Can long-duration storage solve California's resource adequacy challenges?

By Devarsh Kumar, Dinesh Madan, and Aishwarya Jaishankar, ICF

Summary

Over the past 12 months, the two grids most reliant on renewables—CAISO, with reliance primarily on solar, and ERCOT, with reliance primarily on wind—have had rolling blackouts due to shortage of generation. In both cases, extreme weather played a role. In this piece, we look at trends in California and quickly evolving needs for longer duration storage.

Over the 2020-2025 period, the main supply trends are: (i) intermittent renewables increasing from 32% to 43% of installed capacity, (ii) a 15% decrease in dispatchable capacity including closure of the last nuclear units in the state, and (iii) an unprecedented increase in battery energy storage (BES) from less than 1 GW to 14 GW, primarily comprised of 4-hour storage. The reliance on storage is novel as demonstrated by the fact that in 2020 there was only approximately 1 GW of BES in the entire country. These trends set the stage for numerous reliability concerns, including resiliency to unexpected extreme developments.

While ERCOT fundamentals and dynamics are very different from those of CAISO, it is nonetheless useful to examine recent circumstances in ERCOT to illustrate the range of potential extreme outcomes. ERCOT shed load in February 2021 for 70.5 hours and experienced full scarcity prices for 91 hours. This is a clear example of how 4-hour storage would fall significantly short of need and creates risks in extreme events. This can be further exacerbated by the overstatement of the resource adequacy contribution of capacity (e.g., CAISO setting solar contribution at 75% to 80% for several years).

Here we examined a problem that occurs with the addition of 4-hour batteries, namely the lack of power supply in the fifth and sixth hour of high demand in the early evening as solar output goes to zero. This problem is significant, with shortages potentially ranging from 25% of hours in a mid-demand forecast case to 60% of hours in a high demand forecast case. Fortunately, CAISO is recognizing the need for longer duration 8-hour batteries. Nonetheless, we quantify the shortage and highlight the rapidly disappearing lead time for BES to be extended from four to eight hours.

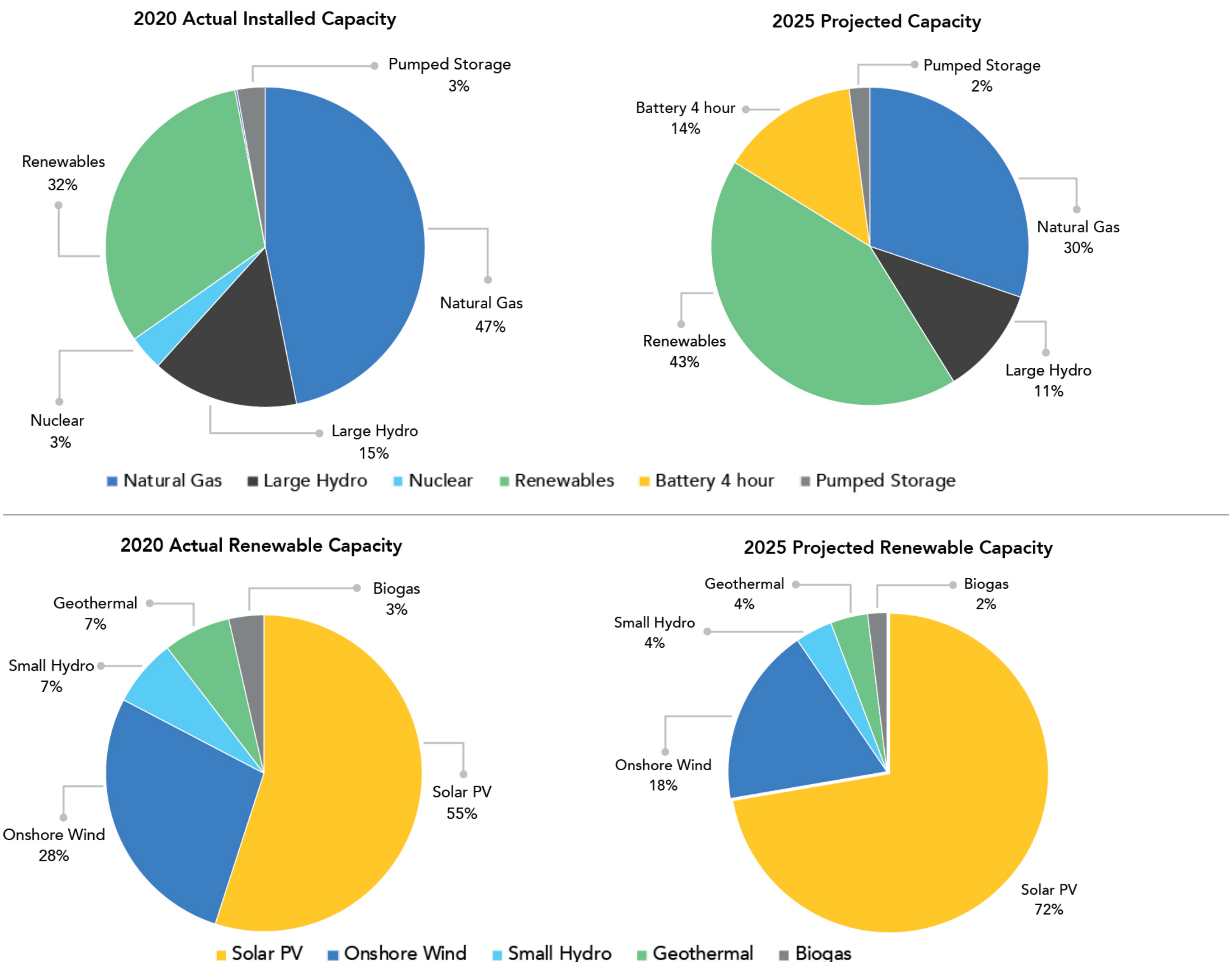
ICF analysis indicates that CAISO will start needing long-duration (six hours or longer) storage as soon as 2025 or risk facing serious reliability challenges. We find that the current assumption that 4-hour storage provides full resource adequacy (RA) credit will quickly be obsolete and puts CAISO at risk of overestimating the true level of reserves. While our findings align with current California Public Utilities Commission (CPUC) projections of declining RA value for batteries over time, the problem is urgent today. It often takes four years or longer for new projects to progress through the interconnection queue and come online, whereas the RA market only requires showings over a three-year period. The CPUC should act quickly to signal the need for longer-duration projects today.

