (except when due to local congestion within the EIM, discussed above). If, on the other hand, incremental demand in an EIM entity area cannot be served by supply from the CAISO BAA, then supply within that EIM entity area is deemed to not be competitive, and resources within the EIM entity area are subject to bid mitigation.[9]

Default Energy Bids

When bid mitigation is triggered, the original offer price submitted by the market participant for a resource offered into the EIM (a "participating resource") is reduced to the higher of (1) the "competitive proxy price" from the pre-market MPM run; or (2) the DEB that is on file for that resource.

[8] Local market power mitigation procedures are found in Sections 39.7 and 29.39 of the CAISO tariff.

[9] The fact that incremental demand in an EIM entity area cannot be served by supply *from the CAISO BAA* does not rule out the possibility that it could be served by competitive supply from *other EIM entity areas*. As the EIM has expanded to include multiple balancing areas and entities, with transfers enabled over multiple transmission paths, it has become increasingly likely that competitive conditions might exist between and among areas located outside of the CAISO BAA, irrespective of limitations on transfers to or from the CAISO BAA.

The first term is a proxy for what the market price would have been at the resource's location if non-competitive transmission constraints did not bind. In the specific situation of mitigation triggered due to limitations on transfers into an EIM entity area (as opposed to local transmission constraints within that area), the competitive proxy price in an EIM entity area is the price at which an increment of supply is estimated to be available from resources in the CAISO BAA (which are deemed to be competitive) had there not been limits on transfers of energy to the EIM entity area from the CAISO BAA.[10]

The second term is a resource-specific value that can be calculated in one of three ways:

1. Variable Cost Option—based on unit heat rate curves, fuel prices, and variable O&M adders;
2. LMP Option—based on the 25th percentile of LMPs at which the resource was dispatched in the past 90 days; and
3. Negotiated Rate Option—based on a value or formula negotiated between the market participant and CAISO, and filed on a confidential basis with FERC.[11]

Generally speaking, the Variable Cost Option appears most applicable to thermal generating units. The underlying engineering properties of a thermal unit are usually stable and well-known and hence the principal variable is the cost of the input fuel.

The LMP Option offers an alternative to a bottom-up engineering cost estimate. Instead, the LMP Option infers the marginal cost of a resource based on data for the LMPs at which it was voluntarily dispatched in the last 90 days. The DEB is set to the 25th percentile of the LMPs in this data set; that is, the LMP that was higher than 25% of the historical LMPs in this data set, and less than 75% of the LMPs, with an adjustment for changes to fuel prices. This approach relies on recent history being a good proxy for current marginal costs (after adjusting for changes in fuel prices), which may be workable for resources with marginal costs that are relatively stable over time.

The Negotiated Rate Option provides for the use of a custom value or formula that is acceptable to both the market participant and to the CAISO. This option is effectively the only potential choice for non-thermal resources whose marginal costs are not relatively stable over time. However, the use of this option is limited to approaches that are acceptable to the CAISO, and since the negotiated DEBs are not public, there is very little information regarding the methodologies that CAISO has accepted for use in determining negotiated rates, beyond the general concept that CAISO views all DEBs as estimates of a resource's marginal cost.[12]

III. Growing Challenges in the Calculation of DEBs

The growth of the EIM in the past few years has resulted in a large number of new resources being subject to the existing LMPM procedures, including the rules for calculating a DEB for use in bid mitigation. Many of these resources present circumstances distinct from resources located within the CAISO BAA, raising the question of whether existing LMPM procedures and DEB options need to be modified.

In the limited case of thermal resources, CAISO has already recognized some of these challenges and has proposed enhancements. CAISO recently proposed revising its restrictions on the commitment cost offers

[10] *See* CAISO Business Practice Manual for Energy Imbalance Market (ver. 10) at pp. 83-84.

[11] The DEB options are set forth in Section 39.7.1 of the CAISO tariff.

