Stakeholder Comments Template

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Please use this template to provide your comments on the FRACMOO Phase 2 stakeholder initiative Draft Framework Proposal posted on May 1, 2017.

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Comments are due December 13, 2017 by 5:00pm

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Comments on California's flexibility and ramping needs

In context of CAISO FRACMOO 2 Proposal

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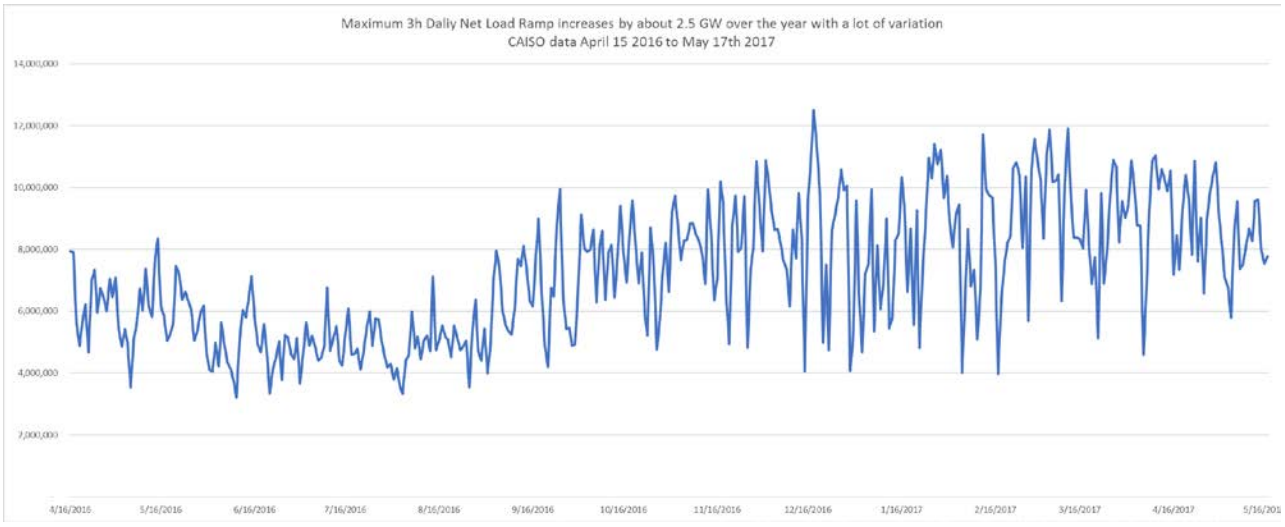
In response to increasing flexibility needs, especially in the afternoon net load ramp, California policymakers have introduced new products and forward procurement obligations. These do not seem to be solving completely the problem of insuring resource adequacy for ramps. The CAISO has properly identified a problem, but there are many issues with their proposed solutions. We offer some recommendations.

Introduction

As anyone who follows the infamous CA "duck curve" knows, there are two principle issues with the duck curve: curtailment due to overgeneration during the belly of the duck, and ramping needs during the neck of the duck. Stakeholders in CAISO's market rules development are trying to better understand to what extent current policy is addressing these problems today and how future problems can be mitigated - at least in the near term - through structural solutions (like better rules for Flexible Resource Adequacy Criteria and Must Offer Obligations (FRACMOO), local capacity resources, etc.).

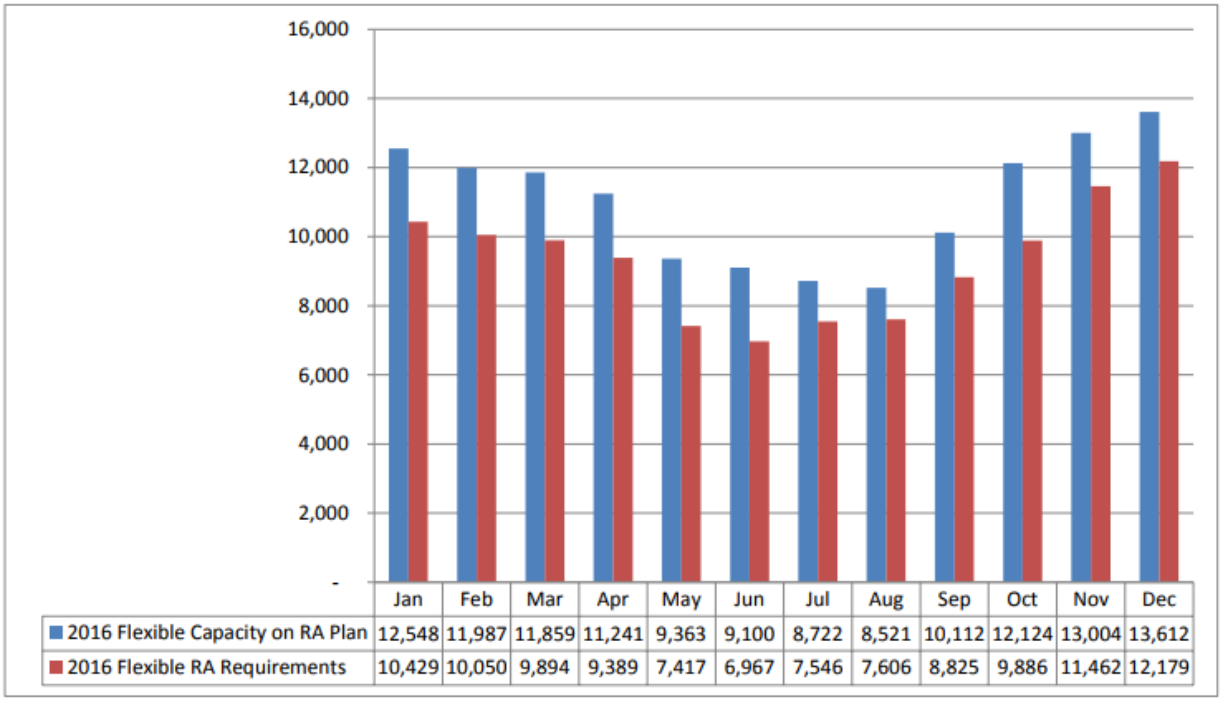
One easy public data set to look at comes from the CAISO Renewables Watch reports of hourly production for the CA thermal fleet, renewables, nuclear and hydro resources as well as imports (undifferentiated). This data shows that the maximum daily 3-hour ramping need for the CAISO system has steadily been increasing over the last year:



The trend is clear, albeit with a lot of noise. There are especially extreme variations in the max daily 3-hour net load ramp in December through March, mostly driven by variation in total load ramps.

Starting in 2015, CPUC-jurisdictional resources participating in the CAISO market were asked to demonstrate of a new kind of resource adequacy, flexible resource adequacy (flex RA), in order to make sure that sufficient ramping resources exist to cover the 3-hour net-load ramp in the afternoon, and to some extent the morning ramp as well. Looking at the CPUC's most recent 2016 Resource Adequacy Report, we can see that in theory more than enough in-state resources (almost all RA showing are in-state) are available to meet this net ramp.

Figure 4. Flexible RA Procurement in 2015 and 2016, CPUC-Jurisdictional LSEs



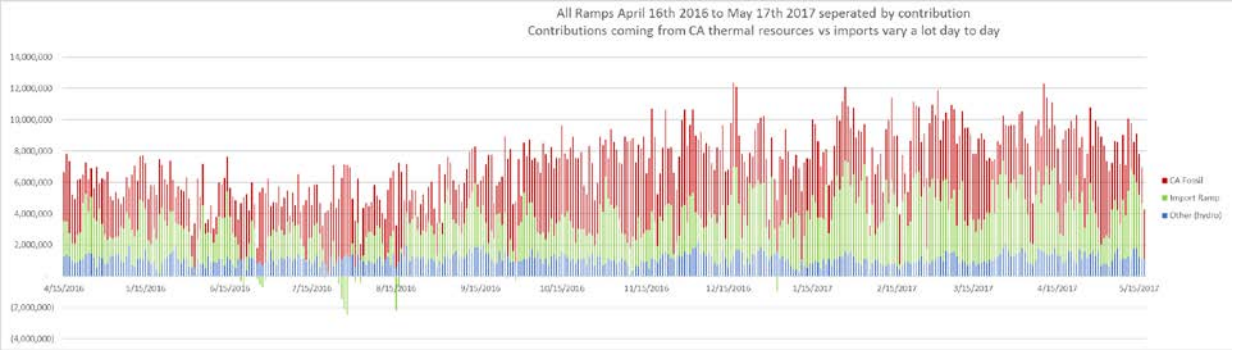
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016 Flexible Capacity on RA Plan	12,548	11,987	11,859	11,241	9,363	9,100	8,722	8,521	10,112	12,124	13,004	13,612
2016 Flexible RA Requirements	10,429	10,050	9,894	9,389	7,417	6,967	7,546	7,606	8,825	9,886	11,462	12,179

In the worst ramp month of the 2016-2017 season, December 2016, the flexibility requirement (with margin for error) projected by CAISO was 12,179 MWs. Jurisdictional load-serving entities (LSEs) contracted 13,612 MWs with must-offer obligations. The actual max ramp was on Dec 18th, with a 12,500 MW 3-hour net load ramp from 3pm to 6pm. It seems the CAISO under-estimated the maximum ramp for that month, but in theory the LSEs contracted resources that were more than sufficient to meet it – and no extraordinary measures were taken, or alerts given by CAISO that day. Yet, of the contracted resources only some amount (hydro and thermal) worked to meet the ramp in reality – contributing less than 7,000 MW in increased output. Imports, typically not candidates for flex RA, did the rest of the heavy lifting – providing over 5,600 MW of ramping towards meeting the biggest 3-hour net load ramp of the season. This points towards a misalignment between the policy support for a set of resources assuring flexible resource adequacy and the actual resources doing the work. This misalignment should concern policymakers.