We believe California's impending challenges in this area are a harbinger of what is likely to crop up across the U.S. as other grids become more renewable- and storage-dependent.

Current and projected CAISO resource mix

Currently, renewables capacity makes up 32% of the CAISO's resource mix[1], 55% and 28% of which are made up by solar and wind resources as shown in Exhibit 1 as actual installed capacity. In our analysis we have assumed that all capacity with executed interconnection agreements come online by 2025, totaling 15.7 GW solar, 1.1 GW onshore wind, and 12.1 GW 4-hour storage[2]. This is also shown in Exhibit 1 as projected capacity. With these additions by 2025, renewables' share increases to 43% of the capacity mix, and batteries increase from today's negligible amount to 14% of the overall mix, largely in the form of 4-hour batteries.

EXHIBIT 1 – CAISO INSTALLED CAPACITY 2020 (ACTUAL) AND 2025 (PROJECTED)



Source: 2020: Oasis – Master Control Area Generating Capability List | 2025: May 2021 CAISO Interconnection Queue

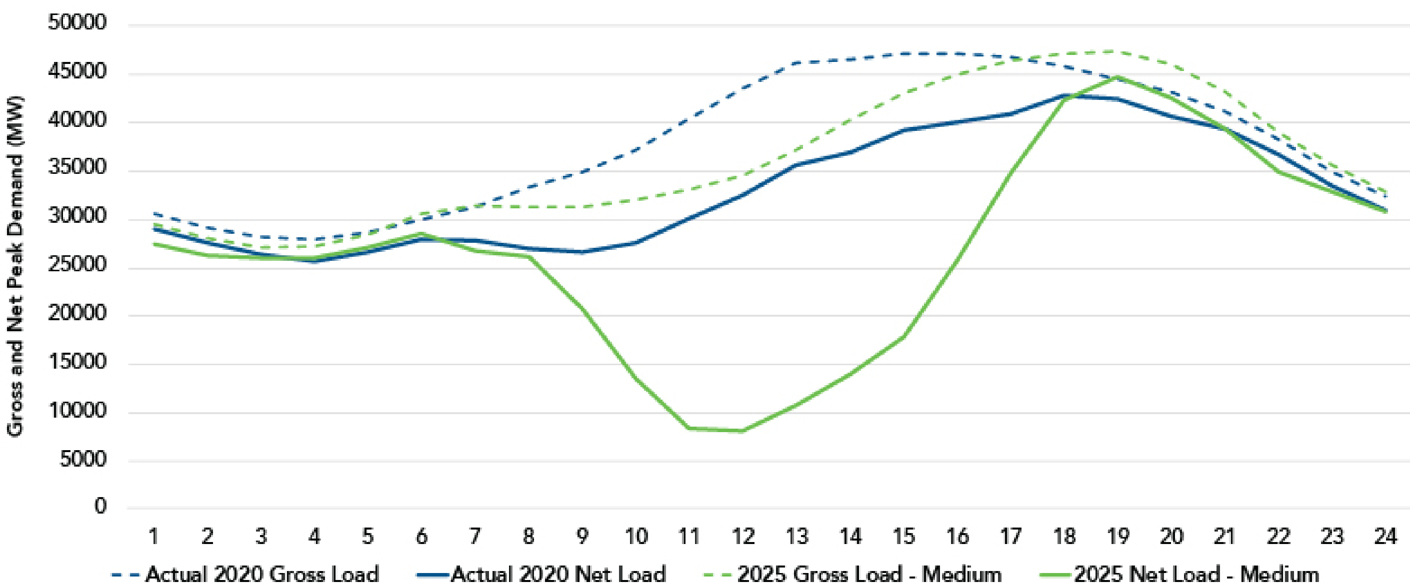
[1] The list of generators operational inside CAISO during 2020 - Master Control Area Generating Capability List (OASIS)