[12] The CAISO Business Practice Manual for Market Instruments, Section D, states that "CAISO believes that under competitive outcomes generators would be paid at least their variable costs. Consequently the Default Energy Bid (DEB) is designed to approximate that cost."

(*i.e.*, start-up costs and costs to operate at the unit's minimum stable output level) that generators may submit, explaining that its past reliance on day-ahead natural gas prices at California trading hubs to set limits on commitment costs may not be appropriate for EIM participating resources located far from these hubs.[13] CAISO explained that there is an increasing need for market participants to have flexibility to submit bids that reflect their own estimates of costs, rather than relying on estimates prepared by the CAISO.[14]

The growing difficulties in accurately estimating resource costs are not confined to commitments costs of thermal resources, however. There are two additional attributes of some EIM participating resources that further increase the challenge of estimating marginal costs:

1. EIM participating resources located outside the CAISO BAA have opportunities to sell their output in the real-time bilateral markets in these regions, and hence may face opportunity costs to selling that output in the EIM instead.
2. Some of the new EIM participating resources are supported by the capability of multi-facility energy-limited hydro systems operated by vertically-integrated utilities to meet native load obligations as well as to support commercial transactions. Such resources face opportunity costs arising from the often-complex tradeoff between producing energy today instead of producing energy in the future.

Opportunity Costs of Alternative Real-Time Bilateral Market Transactions

The EIM operates in the real-time timeframe, with bids and offers due at 75 minutes prior to the start of each trading hour. In the portions of the Western Electricity Coordinating Council ("WECC") outside of the CAISO BAA, real-time trading also occurs on a bilateral basis, with transactions arranged and scheduled up to the WECC scheduling deadline of 20 minutes prior to the start of each 15-minute delivery interval. This means that EIM participants with supply to sell may have a choice to make: whether to use the supply to support sales in the bilateral markets, or whether to use the supply to support offers in the EIM. This choice is most likely to impact estimation of opportunity costs when there are limitations on short-term energy availability, capacity, or the availability of transmission service.[15]

Whenever two mutually exclusive opportunities are present, the marginal cost of pursuing one opportunity includes the foregone value of the other opportunity; that is, the marginal cost includes the "opportunity cost" of the highest value alternative use of the resource (*i.e.*, the profit margin from the alternative use), as well as any variable production costs. In the case of EIM offers, many participating resources could alternatively be used to support bilateral market transactions for the same delivery period. For such resources, the marginal cost at which they would offer their output in the EIM 75 minutes before the hour, from an economic perspective, includes the expected foregone profits from real-time bilateral market transactions for the same delivery interval.

Real-time bilateral transactions occur at dozens of discrete delivery locations throughout the WECC, though there is limited visibility into those transaction opportunities for entities not actively participating

[13] *See* Memo from Keith Casey to CAISO Board re: Decision on Commitment Costs and Default Energy Bid Enhancements Proposal (March 14, 2018), at 2. ("The gas price indices used to calculate reference levels may not reflect the wide variety of generators throughout the ISO balancing area and the broader Energy Imbalance Market footprint, and may not reflect volatile or illiquid gas markets.") http://www.caiso.com/Documents/Decision_CCDEBEProposal-Memo-Mar2018.pdf

[14] *Id.*, at 10. ("The proposed changes will significantly improve suppliers' ability to accurately reflect cost expectations ... and encourage increased participation from flexible resources in the ISO balancing area and the voluntary western energy imbalance market.")

[15] Stated differently, under these conditions, short-run opportunity costs of energy-limited resources are likely to exceed longer-run opportunity costs.

in that market. Real-time bilateral market conditions can diverge significantly from the bilateral electricity index prices that are more broadly published, as these are based on transactions at only four liquid electricity trading hubs, and are for day-ahead transactions of industry-standard multi-hour blocks of energy. Transaction data indicates considerable volatility and divergence between real-time bilateral prices at multiple locations across the west and the day-ahead prices at the primary market trading hubs.[16]

Opportunity Costs of Energy-Limited Resources

The EIM also includes participation by a growing number of entities associated with large storage hydro systems, including Northwest entities such as PacifiCorp, Puget Sound Energy, and Idaho Power Company. More recently, Powerex entered the EIM, with a participating resource supported exclusively by hydro system capability. There are other Northwest hydro entities that conceivably could become EIM participants in the future, such as Bonneville Power Administration and public power agencies.

