Comments of Powerex Corp. on the August 2, 2017 Stakeholder Working Group on Flexible Resource Adequacy Criteria and Must Offer Obligation – Phase 2

Submitted by	Company	Date Submitted
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Powerex appreciates the opportunity to comment on CAISO's August 2, 2017 Stakeholder Working Group discussion regarding Flexible Resource Adequacy and Must Offer Obligation – Phase 2 ("FRACMOO2"). Powerex supports CAISO's decision to reframe this initiative with the core objective of defining forward flexible capacity requirements in a manner that is aligned with the specific operational needs of the market operator. Powerex believes that a comprehensive examination of the flexible capacity needs of the CAISO grid is necessary both to address the current operational challenges faced by CAISO operators, as well as to lay the foundation for making the cost-effective resource investments necessary to achieve California's environmental policy objectives in the future. Neither of these objectives appear likely to be achieved by the limited enhancements considered in earlier stages of this initiative. For that reason, Powerex supports a "reset" in the direction of this initiative.

As explained more fully in these comments, Powerex believes that the CAISO markets need to develop additional tools to (1) reduce the magnitude and steepness of net load ramps when they would otherwise exceed available flexible capacity in real-time; and (2) enable CAISO to procure additional flexible capacity from existing resources, and thus expand the grid's ability to accommodate such ramps without having to limit supply schedules.

Powerex believes that a vital first step in this initiative is to examine more closely why CAISO's real-time flexible capacity needs are growing in the first place. The Working Group presentation showed instances of poor balancing authority area ("BAA") control performance; that is, instances in which the CAISO was unable to consistently operate its grid in real-time at the desired levels of performance to prevent leaning on the grid. Notably, CAISO has experienced these issues despite the fact that the CAISO grid very likely *has access to sufficient resources* to meet peak load and to follow the variations in that load. In other words, the CAISO grid has sufficient energy, capacity and flexibility to reliably serve load; it does not have a current need for additional installed flexible capacity resources for *reliability purposes*.

What CAISO currently lacks from time to time is sufficient flexible capacity to *also* balance other sources of variations in supply or demand, particularly the changes in output from variable energy resources ("VERs"). Balancing changes in VER output is not fundamentally a *reliability* challenge, however; it is an *economic and/or environmental* challenge. That is, consistently integrating the output of VERs is not

necessary to keep the lights on, but it is highly desirable in order to maximize the economic and environmental benefits from using VER output to displace other energy resources that are more expensive, emit greenhouse gases ("GHGs") or both.

The ability of the CAISO grid to accept VER output each and every hour of each and every day is not only limited by its ability to reduce other generation resources, but is also limited by the amount of flexible capacity available in real-time to balance the greater variability and uncertainty associated with VER output. Unfortunately, the CAISO market design currently lacks the tools necessary to:

(i) limit the output from variable energy resources, as needed, to the extent they increase the need for flexible capacity beyond what is available; and

(ii) procure, and set aside, stand-by flexible capacity ahead of real-time operations to balance variable energy resource output.

In Powerex's view, it is the CAISO market's current inability to limit the output of variable energy resources when necessary that transforms what is fundamentally an economic and/or environmental challenge into a real-time reliability challenge. In other words, it is the unfettered acceptance of variable energy resource output in the first place, without considering whether there is sufficient flexible capacity available in real-time to integrate that output, that creates the reliability challenge.

Powerex thus believes that it is imperative for CAISO to develop a market enhancement to ensure that the Day-Ahead and Real-Time Markets do not accept supply schedules that create real-time flexible capacity needs that cannot be met (either in the concurrent hour, or in a future hour when the supply goes away). This enhancement will prevent the economic and/or environmental challenge of integrating renewable resources from becoming a reliability challenge in real-time operations. A second enhancement to provide the CAISO with the ability to efficiently acquire, and set aside, flexible capacity in the day-ahead timeframe will help ensure that CAISO consistently has sufficient flexible capacity in real-time to both maintain reliability and balance VER output without the need to curtail output, to the maximum extent possible. Powerex believes that implementation of *both* of these enhancements will likely result in only very limited additional renewable curtailments given today's mix of resources.

