Comments of Powerex Corp. on
Stepped Constraints Parameters Issue Paper

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Powerex appreciates the opportunity to submit comments on CAISO's May 5, 2016 Stepped Constraint Parameters Issue Paper ("Issue Paper"). Powerex believes that the Issue Paper raises topics of significant interest and importance to all stakeholders throughout the region, including those within balancing authority areas ("BAA") that have elected to participate, or are considering participation, in the Energy Imbalance Market ("EIM"). Efforts to "get the prices right" and to protect reliability by ensuring resource sufficiency in BAAs within the EIM are matters of great importance for California and for entities located within the broader EIM region. These issues will only become more important as additional entities elect to integrate into the EIM footprint.

Powerex addresses the following areas of the Issue Paper:

- Powerex is concerned that the resource sufficiency requirement will be significantly weakened if the current preventative enforcement mechanism is replaced with financial penalties. Financial penalties effectively give EIM Entities an "economic option" to choose to lean on the capacity commitments made by other EIM Entities and CAISO. This is both inequitable and can undermine reliability.
- Powerex believes that well-crafted shortage pricing rules are critical to ensuring just and reasonable prices during periods where there are insufficient resources available to simultaneously meet energy and reserve requirements. Powerex believes that this initiative presents an important opportunity for CAISO to align its shortage pricing rules with industry best practices, eastern markets and Federal Energy Regulatory Commission ("FERC") policy.
- Powerex supports lowering the bid floor from its current level of -$150/MWh to a level of -$1,000/MWh. Adopting symmetrical caps and floors on bid prices supports convergence between real-time prices and day-ahead prices while providing appropriate incentives for accurate scheduling and response to real-time price signals.

Commercially-Motivated Entities Should not Have an "Economic Option" to Lean on Capacity Committed by CAISO and other EIM Entities

As explained in the Issue Paper, within the CAISO BAA there are comprehensive measures to ensure that sufficient capacity is committed prior to the operating hour to ensure, with a high degree of confidence, that load and generation remain balanced. These measures include CAISO's day-ahead Residual Unit Commitment ("RUC") process, its real-time unit commitment,

and its exceptional dispatch authority. CAISO's access to capacity that it can commit prior to real-time is buttressed by the California Public Utility Commission's Resource Adequacy requirements, which ensure that sufficient capacity is secured under forward contracts to meet peak load, with an appropriate margin. This program was recently broadened to require the forward commitment of sufficient flexible resources to meet the most severe single three-hour net load ramp. Together, these measures prevent market participants in the CAISO BAA from causing the CAISO BAA to be resource insufficient.

The Issue Paper recognizes that similar comprehensive measures to ensure resource sufficiency are not present in each of the BAAs that participate in the EIM. While each BA remains responsible for ensuring reliability in its area, each BA also has a mandate to minimize the cost of doing so.

The EIM, by its very nature, permits energy needs in one BAA to be met by dispatching resources in another BAA. This ability is at the core of many of the important economic efficiency benefits the EIM provides. Absent appropriate preventative measures, however, the EIM also provides an opportunity for a BA to significantly reduce the capacity it commits in its own BAA (and to avoid the cost of doing so), and to rely on the ability to access resources in other participating BAAs via the EIM.

The incentive and opportunity for this type of "leaning" were recognized early on in the design of the EIM, and pre-emptive measures were included in the CAISO Tariff to evaluate whether an EIM Entity was, in fact, positioned to "lean" on the other participating BAAs. CAISO performs this evaluation for each BAA participating in the EIM prior to the start of each operating hour. If a BAA does not satisfy the resource sufficiency requirements defined by CAISO, it is effectively "shut out" of the EIM for the hour. This framework has two highly desirable characteristics:

- It ensures that a BA that is *not* resource sufficient is exposed to the reliability consequences of that insufficiency. For example, if load is higher than expected, or Variable Energy Resource ("VER") output is lower than expected, and the BA lacks sufficient committed capacity to balance its system, the reliability consequences will not be avoided simply by importing more energy from other BAAs through the EIM.[1]
- It protects BAs that *are* resource sufficient—and the customers that bear the cost of ensuring their BAA is resource sufficient—from having their capacity commitments depleted through "leaning" by other BAAs that have not made comparable capacity commitments. This leaning would not only be highly inequitable, but it could also pose a reliability risk to resource sufficient BAs who commit resources based on their own needs, not to meet the needs of other BAs.