The ramping resource misalignment problem

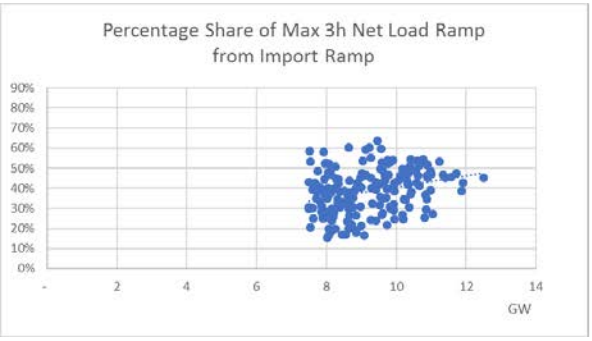
In short, the ramping problem in California today is that resources being paid to be available to meet flexibility needs are not actually delivering this flexibility when it is needed in the real-time operational environment, while other resources not paid to cover this need (or disallowed from being paid to provide it) are the ones meeting a significant portion of the actual need. This could lead to problems down the line as ramping needs continue to increase and California increasingly plans on resources which may not appear.

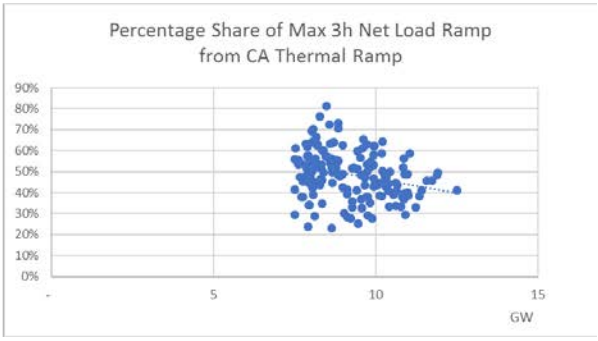
To understand some of what is happening, it is helpful to break down the maximum daily ramps by which resources contributed to meeting them:



One thing that jumps out from the data above is how much variation exists in how thermal (short for thermal resources internal to CA) and import resources are dispatched to manage the largest 3h net-load ramp of the day.

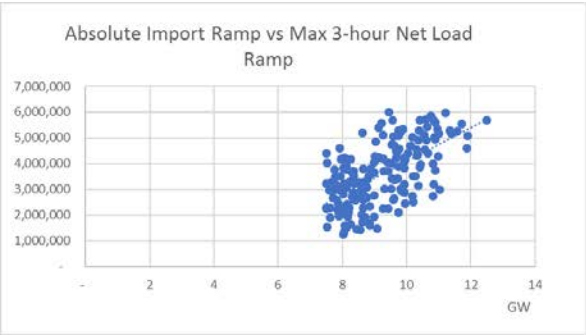
A better way to parse this data set is by concentrating only on the 7.5 GW+ ramps from mid-April 2016 to mid-May 2017 (effectively the 2016-2018 “ramp season” November 2016 through April 2017). The size of the maximum net-load ramp can be a proxy for system stress on any given day. For example, we can look at the fraction of the “work” that imports and CA thermal resources provide as a function of max 3h net load ramp:

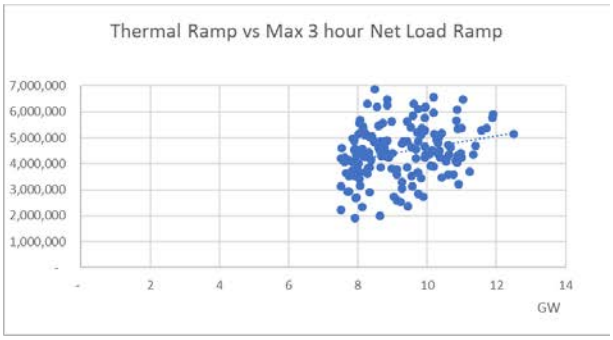




With increasing stress, these first two plots (looking at imports and thermal as percentage of total max net 3h-ramp) show two interesting features: (1) a narrowing of the distribution of the work fraction for imports and thermal as ramp increased and (2) a noticeable trend towards imports doing more "work" as the ramping need increases (imports go from an average of roughly 35% to almost 50% for the

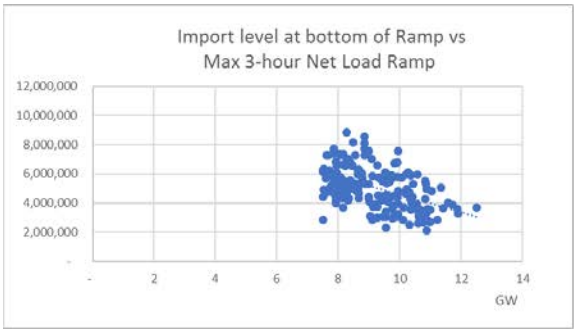
biggest ramp in Dec 2016) with a corresponding drop in thermal. To get a better read on this, we can look at the absolute levels of "work" in these next two plots:

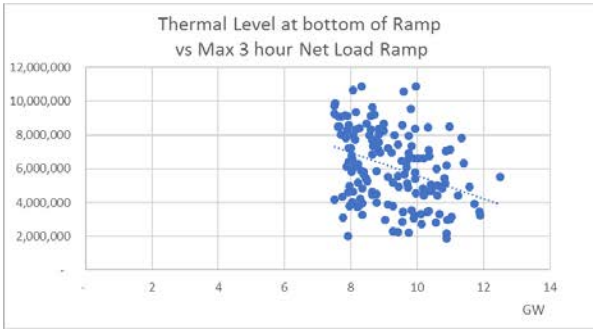




Imports clearly increase their output with max ramp, providing an average of 3 GW for ramps around 7.5 GW going to 5.6 GW as the ramp moves to 12.5 GW. The picture for thermal seems statistically less clear - a general mild increase going from 4GW to 5GW in ramping with a lot of random variation. This points towards imports playing a steadily more important role as a function of system stress, measured here by ramp size.