Estimating marginal costs for hydro systems with storage requires explicitly recognizing the energy-limited nature of these resources. Energy that is generated in one hour will often reduce the energy that can be generated in one or more future hours. Thus, energy-limited hydro resources face opportunity costs associated with foregoing future sales opportunities as a result of making sales in the current hour.

Assessing how additional generation today might affect generation in the future is relatively simple in concept, but can be challenging in practice for energy-limited hydro resources. This is because there are often numerous relationships and constraints that govern the coordinated operation of a hydro system with multiple facilities and storage. The output of each facility is dependent on various input conditions, such as water inflows, and subject to operational constraints, such as on discharge rates or available reservoir storage. Additionally, the operation of one facility can often affect conditions on downstream facilities, which also means that constraints on downstream facilities may impose constraints on the operation of upstream facilities. Understanding these interactions, and how these interactions will change over time, is fundamental to estimating how changes in output in one hour can affect future production.

Moreover, energy limitations can arise over multiple different timeframes. For example, hydro systems may face long-term energy constraints, such as on the total output over a season or a year (or longer) from major facilities with substantial storage. Hydro systems may also face near-term energy constraints, perhaps on the output over a day (or less) from smaller facilities with limited storage, or facing binding environmental constraints. At any point in time, the output from a hydro resource may be limited by—and hence its opportunity costs may be driven by—either near-term or long-term constraints.

An assessment of the future output of a hydro system therefore requires information regarding not only current operating conditions and constraints, but how those conditions and constraints are likely to evolve throughout the forecasting horizon. Relevant future conditions include projected future water inflows, projected future native load requirements, and projected future restrictions on discharge rates and reservoir capacity. And, of course, in order to assess the most efficient projected use of the energy-limited resource—and hence to assess how additional production today may impact the efficient projected use over time—projected future energy market prices at relevant transaction locations are also required.

[16] The volatility between bilateral day-ahead price indices at major electricity trading hubs and real-time bilateral transactions at discrete locations can be assessed from public transactional data, such as the Electronic Quarterly Reports filed with FERC. Additionally, volatility between bilateral day-ahead price indices at major electricity trading hubs and real-time interval prices at discrete locations in the EIM has been documented in the market performance reports compiled by CAISO. *See*, for example, http://www.caiso.com/Documents/Agenda-Presentation-MarketPerformance-PlanningForum-Apr192018.pdf at 71.

As with all projections of future conditions, there may be many different available forecasts, reflecting a range of potential outcomes, multiple sources of forecasting information, and multiple forecasting methods.

The above overview of the challenging nature of the task faced by owners or operators of energy-limited resources, and of storage hydro systems in particular, of estimating the opportunity costs of their resources provides background for the design of a workable bid mitigation framework for energy-limited EIM participating resources.

Challenges of Reflecting Opportunity Costs in DEBs

The participation in the EIM of a growing number of resources whose marginal costs are driven by opportunity costs presents an important challenge for the existing approach to bid mitigation in the CAISO. Namely, the CAISO's estimates of either type of opportunity costs discussed above (*i.e.*, alternative real-time bilateral market opportunities in the same hour, or the tradeoff between current production and future production faced by energy-limited hydro resources) are very likely to differ from the EIM participant's estimates of those opportunity costs.