The current resource sufficiency provisions do not provide an EIM Entity with an option to lean on other EIM participants. Each EIM Entity must either demonstrate that it is not positioned to lean ahead of the hour, or it will be physically prevented from leaning by CAISO. Critically, this

[1] The consequences may include excessive ACE, failure to maintain required contingency reserves, reduced capability to recover from disturbance events and, in the most severe cases, interruption of firm load.

preventative approach ensures that BAs must take steps to either meet the EIM resource sufficiency requirements or carry sufficient capacity resources within the BAA to maintain reliability on a standalone basis, in the event the BAA is "isolated."

During the first year of EIM operations, CAISO has taken steps to enhance this resource sufficiency framework to ensure it sufficiently prevents leaning. For example, CAISO materially increased the quantity of flexible capacity necessary for EIM Entities to pass the resource sufficiency evaluation. CAISO also developed and implemented a more formal tool for determining the required flexible capacity in each hour, and greatly increased transparency by posting these requirements on its OASIS. Consequently, it appears the current EIM resource sufficiency framework is now generally working well and ensuring that all EIM Entities are, indeed, resource sufficient.

Importantly, the Issue Paper does not propose to relax the resource sufficiency requirements, nor does it suggest that CAISO now views leaning on the EIM for capacity as acceptable or appropriate. The Issue Paper does propose, however, to change the mechanism through which the resource sufficiency requirement is enforced. Specifically, the Issue Paper proposes to eliminate the current framework in which an EIM Entity that fails the resource sufficiency tests is "isolated" from the rest of the EIM area, and replace it with a financial penalty. CAISO seeks stakeholder input regarding the appropriate levels of the penalty, recognizing that it "needs to be sufficiently large as to provide proper incentives for the EIM entity or the ISO to ensure adequate bid range from participating resources."[2]

Powerex respectfully disagrees that financial penalties will be successful in ensuring that EIM Entities are resource sufficient. BAs must often make very large forward investments to ensure sufficient resources are available to meet system needs even under very low-probability, high-stress conditions. Capacity investments to cover peak demand, *plus* a typical planning reserve margin, will by definition be needed in very few hours of the year, if any. The financial penalty that applies to those very few hours would need to be implausibly high for a BA to rationally choose to invest in sufficient forward capacity to meet these rare events, rather than simply incur the penalty.

Consider, for instance, an EIM Entity that estimates that, with its existing portfolio of resources and contracts, it will be resource sufficient in all but 10 hours of the year. It could procure additional capacity at, say, $60/kW-year, or it could simply pay the proposed penalty in those 10 hours. It would require a penalty of more than $6,000 per MW of insufficiency in each of the 10 hours for the EIM Entity to have the financial incentive to be resource sufficient. If the financial penalty is less than $6,000 per MW of shortfall, then the EIM Entity can reduce its costs by simply choosing to pay the penalty during the critical 10 hours of the year, instead of procuring additional forward capacity. The Issue Paper, however, contemplates a penalty "at a *percentage* of the system marginal energy cost," suggesting a penalty far below the level necessary to encourage the high levels of resource sufficiency necessary to maintain reliability in all hours of the year.

[2] Issue paper at 10.

Powerex believes that replacing the current preventative enforcement framework with one of modest financial penalties is highly likely to result in a material increase in resource sufficiency failures. As part of a commercially-motivated organization, EIM Entities can be expected to rationally respond to financial incentives and exercise the new "economic option," choosing to pay the penalty and lean on the capacity commitments made by other BAs any time that doing so is less expensive than taking the necessary steps to actually be resource sufficient. A financial penalty structure would transform the current mechanism that *prevents* leaning into one in which EIM Entities are permitted to lean, at a price. It would be unrealistic to create such an option without expecting that at least some EIM Entities would seek to make use of it.