Resources that are going to provide ramp typically have to back down in anticipation in order to have headroom. If a resource back down more to meet bigger ramps, that is a sign that is operational more responsive to different levels of ramp as they occur in the real-time environment. The next pair of plots digs into this by looking at the output from import and thermal resources at the start of the maximum net-load for the day ramp as a function of the total size of that ramp:





Here we see both thermal and import resources decreasing their minimum output by about 3 GW as we move to bigger ramps, but imports are much more tightly clustered around the trend. This could indicate that imports might be more sensitive to daily operating conditions.

Liz Anthony from CEERT shared analysis which points to similar conclusions. The analysis looks at how imports and thermal variations relate to curtailment in the belly of the duck. She segregated March 2017 days by the amount of daily curtailed megawatt-hours (MWhs)[1], and found that the more curtailment happened in a given day, the more likely imports provided a larger fraction of the ramp that day. In short, more system stress (here measured by curtailment) seemed to lead to more "work" from

[1] from the CAISO curtailment reports

the imports. Yet, CA thermal resources are the ones receiving payments through flex RA – further evidence of a disconnect between policy-derived payments and functionality.

In summary, the largest daily maximum 3-hour net-load ramps (7-12.5 GWs) were met in the California 2016-2017 ramping season by a combination of 1-2 GW of ramp from in-state hydro resources, 2-7 GWs of in-state thermal resource ramps and 1-6 GWs of import ramps, with the later acting as the marginal resource. How could this be when flexible RA payments are supposed to pay for 13 GWs of instate ramping resources to show up, out of a total in-state resource pool of up to 34 GW[2] of ramping capacity?

Why aren't in-state resources showing up?

The situation above has not escaped the CAISO's attention. The flex RA payment scheme was always meant to be the first step in an evolution, and they have been tracking performance carefully. In a series of workshops, working papers, and draft proposals they have laid out a narrative which points to two intertwined problems behind the ramping resource planning/operation mismatch: resource commitment issues for the flex RA resources in the day ahead market and large variations between the day-ahead forecasts and actual operational conditions.

Resource commitment issues

Resource commitment issues start from the shape of the duck curve. During peak ramping months like December or March, the thermal fleet must operate at a very low output level during the belly of the duck as most of low demand is met with zero-marginal cost solar, and then transition into a steep ramp as demand increases and solar production declines. The low belly of the duck, combined with the fact that most thermal plants have minimum run rates and many have long startup times, means that many of the thermal plants that could be used to be meet ramping needs are unable to be utilized. This forces a choice: curtail solar or limit the number of plants that can be dispatched. Hence, to reduce curtailment, the work of meeting the ramp must be distributed among fewer, faster-ramping plants with low minimum run rates relative to their peak capacities.

Many power plants that are eligible for and receive flexible RA are just too slow in their ramping capability: a CAISO supplemental issue paper indicates that 27% of the plants receiving flex RA credit, shown as "effective flexible capacity," have less than a 5MW/minute ramp rate (the best plants ramp more than ten times faster). This slow response also makes it hard to use these plants during the steepest one-hour ramps inside the three hours, and for managing intra-hour variability. Though they meet the definition of flex RA, many plants are not committed in the DA market because they are too slow to meet the actual ramping needs of the system.

In that same supplemental issue paper, the CAISO states:

[2] According to CAISO's spreadsheet FlexibleResourceAdequacyEffectiveFlexibleCapacityList-MarketSimulation2014 available on their FRACMOO page.

"*To address hourly and multi-hourly ramps of [this magnitude] . . . the ISO would need to commit slow ramping resources well in advance of the net load ramps. These dispatches will result in either over-supply or frequent and voluminous wind and solar curtailment . . . The best way to mitigate reliability risks and wide-spread renewable curtailment is to ensure the ISO can utilize resources that can ramp quickly."*

Slow ramp rates of the old CA gas fleet (often also contracted as local RA) are a principal reason why the resources receiving Flex RA payments are not performing during periods of system stress. Imports are picking up the slack for now, but CAISO recognizes there is significant need to modernize the gas fleet and incorporate out of state resources into the resource adequacy framework.[3]

Forecast Error

Forecast error issues start with the following fact, described in the CAISO's November 2017 Draft flexible capacity framework proposal: "*the ISO must manage a significant quantity of uncertainty between the day-ahead and real-time markets. This uncertainty can be over 4,000 MW in either direction, swinging more than 6,000 MW in any single day, and can occur even during the largest net-load ramps."* Unfortunately, many resources getting flexible RA credit are not up to the task of adjusting their day-ahead commitments to meet an extra 4-6 GW of ramp. According to CAISO, long-start resources make up approximately 40% of the flex RA resources and "are only available to meet real-time flexible capacity needs if they receive day-ahead commitments." So, if the ramping increases by a few thousand MWs between the day ahead and real time markets, many of the plants currently being paid to provide flexible RA cannot help – it is too late to start them up. These long-start resources effectively knock off 4,000-5,000 MW of ramping capacity shown in the flex RA process, consistent with our analysis above and schedule deviations reported by CAISO.

