



Resource Flexibility

The rapid growth in renewable resources in California represents significant progress toward reaching the state’s renewable energy and greenhouse gas (GHG) reduction goals. Most recently, Senate Bill 100 (de León, Chapter 312, Statutes of 2018) increases the state’s renewable goal to require that 60 percent or retail sales in California be served with eligible renewable resources by 2030 and sets a planning target of 100 percent zero-carbon electricity resources by 2045. Governor Edmund G. Brown Jr. signed Executive Order B-55-18 setting a new statewide goal to achieve carbon neutrality (zero-net GHG emissions) by 2045 and to maintain net negative emissions thereafter.

As discussed in the Renewables Tracking Progress page, wind and solar resources have grown tremendously over the last decade. In particular, solar photovoltaics increased from essentially zero megawatts (MW) in 2001 to more than 9,600 MW of utility-scale and 6,700 MW of rooftop in 2017. Statewide, 5,600 MW of rooftop solar has been installed since 2011.

With this unprecedented growth in renewables in recent years, there has been growing recognition that system operators need additional flexible capabilities to balance supply and demand. This need for flexibility is required to accommodate morning and late-afternoon ramps in energy net load (load minus solar and wind generation) resulting from solar resource output. According to the California Independent System Operator (California ISO), ramps and minimum loads are four years ahead of their initial estimates, primarily due to growth in renewable energy projects.¹ Furthermore, because of expected changes in the dispatchable natural gas-fired fleet, the California ISO is concerned that it needs greater operational control over resources with flexible capacity.²

The Need for Flexible Resources

The California ISO popularized a graphical depiction of the “net load curve” (the “duck chart”) that dispatchable generating resources must satisfy each hour on a “typical” spring day. A net load curve shares many features with a total load curve but subtracts the hour-by-hour contribution of wind and solar generation (or “intermittent” resources). **Figure 1** on the next page illustrates the extent to which resources must be available to ramp up or down to respond to this need. When solar electricity generation peaks at midday, the net load is low and is described as the “belly of the duck.” As solar generation trails off at the end of the day and demand remains high (or increases), the steep ramp upward is referred to as the “neck of the duck.”

1 California ISO presentation at the June 20, 2018, Integrated Energy Policy Report (IEPR) Workshop on Renewable Integration and Electric System Flexibility, <https://efiling.energy.ca.gov/GetDocument.aspx?tn=223856>.

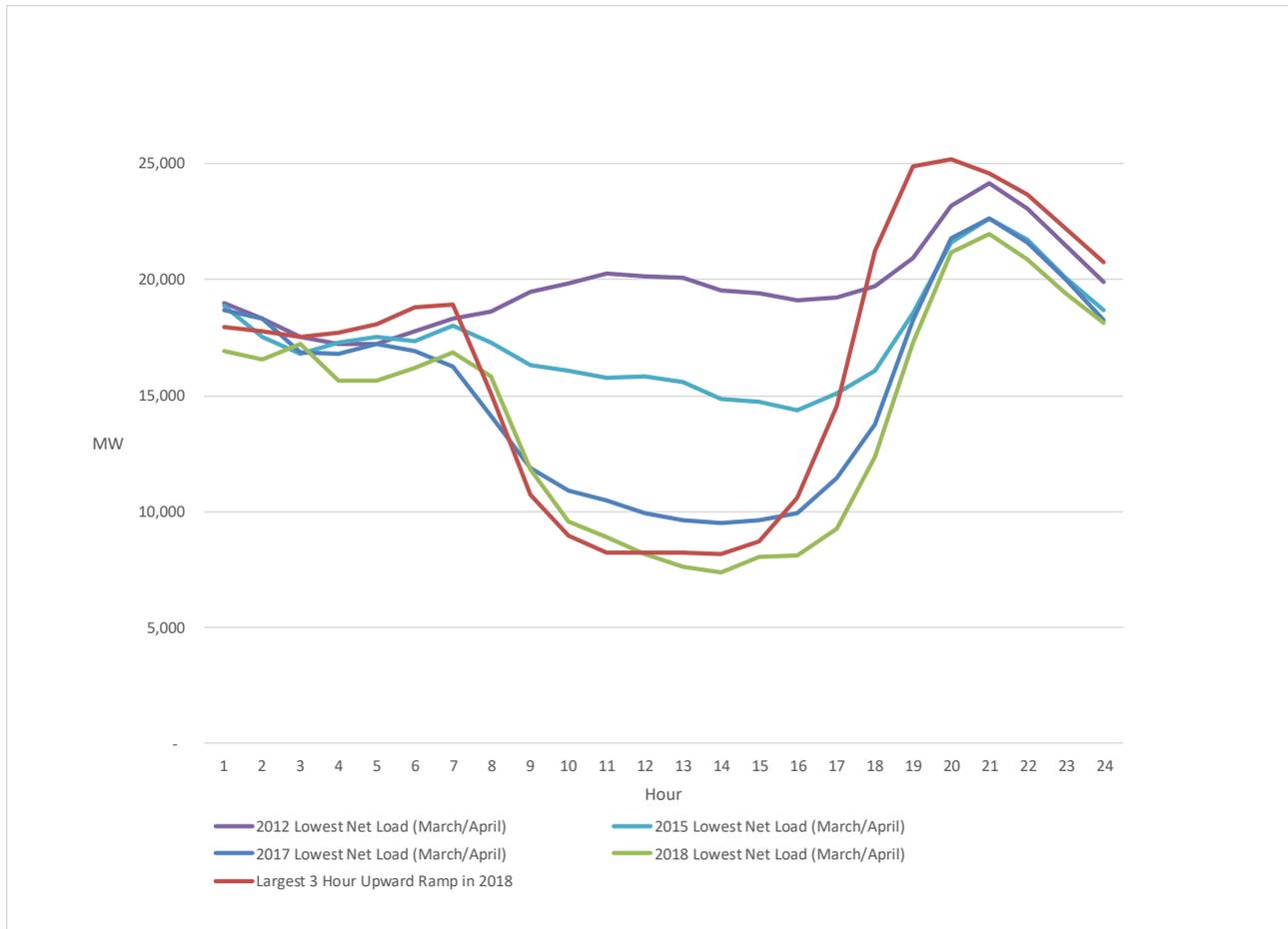
2 The California ISO believes it needs more operational control than is available through California Public Utilities Commission (CPUC) rules or existing California ISO tariffs. This issue is currently being addressed in the California ISO Flexible Resource Adequacy Criteria Must Offer Obligation (FRACMOO 2) Stakeholder Initiative.