[2] May 2021 – CAISO Interconnection Queue with executed interconnection agreement

Demand and local supply outlook

We assessed the supply/demand outlook and potential shortfall in the system across three demand scenarios, namely the Low, Mid, and High scenarios published by CEC in January 2021. We analyzed the firm dispatchable capacity in CAISO, average daily imports, and projected demand in 2025 for Low, Mid, and High scenarios. We calculated the net load shape for each hour in each of the three demand scenarios for 2025 by subtracting the hourly impact of solar[3], onshore wind[4], and small hydro generation[5] on CEC's hourly gross load forecast (Exhibit 2 shows the Mid-case net demand).

EXHIBIT 2 – GROSS AND NET PEAK DEMAND IN 2020 AND 2025 (MID-CASE SCENARIO)



Source: CEC forecast January 2021

The dispatchable capacity in 2025, including 4-hr storage,[6] is 47,337 MW,[7] and without available storage (e.g., after a full discharge) is 36,287 MW as shown in Exhibit 3. Dispatchable capacity (excluding storage) decreases materially between 2020 and 2025 due to gas and nuclear retirements.

[3] CEC's projections for BTM PV solar profiles with a 30% capacity factor is used for solar generation forecast.

[4] EPA's v6 profile with a 36% capacity factor is used for wind generation. forecasts. https://www.epa.gov/airmarkets/documentation-epas-power-sector-modeling-platform-v6

[5] The 2018 profile from ABB's Velocity Suite with 30% capacity factor is used as a representative for small hydro generation in 2025.

[6] ICF analyzed all battery units as 4-hour duration (10% 2-hour storage capacity are included with half capacity credit). The entire battery fleet is fully charged.

[7] This includes CAISO starting capacity of 2020 from OASIS – Generating Capability List and adding firm builds, retirements to arrive at 2025 capacity.

EXHIBIT 3 – DISPATCHABLE CAPACITY AND DEMAND FORECAST FOR LOW, MID, AND HIGH SCENARIOS

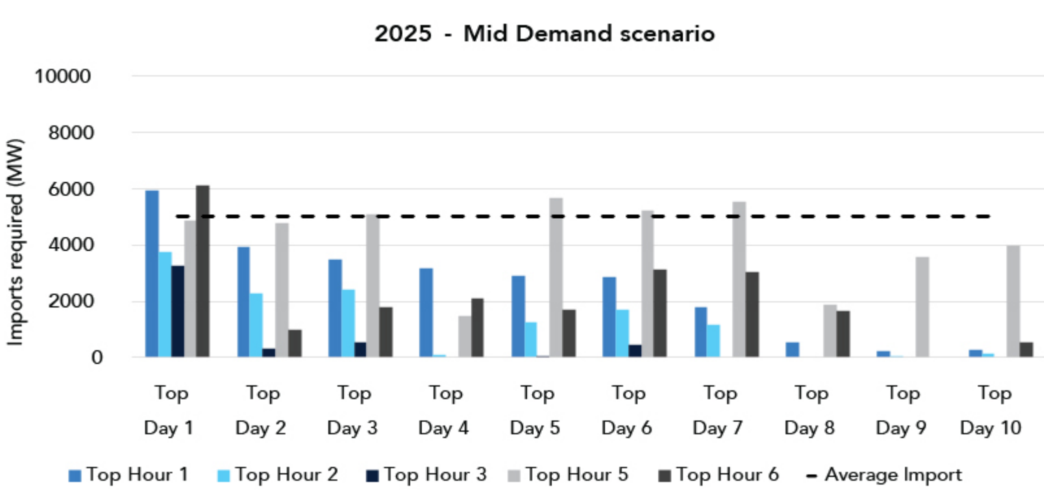
Parameter	2020 (actual)	2025 (Low scenario)	2025 (Mid scenario)	2025 (High scenario)
Total dispatchable capacity (incl. storage) MW	42641[8]	47337[9]	47337	47337
Total dispatchable capacity (excl. storage) MW	42503	36287	36287	36287
Gross peak demand MW	46933	43906	47198	49102
Net peak demand MW	42581	41227	44519	46423