It's a good thing imported resources can fill the gap. These can typically be scheduled on an hour-ahead basis in 15-minute increments (about 7,000 MW from the Pacific Northwest, for example) with a much smaller subset (about 400MW from the Pacific Northwest) able to dynamically adjust in the RTD (five-minute real-time dispatch), though these are usually participating in the Energy Imbalance Market (EIM). Even though they contribute significantly to meeting ramps, very few imported resources are getting flex RA credit. The CPUC 2016 Resource Adequacy report (Table 4) only has 2,008 MW of imported resources receiving RA credit (flex RA typically also gets system RA) for the month of December 2016. RA showings for imports in the Oct 2016-May 2017 window are all in the 1,700 – 2,600 MW range. Even before discounting for minimum run rates and other constraints, this is already far less than the 5,600 MW of ramp that showed up on Dec 18th.

We are not entirely sure what is preventing or discouraging imports from receiving flex RA credit. Real-time Market (RTM) participation, meaning participation in the fifteen-minute market (FMM) and RTD, is often brought up as a barrier but is not required for import flex RA resources not committed in the day-ahead (integrated forward market (IFM) and reliability unit commitment (RUC)). However, according to the CAISO Business Practices Manual, if some capacity is committed day-ahead, any remaining un-

[3] CAISO Electricity 2030

committed capacity under an RA must-offer obligation (MOO) also must offer into the RTM, so this could be keeping imports from participating.

The CAISO FRACMOO Phase 2 proposal

Over the last two years, the CAISO has been running a stakeholder process for improving the FRACMOO process. In November 2017 they released their latest proposal detailing some further analysis and spelling out how they think flexible resource adequacy capacity should be procured. The draft proposal can be essentially captured in their Figure 12 (inset) showing the evolution from the existing products to the proposed set

Essentially, the current flex RA would be replaced by three different nested products addressing flexibility needs in the five-minute real-time dispatch (RTD), the fifteen-minute hour-ahead market (FMM) and the day-head market (IFM). This is nested because resources paid to provide flexibility in the RTD would also supply the FMM and the IFM, and so on. The full proposal is available at on the CAISO website – the latest draft proposal is from November 2017 available on CAISO's FRACMOO page.

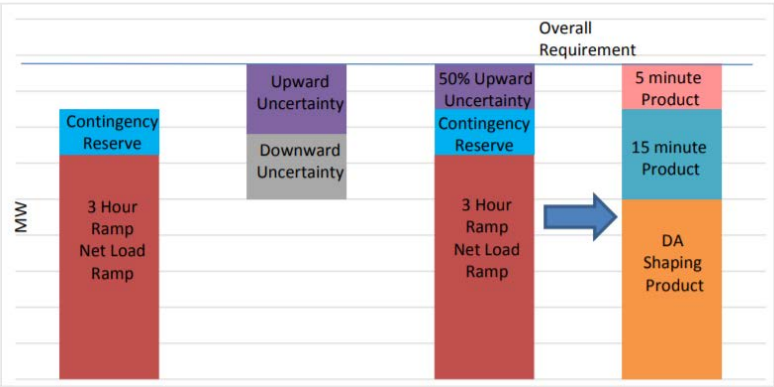
What we like

There are many features to like about the latest CAISO draft proposal for modifying FRACMOO:

(1) *The uncertainty split:* the CAISO recognizes that the "*most efficient way to address this anticipated uncertainty is to develop flexible capacity rules and products that are tied directly to two types of ramping needs: 1) Predictable: known and/or reasonably forecastable ramping needs, and 2) Unpredictable: ramping needs caused by load following and forecast error."* Limiting resource adequacy credits for less flexible resources to just the day-ahead where they are only asked to help address the more known or reasonably forecastable ramping needs represents good alignment between planning and operational needs. This is important not just because it is functionally more practical and efficient but also because it makes possible aligning separate resource functions (managing forecastable variation vs unpredictable variation) with different procurement models (e.g. buy the first on a long-term bilateral basis, use markets and backstops for the other).

(2) *Better regional integration*: The proposal includes a product with a 15-minute time-frame that could improve participation from regional resources. These resources are already doing a lot of the ramping, and have empirically demonstrated their role managing uncertain ramp needs. Monetizing and formalizing their participation in resource adequacy means CAISO can count on these resources in times of stress, and properly account for them in resource adequacy. Hopefully the new proposed day-ahead shaping product will better allow imported resources to target and get paid for managing known ramping

Figure 12: Determining the Requirements for Day Ahead Shaping Product



needs – adjusting transmission and hydrological systems accordingly.

