California State Assembly
UTILITIES AND ENERGY

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OVERSIGHT HEARING

Summer Readiness:
Ensuring Reliability since the August 2020 Outages

Tuesday, May 18, 2021
State Capitol, Assembly Chambers
1:30 p.m.

On August 14-15, 2020, the California Independent System Operator (CAISO) was forced to institute rotating electricity outages in the midst of a west-wide heat wave. It was the first time in nearly 20 years that such rotating outages occurred in California. The outages on the 14th and 15th affected 492,000 and 321,000 customers,[1] respectively, of Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) who lost power for anywhere between 8 to 150 minutes.[2]

With further heat waves forecast, similar grid conditions projected for subsequent days, and Californians suffering from the loss of electricity, Governor Newsom, state agencies, and the CAISO quickly implemented strategies to manage the immediate shortfall of resources on the grid. A statewide mobilization effort to conserve electricity, shift demand, and maximize existing generation resources was undertaken. Those efforts are largely credited in mitigating subsequent rotating outages from August 16-20.

[1] "Customers" defined here as residences and business accounts
[2] Pg. 3, CAISO, CPUC, and CEC; "Preliminary Root Cause Analysis: Mid-August 2020 Heat Storm"; October 6, 2020; http://www.caiso.com/Documents/Preliminary-Root-Cause-Analysis-Rotating-Outages-August-2020.pdf

In January 2021, the CAISO, California Energy Commission (CEC), and California Public Utilities Commission (CPUC) released a final root cause analysis (RCA)[3] identifying three main causes for the rotating outages:

(1) Unanticipated hot weather;
(2) Insufficient reliability planning in the midst of a substantial growth in renewables; and
(3) Market practices masking the true state of supply and demand in the day-ahead energy market.

On October 12, 2020, prior to the RCA's release, this Committee held an oversight hearing on the August 2020 outages. During that hearing, the Committee committed to inviting the three energy entities back to provide a status update prior to summer 2021 on how they were ensuring reliability. The purpose of this hearing is to understand what changes have been undertaken since last August to ensure such rotating outages do not happen again both in the summer of 2021 and into the future.

Findings

- *No single cause, but a series of factors, contributed to the outages in August 2020.*
- *A herculean effort, led by the Governor's office, limited the outages from the high heat events to two days in August. Subsequent heat waves in 2020 did not result in electricity shortfalls, largely due to public conservation efforts.*
- *The state is in a stronger position going into summer 2021 than last summer. The CAISO, CEC, and CPUC have undertaken a number of operational remedies and additional procurement to ensure enough electricity will be available this coming summer.*
- *The energy entities should prioritize and articulate a contingency plan in the event further unanticipated events occur, so that the extraordinary measures that occurred in August 2020 are readily mobilized if needed.*
- *The challenges of maintaining a reliable grid are expected to grow in the coming decades as more renewables come online, more baseload resources are taken offline, and electricity demand grows from electrifying the transportation and building sectors. Yet, the remedies proposed for the August 2020 outages provide a foundation for meeting many of these future challenges.*

What are Rotating Outages and Why are They Used? In California, rotating outages are called by the CAISO for a specified period of time to help ease demand on the electric grid. Their

[3] CAISO, CPUC, and CEC; *FINAL – Root Cause Analysis Mid-August 2020 Extreme Heat Wave*; January 13, 2021; http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf

primary function is to control the risk of a larger outage occurring system-wide. These outages are unique from Public Safety Power Shutoffs, or PSPSes, which are called by the utilities to reduce wildfire risk. In PSPSes, power on at-risk circuits is shut off until a weather event (such as high wind and low humidity) is lessened and the risk of utility infrastructure sparking a wildfire is reduced. In rotating outages, power is shut off to lessen overall demand on the electric system, and the outages are rotated from area to area so no single neighborhood's electricity is down for a prolonged period of time.