In the coming years, however, as more VERs are added and existing flexible capacity is retired, the CAISO grid is likely to become increasingly limited in its ability to accept renewable resource output schedules unless the amount of ***installed*** flexible capacity is expanded. Thus, there is also a need to develop a forward flexible capacity procurement framework to provide timely and accurate incentives to make future flexible capacity investments in order to (1) support continued growth in California renewable and zero-GHG resources, as well as to (2) replace existing flexible capacity resources facing retirement due to economic reasons, including once-through cooling restrictions, or as a result of California's evolving environmental objectives. An efficient forward-procurement framework can help ensure that California environmental policy goals are

achieved through the least-cost combination of (environmentally acceptable) investments, and hence at the lowest total cost to California ratepayers. Forward capacity requirements for renewable integration purposes need to be clearly distinguished from forward capacity requirements to maintain reliability, however. The latter is appropriately defined as sufficient capacity to meet peak load and to follow changes in load; whereas the former is appropriately defined as flexibility to support the economic integration of renewable resources.

I. Renewable Integration is not a Reliability Challenge

At the August 2, 2017 Working Group, CAISO presented important information regarding operational challenges it has experienced in balancing supply and load. In particular, CAISO explained that "Controlling CPS1 scores has been a recurring operational challenge," and that "[a]t certain times, ISO has persistent challenges balancing real-time supply and demand."[1] The implied conclusion—going back to the initial development of the Flexible RA program—appears to be that additional flexible capacity is needed to improve operational performance to acceptable levels.

Powerex believes that the need for flexible capacity should be more clearly differentiated between what is needed to maintain reliability and what is needed to achieve other policy objectives. Capacity is clearly needed to meet load in each hour, and this capacity must be sufficiently flexible to follow changes in load from one hour to the next. Failure to have at least this level of flexible capacity could jeopardize service to firm load customers and would present a clear reliability issue. But flexible capacity is also currently used to balance other changes in demand and supply, most importantly changes in the output from VERs. If there is insufficient flexible capacity to balance VER output, the result should not be an interruption to firm load customers, but a reduction to the amount of VER production that can be accommodated during the relevant hours of the day in the first place. In other words, having sufficient flexible capacity to meet firm load is fundamentally a reliability challenge—without it, the lights do not stay on—but having sufficient flexible capacity to balance changes in VER output is not. Instead, having sufficient flexible capacity to balance VER output is an economic and environmental challenge associated with maximizing the use of VER output to displace other energy resources that are more expensive, emit GHGs, or both.

CAISO's Working Group presentation highlighted the role of variation and uncertainty of VER output in driving the need for flexible capacity. For instance, on March 6, 2017 (a weekday), CAISO reports that the morning ramp between 7:00 a.m. and 10:00 a.m. was 6,724 MW, but only 1,023 MW—or 15% of the total ramp—was associated with

[1] CAISO August 2, 2017 presentation at 17-18, *available at:* http://www.caiso.com/Documents/Agenda_Presentation_FlexibleResourceAdequacyCriteria_MustOfferObligations.pdf

changes in load.[2] The evening ramp on that day totaled 11,049 MW, of which less than half (4,801 MW) was due to increases in load.

Unfortunately, discussions of CAISO's flexible capacity needs generally fail to distinguish between the distinct drivers of the need for flexible capacity—that is, between changes in load that must be balanced to maintain reliability and changes in VER output that must be balanced to maximize the economic benefit of accepting the output of those resources on any given day. Instead, the assessment of flexible capacity needs typically begins with a calculation of "net load," which is the combination of load and VER output. The concept of "net load" is problematic because it creates a false parity between the reliability ***need*** to serve load and the economic and environmental ***goal*** of balancing VER output. "Net load" effectively treats both load service and VER balancing as necessary to maintain reliability, when this is not the case.

As discussed more fully in the remaining sections, Powerex believes that clearly distinguishing between flexible capacity needed for reliability and flexible capacity needed to achieve California's environmental policy objectives will allow CAISO to develop necessary enhancements to its market optimizations as well as support the development of appropriate forward contracting programs specific to each of these distinct objectives.