It has already been recognized that the published day-ahead price indices for natural gas often fail to reflect intra-day market conditions, or prices at locations far away from the liquid California trading hubs.[17] Similarly, published day-ahead electricity price indices at major trading hubs may fail as estimates of real-time bilateral electricity market opportunities, or opportunities at distant locations. The information-related limitations to estimating the opportunity cost component of marginal costs are compounded by the timeline for updating the calculation of DEBs—which currently occurs the day prior to the operating day—and by the lack of hourly granularity of DEB values. Since DEBs must be finalized the day prior to EIM operations, they cannot reflect the actual real-time bilateral market conditions on any given day. And since DEBs are specified at a daily level, rather than an hourly level, they cannot reflect how real-time market conditions vary within the day, for example due to transmission outages or unexpected levels of load.

For energy-limited storage hydro systems, there are further challenges in calculating DEBs, which are likely to lead to a divergence between the opportunity costs estimated by the CAISO and those estimated by the EIM participant. First, as a practical matter, the CAISO would likely need to rely on a simplified representation of the relationships, constraints, and conditions on the hydro system being evaluated.

A CAISO estimate of hydro opportunity costs will also need to develop methodologies and procedures to estimate current and future conditions including inflows, native load, reservoir limitations, and market prices. Information regarding future electricity market prices generally exists only for a few major market hub locations, and typically only for future monthly on-peak and off-peak products, out to approximately two years. A methodology might need to be developed to interpolate this available information to project future prices with sufficient granularity and at multiple relevant locations.

The above makes it likely that CAISO's estimates of opportunity costs will differ from the estimates of the EIM participant associated with the resource in many hours.[18] Even if the *average* difference between the

[17] *See* footnote 13, *supra*.

[18] We note that there may be periods in which the market and operational conditions and constraints on a hydro resource are relatively stable, implying that marginal costs would also be relatively stable. Under such conditions, a DEB based on recent LMPs (or LMPs for "like periods") at which the resource was willing to be dispatched might be workable. However, this type of approach would still require determination of whether and when an approach based on historical LMPs could be applied, as well as the development of an alternative approach for estimating marginal costs when historical LMPs could not be used. Hence, it would not eliminate the unavoidable challenges of estimating marginal costs of storage hydro or other energy-limited resources.

two estimates, measured over time, is relatively modest, the two estimates may differ materially in any given hour. Stated differently, there is likely to be a substantial degree of uncertainty around any CAISO estimates of the marginal cost of energy-limited hydro resources in the EIM. This estimation uncertainty has important consequences for the use of such estimates as DEBs under the existing LMPM design in the EIM.

IV. Consequences of Inaccurate DEBs

For resources with marginal costs that are primarily based on opportunity costs, the use of a DEB based on a CAISO estimate of those marginal costs creates important risks of adverse outcomes. Specifically, the potential application of a DEB that is less than the EIM participant's estimate of its marginal costs is particularly problematic, since it creates the potential that the resource's offer price will be replaced by a price that is below the resource's marginal cost (as evaluated by the EIM participant).

The most direct adverse consequence of replacing a resource's offer price with a price that is below its marginal cost, as evaluated by the EIM participant, is that the resource may be dispatched to make sales in the EIM at prices that are less than the marginal costs incurred to provide the energy.

There are additional adverse consequences for energy-limited hydro resources. For such resources, the harm is not only financial, but the lower DEB can lead to dispatching the resource beyond the total energy that the EIM participant sought to make available over the course of the day. Thus, a DEB that is less than the EIM participant's estimate of its resource's marginal costs can interfere with the intended physical operation of energy-limited resources, depleting limited energy and reducing what is available for production in future hours, either to support sales or to serve native load requirements. Additionally, the application of the DEBs to an EIM participant's resources may increase the dispatch of its energy-limited resources relative to its other resources, such as a thermal resource without an energy limit, requiring greater dispatch of more expensive units later. This will directly increase the cost to the EIM participant of serving its own load or decrease its profits if it is a net seller (after meeting its native load).