Maintaining the electric grid requires a delicate balance of matching supply and demand in real-time. If any one part of the system becomes off-balance, the entire electric system runs the risk of shutting down. In order to avoid close calls, the CAISO is required to have contingency reserves,[4] which are extra resources that can come online quickly to ensure the grid can respond in case a major element fails. Since 2003, when a widespread power outage shut off power to more than 50 million people across the northeastern United States and parts of Ontario, the federal government has required mandatory reliability standards for U.S. electricity providers.[5] These standards[6] require grid operators to identify the most severe event that could destabilize their grid and lead to cascading outages throughout the entire west; CAISO must then carry reserves equal to a percent of that potential lost load.[7]

During parts of August 2020, CAISO had difficulty maintaining their required reserves, necessitating rotating outages. Had CAISO operated with insufficient reserves, they risked causing uncontrolled outages and destabilizing the rest of the western grid. Consequently, on both August 14 and 15, CAISO ordered controlled, rotating outages resulting in load shed of about 500 megawatts (MW) in order to maintain their mandatory reserves.[8]

A Fine Balance – Challenges in Matching Electricity Supply and Demand in California during High Heat Events. During the summer of 2020, the western United States experienced extreme heat waves. For August 14-19 and again over Labor Day weekend, temperatures reached upwards of 10-20 degrees above normal. These west-wide heat waves affected electricity demand and supply. Usually in the summer, high day-time temperatures can be offset by cool evenings. But during the heat waves, limited overnight cooling occurred, so air conditioners continued to run into the evening and next day, increasing the demand on the system. Moreover, the extreme heat negatively impacted generation, which operates less efficiently during extreme

[4] Also referred to as operating reserves or ancillary services.
[5] US-Canada Power System Outage Task Force; *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*; April 2004.
[6] For CAISO, they are the North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) standards.
[7] For CAISO, this single contingency is the loss of the Diablo Canyon nuclear power plant. WECC rules require 6% contingency reserves for this loss. CAISO also requires electrical entities to maintain an additional 9% in reserves to account for other potential plant outages or higher-than-average peak demand, leading to a total 15% planning reserve margin.
[8] Pg. 28 and pg. 31; *Final Root Cause Analysis* (citation 3)

temperatures, decreasing overall supply on the electric grid. As part of the RCA, the CAISO, CEC, and CPUC evaluated how specific resource types performed during the August and September extreme heat waves, noting capacity reductions for a number of resources. This additional analysis is provided in Appendix B. The increased demand alongside decreased supply during the extreme heat waves resulted in system shortfalls, thus requiring rotating outages to be called.

Additionally, the current resource mix during Californian summers can result in large fluctuations in the late afternoon from solar generation going offline. This is because air conditioning and other load being served by solar during the day must quickly be met by other resources when the sun goes down in the evening. This rapid daily shift in supply and demand can last a few hours in the early evening (typically from 4pm-9pm), and is known as *net demand peak* or, simply, *net peak* (the peak of customer demand *net* the solar and wind generation). These changes in the resource mix and timing of the net peak have increased the challenge of maintaining system reliability, and this challenge is amplified during an extreme heat wave.

What have we learned since the August 2020 outages? As noted above, the RCA identified three main causes for the rotating outages:

(1) Unanticipated hot weather;
(2) Insufficient reliability planning in the midst of a substantial growth in renewables; and
(3) Market practices masking the true state of supply and demand in the day-ahead energy market.

The RCA stressed that no single event led to the outages, but rather a confluence of events created the environment that necessitated rotating outages statewide. Additionally, the CAISO's Department of Market Monitoring released an independent review on November 24, 2020 confirming this conclusion and noting that no evidence of market manipulation was found during the August events.[9]

Thus the three main causes identified are worth interrogating and remedying prior to upcoming summers. The first cause is fairly straightforward – these types of extreme weather events are likely becoming more normal. Our planning and governance of the electric sector must better anticipate climate-change induced events. Moreover, the west-wide nature of the August heat wave highlights how solutions and governance cannot be isolated to California. Unfortunately, the solutions to this first cause – incorporating extreme weather conditions into long-term electricity planning, better coordination and transparency with western states – are not simple nor quickly implementable.

[9] Department of Market Monitoring, CAISO, *Report on system and market conditions, issues and performance: August and September 2020*; November 24, 2020.