II. Ensuring CAISO's Market Optimizations Produce Feasible Solutions from a Flexible Capacity Perspective

The information presented by CAISO at the Working Group highlights a critical issue: despite all of the CAISO market optimizations enforcing ramping and security constraints, the CAISO nevertheless experiences instances in which it appears to run out of flexible capacity. This strongly suggests that the recognition of the need for flexible capacity in the market optimization is not as robust as it needs to be. As discussed more fully below, Powerex recommends that CAISO examine specific enhancements to its Day-Ahead and Real-Time Markets in order to (1) recognize the flexible capacity needs associated with accepting different types of self-schedules or economic offers; and (2) enable CAISO to procure flexible capacity on a day-ahead basis.

A. CAISO Market Software Needs to Recognize the Flexible Capacity Needs Associated with Different Types of Supply Schedules

The instances of poor BAA control performance discussed at the Working Group do not appear, fundamentally, to be the result of a reliability challenge. That is, Powerex believes there is likely sufficient capacity and flexibility available to reliably meet load in

[2] *Id.* at 19-21.

the CAISO BAA at all times, and to balance the variations in that load. The instances of poor BAA control performance are instead indicative of a different problem: the production by VERs in amounts that, at times, exceed the CAISO's ability to balance the variation and uncertainty associated with those levels of production. Powerex believes it is highly inappropriate for VER production levels to lead to poor performance in reliability metrics when reliability can be fully maintained, without leaning on the grid, by reducing the amount of VER output that the CAISO accepts during times of limited flexible capacity.

For instance, it appears likely that the poor CPS1 performance during HE 7-8 on March 6, 2017 could have been avoided by limiting the upward ramp of solar generation during those hours, rather than apparently allowing it to outrun the downward ramping capability of other resources. Similarly, it appears likely that the poor CPS1 performance during the midday hours on March 26, 2017 could have been avoided by reducing the total amount of solar or wind output that was produced at that time, instead of permitting it to exceed the ability of the CAISO grid to absorb that output and creating inadvertent interchange into the rest of the WECC. Finally, challenges in meeting upward "net load" ramps in the evening peak can be addressed by limiting VER output in the hours prior to the ramp, as necessary. In all cases, timely action to limit VER output to levels that could be balanced by available flexible capacity would have reduced or eliminated the control performance problems that occurred. In effect, the lack of such actions transformed the economic challenge of renewable resource integration into a potential reliability challenge.

In Powerex's view, improved BAA control performance does not require the addition of new flexible generating resources at this time, as existing resources appear sufficient to serve load (from an energy, capacity and flexibility perspective). Rather, improved BAA control performance requires more accurate recognition of the limitations of available flexible capacity, and tools to make sure those limitations are not exceeded. In other contexts, CAISO has recognized this concept, and already has tools in place to limit schedules based on available system capabilities. For instance, CAISO will refuse to award export schedules—or may curtail previously awarded export schedules—if there is insufficient committed capacity to support those schedules *and* to also meet forecast load with a high degree of certainty. Similarly, CAISO may refuse to accept import schedules—or may curtail existing import schedules—if accepting the schedule poses operational challenges. It seems equally prudent for CAISO to develop the tools and procedures necessary to evaluate the flexible capacity needs associated with different types of supply self-schedules or economic offers, and to limit acceptance of supply schedules to those that are consistent with the quantity of flexible capacity available.