The first EIM entrant, PacifiCorp, explained the adverse consequences it experienced as a result of its hydro resources being dispatched in the EIM according to a DEB:

> *PacifiCorp's hydro resources have unique operating characteristics that require it to manage a multitude of operating constraints, such as flow requirements, fish passage, flood control and other environmental and recreational requirements. These requirements limit the amount of energy that can be used in the summer period due to lower inflows into the reservoir. PacifiCorp schedules its resources for the operating day with a limited amount of energy flexibility, however, due to the DEB constraint, it cannot communicate the value of the limited energy to the market. … During summer periods when power prices are high in the California market, the DEB price of PacifiCorp's hydro resource is relatively low and can cause the unit to be dispatched by the market early in the day, removing the capability to operate the resource as scheduled to meet PacifiCorp's retail load across the more expensive peak time of the day.*[19]

The adverse economic impacts of inefficiently depleting an energy-limited resource extend beyond the seller of the resource's output. The application of the DEBs might increase production from the energy-

[19] Affidavit of Kelcey Brown, Exhibit 2 to August 31, 2017 filing of Nevada Power Co., Sierra Pacific Power Co., and PacifiCorp in Docket Nos. ER17-2392, et al., at P 11.

limited resource in the EIM, with this additional production inefficiently displacing generation from other, non energy-limited resources elsewhere in the EIM. There is a loss of market efficiency when this occurs, as less of the finite amount of energy from these flexible resources will be available to the market during subsequent higher-priced hours, when this additional supply would have been more valuable.

EIM participants will likely seek to limit the consequences of having their offer prices replaced by a DEB that is below their estimates of the marginal cost of the resource. More specifically, during hours that an EIM participant anticipates an increased likelihood of bid mitigation, and where such mitigation would apply a DEB that is below their own estimate of the resource's marginal cost, it would be expected that the EIM participant would reduce its participation in the EIM.

The response of sellers to risks of non-compensatory market outcomes is well-documented. For instance, during the cold-weather events that affected several areas of the country in the winter of 2013-2014, multiple organized markets received temporary waivers of bid caps that prevented generators from reflecting their full costs in prices. As explained by FERC staff, these waivers from bid caps "provided greater certainty to generators participating in the markets that they could recover their actual costs of supplying energy."[20]

The potential for EIM participation to be discouraged as a result of the risk of bid mitigation to levels below a seller's estimate of its marginal costs was described in a recent FERC filing by the CAISO. In its filing, CAISO explained that certain aspects of its LMPM procedures have unintentionally resulted in bid mitigation of Powerex's EIM offers more frequently than anticipated, and that the Negotiated DEB for Powerex's participating resource is often less than Powerex's own estimate of its marginal costs, including opportunity costs. This has resulted in Powerex limiting its participation in the EIM during certain hours in which these outcomes are more likely:

> *This issue has manifested itself both during parallel operations and in the first few days of Powerex's actual participation in the EIM that began on April 4. For the first few days of actual operations going from April 4 through April 8, Powerex has been mitigated on average on 67 percent of the hours in the FMM and about 35 percent of the hours in the RTD.*
>
> *In order to avoid being forced to sell at a bid price that Powerex has found does not represent its opportunity cost, and after conferring with the CAISO, Powerex has exercised its right to reduce the amount of transmission available to support EIM transfers to the CAISO balancing authority area and the remainder of the EIM area in intervals when Powerex anticipates this sequence of events will occur.*[21]

If the risk of inaccurate DEBs leads to reduced EIM participation, the full benefits of the EIM will not be achieved. The benefits of an organized market are driven by the ability of sophisticated software to identify the least-cost manner to serve load, subject to transmission and security constraints, on a granular sub-hourly basis. These benefits increase as more resources participate and are available through the EIM; the more options that are available to the EIM optimization, the greater the savings in production costs that can be achieved. Therefore any factors that discourage participation—whether by reducing the quantity of economic offers, reducing the transmission made available to the EIM, or

[20] FERC Staff presentation, *Commission and Industry Actions Relevant to Winter 2013-14 Weather Events*, Docket No. AD14-8, October 16, 2014, at 5.