Powerex recognizes that, for some BAs, the decision to "go short" sufficient flexible capacity on a yearly, monthly and/or day-ahead basis and instead rely on the EIM for capacity may not be a viable option, due to their specific regulatory or compliance requirements or other unique circumstances. However, based on Powerex's extensive experience in western bilateral energy markets, it simply is not credible to suggest that every BA in the Western Interconnection will consistently procure sufficient forward capacity to avoid being capacity deficit in real-time, if afforded both the opportunity and economic incentives to avoid the cost of doing so. This is perhaps best evidenced by the fact that the merchant affiliates of certain BAs are well known to be frequent purchasers of energy in the day-ahead and real-time markets precisely on those days and hours of highest demand and greatest scarcity.

Importantly, the factors that lead to tight system conditions in one BA can often affect other BAs in the region, such as heat waves or cold snaps. Therefore, it is likely that the hours in which some EIM Entities would be short capacity—and hence will "lean" on the EIM—are precisely the times that other BAAs have little or no surplus capacity to be leaned upon. Under such conditions, reliability could potentially be jeopardized across the CAISO/EIM area. But even when reliability is not directly compromised, this would be only because the costs incurred by California investor-owned utilities and their customers to have sufficient capacity available even under tight conditions was made available to EIM BAAs that did not make similarly prudent investments. Simply put, BAs *with* robust resource sufficiency frameworks and practices will end up sharing that capacity with BAs that do not, and without appropriate compensation.

The Issue Paper explains that it seeks to replace the "isolation" mechanism because this approach impacts prices in the isolated BAA and it prevents efficiency benefits of EIM transfers to be realized in that hour. But the current enforcement framework has been successful in ensuring that EIM Entities are resource sufficient in a very high percentage of hours, meaning that the economic consequences of "isolation" are experienced only rarely, and the economic cost of those consequences is likely very limited. Powerex urges the CAISO to share its analysis of the economic consequences of "isolation" to date in the EIM, so that stakeholders can better understand precisely what problem the Issue Paper is attempting to solve. If the "isolation" framework has resulted in—or is expected to result in—an inability to realize a material amount of EIM economic benefits, Powerex suggests that CAISO perhaps explore with stakeholders alternative ***preventative*** enforcement designs, rather than relying on financial incentives alone.

In short, Powerex believes that financial penalties will be a far less effective in ensuring EIM Entities are resource sufficient than the current enforcement mechanism, particularly in the critical hours of region-wide scarcity when the cost of being resource sufficient is greatest. This, in turn, would create a significant risk of increased capacity leaning and reduced reliability. Moreover, the economic consequences of the current enforcement mechanism arise only in the infrequent instances in which an EIM Entity is not resource sufficient. Powerex believes the best way to avoid these limited economic consequences is simply to ensure that EIM Entities continue to satisfy the resource sufficiency evaluation, rather than weakening the consequences when EIM Entities fail it.

Powerex does believe, however, that CAISO can take steps to reduce the cost to EIM Entities of satisfying the resource sufficiency requirements. It is entirely possible that the most economic resources capable of satisfying an EIM Entity's resource sufficiency requirement are not physically located within that BAA at all. CAISO could explore a transfer mechanism to allow a resource located in one EIM Entity to be used, upon mutual bilateral agreement, to satisfy the resource sufficiency requirements of a different EIM Entity, subject to deliverability limitations.

Ensuring Accurate "Shortage Pricing"

The Issue Paper explains that, when the EIM was initially implemented, CAISO observed instances in which there were insufficient resource bids available to meet the load forecast. This, in turn, triggered application of the $1,000/MWh power balance constraint relaxation parameter or "penalty price." The Issue Paper discusses approaches taken in other ISOs and RTO to prevent small transient shortage conditions from triggering extreme prices.[3]