Powerex acknowledges that CAISO's Day-Ahead and Real-Time Markets currently recognize the need for flexible capacity to some degree, albeit in different ways. The Day-Ahead Market, for instance, performs a least-cost, security-constrained optimization across the 24 hours of the trading day, meeting day-ahead demand while enforcing constraints on changes in unit output from one hour to the next. This ensures

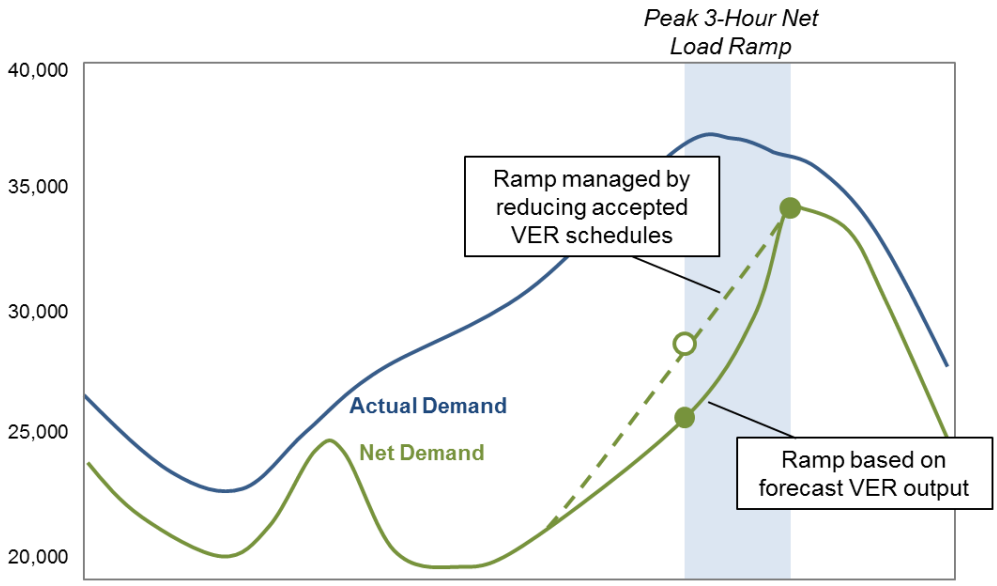
that the resulting supply schedules are feasible to meet day-ahead demand at an hourly granularity level, but it does not ensure that additional flexible capacity is "set aside" to be available in case real-time conditions change. In other words, the day-ahead optimization appears to not recognize the uncertainty associated with day-ahead load forecasts or the uncertainty associated with day-ahead generation schedules, especially from VERs.

The current Day-Ahead Market also does not appear to recognize the flexible capacity needs due to intra-hour variations in load or intra-hour variations of supply (particularly VER supply). The Day-Ahead Market solution may appear feasible at the hourly level by assuming that load and generation move smoothly in a "straight line" from one hourly value to the next, but may be infeasible if changes in any given sub-hourly interval are greater than this assumed "straight line" rate of change.

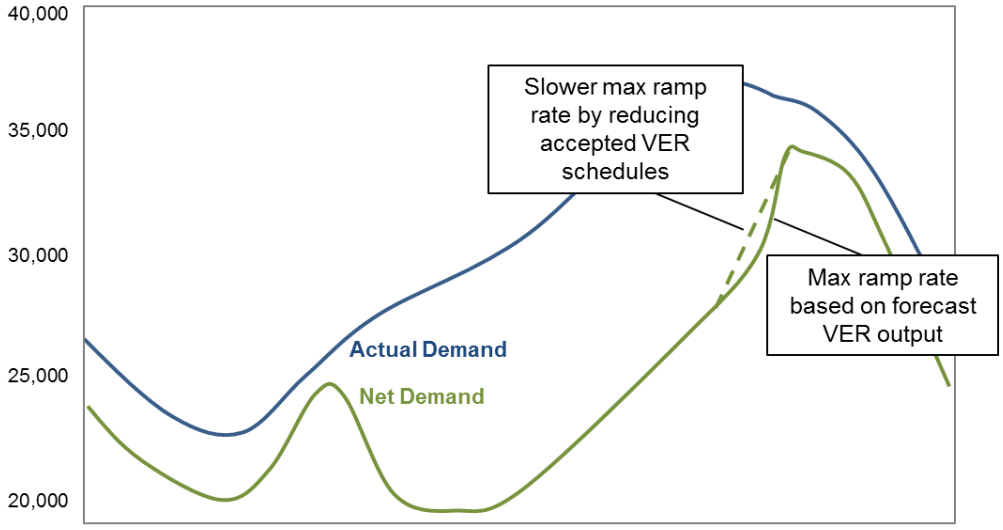
In contrast, the Real-Time Market optimization recognizes the flexible capacity needs associated with both forecast movement and with uncertainty in both supply and demand; it also recognizes the need for flexible capacity to balance variations within each hour. But, similar to the Day-Ahead Market, the Real-Time Market also does not comprehensively recognize all intra-day needs for flexible capacity. This is because it is limited in its optimization horizon, with most of the associated processes extending just one, or a handful of, hours into the future. For example, this limited optimization horizon can prevent the real-time optimization from fully recognizing the future flexible capacity needs associated with accepting solar resource output beginning in the mid-afternoon hours. In the hour that the additional solar output starts being delivered, the CAISO's real-time processes acknowledge that it will need to reduce other sources of generation to absorb the solar output, and also recognizes the need to meet variations and uncertainty in supply and demand in that hour, through the Flexible Ramping Product. But the existing Real-Time Market optimization, with its limited "look-ahead" horizon, does not recognize that the additional solar generation accepted in mid-afternoon hours will also increase the total magnitude, as well as potentially the steepness, of the evening ramping requirements. It is not until several hours later, when evening ramping requirements fall within the relatively short optimization horizon of the Real-Time Market, that the additional flexible capacity needs become apparent, by which time the potential actions available to CAISO operators, having already accepted the mid-afternoon solar output, are considerably more limited.