Source: CEC Demand Forecast, January 2021

Resource adequacy shortage

We determined total capacity requirement by including a reserve margin[10] of 17.5% of gross load to account for forced outages, forecast error, and operating reserves, and compare that with available dispatchable capacity in each hour to assess the need for imports to meet the required levels of resource adequacy. The analysis focuses on how much import is needed to meet the top six net peak load hours[11] of the top 10 peak demand days. Exhibit 4 summarizes the results for the top 10 load days in a year and compares them with the dispatchable capacity, including storage, for the top six load hours in each day to get the net import required to meet the demand. Relative to the Mid demand reference case, the High demand scenario has 4% higher peak load and 6% higher total energy demand, while the Low demand scenario has 7% and 10% lower peak and energy demand, respectively.

EXHIBIT 4 – NET IMPORTS REQUIRED TO MEET THE TOP 10 DAYS AND 6 HOURS OF DEMAND

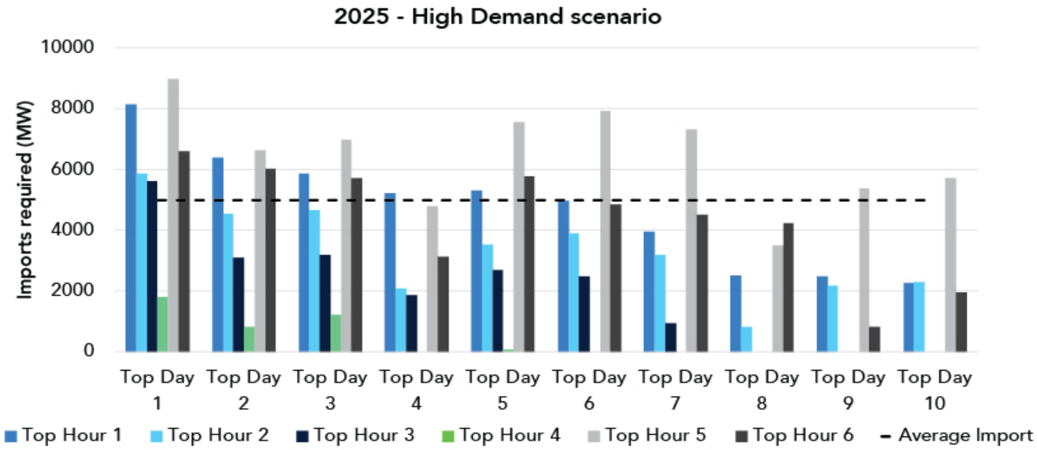


[8] In 2020, Gas – 30.3 GW, Nuclear – 2.3 GW, Large Hydro – 9.6 GW, Geothermal 1.4 GW, Biogas/Biomass – 731 MW, Pumped Storage – 1.8 GW, 4hr. battery – 137 MW, Solar PV – 11.3 GW, Onshore wind – 5.7 GW, Small Hydro – 1.4 GW. The contribution of each category is based on CAISO's Net Qualifying Capacity List 2020 for September.

[9] The capacity in 2025 includes 4 GW of gas retirement 3.3 GW of nuclear retirement, 15.7 GW of solar builds, 1.1 GW onshore wind builds and 12.1 GW of storage builds.

