White Paper

CAISO's Lifeboat for Flexible Resources

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Shareables

- CAISO has experienced surplus flexible capacity, but this is set to change with phase-II of Flexible Resource Adequacy Must Offer Obligation (FRAC-MOO) program.
- More than 18 GW of capacity will be removed from the Effective Flexible Capacity (EFC) list, enabling existing qualifying resources to obtain higher capacity prices in near term.
- ICF expects a market correction in capacity prices for superior flexible resources, and especially assets located in constrained regions could be undervalued.

Executive Summary

A likely upcoming modification to CAISO's flexible resource adequacy program could provide the basis for higher capacity payments to combustion turbines and other highly flexible generation. The current flexible capacity program is oversupplied and of little value, with projected demand of 15.7 GW in 2018 but over 35 GW of qualified supply. Under proposed reforms, approximately 18 GW of existing supply will no longer qualify, primarily steam turbines (including portions of or entire combined cycle plants – though retrofit options may be possible for owners).

The remaining assets, primarily gas turbines and hydro, will likely see higher payments: CAISO has stated its intent that "resources with needed operational attributes receive price signal that reflect the need for that type of capacity".[1] The phase-II proposal is under further revisions, based on the stakeholder feedback, and the final draft proposal is expected by end of the year and is expected to be in effect for the 2020 resource adequacy (RA) compliance year.

CA Capacity Market Construct

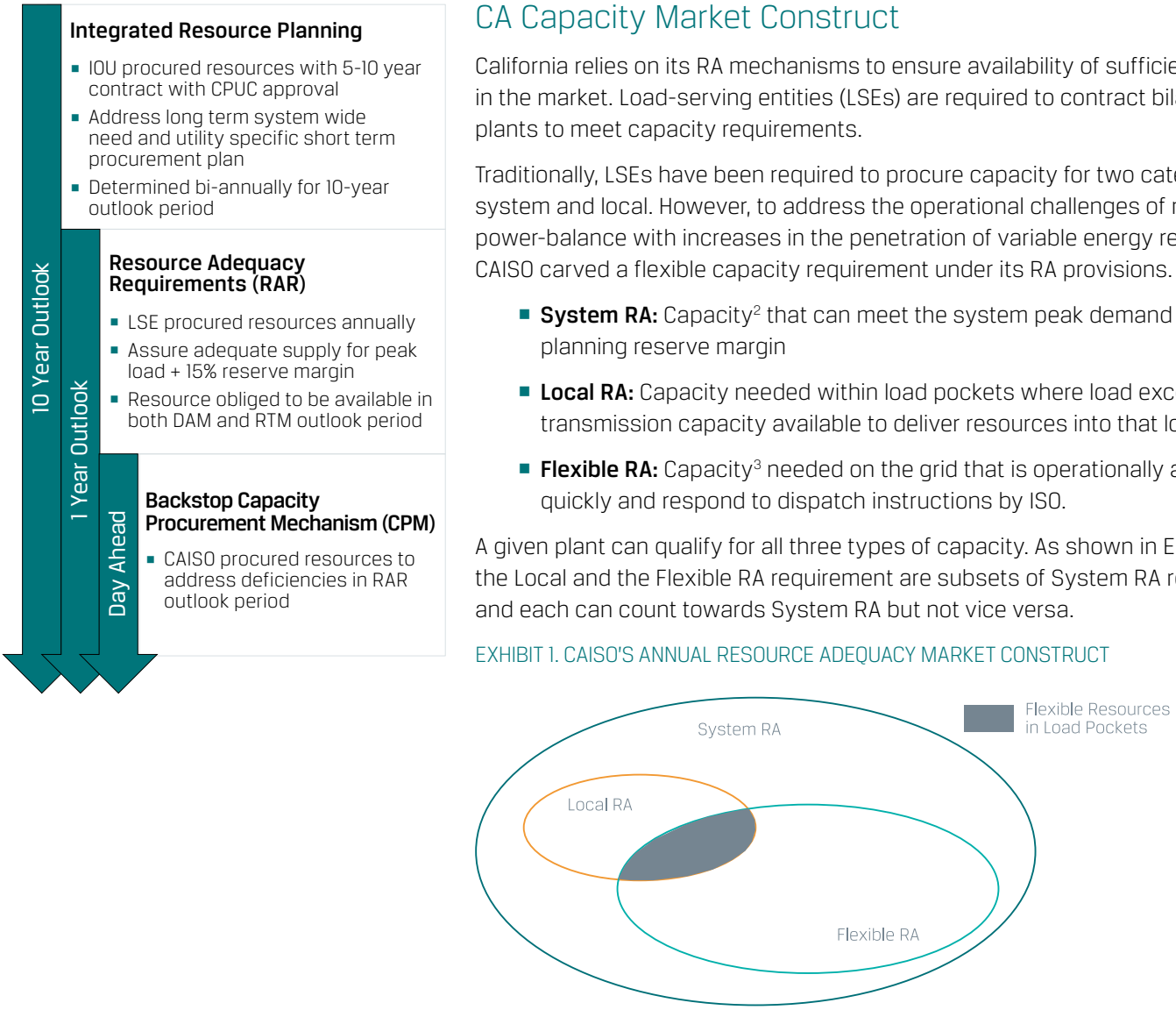
California relies on its RA mechanisms to ensure availability of sufficient capacity in the market. Load-serving entities (LSEs) are required to contract bilaterally with plants to meet capacity requirements.