Powerex urges CAISO to explore ways to improve the recognition of flexible capacity requirements within the Day-Ahead and Real-Time Market optimizations. In particular, Powerex believes that CAISO could define the need for flexible capacity as a function of the specific supply schedules that are awarded. Different types of resources would likely imply different quantities of flexible capacity needs, based on both the forecast movement—that is, the timing, magnitude, and rate of change of the expected hourly quantities—as well as on the uncertainty, referring to the probability that actual deliveries will be less than the hourly scheduled quantities.

By more comprehensively assessing the flexible capacity needs associated with different types of supply schedules, the CAISO will be able to ensure that the size and speed of net load ramps do not exceed the capability of flexible resources available in real-time, as illustrated below:



Solid green line shows peak 3-hour net load ramp with VER schedules based on forecast. If this exceeds flexible capacity available in real-time, a feasible 3-hour ramp can be achieved by limiting VER supply schedules in the hours prior to the forecast ramp, shown by the dashed green line.



Similarly, the maximum ramping rate can be maintained within the capability of available flexible capacity by reducing VER schedules in the hour prior to the forecast maximum ramp.

The foregoing enhancements would permit CAISO to more fully recognize, *in the concurrent hour and in future hours,* flexible capacity needs implied by a given mix of accepted supply resources, and to ensure that these flexible capacity needs do not exceed the quantity of flexible capacity that is available from flexible resources that have made offer commitments into the market in the relevant hours. Powerex views this as a critical first step in improving the operational performance of the CAISO grid, since it would help ensure that all market solutions are feasible with respect to flexible capacity availability throughout the operating day. As discussed in the following section, however, Powerex believes CAISO could also implement enhancements that allow it to expand the available flexible capacity, increasing its ability to accept VER supply schedules and minimizing the occurrence of any curtailments.

B. A Day-Ahead Flexible Capacity Product Will Enable CAISO to Procure Flexible Capacity from Existing Resources

In addition to more fully recognizing the quantity of flexible capacity that a given market solution requires, Powerex believes that CAISO needs the tools to increase the amount of flexible capacity that is available to the market. Powerex therefore recommends that CAISO evaluate introducing a formal flexible capacity product into its Day-Ahead Market to allow it to set aside flexible capacity and secure a commitment to offer that capacity in the Real-Time Market, in exchange for a capacity payment. CAISO already uses a similar capacity procurement approach to meet its contingency reserve requirement by procuring spinning and non-spinning reserve in the Day-Ahead Market; it also procures regulation reserve in the Day-Ahead Market. Resources that provide those products receive capacity compensation in return for being available to be deployed for energy in real-time. Moreover, the procurement of these capacity products is co-optimized with the scheduling of day-ahead energy, permitting the optimization to find the best use for resources that offer to provide energy or capacity.