The second cause is also seemingly straightforward – regulators failed to adequately plan not just for extreme events but also in conditions with heavy renewable penetration. This is not a new issue for the CAISO, CEC, and CPUC. Since 2016, these entities have worked to examine the impacts of significant renewable penetration on the grid, most famously with CAISO's efforts to educate and inform around the "duck curve."[10] Fortunately, the solutions to the second cause are in reach. While not simple, remedies to resource adequacy, planning reserves, and bringing additional capacity online are within the current activities of the CAISO, CEC, and CPUC. These solutions have been a primary focus of the entities' efforts since last summer and will be discussed in the next section.

The third cause is more obscure but equally important. The practices which concealed the tight electricity conditions included under-scheduling of demand in the day-ahead market and convergence bidding. Convergence bidding allows for the buying or selling of "virtual" electricity in the day-ahead market to then close those trades with the opposite transaction in the real-time market. These are financial trades; no physical electricity is ever delivered. The theory behind convergence bidding is that it creates a controlled avenue for arbitrage, increases market efficiency, and may assist in reliability. During the August rotating outages, however, the convergence bids were largely unidirectional (supply bids, not demand), which alongside the under-scheduling of load, masked the very tight grid conditions in the markets. In other words, these financial bids to supply electricity in the day-ahead market – which carried no actual electricity – made it appear as if there were more supply in the day-ahead market than in reality. As a result, the CAISO allowed power to be exported prior to the emergency. By August 16, CAISO recognized the issue and temporarily suspended convergence bidding. The CAISO has since made changes to its market enhancements and restored convergence bidding. The CPUC is also exploring technical solutions to allow its jurisdictional utilities to provide customer usage data more frequently to community choice aggregators and energy service providers in order to improve load scheduling accuracy.

Additional Actions Completed and Underway. In an effort to address the three main causes for the rotating outages as described above, the CAISO, CEC, and CPUC have undertaken a series actions to reduce the likelihood of rotating outages during summer 2021 and beyond. Many of these actions arose as recommendations in the RCA.[11] Table 1 below identifies each recommendation, alongside milestones the energy entities have reached in meeting the recommendation. The milestones and status shown in Table 1 reflect information collected in April 2021; it is likely further progress has been made in the subsequent weeks that is not reflected in this table.

[10] The duck curve is a graph of power production over the course of a day that shows the timing imbalance between peak demand and renewable energy production. In California the amount of power that must be generated from sources other than solar or wind displays a rapid increase around sunset and peaks in the mid-evening hours, producing a graph that resembles the silhouette of a duck.
[11] Beginning on pg. 70, *Final Root Cause Analysis* (citation 3).

	Table 1 - CAISO, CEC, & CPUC Planning & Procurement Actions					
	Recommend-ation	**Description**	**Proposed Time Horizon**	**Responsible Entity**	**Milestone(s)**	**Status**
1	New Generation Construction	Procurement of new capacity that will be online by summer 2021 based on prior authorization, including ~2,100 MW of storage and hybrid storage resources and ~300 MW of solar and wind resources.	Near-term (summer 2021)	CPUC	February 1, 2021 - entities that elected to self-provide their procurement obligation to meet the 3,300 MW ordered,[12] submitted reports to the CPUC on the status of their projects. CPUC staff is analyzing these data. Q2 of 2021 - the CPUC will use the data from the February 2021 filings to determine whether any projects have suffered delays or failures that necessitate the need for backstop procurement.	In progress
2	Procurement Tracking	Tracking progress on procurement projects that are currently under construction to ensure there are no regulatory barriers preventing them from being completed by their targeted dates.	Near-term (summer 2021)	CPUC	November 2020 - the CPUC prepared an analysis and slide deck on new resources in development across multiple proceedings.[13]	Completed