[21] CAISO *Petition for Limited Tariff Waiver and Request for Expedited Consideration*, Docket No. ER18-1339 (April 10, 2018) at 12.

discouraging an entity from joining the EIM—will likely reduce the benefits of more efficient dispatch that may be achieved by the EIM.[22]

V. Potential Solutions

The core purpose of automatic bid mitigation measures is to produce outcomes that are consistent with competitive conditions. This is generally regarded as ensuring that sellers with material market power do not increase their offer prices to levels materially above marginal costs. But a logical corollary to that condition is that sellers' offers should only be mitigated when the offer prices do, indeed, reflect an attempt to exercise market power, and not when those offers reflect the seller's estimate of its resource's marginal costs.[23] When there is uncertainty surrounding CAISO's estimates of marginal costs—as is the case for energy-limited resources in the EIM—this task is challenging. It is necessary to determine when the difference between an EIM participant's offer and CAISO's estimate of marginal costs is due to an attempt to exercise market power, which requires mitigation, and when it simply reflects differences in the estimates of marginal costs, which does not require mitigation.

A bid mitigation framework that replaces the submitted offer prices of EIM resources with CAISO's estimates of marginal costs, without accounting for the uncertainty surrounding CAISO's estimate, can be expected to discourage EIM participation, if the resulting DEBs will frequently be lower than an EIM participant's own estimates of its marginal costs. In order to support EIM participation, we suggest that the CAISO consider LMPM alternatives that would reduce the risks to EIM participants that their resources will be dispatched in a manner, and at a price, inconsistent with their own determination of marginal costs.

Some improvements should be pursued regarding the conditions under which bid mitigation applies. As discussed previously, the current structural test for transfers between EIM entity balancing areas examines only whether supply *from the CAISO BAA* can be delivered to the EIM entity area being tested. Thus, as the EIM grows, the structural test may need to take into account whether competitive supply conditions exist between and among entities located outside of the CAISO BAA.

Even if the conditions under which bid mitigation occurs in the EIM are more carefully delineated, however, EIM participants with resources that have significant opportunity costs will continue to be exposed to a risk that mitigated bids will be below their estimates of the resources' marginal costs in a material number of intervals in which mitigation occurs.[24] A straightforward way to reduce this risk is to increase the calculated DEB value for certain types of resources, adding a reasonable bandwidth to account for uncertainty. Such an approach would appear consistent with CAISO's recent steps to ensure suppliers have sufficient bidding flexibility to accurately reflect their costs.[25]

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[22] The adverse consequences are amplified if the resources and entities that are discouraged from participating in the EIM have substantial flexibility, such as energy-limited hydro systems, which provide not just energy, but the ability to follow rapid changes in the need for energy across the EIM footprint.

[23] *See*, *e.g.*, comments of Dr. David Patton of Potomac Economics and external market monitor for MISO, NYISO, and ISO-NE, discussing the conduct and impact test used in those markets, at the October 28, 2014 FERC Technical Conference, Docket No. AD14-14-000, at 158-159. ("I think it's valuable to design mechanisms to limit the mitigation to only those cases where you really believe there's an exercise of market power happening.")

[24] The risk that a DEB will be less than an EIM participant's estimate of its resource's marginal costs could vary depending on the methodology used to calculate the DEB, which, as we suggest, may depend on the time horizon for applicable energy limitations.

[25] This type of approach would also be consistent with the standard principles of statistical inference; namely, when there is a higher degree of uncertainty surrounding a predicted value, a greater difference between an observed value and the prediction is required in order to draw a valid conclusion.