A day-ahead flexible capacity product would be a natural complement to these existing practices. The new flexible capacity product would be for the purpose of securing flexible capacity that will be available to be dispatched in the 15- and 5-minute markets, as opposed to procuring capacity that provides contingency reserve or second-to-second regulation.

Developing a formal day-ahead flexible capacity product would have at least two important benefits. First, it will increase the quantity of flexible capacity available to the CAISO in real-time. Currently, the flexible capacity available to CAISO is limited to resources that submit economic offers in the Real-Time Market, which is only a subset of the flexible capacity that may actually exist, either within the CAISO BAA or outside of it. A day-ahead flexible capacity product would provide additional compensation that could overcome some of the existing barriers that discourage resources from submitting offers into the Real-Time Market, including the need for external resources to acquire transmission service or to procure fuel. A capacity payment would also be necessary to compensate sellers of that product for the opportunity costs associated with foregoing day-ahead energy transactions in order to provide “stand-by” flexibility to CAISO in real-

time. In addition, an explicit flexible capacity product would enable resource owners to offer flexible capacity independently of offering to sell energy (though they could elect to offer both).

Second, implementing a flexible capacity product will provide the framework necessary to "hold back" an internal or external flexible resource from being scheduled for energy in the CAISO's Day-Ahead Market in order to provide real-time upward flexibility. In this manner, the Day-Ahead Market will be able to explicitly recognize that scheduling a flexible resource to produce energy entails a "cost" in terms of reducing the flexible capacity that will be available for dispatch in the 15- and 5-minute markets. This, in turn, will permit the market optimization to more efficiently select between potential supply schedules based not only on the offer price for energy, but on the cost of procuring the associated necessary flexible capacity. Developing this ability to "hold back" flexible capacity from being scheduled for energy in the Day-Ahead Market is also vital to ensuring that any longer-term programs developed to secure flexible resources do, indeed, result in additional flexible capacity available to CAISO in real-time. Absent the development of a day-ahead flexible capacity product, any flexible resources procured under a long-term contract may be fully scheduled for energy in the Day-Ahead Market, with the intended flexibility benefits largely nullified.

Powerex believes it is likely that a significant amount of existing flexible capacity resources in the west could be procured and set aside on a day-ahead basis to be available in the CAISO's 15- and 5-minute markets. As has been extensively documented in other contexts, the amount of voluntary participation in CAISO's Real-Time Market by external resources declined significantly after the introduction of the Fifteen Minute Market in 2014. This decline did not reflect a change in the installed quantity of flexible resources, but rather reflected changes in CAISO's market design that introduced significant new price and quantity uncertainty for external resources participating in the CAISO Real-Time Market. Introducing a day-ahead flexible capacity product could provide the appropriate price signals necessary to once again encourage flexible resources to participate in the CAISO Real-Time Market. Developing products that allow the CAISO to procure its flexible capacity needs from *existing* resources—in the amounts that it needs, and in just the hours it needs—seems to be the obvious "low hanging fruit" to meeting CAISO's flexible capacity challenges at the lowest cost to consumers, and should be fully explored before turning to more costly solutions such as entering into long-term contracts to support building new flexible resources.

Moreover, by including a new flexible capacity product in the CAISO's co-optimized Day-Ahead Market, this new product can be procured in an efficient manner, *and only to the extent it is economic to do so*. For example, if it is economic to reduce the amount of solar, wind, or hourly import schedules during the mid-afternoon hours on some days in order to reduce the quantity of flexible capacity that is required (in either the same mid-afternoon hours or later in evening peak hours when the supply inevitably ramps down), the CAISO's market optimization software would be able to identify such an outcome, reducing the quantity of flexible capacity procurement. In addition, the

CAISO's co-optimized Day-Ahead Market should be able to efficiently decide *which* resources are awarded flexible capacity, as opposed to energy (or other products) in the day-ahead timeframe, consistent with how it currently decides to award spinning, non-spinning and regulating reserve products as opposed to energy today.