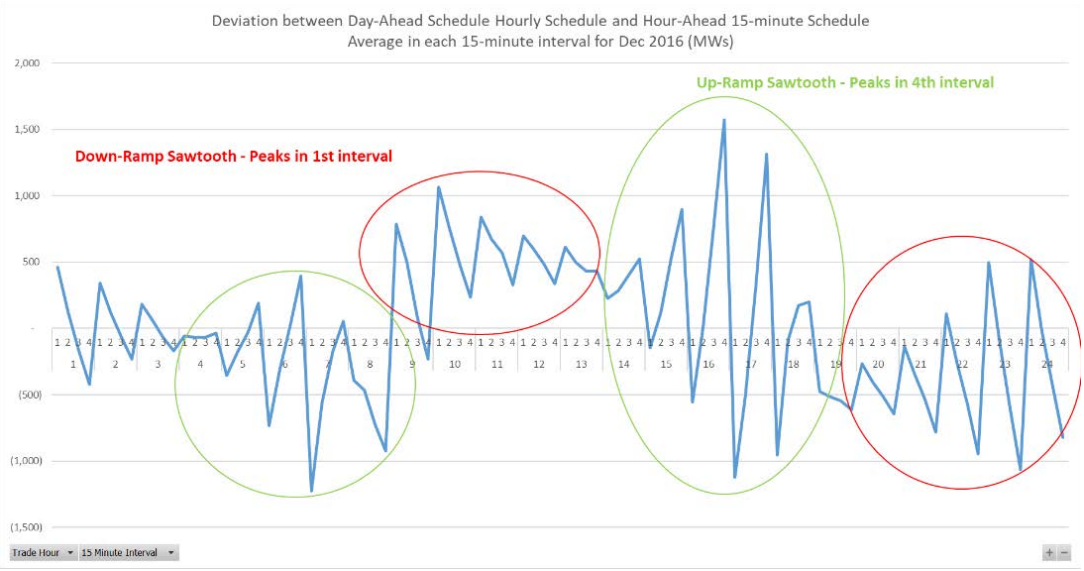
(3) *Paying only for what you get:* The proposal wants to redefine how resources are credited as capacity for the purposes of day-ahead shaping of the resource mix. This is easier with the predictable-unpredictable split, which re-focuses day-ahead adequacy on more predictable needs. It allows planners to stop crediting resources for providing flexibility when their operating constraints and the operational environment (e.g. duck belly) mean this flexibility should be discounted and allows for a closer look at capacity that could be made available from variable resources. It takes the burden off resources looking to meet predictable needs from having to meet unpredictable needs as this is now a new resource adequacy category.

What we don't like

(1) *CAISO brings up uncertainty and forecast error too broadly in the context of ramping*. In the November 2017 Draft proposal, CAISO provided a lot of data for the purposes of understanding ramping need. They discuss the deviations between various forecasts and actual dispatch, illustrated in the inset graphs.

Clearly some of the deviations depicted are quite predictable. For example, during a ramp-up period like the one shown, the orange line (FMM forecast) will start below the blue line (Day-ahead forecast) at the beginning of the hour and gradually move up above it by the end of the hour. This means FMM market will require an extra negative adjustment (reduced generation) in the first fifteen-minute interval and gradually turns that into an extra positive adjustment (need for extra power) by the fourth interval before jumping back down for the first interval of the next hour.

This saw-tooth pattern is reversed for down ramps, but in any case is entirely predictable. In the chart above we averaged all the 15-minute deviations between DA and HA for December 2016 and the saw-tooth pattern emerges quite clearly, with swings proportional to the average slope of the ramp during each hour interval.



This means that an important fraction of the variability/uncertainty CAISO describes is clearly limited to a certain interval, and shouldn't be reflected in a definition of the overall ramp. This can be illustrated by the fact that a battery set ahead of time to charge and discharge in the saw-tooth pattern would smooth out the saw-tooth deviation without a big change in its state of charge or average output (saw-tooth schedule deviations might also be reduced by the change to fifteen-minute day-ahead schedules mentioned in CAISO's 2018 Policy Roadmap). In the Dec 18th maximum 3-hour net load ramp event, deviations from DA to FMM for that day swung between -2,000 MW and 1,500 MW, but the 3pm to 6pm daily maximum net-load ramp in fact decreased in the hour-ahead FMM forecast by about 280 MW from the day-ahead forecast and had only increased about 117 MW[4] in real-time compared to the day-ahead forecast.

The point here is there are various kinds of needs in the real-time markets which can be matched to different resources. Some resources will be better at providing the steady increase in MWs to manage an extra one or three-hour ramp when it unexpectedly shows up in the hour-ahead window, some are good for adjusting the sawtooth pattern, and others provide the ability to deal with more rapid fluctuations or adjust for a small-time shift in the start/end of the ramp. CAISO's description of uncertainty tends to lump all these together. Their proposal, with the idea of requiring the fifteen-minute product and the five-minute product target resources that can sustain output for three hours completely discounts limited-use resources that can, for example, deal with the saw-tooth pattern or rapid positive/negative fluctuations. The proposal paints with too broad a brush in describing system needs.

(2) *Too much nesting*. The framework proposed by the CAISO involves a nesting requirement, where a five-minute product can also serve as a fifteen-minute product which can also serve as a day-ahead shaping product. But for nesting to work, requirements, like the three hours persistent output rules or the must-offer windows, must match up. It seems smarter to think about entirely different buckets with different rules, like PJM's Reg A and Reg D regulation products (Reg D is a faster regulation product with a zero-net-energy profile).