The issue that these mechanisms are designed to address can be illustrated using a stylized example, consisting of a total of 1,000 MW of offers ranging from $20/MWh to $30/MWh. If the market is run with a load forecast of 999 MW, the clearing price will be $30/MWh. But if the load forecast is 1,001 MW (just 0.2% higher), the market will be unable to balance supply and demand; the "power balance constraint" will not be satisfied, and the market price will be based on whatever administratively-established value the market software has been programmed to use in such conditions. In the case of the CAISO, that value is currently $1,000/MWh.[4]

As the Issue Paper points out, there is little rationale for allowing such a small change in load forecast to cause an extraordinary jump in market clearing prices. Exhausting the last MW of resources available to the market software does not necessarily mean that the grid (and its consumers) will actually experience a critical reliability emergency. This is because all BAs maintain reserves that are available to meet the system needs, in addition to the energy offered into the organized market.[5] "Dipping into" these reserves has an economic cost, both in terms

[3] Issue Paper at 7-8.

[4] Issue Paper at 8, fn. 2.

[5] The most granular of CAISO's real-time markets, its Real-Time Dispatch ("RTD"), operates in 5-minute intervals and is run 7.5 minutes prior to the start of each interval ("T-7.5"). The RTD is run with a forecast of average conditions during the relevant 5-minute interval. Therefore, any changes to actual

of the direct costs of the reserves being deployed for energy, but also in terms of reducing the reserve capacity available to the BA to maintain reliable operations. This economic cost can be relatively low for small quantities, but increase substantially as reserves are further depleted.

At the heart of the Issue Paper's proposal, then, is determining the appropriate price for energy when meeting forecast load requires or implies reducing the amount of reserve capacity below target levels needed for reliability. This question is part of the broader issue of "shortage pricing" in organized markets. Powerex welcomes CAISO initiating this discussion with stakeholders, as the prices established during such conditions have drawn considerable attention over the past 18 months, especially in the EIM. If the prices established when the market software perceives a lack of sufficient resources are set arbitrarily high, the result can be price spikes that distort the average price of energy, harm consumers, and create controversy. At the other extreme, if energy prices do not reflect shortage conditions at all, price volatility will be artificially suppressed and the market will fail to provide a price signal regarding the need for additional resources, accurate scheduling, or both. Neither outcome is desirable.

As explained more fully below, Powerex believes that all stakeholders—as well as market efficiency—are best served by a market design that reflects the full economic cost of meeting forecast load. If balancing generation and forecast load requires or implies reducing the levels of reserves carried by a BA below the target levels necessary to ensure reliability, this needs to be reflected as an additional cost of energy. This additional cost or "penalty price" should be proportional to the size of the shortage, and it should be applied to both under-supply shortages as well as over-supply shortages.

Shortage Pricing is a Recognized Necessary Feature of Well-Functioning Organized Markets

It is a basic principle of locational marginal pricing and sound market design that prices should reflect the value of meeting the next increment of demand at a particular location given system constraints. During periods where there is sufficient supply to meet energy and reserve requirements, competitive pressures should drive prices toward the variable operating costs of the marginal generation unit. In contrast, during periods when the market operator is required to reduce reserve requirements to meet real-time energy needs, prices should increase above the variable cost of the highest cost unit to reflect the increased reliability risks during such periods. As FERC staff has observed,

> when the amount of physically available supply of capacity is less than that needed (at the price desired) to meet energy demand and operating reserve requirements, additional energy demand can be met only by reducing the amount of operating reserves. The marginal cost of energy then includes the opportunity cost associated with reducing operating

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conditions—such as load or Variable Energy Resource ("VER") output—that occur after T-7.5 will need to be balanced by deploying other resources. And even if the load forecast is correct in terms of the *average* load during the entire 5-minute interval, the BA will still need to deploy resources to balance moment-to-moment variations within the interval. These additional balancing reserves include regulation and load-following capacity, as well as capacity carried to cover defined disturbance events, such as contingency reserve and primary frequency responsive capacity.