[12] D.19-11-016

[13] https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442466860

					Q2 2021 - Data collected from Integrated Resource Plans will be aggregated and include information on existing, developing, and planned resources.	In progress
3	Adjustments to Energy Market Processes	Actions to adjust market processes, improving the ability to limit exports to better match system conditions.	Immediate	CAISO	These measures alleviated pressures during the Labor Day weekend heat wave.	Completed
4	Increase Resource Adequacy (RA) requirements for load-serving entities to more accurately reflect the increased risk of extreme weather events	Current planning targets were developed in 2004 and have not been updated since. The load forecast should be updated to better account for heat storms like the ones encountered in August and September. Once updates are developed, the CPUC, CEC, and CAISO should ensure they are used consistently across all long- and short-term planning programs.	Near-term (summer 2021)	CPUC	February 2021 - CPUC hosted several workshops on reliability including planning reserve margin, import rules, hybrid resource qualifying capacity rules, demand response qualifying capacity rules, changes to the RA penalty structure, and larger structural changes to the RA framework. A proposed decision in this proceeding[14] is expected in June of 2021.	In progress

[14] R. 19-11-009

5	Bringing Additional Resources Online	Expedite regulatory and procurement processes to develop additional resources that can be online by 2021. This includes coordination with non-CPUC jurisdictional entities and will most likely focus on "demand-side" resources and accelerating online dates of resources under development.	Near-term (summer 2021)	CAISO, CEC, & CPUC	February 11, 2021 - the CPUC directed[15] the state's three large investor-owned utilities (IOUs; PG&E, SCE, & SDG&E) to seek contracts for additional supply-side capacity. The IOUs later requested approval for **~564 MW** by summer 2021; the CPUC approved those contracts on March 18.	Completed
					March 25, 2021 - the CPUC directed[16] the IOUs to take multiple actions, including 1) launching a new statewide Emergency Load Reduction Program pilot; 2) modifying the IOUs' existing demand response and Critical Peak Pricing programs; 3) funding a new statewide Flex Alert paid-media campaign; and 4) authorizing additional capacity procurement to meet an increased planning reserve margin of 17.5 percent.	Completed; except for additional IOU procurement for the increased planning reserve margin. (In progress)

[15] D. 21-02-028
[16] D. 21-03-056

					Coordination with Non-CPUC-jurisdictional entities Regarding Additional Procurement – The CAISO and CEC have begun outreach to understand the procurement positions of non-CPUC-jurisdictional entities and concerns for summer 2021. A limited number of these entities have voluntarily increased their planning reserve margins in preparation for summer.	In progress
6	Modernize Flex Alert[17]	The program design and targeting have not changed since its inception in 2001. The program should be redesigned to better target social media and to take advantage of home automation devices. The CEC, CAISO, and CPUC should coordinate to add funding from all LSEs to better target conservation messaging and utilize automated devices.	Near-term (summer 2021)	CPUC	The CPUC funded[18] a new statewide Flex Alert paid-media campaign, authorizing $12 million per year, for two years, collected from all customers in PG&E, SCE, and SDG&E service territories.	In progress

[17] Flex Alert was designed as a voluntary conservation program during the 2000-2001 California Electricity Crisis. It is largely a media campaign asking the public to conserve electricity on peak demand days.
[18] D. 21-03-056 in R. 20-11-003

7	Market Enhancements	Improve market practices to ensure actual balance of supply and demand during stressed operating conditions are accurately reflected. Furthermore, market practices should ensure sufficient resources are available to serve load across all hours, including the peak and net demand peak.	Near-term (summer 2021)	CAISO	March 24 - CAISO approved the first phase of the RA enhancements; the changes were filed with the Federal Energy Regulatory Commission (FERC) on March 29.	In progress - target this summer.
					March 24 - the CAISO Board approved a package of market enhancements to prepare for this upcoming summer. The package was filed at FERC on March 26.	In progress - target June 15, 2021.
					March 10 – the CAISO presented two additional market enhancements to the Energy Imbalance Market (EIM) Governing Body for their approval. These two changes consisted of 1) ensure each balancing authority area participates in the EIM with sufficient resources, and 2) addressing a market modeling issue regarding energy interchanges between EIM balancing authority areas and the CAISO balancing authority area that caused operational issues during last summer's tight conditions.	In progress