California Energy Commission – Tracking Progress

The ramps up in the evening and down in the morning (“the tail of the duck”) have become more pronounced and steeper than the California ISO anticipated, largely due to faster-than-expected growth in rooftop solar photovoltaic (PV) and progress toward the renewable goals. In 2013, the California ISO projected that net load could be as low as 12,000 MW by 2020 and that meeting peak demand may require generators ramping up as much as 13,000 MW in three hours. Recent events illustrate that the grid is already experiencing unprecedented operational fluctuations that grid operators were expecting in 2020³. On February 8, 2018, the net load reached a minimum of 7,149 MW, and on March 4, 2018, the maximum three-hour ramp was 14,777 MW, with the peak shifting to later hours in the day. **Figure 1** uses California ISO data for March and April for years 2012, 2015, 2017 and 2018 and depicts the day with the lowest net load for all years, as well as the day in 2018 with the steepest 3 hour ramp (March 4, 2018). This figure is illustrative of the deepening mid-day trough and associated steep afternoon ramp that is creating the need for available flexible capacity.

Figure 1: California ISO Net Load and Three-Hour Ramp



Source: Developed by Energy Commission staff using data from the California ISO

³ <http://www.caiso.com/Documents/Agenda-Presentation-2019DraftFlexibleCapacityNeedsAssessment.pdf>.



California Energy Commission – Tracking Progress

In response to the many challenges of integrating such large quantities of renewable energy, the Energy Commission, CPUC, and the California ISO are looking to better manage oversupply and minimize curtailment, accelerate deployment of storage and demand-side programs, improve supply-side forecasting techniques, and take advantage of regional diversity in both supply and demand.

Flexibility Requirements

In the past, a standard one-hour time resolution was sufficient to match large amounts of renewable resources with firming resources that can compensate for the intermittency of renewables. However, operational concerns in the California electrical system are increasingly focused on much shorter time scales. For example, there may be plenty of reserve generation capacity but a lack of fast-responding resources that can follow a rapid change in generation and load. Thus, key characteristics of firming resources include not only total capacity, but also response times and ramp rates (megawatts per minute).

Analyses to date suggest that flexible capacity has to address variability in load and power production in three time scales: (1) seconds-to-minutes, (2) 5-10 minutes, and (3) multi-hour. Variations in the seconds-to-minutes time scale can be addressed by expanding the existing regulation service, such as using automatic generation control on existing generators. Storage is increasingly seen as a possible solution to these regulation concerns. The 5-10 minute flexibility requirements address discrepancies between the 5-minute real-time market schedules and actual loads or generation encountered during these intervals. Multi-hour ramps up and down have been a feature of California's electrical system for decades, but the introduction of large amounts of renewable capacity with strong diurnal cycles exacerbates these traditional patterns, especially in winter and spring months, and is the focus of flexible capacity studies at the California ISO. Improved forecasting of load and intermittent renewable production is one approach for addressing this issue.

Currently, the California ISO is attempting to improve its forecasting methods and apply them to a newly configured day-ahead market via the Day Ahead Market Enhancement (DAME) stakeholder process.⁴ By moving the day-ahead market from an hourly forecast to a fifteen-minute forecast, the California ISO intends to improve market efficiency and better align resources to meet ramping needs. The change to a fifteen-minute granularity will apply to the Western Energy Imbalance Market and will require design changes to the Western EIM as discussed in the Second Revised Straw Proposal for the DAME initiative.⁵

Market changes, as well as flexible resource development, may help the electricity system evolve to include larger shares of renewables in the resource mix. For example, in 2016 the California ISO introduced a formal flexible ramping product into its market system following

⁴ <http://www.caiso.com/informed/Pages/StakeholderProcesses/Day-AheadMarketEnhancements.aspx>.

⁵ <http://www.caiso.com/Documents/SecondRevisedStrawProposal-Storageas-TransmissionAsset.pdf>.



California Energy Commission – Tracking Progress

Federal Energy Regulatory Commission (FERC) approval.⁶ Scheduling renewables in smaller time intervals, such as the real-time market, can reduce the amount of reserves required since the opportunity for differences between forecast and actual generation is reduced from an hour to a shorter time interval. In addition, expanding the geographic footprint of the market can help in two ways. First, greater diversity of renewable resources can reduce the coincidence of production patterns. Second, loads in larger regions outside the California ISO can help absorb excess production and generating resources in those regions may be able to assist California with upward ramping requirements.

Overgeneration

Overgeneration is the condition represented by the “belly” of the duck curve. Overgeneration exists when net load falls below the total minimum generation level of other resources that must be on-line. Spring months with high wind and solar production coupled with low loads are the prime time for overgeneration conditions.⁷ Some options to solve overgeneration include relying on more flexible generating facilities from either a physical or contractual perspective,⁸ curtailing renewable generation, using energy storage technologies, or by exporting power outside the California ISO balancing authority area. In addition, tools such as demand response and time-of-use rates can be used to shift the timing of energy consumption to maximize the use of renewable energy.