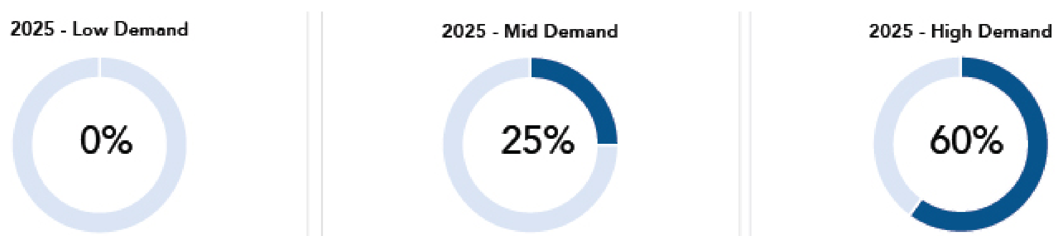
[10] Reserve margin is calculated as 17.5% of gross load Planning Reserve Margin - http://www.caiso.com/Documents/Feb5-2021-Legal-and-Policy-Brief-ReliableElectricService-ExtremeWeatherEvent-R20-11-003.pdf

[11] Top 6 load hours is analyzed to see if 4 hours storage is sufficient or not.



In both the Mid and High Demand scenarios, there are a number of days in which the import need exceeds the five GW of firm imports assumed by the CPUC.[12] Exhibit 5 shows the percentage of the top fifth and sixth load hours that face a shortage, even after accounting for energy remaining in 4-hour batteries not fully needed during the first four hours and therefore available for dispatch in hours five and six. For the Mid and High scenario, 25% and 60% of the top fifth and sixth hours of the top 10 load days face shortages, respectively.

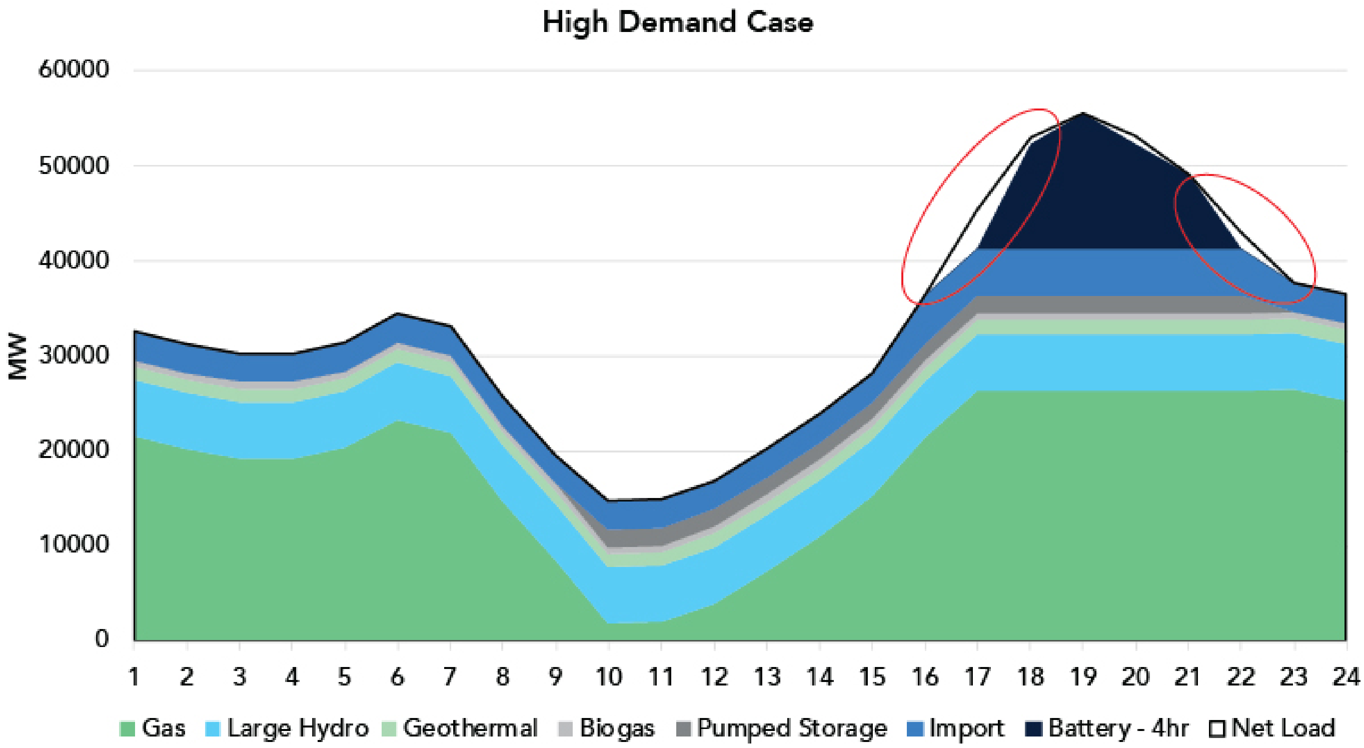
EXHIBIT 5 – HOURS (%) WITH SHORTAGES FOR THE 5TH AND 6TH HOURS IN THE TOP 10 LOAD DAYS