(3) *Is regional coordination going to work under this framework*? Given that some of the must-offer requirements for various products, especially the 15-minute product, are still undefined in the proposal, it is unclear how well imports will participate. Given that they are providing ramp but are not compensated for that capacity, it seems like external resources should want to participate in a scheme that will pay them for what they already do. Two questions arise: (a) will California LSEs be sufficiently incentivized under the new proposal to acquire the fifteen-minute product from external resources (i.e. imports) and (b) will the must-offer obligations (MOOs) be structured in ways that align well with how transmission is allocated or paid for. If imports end up effectively having to dispatch their resource, or even just their committed but un-utilized resource, in the RTD then they will need dynamic scheduling and that will reduce the

[4] 800 MW if we compare the HE 19 to HE 16 deviations averaged hourly – the very last five minute interval of HE 19 has a downward -2,041 MW deviation of the day-ahead schedule from the real time three-hour ramp. But looking at the very next 5-minute interval, this deviation in the three-hour ramp is now -1,915 MW. This illustrates how much high frequency "noise," including the sawtooth pattern, there is in the three-hour ramp definition.

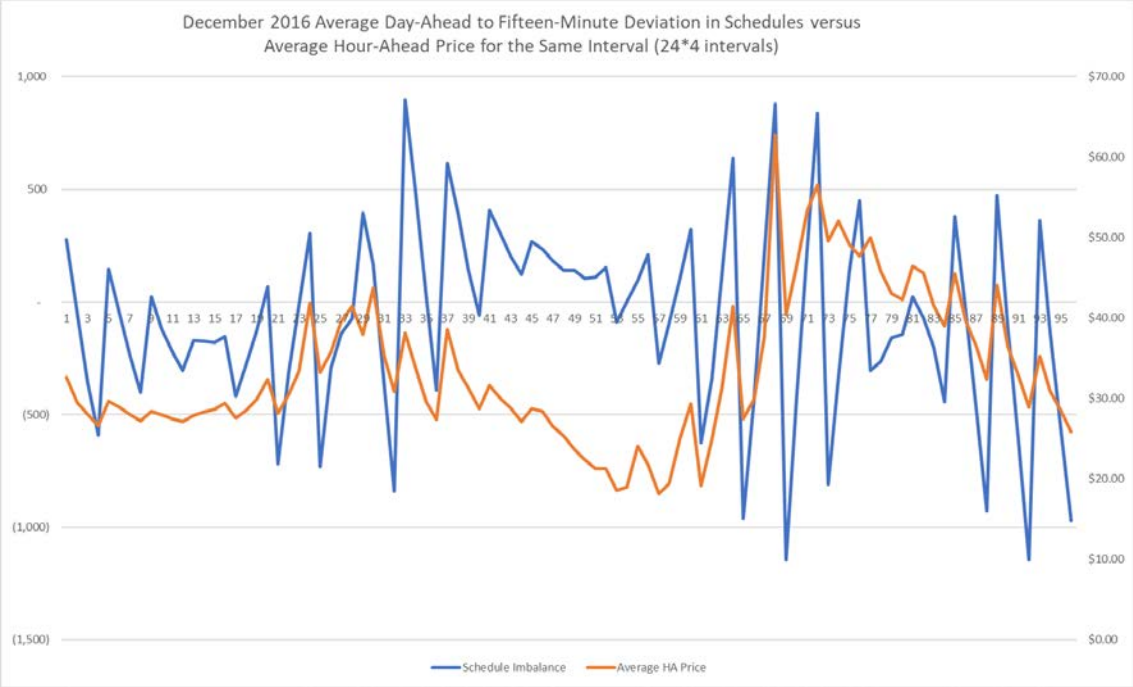
resources available for bilateral forward contracting. Given CAISO's stated policy goal (in their Electricity 2030 vision) to better integrate with neighboring balancing areas, and the empirically evident role that imports play in meeting ramping needs today, it is incumbent on the CAISO to better describe how they will facilitate import participation and exclude LSE's from showing "dud" resources for their flex RA showings.

(4) *What is day-ahead shaping really?* We find the following sentence in the CAISO's Nov 2017 draft proposal document quite problematic: "*the ISO current proposal shifts the goal from simply addressing the three-hour net load ramp to allowing the ISO to shape all hours of the IFM*." It doesn't seem like the CAISO should be in the business of "shaping", instead the market should be doing that (with some help from multi-period optimization). The idea behind flex-RA was that the CAISO could claim to identify a uniquely binding constraint, the three-hour net load ramp, measured on a *single scale* for all resources that could be procured on a forward basis. Moving to "day-ahead shaping" resource adequacy sounds like a multi-dimensional problem (the CAISO draft proposal doesn't clearly define was it meant by this term), resolvable by a variety of resources with various capacity along each of the dimensions (e.g. three-hour ramp, one-hour ramp rate, start times, Pmin, etc.). It seems sensible to only require each LSE to forward contract a portfolio of resources with the right profile, with different resources contributing different aspects as opposed to a stack of flex-RA all providing the same single product. Granted flex-RA currently has three sub-categories, the notion of day-ahead shaping sounds an order of magnitude too complex for creating an efficient market.

(5) *Resource adequacy allocation*. Currently, CAISO analysis is used to allocate to each CPUC-jurisdictional LSE a share of flex RA they must procure. This is based on each LSE's net-load profile. With a variety of day-ahead shaping needs, a fifteen-minute product and a five-minute product, this allocation analysis will become much more complex (with methodology subject to many more differences of opinion). Also, one LSE's surplus or deficit in one area may cancel some of another's.