Included in the list of options for addressing overgeneration is curtailment of renewable energy resources. While this is one of the least desirable solutions, it is sometimes necessary to balance the system. **Figure 2** summarizes monthly renewable energy curtailment in the California ISO balancing area since January 2016. As shown in **Figure 2**, curtailment has occurred each month, with the highest levels in late winter and early spring, although curtailment was also high in October 2018. Allowing for energy transfers to other balancing authority areas in the real time market is another solution for overgeneration.

⁶ FERC, Docket No. ER16-2023-000, September 26, 2016. See <https://www.ferc.gov/CalendarFiles/20160926164141-ER16-2023-000.pdf>

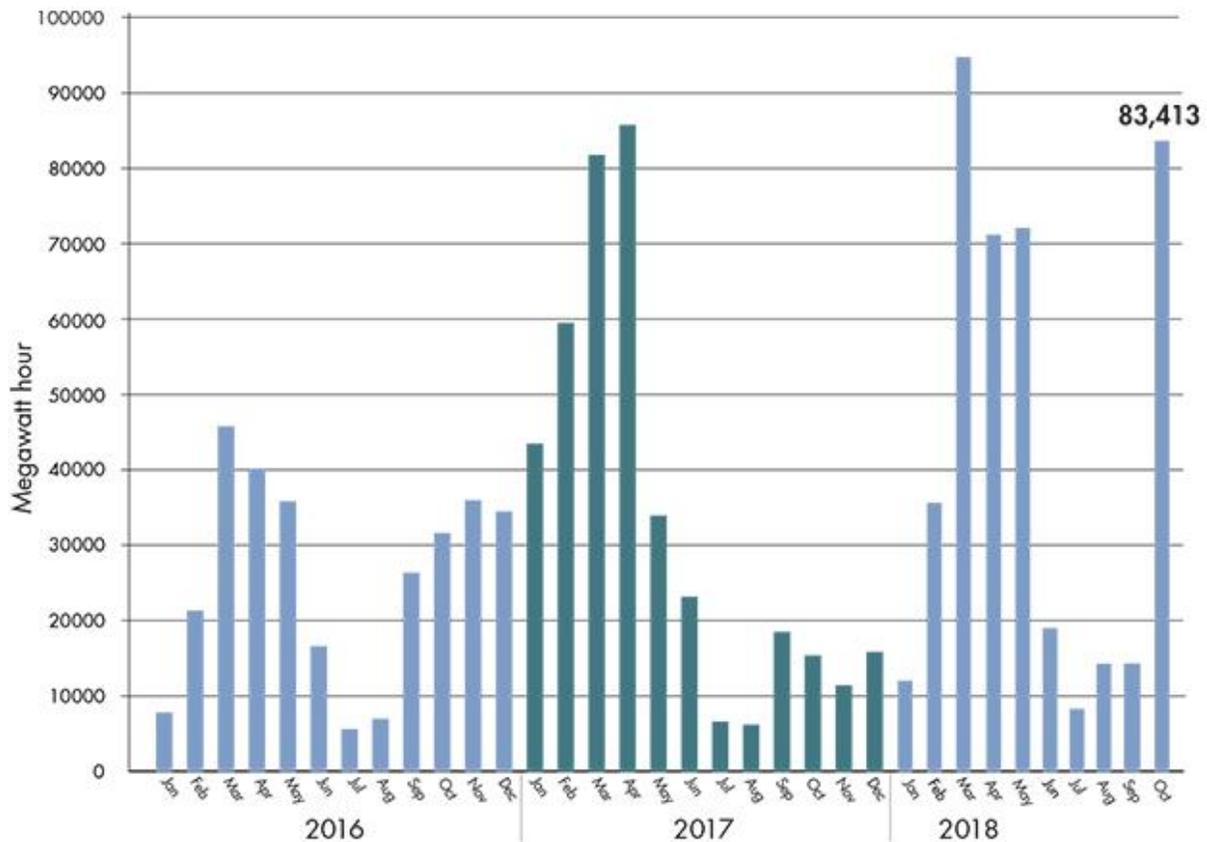
⁷ See California ISO report for a summary of overgeneration issues and its study results. <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M152/K411/152411557.PDF>.

⁸ For example, there may be a need to retrofit existing natural gas plants to reduce minimum generation levels.



California Energy Commission – Tracking Progress

Figure 2: California ISO Monthly Renewable Energy Curtailment



Source: California Independent System Operator <http://www.caiso.com/informed/Pages/ManagingOversupply.aspx>

Regional Approach to Flexibility Issue

The development of a regional grid is an important tool to help integrate renewable resources. Initiated in 2014, the Western Energy Imbalance Market (EIM) is a wholesale energy market that allows participants to buy and sell energy in real-time. Its benefits have grown as more entities join and increase access to more generation and transmission. The Western EIM began with the inclusion of PacifiCorp, but continues to expand with the addition of NV Energy, Arizona Public Service, Puget Sound Energy, Portland General Electric, Idaho Power Company, and Powerex as participants. The list of pending participants includes Seattle City Light, Los Angeles Department of Water and Power, Sacramento Municipal Utility District (SMUD), Balancing Area of Northern California, Salt River Project, Public Service Company of New Mexico, and Northwestern Energy. In addition, the Bonneville Power Administration (BPA) and the Centro Nacional de Control de Energia (Baja California) have expressed interest in joining the Western EIM.