The enhancements described in this section are necessary to ensure that CAISO's market solutions are feasible and efficient with regard to flexible capacity needs. Simply put, CAISO needs to be able to define and enforce limits on the quantity of supply schedules it accepts from different types of resources, particularly from VERs, which require greater levels of flexible capacity from the system. Together with a more robust framework for remaining within the limits of available flexible capacity, CAISO also needs the tools to be able to procure and set aside flexible capacity on a day-ahead basis in order to expand the amount of flexible capacity available to be dispatched in its 15- and 5-minute markets. Powerex believes these enhancements will help avoid the highly problematic outcomes discussed in the Working Group meeting, in which the CAISO market solutions did not limit the supply from VERs in the first place, and consequently experienced reduced reliability performance metrics when the need for flexible capacity appears to have exceeded the quantity that was available. Implementing these enhancements will also enable the CAISO to efficiently and reliably integrate additional renewable resources, through acquisition of flexible capacity in the day-ahead timeframe, including from external resources.

III. Forward Contracting to Ensure Reliability is Distinct from Forward Contracting to Support Meeting California's Environmental Policy Goals

The distinction between flexible capacity needed for reliability and flexible capacity needed for renewable integration also has implications for programs to procure capacity on a forward basis. As discussed more fully below, the existing Resource Adequacy program should continue to be strictly a reliability program driven by the need to meet load in each hour of the day, and the need to follow changes in load throughout the day.

A separate program is needed to help identify and secure the most efficient portfolio of resources that meet California's environmental objectives. Meeting California's environmental goals will undoubtedly require new investment. Importantly, determining the investments necessary to achieve California's environmental policy objectives, and in particular its Renewable Portfolio Standard, in a cost-effective manner presents an economic challenge, not a reliability challenge. Consequently, Powerex believes that such forward procurement should occur through a program specifically designed to achieve the economic integration of renewable resources, and should be entirely separate from any forward procurement program for reliability. Moreover, while new investments may not need to be in place *today,* the long lead times for building new facilities; negotiating and executing contracts; submitting those contracts for approval; and getting a new forward procurement program up and running all mean that work on the design of such a program needs to proceed immediately.

A. Enhancing the Existing RA Program to Ensure Reliability

The objective of preserving reliability is limited to ensuring, on a forward basis, that there are sufficient physical resources to reliably serve load in each hour. New resources will be required for reliability as load grows and/or as existing resources retire. This reliability objective has historically been met with reference to forecast load plus a reserve margin—and without an explicit "flexibility" requirement—under the standard Resource Adequacy program. That is, the flexibility inherent in the least-cost generating resources necessary to provide adequate capacity has generally been more than sufficient to balance variations in load within each day. Absent evidence that CAISO load is materially more variable than in the past,[3] reliability requirements would appear to be adequately met through the existing standard Resource Adequacy program and do not appear to require an explicit amount of "Flexible RA."

There are aspects of the existing RA program that may needlessly exacerbate CAISO's operational challenges, however. In particular, the RA requirement is currently based on the forecast peak load for each month, but this defined amount of capacity is required to be demonstrated for all hours rather than just for the hours in which the peak load is expected to occur. This requirement makes it economically attractive for LSEs to use multi-hour block energy imports to satisfy the RA requirement. From an operational standpoint, however, these multi-hour energy imports are typically not just "capacity" but also "must take" energy, exacerbating oversupply conditions during the hours of the "belly of the duck".

With these challenges in mind, Powerex recommends that CAISO consider refining the manner in which the RA program specifies the forward contracting requirement. Rather than calculating a single value for each month, based on that month's projected peak load plus a planning reserve margin, the RA requirement could be defined as a set of values specific to each hour of the day in that month. This would continue to ensure that sufficient RA capacity is contracted for on a forward basis, but without the unintended consequence of over-procurement during hours of the day with lower load.