> reserves. Ideally, during shortages, the price of operating reserves would reflect this opportunity cost, and the price of energy would reflect this opportunity cost in addition to the marginal out-of-pocket cost of producing energy.[6]

Well-designed shortage pricing mechanisms play a critical role in ensuring that tight supply conditions are reflected in market clearing prices and creating efficient short-term and long-term price signals. In particular, applying shortage pricing sends a "short-term price signal to incent performance of existing resources and help to maintain reliability."[7] By ensuring that, during periods of scarcity, energy prices increase above the variable cost of the marginal resource, shortage pricing encourages resources to show up where and when they are most needed.

Markets that have adopted more comprehensive shortage pricing also tie the penalty price to the magnitude of the shortage. As summarized by Dr. Scott Harvey:

> [S]hortage pricing needs to be rationally related to the degree of shortage.
>
> - The shortage component of energy prices ***should not be zero*** when the ISO is having difficulty balancing load and generation and needs additional resources.
> - The shortage component of energy prices ***should not be $1000*** just because ***some*** capacity providing regulation is used to meet load during the interval because of ramp constraints.[8]

The additional revenues received through shortage pricing that increases energy prices above the variable operating cost of the last unit dispatched can improve investment signals, both for maintaining existing resources and for developing additional resources necessary to meet system needs. As FERC staff has recognized, one of the primary goals of "shortage pricing is to facilitate long-term economic entry through the construction of new supply resources and exit of resources that are no longer economic."[9] The revenues associated with shortage pricing, in turn, reduce the costs that need to be recovered under resource adequacy capacity contracts. Importantly, unlike resource adequacy capacity contracts, the revenues associated with shortage pricing are:

1. targeted toward those specific resources that deliver power on the grid when and where it is needed most; and

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[6] *Price Formation in Organized Wholesale Electricity Markets*, Staff Analysis of Shortage Pricing in RTO and ISO Markets, Docket No. AD14-14-000 at 5 (Oct. 2014), *available at* http://www.ferc.gov/legal/staff-reports/2014/AD14-14-pricing-rto-iso-markets.pdf.

[7] *Id.* at 4.

[8] Presentation of Dr. Scott Harvey at the April 17, 2015 Market Surveillance Commitment meeting, at 21. (Emphasis added) Available at: http://www.caiso.com/Documents/Discussion_EnergyImbalanceMarketPotentialPricingSolutions-MSC_Presentation-April2015.pdf

[9] *Id.*

2. funded specifically by those load and generation customers whose imbalances contribute to real-time shortage conditions.[10]

The specific circumstances of the CAISO, and in particular of the EIM, make well-designed shortage pricing important for yet another critical reason: to encourage voluntary resource participation in these CAISO-operated markets. Resources located outside the CAISO BAA have opportunities to sell their output without participating in the CAISO markets. Even resources located in BAAs that have elected to join the EIM are not required to be "participating resources." These external resources can only be expected to voluntarily participate in the CAISO real-time market and EIM if they provide additional opportunities beyond those already available. Efficient stepped shortage pricing compensates resources able to respond to real-time conditions, and can be a powerful incentive for flexible resources to participate. But if real-time price volatility is suppressed and prices rarely rise materially above day-ahead market prices even in the face of operational challenges, then a resource owner may rationally conclude that there is no reason to participate in the CAISO real-time markets rather than transacting all of their output in the forward and/or day-ahead markets.

Shortage pricing also provides appropriate incentives for accurate scheduling by both generation customers and by load customers. If real-time prices largely just track day-ahead prices, with minimal volatility, then customers will effectively have a free option whether to fully schedule their expected output and load on a day-ahead basis or to defer some of these transactions until the real-time market. For instance, a load customer that regularly under-schedules its load increases the need for real-time resources to be dispatched, potentially driving the system into shortage conditions. But if real-time energy prices do not reflect this shortage, the customer will have no financial incentive to make its schedules more accurate to reduce its persistent negative imbalances.