The Western EIM is a mechanism to balance deviations in supply and demand and dispatch least-cost resources every five minutes. With the Western EIM, excess energy in the California



California Energy Commission – Tracking Progress

ISO balancing area can be transferred to other areas in real time. Through the second quarter of 2018, the Western EIM has provided gross benefits of \$402 million and has reduced greenhouse gas emissions in the west by 306,000 metric tons of carbon dioxide equivalent.⁹

Increasing the regional scale of the system beyond what can be achieved with the Western EIM can provide additional flexibility while reducing costs and GHG emissions. PacifiCorp has shown interest in joining the California ISO as a participating transmission owner rather than continuing to operate as a separate balancing authority. This would reduce scheduling restrictions and facilitate least-cost dispatch. SB 350 (de León, Chapter 547, Statutes of 2015) established a process and criteria for expansion of the California ISO to include other western utilities.¹⁰ The California ISO has completed the economic and environmental impact studies required by SB 350 and has submitted them to the California Legislature.¹¹ However, in August 2018 the California ISO expansion bill did not make it out of committee and the future of the expansion may be in doubt.

Another potential regional approach to meeting the flexible capacity need has been to consider additional import capability from the Pacific Northwest. The Energy Commission and the CPUC asked the California ISO to consider studying enhancements to the transmission system that could bring more carbon-free imports to California from BPA (which may aid the California ISO with meeting ramping needs). According to BPAs presentation at the June 20 IEPR Workshop on Integrating Renewables, the analysis will be a part of the California ISO 2018/2019 Transmission Planning Process and BPA will participate in the study.¹²

How Texas Approaches Integrating Renewables

The California ISO is not alone in dealing with renewable resource integration issues. The Texas electric grid operator, the Electric Reliability Council of Texas (ERCOT), wind capacity in Texas has grown by about 17,000 MW in the last decade. According to the American Wind Energy Association, as of October 2018 there were more than 23,000 MW of wind resources installed in the ERCOT balancing area, about four times the wind capacity in California.¹³ To integrate this large amount of intermittent resources, Texas imposed market rules to ensure the stability and reliability of the grid, as well as penalties for non-compliance. ERCOT controls dispatch of the wind resources in real time and uses five-minute wind forecasts so that ERCOT staff can match resources to loads for ramping and inertia requirements. Also, market signals (prices) are used to keep adequate amounts of capacity available for ancillary services and to

9 https://www.westerneim.com/Documents/ISO-EIMBenefitsReportQ2_2018.pdf.

10 Senate Bill 350 (De Leon, Chapter 547, Statutes of 2015).

11 <http://www.caiso.com/informed/Pages/StakeholderProcesses/PacifiCorpIntegrationStudies.aspx>

12 https://www.energy.ca.gov/2018_energypolicy/documents/2018-06-20_workshop/2018-06-20_presentations.php.

13 In June 2018, about 5,700 MW of wind was installed in California. California Energy Commission, Renewable Energy Tracking Progress, updated July 2018.



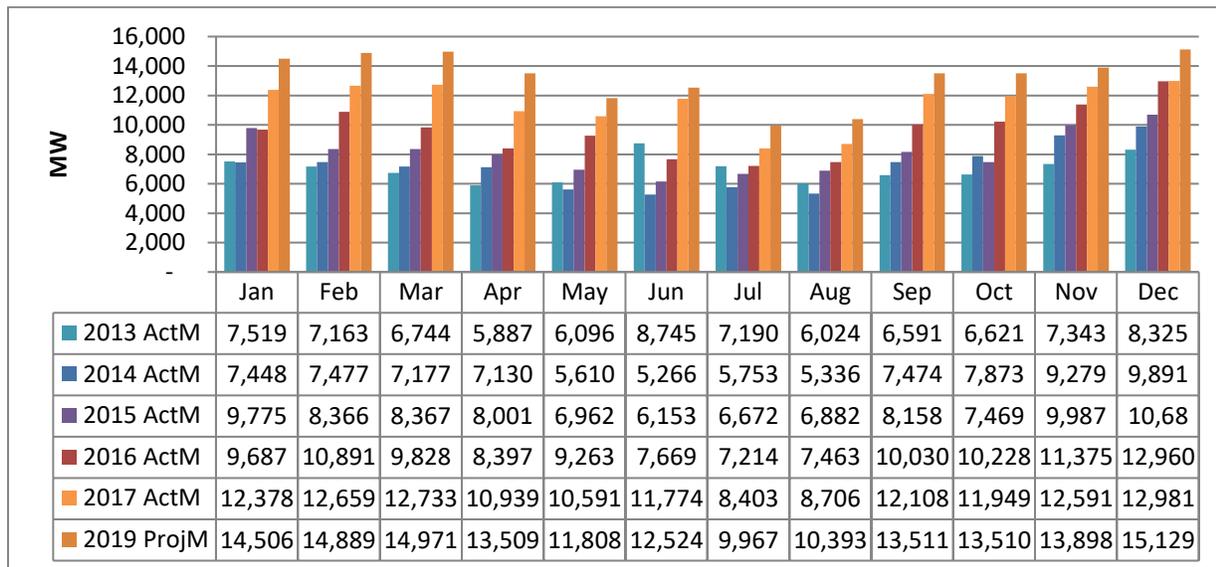
California Energy Commission – Tracking Progress

ensure the ERCOT grid is stable. (See Chapter 3 of the *2017 California Integrated Energy Policy Report*¹⁴ for more detail on renewable integration in ERCOT.)

Ramps

As with its previous studies, California ISO analyses completed in May 2018 show that the problem of rapidly increasing net load ramps is most severe November through March.¹⁵ **Figure 3** provides an estimate of the maximum ramp over 180 minutes by month for five historical years and projected for 2019 based on renewable projects now in the pipeline.¹⁶ **Figure 3** shows that maximum monthly 180-minute ramps were relatively uniform throughout the year up to about 2014 but become much larger for the eight nonsummer months in the following years. The implication is the need for flexible resources to satisfy this increasing ramp for these nonsummer months, the opposite of the traditional capacity planning focus on summer peak months of July to September.