Traditionally, LSEs have been required to procure capacity for two categories: system and local. However, to address the operational challenges of maintaining power-balance with increases in the penetration of variable energy resources, CAISO carved a flexible capacity requirement under its RA provisions.

- **System RA:** Capacity[2] that can meet the system peak demand and 15% planning reserve margin
- **Local RA:** Capacity needed within load pockets where load exceed transmission capacity available to deliver resources into that local area.
- **Flexible RA:** Capacity[3] needed on the grid that is operationally able to ramp quickly and respond to dispatch instructions by ISO.

A given plant can qualify for all three types of capacity. As shown in Exhibit 1, both the Local and the Flexible RA requirement are subsets of System RA requirement and each can count towards System RA but not vice versa.

EXHIBIT 1. CAISO'S ANNUAL RESOURCE ADEQUACY MARKET CONSTRUCT



Source: ICF

[1] Flexible Resource Adequacy Criteria and Must Offer Obligation – Phase 2, Revised Straw Proposal, May 8 2017

[2] Net Qualified Capacity: Resource capacity that is eligible to be included on system and local RA showings

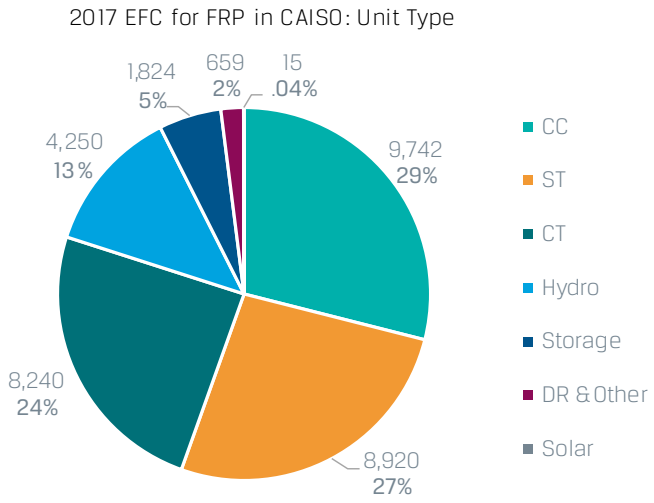
[3] Effective Flexible Capacity: Resource capacity that is operationally able to respond to dispatch instructions to manage variations in load and variable energy resource output. Only EFC of a resource is eligible for flexible RA showings

System and Local RA are essentially measured by a plants' installed maximum capacity, with renewables given monthly derate factors. Credit for Flexible RA (referred to as Effective Flexible Capacity, EFC) is given according to the amount of MW capable of being ramped up within three hours:

- For resources with startup times greater than 90 minutes, three hour MW ramp starting from minimum operating power condition
- For resources with startup times less than 90 minutes, three hour total MW ramp

In phase-I of the program virtually all dispatchable technology types are classified as flexible resources, regardless of their operational attributes: start-up time, minimum run-time, and minimum operating levels. Moreover, there is no cap on long-start resources that can meet the monthly flexible capacity needs. Therefore, with the projected demand of 15.7 GW in 2018, there are 35 GW of resources qualified as EFC under the current eligibility rules. Exhibit 2 shows the breakdown of flexible resources under phase-I.