A real-time market with appropriate shortage pricing provides strong incentives to schedule accurately. This is <u>not</u> because shortage pricing makes the real-time price higher or lower than the day-ahead price *on average*, but because shortage pricing effectively penalizes customers that systemically have negative imbalances (*i.e.,* real-time purchases) in the same intervals that supply is tight on the system as a whole. Similarly, shortage pricing effectively penalizes customers that systemically have large positive imbalances (*i.e.,* dispose of energy in real-time) in the same intervals that the system as whole is experiencing oversupply conditions. Efficient shortage pricing therefore encourages customers to schedule based on an objective forecast of generation and/or load, as this both reduces the size of the imbalance and also ensures any residual imbalances are random. Customers that strive to schedule accurately can expect to be largely unaffected by the price volatility associated with shortage pricing, as they will tend to settle both their positive and negative imbalances at the average price, with their exposure to upward and downward price volatility effectively canceling out over time.

[10] The benefits of shortage pricing with regard to ensuring resource adequacy have been explored by Professor William H. Hogan. *See, e.g., Electricity Scarcity Pricing and Resource Adequacy*, available at https://www.hks.harvard.edu/fs/whogan/Hogan_HEPG_022714.pdf ("…better scarcity pricing would make the capacity market less important and thereby mitigate some of the unintended consequences." *Id.* at 12).

Efficient Shortage Pricing Must Apply to Under- and Over-Supply Conditions, and not be Distorted by Asymmetrical Market Rules

For shortage pricing to encourage objective scheduling of resources and loads, it must apply to both under-supply conditions and over-supply conditions. Additionally, rules or practices that skew the prices during shortage conditions, or distort whether or not shortage conditions are recognized, should be reviewed and changed if necessary.

An important improvement to ensuring symmetric shortage pricing would be to lower the current bid floor. Since the current bid floor is -$150/MWh, whereas the bid cap is $1,000/MWh, energy prices during a shortage would have a far greater ability to spike upward than to spike downward. Consequently, customers face greater financial risk from negative imbalances—which potentially expose it to buying at $1,000/MWh—than from positive imbalances, which potentially expose it to selling at -$150/MWh. The asymmetrical price outcomes will tend to encourage customers to overschedule loads and underschedule resources, rather than to schedule based on an objective forecast of their output or load. The asymmetrical prices may also pose a structural impediment to convergence between real-time and day-ahead prices. Powerex therefore supports lowering the bid floor, and associated over-supply penalty price, to -$1,000/MWh, mirroring the existing bid cap and under-supply penalty price.

A further aspect of the CAISO market design that affects the application of shortage prices is the load bias limiter. In both the CAISO BAA and in the EIM, the CAISO is able to manually adjust the load forecast used in executing the real-time market; a practice it refers to as a "load bias." To the extent such manual adjustments result in a more accurate market dispatch solution than without the adjustment, load biasing appears both appropriate and beneficial. In certain instances, CAISO will limit or over-ride the manual load forecast adjustment that can be entered by its operators, however. This is referred to as the "load bias limiter." Powerex understands the appropriate purpose of a load bias limiter is to detect and override a manual load bias that was entered in error (*e.g.,* an operator entering "1,000 MW" rather than "100 MW" of load bias). This ensures that an erroneous manual load bias does not distort the dispatch solution and associated prices.

However, we understand that the load bias limiter currently implemented by the CAISO does not achieve the objectives of either detecting an erroneous manual load bias or correcting the dispatch solution and price. In fact, the currently implemented load bias limiter is an automated tool that simply restricts a load bias from exceeding the available resources offered in the market, *even if the forecast adjustment was entirely accurate.* The reverse is not true, however: the load bias limiter does not prevent a manual load forecast adjustment from eliminating shortage conditions. The net result is that the load bias limiter does not identify or correct for errors in the load bias, but rather it simply reduces the frequency with which the CAISO market software applies shortage pricing, compared to the frequency of shortages that would be recognized if the market was run strictly using the most accurate load forecast available.

Concerns over the use of the current load bias limiter function were previously raised at FERC in the context of the Available Balancing Capacity ("ABC") mechanism in the EIM. In response,

CAISO committed to revisiting the load bias limiter in a future stakeholder process.[11] Given that the Issue Paper deals specifically with shortage pricing in the CAISO markets, and that the current load bias limiter appears to play an important role in whether or not shortage pricing is applied, Powerex suggests that this stakeholder process is the appropriate forum in which to revisit the design and use of the load bias limiter.