The critical question, then, is how much of a price margin is appropriate for energy-limited resources and, especially, hydro resources with significant storage? This is largely an empirical question, which should be explored with market participants. But it is also a question that can be informed by the approaches and experiences in other organized markets. The use of a defined offer price range would be similar to the "conduct and impact test" used by several other ISO or RTO markets to address market power concerns. Under the conduct-and-impact test, a resource's offer price is only deemed to require mitigation if two conditions are met: (1) the offer price exceeds a defined "conduct threshold"; *and* (2) the joint impact of all resource offers above the conduct threshold is to raise market prices by more than a defined "impact threshold." The first criterion defines a threshold beyond which a market participant's offer price is regarded as being so high as to clearly be misaligned with the resource's marginal cost, after allowing a margin for uncertainty or error in the estimation of those marginal costs. The second criterion tests whether the combined effect of all resources with offers that exceed their respective conduct thresholds produces a significant impact on market prices. If the impact on market prices does not exceed the impact threshold, then no mitigation is applied, even to resource offers that exceed the conduct threshold.

The specific conduct threshold levels adopted in these ISO/RTO markets depends on whether a resource is located in an area where supply is frequently constrained by transmission congestion, or in an area that is generally (though not necessarily always) unconstrained. Resources in generally unconstrained areas are afforded more latitude in their offer prices prior to triggering concerns about the possible exercise of market power, with conduct thresholds of up to $100/MWh or 300% above the resource's reference price, whichever is lower. Additionally, offers below $25/MWh are not subject to mitigation.[26]

Inquiry into these conduct threshold values in other organized markets is a useful starting point for considering ways to reduce the risk of over-mitigating offer prices due to the impact of uncertainty or incomplete information on estimates of marginal costs. For instance, EIM participating resources with significant opportunity costs, such as energy-limited hydro resources, might be eligible to select a mitigation option based on a broad market price index subject to the application of thresholds similar to the conduct thresholds discussed above. The specific approach for energy-limited resources participating in the EIM would not have to use the reference price percentages or $/MWh price points used for the conduct thresholds in other markets; the levels that appropriately balance the risk of over-mitigation while protecting against the exercise of local market power in the EIM may be higher or lower than these conduct thresholds. However, the use of these conduct threshold values that provide a margin for uncertainty in estimating resources' marginal costs—and their success as gauged by the competitiveness of the markets in which they have been applied—provide compelling reasons to explore their use the CAISO LMPM and DEB framework.

VI. Conclusions

Bid mitigation is not without cost. The benefit of bid mitigation stems from preventing the exercise of market power to raise prices. But bid mitigation can also impose a cost—on both individual participants and on the market as a whole—if it leads to inefficient dispatch or discourages participation in the market.[27]

[26] These thresholds are used in ISO New England, NYISO, and MISO, and are described in greater detail in FERC Staff Report, *op. cit.*, Appendix A. Generally unconstrained areas are defined differently in each market. For instance, in MISO, a "narrow constrained area" is an area with transmission constraints that are expected to bind in at least 500 hours of a 12-month period, and in which one or more resources are pivotal in relieving that constraint. (*Id.* at A-8)

[27] An advantage of the conduct and impact approach to market power mitigation is that the market monitor specifically test whether or not offers exceeding the conduct threshold have a material impact on price and, if they do not, mitigation is not triggered.

The expansion of the EIM to include resources with significant opportunity costs, particularly the larger hydro systems of the Northwest, accelerates the need to address deficiencies in the CAISO's existing bid mitigation framework. This is driven by the increased uncertainty surrounding CAISO's estimates of the marginal costs of such resources, which will result in frequent divergence between DEBs based on those estimates and the EIM participant's own assessment of its marginal costs in any given hour. In light of this, we suggest consideration of alternative bid mitigation approaches that expressly recognize the uncertainty of any CAISO estimates of marginal costs. Experience from ISO/RTO organized markets that utilize a conduct-and-impact test suggests that a margin might be applied in situations in which there is uncertainty about whether or not an EIM participant's offer reflects the exercise of market power, as opposed to reflecting the participant's estimate of its marginal costs. The implementation of such an approach in the EIM could significantly reduce the risks that are likely to otherwise discourage participation in the EIM, especially by energy-limited hydro resources.