B. A Forward Procurement Framework for Meeting California's Environmental Policy Objectives at Least Cost

The enhancements discussed in Section II will likely mean that, under certain limited conditions, CAISO may need to decline to accept self-schedules or economic offers from VERs. Powerex believes these events should initially be infrequent and limited in magnitude, particularly if CAISO indeed develops the ability to procure flexible capacity on a day-ahead basis. As VERs continue to be added, however, there is the potential

[3] Powerex recognizes that the growth of behind-the-meter solar generation likely has increased the variation in load, but whether this has occurred to an extent requiring an explicit flexibility component for RA is unclear.

that, over time, the frequency and magnitude of the limitations on VER schedules—that is, VER curtailments—will increase.

The magnitude and frequency of curtailments can be reduced through longer-term investment decisions, such as by diversifying among different types and locations of VER facilities (*e.g.,* out-of-state wind facilities), or by developing storage resources. However, it is unclear whether the cost of these approaches would exceed the cost of simply "overbuilding" the least expensive renewables to meet RPS objectives even after accounting for growing levels of curtailments. It is therefore not yet clear what particular mix of new investments will achieve these environmental goals in the most cost-effective manner. Several broad approaches are possible:

- **Overbuild California solar**—in-state solar appears to generally be the lowest-cost renewable resource in California. As in-state solar continues to grow, so will curtailments, due to oversupply conditions and limitations on flexible capacity, requiring renewable resources to be "overbuilt" in order to meet the applicable RPS targets.

- **Build out-of-state resources, such as wind**—diversification of the renewable portfolio would reduce oversupply and flexible capacity requirements, thereby reducing the risk of curtailment and avoiding the need to overbuild. However, the more distant high-quality renewable resources are likely more expensive to build, and may require new transmission infrastructure to deliver the renewable resource output to California.

- **Acquire additional resources to provide flexible capacity and storage**—additional resources could be acquired that provide flexible capacity to manage the variation and uncertainty in renewable resource output, as well as storage to absorb renewable resource output during oversupply conditions.

The foregoing is not intended to be either exhaustive or detailed, but to illustrate the wide array of potential strategies that could be employed to achieve California's environmental policy goals. These examples also help illustrate some of the potential tradeoffs between different approaches. For instance, is the additional cost of a more diversified mix of renewable resources greater or less than the additional cost of overbuilding a less diverse set of in-state resources? Is it greater or less than the cost of adding flexible capacity and/or storage resources?

A forward procurement program to support California's environmental policy objectives would help clarify these tradeoffs and would require procuring flexible capacity and storage on a forward basis in amounts consistent with the broader environmental strategy. CAISO could support such a program by providing the technical capability to establish the flexible capacity needs and forecasted oversupply implied by a particular mix of renewable resources on the grid.

Separating forward procurement for reliability from forward procurement for renewable integration has an additional benefit: the ability to ensure that the resources used to achieve California's environmental policy goals are themselves consistent with those goals. For instance, one way of meeting the RPS goal might be to increase in-state solar generation and also build new natural gas units to provide additional flexible capacity to balance the variation in that output. But it may be viewed as counterproductive for California's goals of increasing the use of renewable resources to result in the addition of new fossil-fueled generation. A forward procurement program designed specifically for the purpose of supporting California's environmental policy objectives could consider environmental attributes as well as costs when evaluating different alternatives. Such a program would be able to implement a policy preference for flexible capacity to be procured from new non-emitting resources, even if there were lower-cost fossil-fueled resources available.

Importantly, Powerex believes that if a robust program for the forward procurement of "renewable integration" resources to provide additional flexible capacity and/or storage is not developed in the coming years, the likely result will be more frequent and larger renewable curtailments, and/or the need to build more diverse but distant out-of-state renewable resources, even if they are substantially more expensive than in-state resources. The end result may be a substantially higher total cost to meet California's RPS and broader environmental objectives than if an effective program for forward procurement of flexible capacity and/or storage were in place.

Finally, it should be noted that, while there are two distinct objectives of the forward procurement programs discussed above—reliability as distinct from renewable integration—there is nothing to prevent the same resource from satisfying the criteria under both programs. For example, a pumped-storage hydro resource may be qualified to provide both capacity under the RA program, as well as clean flexible capacity to support renewable integration under the new forward procurement program for environmental policy needs.