Implementing Efficient Shortage Pricing in CAISO Markets

Powerex urges CAISO to take steps to more fully implement efficient shortage pricing in its markets. Doing so would align the CAISO market design with best practices in other organized markets and with FERC policy. Perhaps even more importantly, efficient shortage pricing—whereby energy prices *gradually* rise above the variable production cost of the marginal unit during periods of scarcity—can encourage greater participation by flexible resources, and help reduce the risk of more severe shortages and associated price spikes. This point bears emphasizing: advocating for efficient shortage pricing should not be misconstrued as advocating for sudden, extreme and arbitrary price spikes. Rather, efficient shortage pricing will provide more frequent but generally more moderate price signals that better reflect the challenges of balancing load and generation in real-time.

Powerex believes the following broad measures can be used to implement efficient shortage pricing within the CAISO BAA:

1. To the extent CAISO does not already do so, permit the market optimization to deploy regulating up and down reserves to meet forecast energy needs. The manner in which this is implemented should be consistent across both the 15- and 5-minute markets to avoid creating structural impediments to price convergence.
2. Apply graduated penalty prices when these reserves are deployed for energy needs, where the stepped prices reflect the increasing risk to reliability as more reserves are depleted. The designs adopted in eastern markets appear to be a good starting point.
3. Apply penalty prices for reserve shortages as adders to the variable cost of energy of the marginal resource. For instance, if a resource with a $40/MWh variable energy cost is deployed for energy instead of being used to carry regulation up reserves, and total regulation reserve falls below target procurement levels such that a $50/MWh penalty price is applied, the energy price would be $90/MWh. This reflects the fact that meeting an additional megawatt of forecast load entails not only producing additional energy from the lowest cost resource, but also preventing the demand for regulation reserve to be

[11] *See, e.g., Cal. Indep. Sys. Operator Corp.*, Answer Of The California Independent System Operator Corporation To Comments, Docket No. ER15-861-006 at 20-21 (Nov. 24, 2015) ("As the CAISO has explained in its monthly reports to the Commission, the CAISO is currently exploring enhancements to the load bias limiter to address the potential for the limiter, as currently configured, to be under-applied (in cases of sudden changes in load bias) or triggered unnecessarily (in intervals where a persistent bias is unintentionally applied). The CAISO will soon commence a stakeholder effort to consider these enhancements, and will determine, as part of that effort, the appropriate means of documenting the application of the load-bias limiter (e.g. through business practice manual and/or tariff revisions)." (Internal footnote omitted))

fully met. The example in the Issue Paper—in which the regulation reserve penalty price was taken as the entire cost of deploying those reserves for energy, rather than being additive—does not accurately apply this principle.

4. When regulation reserves cannot be further depleted to meet 15-minute or 5-minute energy needs, it is appropriate to apply a high penalty price equal to the energy bid cap, reflecting the price at which additional forecast load can no longer be met.
5. Structure penalty prices for over-supply shortages symmetrically to those for under-supply shortages. That is, the CAISO real-time optimization may deploy regulation-down reserves to balance generation and forecast load, applying graduated penalty prices if this causes regulation-down reserves to fall below required levels. These penalty prices should escalate up to the value of the bid floor, which should be changed to -$1,000/MWh to provide for symmetric treatment with under-supply shortage pricing.
6. Re-design the load bias limiter to ensure that it achieves its intended purpose of detecting and correcting erroneously-entered manual load adjustments. This will ensure that the limiter will have no systemic effect whatsoever on either the frequency or the magnitude of shortage pricing. The accuracy of manual load forecast adjustments depends only on the system conditions it is attempting to forecast. Whether or not the adjusted load forecast triggers shortage pricing is irrelevant to assessing the accuracy of the adjustment.

The steps necessary to implement efficient shortage pricing in the EIM Entity BAAs will differ, as the market software does not co-optimize energy and ancillary services, and the EIM dispatch also includes the recently introduced ABC mechanism. Nevertheless, the objective in the EIM should be the same as for the CAISO BAAs: ensure that energy prices gradually rise above the variable operating cost of the marginal resource when meeting forecast load requires reducing regulation or other reserves below the target levels for reliable operation.