EXHIBIT 2. EXISTING EFFECTIVE FLEXIBLE CAPACITY IN CAISO UNDER PHASE-I CRITERIA



Source: ICF

Step 1: Flexible Capacity Need Assessment

CAISO determines need for each month as: (Largest three hour net-load ramp) + (the higher of 3.5% monthly peak load or most severe single contingency)

Step 2: Allocation of Quantities

- CAISO specify flexible needs into three categories
- Capacity is allocated to LSEs based on their contribution to the net load ramp

Step 3: Procurement

- LSEs are obliged to procure their share of flexible capacity and produce bilateral contracts for Flexible RA showings

Challenges with Flexible Capacity

California has set the target of 50% RPS by 2030 and its senate has already approved an ultimate goal of 100% RPS by 2045. The increased share of renewable generation in CA, particularly solar PV, requires significant reliance on flexible resources. However, the capacity from steam turbine and combined cycle units, which accounts for the majority of the qualified capacity in the current EFC list, presents key operational risks for CAISO:

- **Insufficient ramping speed:** 43% of flexible capacity showing for 2017 have ramp speeds less than 10MW/min.[4] In theory the ISO can address this by committing multiple slow ramping resources, but it limits the ISO's ability to manage intra-hour variability and renewable curtailment.
- **High minimum operating level:** To meet the upcoming ramping needs in the evening the ISO needs to dispatch large quantities of capacity with high minimum operating level (Pmin). This dispatch leads to over-generation and curtailment of clean energy. In January 2017 for example, over 40 GWh of renewables were curtailed in California.[5]
- **Long Start Resources:** The resources that qualify as long start are not obliged to participate in real-time if they don't receive commitment in the day ahead market. Hence, large quantities of flexible long start resources limits the ISO's ability to address the real-time flexibility needs. For 2017, typically 40% or more of the fleet shown on the Flexible RA showings are long start resources.[6]
- **Non-availability on the weekends:** In 2016, many of the largest ramps were observed on weekends and in the current qualifying criteria, certain categories of resources are not required to be available on holidays or weekends.

Since 2015, the RA contract prices have remained flat at an average of $2.6/kW-mo in the CAISO region.[7] Furthermore, the on-peak spark spread forward for gas turbines in CAISO is expected to remain below $2.5/MWh through 2021.[8] With insufficient revenue from the energy and ancillary services markets, RA revenues are becoming more vital to prevent the economic retirement of the flexible resources and meeting the state policy goals.

[4] FRAC-MOO, Supplemental Issue Paper: Expanding the Scope of the Initiative, November 2016

[5] Market Performance Report: January 2017, CAISO

[6] FRAC-MOO, Supplemental Issue Paper: Expanding the Scope of the Initiative, November 2016

[7] 2016 Resource Adequacy Report, CPUC, June 2017

[8] 10,000 Btu/kWh. Assumed NP-15 On-Peak electricity futures and zonal gas price futures for PG&E Gate

Proposed Enhancement in Phase-II

In order to increase the overall availability and improve the average ramp rate of the flexible capacity fleet, CAISO proposes that a flexible resource must have[9] :

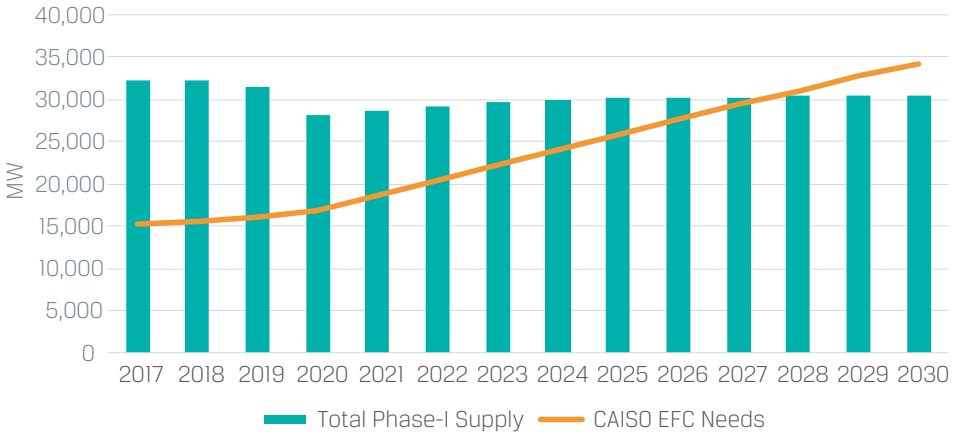
- Start-up time of less than 4.5 hours
- Minimum run time of less than 4.5 hours
- Should be available seven days a week under each category

These modifications to qualifying criteria will eliminate 18 GW of inferior flexible resources, which mainly includes combined cycle and steam turbine units (Exhibit 2). The ineligible resources include 1.3 GW of long-start capacity, 1.1 GW with minimum run-time higher than 4.5 hrs, and 15.5 GW of resources which have both a long start-up time and min-run time. The phase-II update is expected to mitigate the associated Pmin burden for the gird operators and minimize the curtailment of renewable resources. With 18 GW of resources deemed ineligible for flexible RA, there would be 18.7 GW of EFC left for the projected need of 16.8 GW in 2020.