While we analyzed the top six load hours initially, the 4-hour storage fleet is further challenged to meet peak needs that can extend eight hours or more. Exhibit 6 illustrates the dispatch of storage and other resources during a hot summer day. While the peak hour is met even in the High Demand case, there is insufficient stored energy to meet near-peak hours.

[12] The CAISO Summer Load and Resources Assessment 2021 assumes 3922 MW, 5340 MW, 6095 MW and 5921 MW in June, July, August and September 2021, respectively, as firm imports. We expect that these firm import levels may further decrease with greater renewable penetration and coal retirements in the neighbouring regions, as observed during the 2020 August heatwaves.

EXHIBIT 6 – ILLUSTRATIVE SHORTAGE OF CAPACITY (MW) IN THE 5TH AND 6TH HOURS IN A HIGH DEMAND SCENARIO



Next steps and actions required

The CPUC is aware of this problem. Recently, proposals issued to the CPUC for replacement of the Diablo Canyon nuclear plant have included procurement of storage capable of 8-hour dispatch or longer. In the RA market, studies published by the CPUC show that 100% reliability credit exists for 4-hour storage until penetration is 18% of system peak. Storage penetration will quickly exceed this threshold. By 2025, storage currently anticipated to reach 25% of peak.

However, we find that the signaling today in the market is still primarily focused on 4-hour batteries achieving full RA credit. There is no specific incentive in the market for developers to design for longer durations. To be online by 2025, these resources will need to start the development cycle very soon. Moreover, ICF has assumed average hydrologic conditions in this analysis. Less than normal hydrologic conditions, which is a likely scenario with the changing climate conditions, will further highlight the need for longer duration storage or other reliable clean technologies. This issue points to the possibility of continuation of RA and reliability challenges over the mid-term if not quickly addressed.

About the authors

Devarsh Kumar

Energy Markets Consultant - Power

Devarsh is an Energy Markets Consultant in ICF's Energy Advisory Group. He has been involved in techno-economic assessment of energy assets and wholesale power market assessment in U.S. electricity markets, with focus on WECC, CAISO and MISO markets. He is skilled in market price-forecasting , nodal basis risk assessment and portfolio valuation. He holds a Master's degree in Infrastructure Civil Engineering from IIT Madras, India and a Bachelor's degree in Civil Engineering from IIT Madras, India.

Dinesh Madan

Energy Markets Director - Power

Dinesh is a technical director in ICF's Energy Advisory and Solutions line of business. He joined ICF in 2005 and has been extensively involved in the areas of energy market modeling, wholesale power market assessment, asset valuation and financial modeling, restructuring and litigation support including contract evaluation and risk assessment. He is an expert in US electricity markets, with a special focus on ERCOT and CAISO and with a strong understanding of market design and issues affecting wholesale and retail power markets.

Aishwarya Jaishankar

Energy Markets Consultant - Power

Aishwarya is an Energy Markets Consultant in ICF's Energy Advisory Group. Her work includes energy modeling, price forecasting, asset valuation, policy analysis and wholesale power markets assessments of WECC and CAISO markets. Aishwarya holds a Master of Environmental Management degree from Duke University and an undergraduate degree in Mechanical Engineering from VIT Vellore, India.

Devarsh Kumar
Devarsh.Kumar@icf.com

Dinesh Madan
Dinesh.Madan@icf.com

Aishwarya Jaishankar
Aishwarya.Jaishankar@icf.com

icf.com/energy

twitter.com/ICF
linkedin.com/company/icf-international
facebook.com/ThisIsICF
#thisisicf

About ICF

ICF is a global consulting services company, but we are not your typical consultants. We help clients navigate change and better prepare for the future.

Our experts have been embedded in every corner of the energy industry for over 40 years, working at the intersection of policy and practice. We work with the top global utilities, plus all major federal agencies and relevant energy NGOs, to devise effective strategies, implement efficient programs, and build strong relationships with their customers. From creating roadmaps to meet net zero carbon goals to advising on regulatory compliance, we provide deep industry expertise, advanced data modeling and innovative technology solutions, so the right decisions can be made when the stakes are high.