In the EIM BAAs, Powerex believes that efficient shortage pricing can be implemented by taking the following steps:

1. For each EIM Entity, identify the critical quantity of ABC that represents the desired level of regulation or load-following reserves needed for reliable operation within each market interval. This is necessary in order to distinguish between ABC that can be deployed for energy without impacting reliability, as opposed to ABC that represents the required regulation reserve.
2. Deployment of ABC for energy does not necessarily require a penalty price, so long as the ABC remains above the critical quantity of regulation or load-following service identified above.
3. Deployment of ABC ***does*** require applying stepped penalty prices if the ABC is depleted below the critical quantity. In this manner, each EIM Entity BAA will effectively have its own demand curve for ABC, analogous to CAISO's regulation reserve demand curves that drive shortage pricing within the CAISO BAA, as discussed above.

4. If ABC is fully depleted to meet energy dispatch, apply penalty prices equal to the energy bid cap of $1,000/MWh.
5. Apply symmetrical shortage pricing for over-supply shortages. To the extent downward regulation or load-following reserves are not currently designated as ABC, an analogous framework for giving CAISO visibility into these resources may need to be developed. When downward reserves are fully depleted to meet energy dispatch, apply a penalty price equal to the bid floor, which should be lowered to -$1,000/MWh to mirror the bid cap.
6. Re-design the load bias limiter, as described above for the CAISO BAA.

Powerex believes that the foregoing steps will allow CAISO to adopt industry best practices and FERC principles of price formation. Powerex encourages CAISO to continue to work with stakeholders to more fully define the specifics of each of the above steps.

Summary of Shortage Pricing Comments

Powerex strongly supports measures to apply efficient shortage pricing in the CAISO markets, including the EIM. Parameter prices that increase in stepwise fashion with the magnitude of the shortage, that apply to both over- and under-supply conditions, and that are triggered in an objective and symmetric manner can accurately reflect system conditions experienced in real-time. Efficient shortage pricing can provide targeted additional compensation to those flexible resources that increase and decrease their production on the grid when and where it is needed most. This can reduce total costs to consumers by reducing the additional compensation necessary through the forward Flexible Resource Adequacy program, which both a less efficient means of compensating flexible capacity resources, and allocates the costs broadly across all loads without regard to their real-time imbalances.

While taking steps to suppress real-time price volatility and avoid meaningful shortage pricing may be superficially appealing, this will not lead to sustainable, competitive and robust market outcomes. Suppressing price volatility or shortage pricing will fail to encourage voluntary participation in the CAISO markets and will undermine investment incentives in flexible resources, both of which are necessary for the CAISO to balance generation and load in real time, especially given the increasing amount of VER participation.

Rather than attempting to suppress real-time price volatility, Powerex urges CAISO to improve real-time price formation by applying best practices of market design, including shortage pricing. By implementing efficient shortage pricing, CAISO and EIM prices will experience more frequent but gradual and stepped increases in energy prices above the variable cost of the marginal unit during periods of under-supply shortages, and will experience more frequent but gradual and stepped decreases below the variable cost of the marginal unit during periods of over-supply shortages. Rather than abruptly and disruptively transitioning from energy prices equal to the variable cost of the marginal resource to an extreme price spike, efficient shortage pricing provides for a more gradual price signal that more accurately reflects tightening system conditions.

Efficient shortage pricing will send appropriate price signals that:

1) Reflect the extent of the reliability risk;
2) Encourage accurate and objective load and resource scheduling behavior;
3) Encourage participating resources to perform according to scheduled and dispatched quantities;
4) Encourage additional flexible resources to voluntarily participate in the CAISO markets and EIM; and
5) Encourage additional investment in flexible resources.

Powerex believes that implementing efficient shortage pricing in the CAISO markets and EIM can help lead to more robust and competitive real-time market outcomes. It is through such increased real-time market participation that customers will ultimately be best protected from price spikes and the risk of shortages. Powerex therefore encourages CAISO to continue to work with stakeholders toward this objective.