Resulting Supply-Demand Dynamics

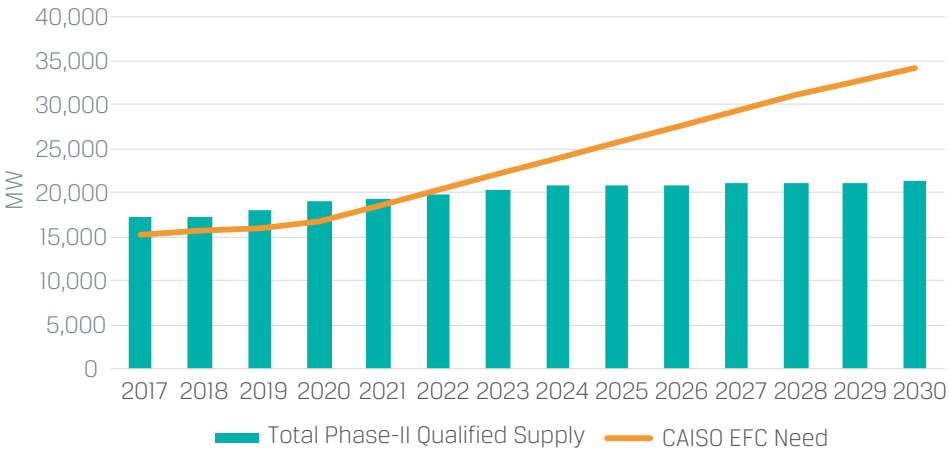
Exhibit 3 provides the Supply-Demand (S-D) balance for the annual flexible capacity through 2035 with phase-II criteria. Considering the ineligible resources, firm builds, and firm retirements through 2021 CAISO appears to have insufficient flexible capacity in the market. Furthermore, the underlining renewables growth considered for assessment is thew 50% RPS scenario for 2030. An accelerated growth of renewables may further tighten the S-D balance.

EXHIBIT 3. ILLUSTRATIVE EFFECTIVE FLEXIBLE CAPACITY IN CAISO UNDER PHASE-I OF THE FRAC_MOO PROGRAM



[9] Source: FRACMOO 2 revised straw proposal dated 05/01/2017

EXHIBIT 3. ILLUSTRATIVE EFFECTIVE FLEXIBLE CAPACITY IN CAISO UNDER PHASE-II OF THE FRAC_MOO PROGRAM



Source: ICF

Impact on Thermal Assets Valuations

To understand the impact of revised criteria in phase-II, an analysis was performed on a representative model of the CAISO grid using ICF's Integrated Planning Model (IPM) tool. Key findings from the study are:

- Capacity prices for qualified flexible resources will see an upwards trend in the near-term. Flexible generators with superior characteristics may obtain long term contracts considering a tighter S-D outlook beyond 2021 and the ISO's long-term needs for reliability.
- CAISO's numerous initiatives, in addition to Flexible RAR construct, will need generation injection in transmission constrained pockets like the San Diego IV Area. Flexible generation assets located in or around such load pockets need to be appropriately valued as they can address multiple RAR for LSEs (Exhibit 1).
- With an increasing share of Flexible RA capacity in System RAR, standalone demand for non-flexible resources is projected to decline significantly by 2035. A significant portion of these generators would only be able to secure RA contracts for a few months with peak periods. The non-flexible capacity glut in the CAISO region is likely to drive shuttering of slow-starting natural gas plants.
- The growing share of zero-marginal cost renewables in the energy market has significantly increased the risk of early economic retirement of high fixed cost thermal units. However, certain existing long-start thermal units could implement operational changes and/or retrofit for improved flexible operation that could allow for improved operation at sub-4.5 hour run times (currently the likely barrier to phase-II qualification for many units).

While it is unclear if the projected flexible capacity shortage in the mid-2020s would result in procurement of new thermal resources, ICF believes that the

flexible RA mechanism would serve as a lifeline for existing natural-gas based superior thermal generators in California. After the working group meeting on August 2nd, the proposal is undergoing another round of stakeholder comments for addressing hourly and sub-hourly ramping needs with shorter duration flexible RA products. The draft final proposal is expected by the end of 2017 and will likely be in effect for the 2020 RA compliance year.

About the Authors

Patrick Milligan is an associate with ICF's Commercial Energy division with expertise in market modeling and forecasting, portfolio valuation and risk assessment across North American markets, and frequently works across both engineering and economic models to assess risk for renewable projects.

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