Figure 3: Comparing Historical and Projected Maximum Three-Hour Ramps by Month



Source: California ISO, *Final 2019 Flexible Capacity Needs Assessment*, Figure 1, page 8, and Energy Commission staff

For the first time, the California ISO study for 2017 flexibility requirements included behind-the-meter PV generation. This increased the three-hour ramps considerably. As noted earlier, the rapid growth in behind-the-meter PV capacity means that the load curve does not remain static,

14 California Energy Commission staff. 2017. *2017 Integrated Energy Policy Report*. California Energy Commission. Publication Number: CEC-100-2017-001-CMF. https://www.energy.ca.gov/2017_energy_policy/index.html.

15 California ISO, <http://www.caiso.com/Documents/2018FinalFlexibleCapacityNeedsAssessment.pdf>.

16 Energy Commission staff used data directly from the California ISO study for the forecast year, while historical data reflect Energy Commission staff analysis of data from the California ISO.



California Energy Commission – Tracking Progress

but is lower during the middle hours of the day, creating ramping requirements where none would have existed without the behind-the-meter PV.

Effective Flexible Capacity

Since the California ISO assessments assume that the great majority of renewable resources will continue to be “must take,” the California ISO wants to ensure that sufficient flexible capacity will be available to satisfy these growing ramping requirements. The California ISO proposed,¹⁷ and the CPUC accepted,¹⁸ a definition of effective flexible capacity for each generating facility that accounts for its start-up time, ramping ability over three hours, minimum generation level, and net qualifying capacity.¹⁹ **Table 1** assesses the collective amount of effective flexible capacity by generating technology and fuel type.²⁰ While California has mandated higher renewable energy minimums and a reduction in carbon emissions, about 75 percent of flexible capacity available to meet ramping needs is fired by natural gas.

Clearly, the total 32,308 MW of existing flexible capacity expected to be available in 2019 exceeds the largest California ISO estimate of 2019 requirements. However, there are three concerns suggesting that the balance between requirements and capabilities is tighter than it might appear in comparing **Figure 3** with **Table 1**, as explained below.

Table 1: Effective Flexible Capacity by Generating Technology and Fuel Type (Megawatts)

Generating Technology	Natural Gas	Coal	Fuel Oil	Hydro	Renewables	DR & Storage	Total
Steam	5,428	373	-	-	595	-	6,395
Combined Cycle	11,772	-	-	-	-	-	11,772
Combustion	7,423	-	165	-	7	-	7,595
Reciprocating	100	-	-	-	10	-	110
Hydro	-	-	-	4,338	-	-	4,338
Pump Storage	-	-	-	1,457	-	-	1,457
Photovoltaic	-	-	-	-	-	-	-
Other	-	-	-	-	2	76	78
DR Programs	-	-	-	-	-	563	563
Total	24,722	373	165	5,795	614	639	32,308

Source: California Energy Commission staff analysis of California ISO data
(<http://www.caiso.com/Documents/2019NetQualifyingCapacity-EffectiveFlexibleCapacityValues-RRResources.html>)

17 <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M064/K141/64141005.PDF>, slide 18.

18 CPUC, Decision 13-06-024, Rulemaking 11-10-023, Decision Adopting Local Procurement Obligations for 2014, A Flexible Capacity Framework, and Further Refining the Resource Adequacy Program, June 27, 2013, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M070/K423/70423172.PDF>.

19 Effective flexible capacity is the number of megawatts eligible to be counted towards meeting a load serving entity’s 3-hour net load (load minus wind and solar generation) ramping requirements.

20 Calculated by Energy Commission staff from the Final Effective Flexible Capacity List for 2019 posted by the California ISO. <http://www.caiso.com/Documents/2017EffectiveFlexibleCapacity-ResourceAdequacyResources.html>.



California Energy Commission – Tracking Progress

Nearly all of the steam turbine capacity is very old, and most of it uses once-through cooling (OTC) technology. Facility owners must comply with State Water Resources Control Board (SWRCB) OTC policy by retiring or retrofitting the power plants. (For more information, see the Tracking Progress page on [Once-Through Cooling](#).) Responses to SWRCB information requests reveal that nearly all generator owners plan to comply by retiring, although many would prefer to repower if long-term contracts can be secured from load-serving entities (LSEs). All OTC facilities in the California ISO balancing authority area are scheduled for shutdown by the end of 2020, although there may need to be adjustments to the compliance schedule due to construction delay and other litigation issues. Retiring all of the remaining natural gas steam boiler effective flexible capacity (5,428 MW) would reduce the remaining effective flexible capacity of the generating fleet to about 27,000 MW if no additional effective flexible capacity was added. Such retirements are already occurring and impacting the total effective flexible capacity. Since the 2016 resource flexibility update, about 3,500 MW of gas-fired steam turbines have retired (or are unavailable to meet this effective flexible capacity need). This reduction in capacity has been partially offset by increases in available flexible capacity, primarily from gas-fired combine cycles.²¹

In addition, much of the fossil-fired generating fleet must shut down for annual maintenance, and the optimal time has typically been in the winter months, when loads have been low. The recent increase in need for much larger amounts of flexible capacity in winter months means that there are now competing motivations for when to schedule maintenance: (1) avoid winter months to make capacity available for flexibility requirements, versus (2) continue maintenance in off-peak months when it is not needed for base capacity.