(6) *What about reserves?* Theoretically the flexiramp reserve product deals with some of the ramping uncertainty in the five-minute market/dispatch (a substitute for stochastic forecasts). Could/should some of the needs identified by CAISO really be thought of as a similar reserve need as opposed to a capacity issue? It would be useful for CAISO to detail how their proposed products interact with existing products like flexiramp, and how the logic used to justify flexi-ramp applies or doesn't apply in this context. Also, some of the larger swings in the ramping needs are quite infrequent but knowable in the hour-ahead time frame, so the most economic capacity for a limited number of instances could be more of a reserve product using limited-use (limited instance) resources.

(7) *Planning vs markets*. The CAISO proposal develops a multitude of new resource adequacy needs with the clear implication that these should be good candidates for forward procurement under the CPUC's resource adequacy mandate. In aggregate, though, this becomes more and more prescriptive and impinges on market efficiencies. The market is clearly dealing with some issues well. Take for example the saw-tooth pattern identified earlier. If we plot average hour-ahead prices for the same intervals, we see a similar saw-tooth pattern in almost perfect alignment with schedule deviations:



Moving to a fifteen-minute interval in the day-ahead market should eliminate a lot of the saw-tooth pattern, but in the meantime market prices seem to be responding well, indicating that the saw-tooth management may not be worth incorporating into resource adequacy.
On the other hand, markets don't seem to be giving much of a signal for provisioning the three-hour ramp need. In 2016, for example, the daily maximum arbitrage between lowest and highest hour in the day-ahead market was only over $100 six times despite many more big (7.5GW+) ramp occurrences. A 100% efficient storage unit would only have made about $13/kW-year through arbitrage that year, not enough to justify investment. If it were able to get RA credit at prevailing rates for system RA, it could add another $30-40/kW-year and investors might start to be interested. But the question remains: is the market over-provisioned, inadequately signaling need, or both?

A multitude of forward procurement requirements with products in multiple markets starts to look like an excess of regulation. It may be wiser to concentrate limited regulatory resources on a few key guard-rails and then let the LSEs manage or mitigate their exposure to market prices through both supply-side and demand-side measures. For the later, facilitating the participation of a diverse set of resources in the energy markets should provide plenty of resource to manage ramp at least cost. A broad regional entity like the Energy-Imbalance Market, for example, should supply a lot of capacity for managing forecast errors in the FMM and RTD.

Recommendations

(1) The CAISO should further differentiate grid capacity needs in their analyses. Apart from predictable day-ahead shaping needs, the fifteen minute and five-minute uncertainty and forecast error should be further put through a low-pass filter to split off uncertainty related

to multi-hour ramping needs from shorter duration fluctuations with very little net-energy impact. Those late fluctuations should further be split between knowable compensating signals for time-frame mismatch during a ramp and genuine un-predictable fluctuations.

(2) Flexible resource adequacy through forward procurement should start with only the more predictable needs, like day-ahead shaping and a low-pass filtered fifteen-minute market product, that may require more advanced notice, commitment or changes in operational practices.

(3) For day-ahead shaping, we believe the CAISO should study moving away from ramp as a resource adequacy criterion, and instead look at "shift", the ability to move MWhs from one part of the day ahead schedule to another. For a dispatchable resource, like a natural gas plant, shift can be thought of as the ability to move its output up and down relative to a steady schedule. "Shift" could be further segregated, like ramp today, into an all-day available product, a faster responding product during key periods of the day, and infrequently called reserve ideal for some of the more economic demand-side options.

(4) Other capacity needs should be further characterized, including a description of what current resources can and do meet these needs today, how frequently various levels of need occur, and how they interact with reserve products like the flexiramp. The data presented so far by CAISO cries out for more signal analysis and filtering. Only after further characterization, in consultation with stakeholders, should the CAISO move on in the stakeholder process to define new resource adequacy products and recommended them CPUC. The onus is on CAISO to show that a market gap exists.

(5) To help California move away from heavy-handed planning requirements, CAISO should continue to improve visibility and coordination with neighboring balancing areas, develop a methodology for characterizing the level of risk in the market for undersupply, and follow barriers for resource adequacy that could be removed through policy. It could also develop backstop products that do not distort market participation incentives by reducing energy prices.

Looking Forward

As many have suggested, expanding the CAISO footprint to participation in a regional RTO would help considerably with regional coordination and visibility into resource adequacy. Yet in the absence of such, there is still plenty that can be done to stimulate better coordination of long-term procurement for predictable resource adequacy needs and to coordinate fast response to uncertainty using the widest possible set of resources.

Nobody can know for sure what it will mean to adapting to increasing levels of variable renewable resources, both at the utility and distribution scale, but it seems safe to bet that this will require changes not just in operational practices but also in our planning practices. For example, "shift" could not only become the main product for managing variability in net-load, it could also come to dominate over products solely targeted at meeting peak load. If sufficient energy is available for any given 24-hour period, all the system needs to meet peak load is to shift MWhs to those intervals (with the caveat that some "shift" resources will need to be more nimble to manage short-term deficits and surpluses) while preventing gluts and curtailment during other intervals. As the gas fleet capacity factor diminishes in

alignment with greenhouse reduction goals, they will be able provide less and less shift, so we need to prepare the way today for other resources to participate to meet this need with the fewest administrative and panning mindset barriers.