Finally, even if sufficient physical flexible capacity exists, such resources may not be available to the California ISO when flexibility is needed. The California ISO markets have traditionally featured a large amount of self-scheduling. While generation owners can specify the price(s) at which the California ISO can induce changes in the amount of energy or ancillary services they provide, a self-scheduled generation resource does not specify such a price or prices, effectively precluding the California ISO from changing the amount provided. Utilities — load-serving entities that own generation — will frequently self-schedule their own generation to satisfy their load and ancillary service requirements, thereby reducing the amount of capacity that the California ISO can (re)dispatch to meet operational needs. For example, LSEs, through their scheduling coordinator, choose when to generate to serve their load. For capacity that is nominated to satisfy current system and local resource adequacy requirements, the generating capacity must be available to the California ISO if it is not self-scheduled. If it is self-scheduled, then the resource adequacy obligation is satisfied.

However, for flexible capacity that must be responsive to intermittent wind and solar generation, the California ISO wants to have greater control to ensure that it can dispatch capacity up or down to satisfy net loads. LSE/generator contracts with self-scheduling will still be allowed, but

²¹ EFC capacity is not the same as nameplate or net qualifying capacity. Old, slow-moving steam turbines have much lower EFC ratings than the associated nameplate ratings.



California Energy Commission – Tracking Progress

such capacity will not count as flexible. An LSE wishing to continue to self-schedule will be required to satisfy its share of the aggregate, or combined, flexible capacity requirements by nominating other capacity that is both physically flexible and can be dispatched up or down by the California ISO.²² Beginning with calendar year 2015, the flexibility requirements adopted by the CPUC in Decision (D) 13-06-024²³ (parallel requirements were established by the ISO for non-CPUC jurisdictional LSEs within its balancing authority area) were matched by complementary obligations on effective flexible capacity to submit economic bids into California ISO markets and to respond to dispatch instructions.

Balancing Requirements With Expected Capabilities

In D.13-06-024, the CPUC determined that it would implement in 2015 the general approach of imposing an effective flexible capacity requirement proposed by the California ISO.²⁴ Numerous implementation questions were resolved in D.14-06-050. In June 2015, the CPUC adopted comparable requirements for 2016 using results from a California ISO study for 2016 that largely replicated its analyses for 2015.²⁵ The CPUC reached a similar conclusion for 2017 in its annual resource adequacy decision, D.16-06-045.²⁶ In addition, while the CPUC has recognized the need to replace the interim flexible resource adequacy program with a “durable” approach, the interim remains in place for 2018 (D.17-06-027²⁷) and again for 2019 (18-06-031²⁸).

The evolution of flexibility requirements satisfactory to both the CPUC and California ISO has resulted in mechanisms that assure that an appropriate mix of flexible capacity is available to the California ISO each month. The approved mechanism allows the use of limited resources to satisfy a portion of the flexibility requirements. In D.14-06-050, the CPUC established the following three categories on an interim basis:

- Category 1: Base Flexibility (must offer from 5 a.m. to 10 p.m. daily, year round)
- Category 2: Peak Flexibility (must offer 5 hours per day defined seasonally with at least one start per day)

22 To “nominate” capacity means to submit a proposed schedule and price points to the California ISO scheduling process and to accept the results of the California ISO’s market optimization process.

23 CPUC, Decision 13-06-024, Rulemaking 11-10-023, Decision Adopting Local Procurement Obligations for 2014, *A Flexible Capacity Framework, and Further Refining the Resource Adequacy Program*, June 27, 2013, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M070/K423/70423172.PDF>.

24 D.13-06-024, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M070/K423/70423172.PDF>.

25 CPUC D.15-06-063, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M152/K977/152977475.PDF>.

26 Decision 16-06-045, Rulemaking 14-10-010, *Track 1 Decision Adopting Local and Flexible Capacity Obligations for 2017, and Further Refining the Resource Adequacy Program*, June 23, 2016, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M164/K214/164214092.PDF>.

27 <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M192/K027/192027253.PDF>.

28 <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M217/K015/217015083.PDF>.



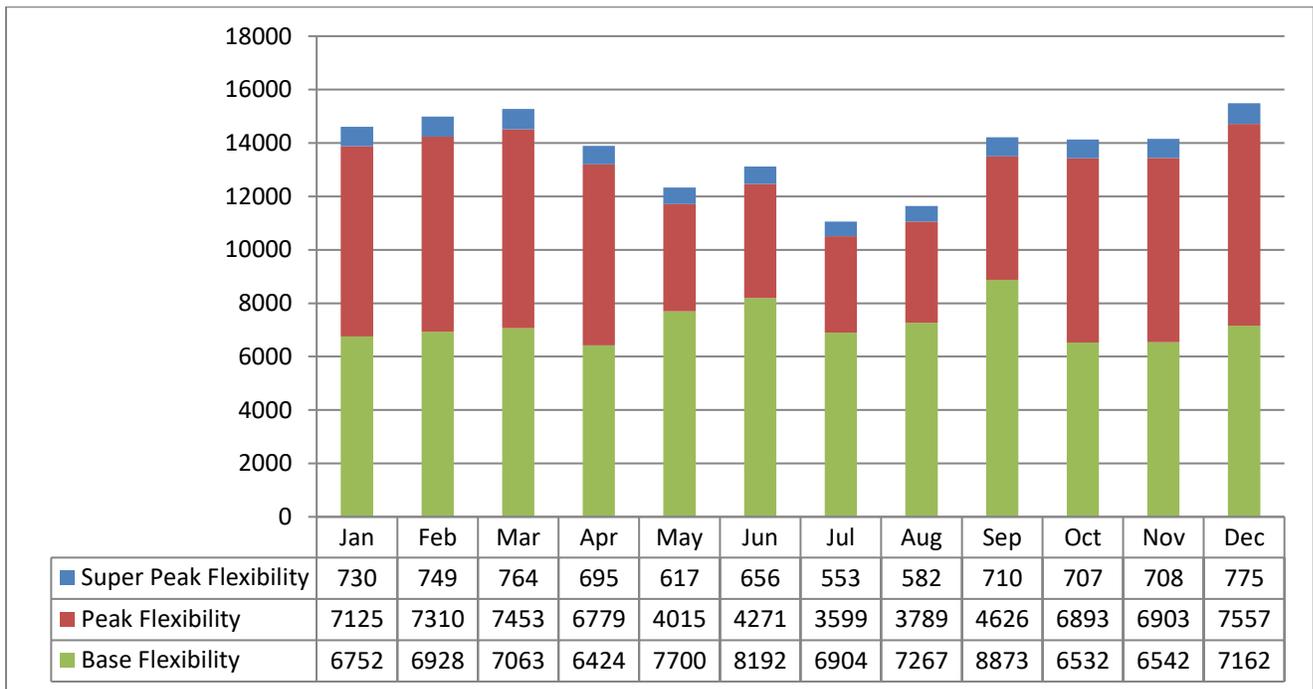
California Energy Commission – Tracking Progress

- Category 3: Super-Peak Flexibility (must offer 5 hours per day defined seasonally, with obligation complete after five starts per month)

The California ISO created obligations on the generators that matched these three categories.

Figure 4 represents total flexibility requirement allocated by the California ISO to the CPUC, and how the three categories could be used to satisfy the overall requirements for CPUC-jurisdictional LSEs. The numeric limit for Categories 2 and 3 is a maximum, while the limit for Category 1 is a minimum. In effect, peak and superpeak resources are allowed to be chosen up to specified monthly limits, while Category 1 can be used as much as the LSE desires. Each LSE can establish its own preferred combination of specific generating resources, or other programs allowed providing flexible capacity, guided by these aggregate limits. The CPUC adopted these quantities in D.17-09-020.

Figure 4: Monthly Flexible Capacity Limits by Resource Category for CPUC-Jurisdictional Entities



Source: CPUC, Decision Adopting Flexible Capacity Obligations for 2019, page 5

Improving Analytic Methods

The focus of this Tracking Progress page reflects the short-run perspective of the resource adequacy program. Like other aspects of resource adequacy, the main goal is to identify resources that can and will assure reliability by responding to California ISO dispatch instructions. The flexibility requirements established in 2015 and continuing through 2019 have been labeled an “interim approach.” It is widely recognized that both short-term and long-term resource adequacy methods need improvement. The CPUC included a substantive review of



California Energy Commission – Tracking Progress

short-term methods in a September 2016 scoping memo and ruling.²⁹ Among other topics, the scoping memo for the rulemaking includes consideration of a more permanent method for assessing flexible capacity requirements and multi-year resource adequacy requirements. More recently, the CPUC opened a new rulemaking, R.17-09-020, (successor to R.14-10-010) for the 2019 and 2020 compliance years and to address changes and refinements for resource adequacy.³⁰

Assessing long-term future capabilities versus requirements is necessary to determine whether there is a need for additional flexible capacity and/or solutions to overgeneration projections. This assessment needs to take into account generating resource development in the pipeline, expected generating resource retirements due to age or regulatory mandates (like the OTC policy), changes in electricity demand and hourly use, and the potential for renewable curtailment. The CPUC has attempted to develop a long-term assessment by working with the California ISO in the 2010, 2012, and 2014 long-term procurement planning proceeding (LTPP) rulemakings and more recently in the integrated resource plan (IRP) proceedings.

Through the Flexible Resource Adequacy Capacity Must Offer Obligation 2 stakeholder initiative, the California ISO is attempting to develop a comprehensive framework to the flexible resource adequacy issue that uses market signals to ensure generation retention and retirement, allows intertie resources to help meet flexible requirements, and provides LSEs and local reliability areas more choices in meeting requirements based on their policies and business objectives.³¹ Also, the need for meeting future hourly and sub-hourly ramps is being studied, as historical data are showing a growth in this resource need as well, similar to what is occurring with three-hour ramping needs. **Figure 5** below compares these ramping requirements for 2016, the last year for which this data is available.

29 CPUC, Rulemaking 14-10-010, Assigned Commissioner and Administrative Law Judge's Phase 3 Scoping Memo and Ruling, 9/13/2016. See <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M166/K987/166987422.PDF>.

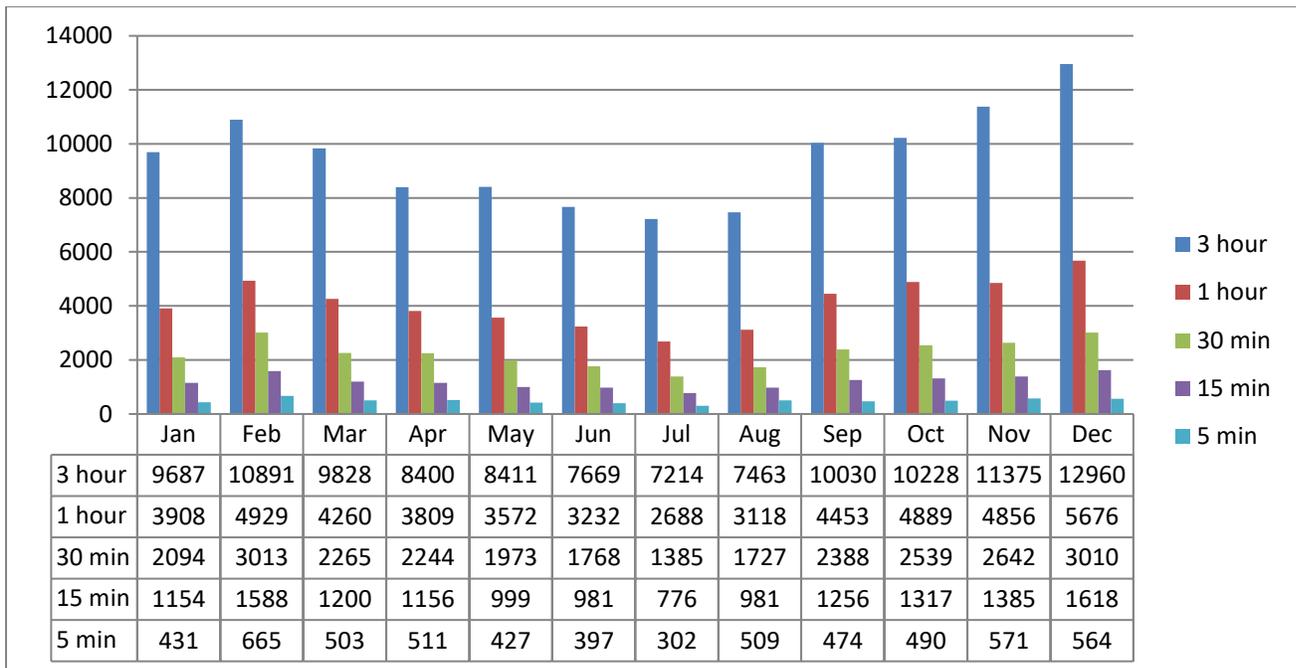
30 <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M196/K747/196747674.PDF>.

31 California ISO Presentation, *Flexible Resource Adequacy Criteria and Must Offer Obligation Working Group Meeting*, September, 26. 2017. http://www.caiso.com/Documents/Presentation-FlexibleResourceAdequacyCriteria_MustOfferObligationSep26_2017.pdf.



California Energy Commission – Tracking Progress

Figure 5: Maximum Upward Ramps for Various Time Frames Within the Same Three-Hour Window



Source: California ISO Flexible Resource Adequacy Criteria and Must Offer Obligation Working Group Meeting, September 26, 2017 presentation, page 13

To determine when new resource additions, if any, will be required, a transition needs to be developed between the short-term mechanism for meeting flexibility needs (as adopted in the resource adequacy program by D.14-06-050, D.15-06-063, and D.16-06-045) and the long-term approach that has been considered in the past LTPP rulemakings. With the passage of SB 350, the relative priority of these considerations shifted. The California ISO is focused on increased regionalization, which offers the opportunity of a large and more diverse market. Such a market would alter projections of flexibility requirements by changing the location and technology of renewable development, and would offer a more diverse range of market solutions to address flexibility requirements. The CPUC is continuing integrated resource planning, which may increase its focus on the extent to which preferred resources and storage can be used to reduce flexibility requirements and to satisfy a larger portion of any needs than in the past. In his signing statement for SB 100, Governor Brown noted that, “The next step is to integrate these goals into our existing clean energy efforts, including the Integrated Resource Planning process, which will ensure that Californians continue to have safe, reliable, and affordable energy.” Moreover, Assembly Bill 33 (Quirk, Chapter 680, Statutes of 2016) requires the CPUC to analyze the potential for long-duration bulk energy storage to help integrate renewable resources.

Parties to the LTPP/ IRP proceedings have used production cost models to help evaluate the need for flexible capacity for varied resource portfolios. The September 23, 2016, *Administrative Law Judge Ruling Directing Production Cost Model Requirements* provided direction to parties that use these types of models in their IRP analyses. Parties were directed to use consistent



California Energy Commission – Tracking Progress

definitions and reliability metrics for modeling (both deterministic and stochastic), produce consistent model output results, and use consistent modeling methodologies. The ruling directed parties to use, at a minimum, Scenario 2: the Default Scenario with the midlevel additional achievable energy efficiency sensitivity to ensure comparability of modeling results.³²

While these modeling requirements are being used to develop a framework for resource optimization modeling in the IRP process, this framework may be useful in modeling flexible resource needs for achieving the 60 percent RPS requirement. The CPUC has completed its capacity expansion modeling (using the RESOLVE model) for the SB 350 /IRP proceeding and more granular, hourly production-cost modeling will be conducted using the new resource portfolios as a key input assumption. The new portfolios will include significant increases in solar generation capacity to meet state mandates for renewable generation and greenhouse gas reductions for all three of the scenarios (Default Scenario with 50 percent RPS and 51 million metric tons carbon dioxide, the 42 MMT Scenario, and the 30 MMT Scenario) The addition of this solar capacity may shed light on the amount of flexible capacity resources needed to meet upward and downward ramping requirements. This IRP modeling and analysis were discussed at a November 2, 2017, workshop at the CPUC³³, and modeling efforts for IRP are continuing to date.

Additional References:

National Renewable Energy Laboratory Grid Integration Webinars:

<https://www.nrel.gov/esif/grid-integration-webinars.html#video2>.

National Renewable Energy Laboratory, *Modernizing Our Grid and Energy System*, NREL/BK-5C00-68026, March 2017. <https://www.osti.gov/biblio/1346919-esif-modernizing-our-grid-energy-system>

California Independent System Operator: Fast Facts, *What the duck curve tells us about managing a green grid*, 2016.

http://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

California Independent System Operator: Fast Facts, *Managing An Evolving Grid*, 2018. <http://www.caiso.com/Documents/ManagingAnEvolvingGrid-FastFact.pdf>

National Renewable Energy Laboratory, *North American Renewable Integration Study*. <https://www.nrel.gov/analysis/naris.html>.

³² CPUC, Rulemaking 16-02-007, Administrative Law Judge Ruling Directing Production Cost Modeling Requirements, September 23, 2016. <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M167/K501/167501732.PDF>.

³³ <http://www.cpuc.ca.gov/General.aspx?id=6442451195>.



California Energy Commission – Tracking Progress

Contact:

Richard Jensen, richard.jensen@energy.ca.gov

Next Update:

November 2019 with updates provided annually