					The CAISO is considering market enhancements for managing load, as well as export and wheel scheduling priorities.	In progress - target to be in place by July 1, 2021
8	Enhanced Communication Protocols	Develop improved warning and trigger protocols to forewarn the severity of an extreme event and initiate coordination with one another, other state agencies and the Governor's Office, the IOUs, municipal or publicly-owned utilities, and community choice aggregators.	Near-term (summer 2021)	CAISO, CEC, & CPUC		In progress
9	Contingency Plan	Drawn from actions taken statewide last August. The Plan will be ready to be deployed in case of unanticipated stressed conditions, laying out a process to sequence emergency measures in rank order to minimize environmental, equity, and safety impacts. The measures will include requesting load flexibility and conservation from large users, moving demand to microgrids and back-up generation (including emergency use of diesel), and temporarily increasing capacity of existing generation resources.	Near-term (summer 2021)	CAISO, CEC, & CPUC		In progress

10	Consider New Resources	Consider whether new resources are needed to meet the mid- and longer-term timeframes reflective of the reevaluation of the forecast. Conduct a production cost analysis to ensure that additional resources will meet reliability needs during all hours of the year.	Mid- to Long-term	CAISO, CEC, & CPUC		Ongoing
11	Load Shifting	Accelerate the deployment of demand-side resources by 1) defaulting all customers to time of use rates; 2) exploring other dynamic rate designs paired with automated devices for demand management.	Mid- to Long-term	CPUC & CEC		Ongoing
12	Improving Long-term Planning	Continue efforts to expand assessments to support mid- to long-term planning goals including the following: 1) continue mid-term efforts from SB 100, IRP, and the transmission planning process to address electric sector reliability; 2) update (likely broaden) the range of climate scenarios to be considered in CEC forecasting; 3) consider developing formal crosswalks between the CEC forecast and emerging SB 100 scenarios to bridge gaps between planning considerations across various planning horizons.	Mid- to Long-term	CAISO, CEC, & CPUC		Ongoing

Short-term solutions between mid-August and early September 2020 – Use of Contingency Measures. All the contributing factors – high heat events, reduction in supply, and increase in demand – occurred during August 14-19 and September 6-7, 2020. However, rotating outages were only called on August 14th and 15th despite August 16-19 forecasted to have much higher supply shortfalls. By August 16, Governor Newsom had declared a State of Emergency.[19] This proclamation gave state agencies maximum discretion to permit the use of stationary and portable generators, as well as auxiliary ship engines,[20] to reduce load and increase generation through August 20. Utilities like PG&E and SCE could use backup resources they had in place for PSPS events to help reduce load during peak times. Additionally, on August 17, Governor Newsom issued Executive Order N-74-20,[21] suspending restrictions through August 20 on power during generation during peak demand periods.

These actions by the Governor occurred alongside conservation messaging and awareness encouraging Californians to reduce their electricity usage. This messaging occurred through statewide campaigns such as the Flex Alert, extensive media coverage, and targeted load shedding from large industrial users. Neighboring balancing authorities such as Los Angeles Department of Water and Power not only asked their customers to conserve during this time, but also brought additional generation online to help meet demand.[22] As a result, on August 17-19 the state reduced peak demand significantly – by as much as 4,000 MW – thus preventing further rotating outages from being called.

Similar to mid-August, California experienced another period of high temperatures and demand over Labor Day weekend.[23] Yet, this subsequent high heat event did not result in rotating outages, largely due to considerable conservation from the public.[24] The CAISO notes that in September their communications and outreach teams were better positioned and used stronger messaging on the potential for outages in advance of another forecasted heat wave.[25] The general public was also likely more aware of the impact of a Flex Alert event, making conservation more appealing.

The statewide mobilization effort to conserve electricity, shift demand, and maximize existing generation resources that was undertaken during August 2020 was not the ideal scenario, but did

[19] Office of governor Gavin Newsom; "As West Coast Faces Historic Heat Wave & Energy Shortages, Governor Newsom Signs Heat Emergency Proclamation to Free Up Energy Capacity"; August 17, 2020. https://www.gov.ca.gov/wp-content/uploads/2020/08/8.16.20-Extreme-Heat-Event-proclamation.pdf
[20] For instance, the CEC coordinated with the US Navy and Marine Corps to disconnect 22 ships from shore power, move a submarine base to backup generators, and activate several microgrid facilities, resulting in about 23.5 MW of load reduction.
[21] EO N-74-20 https://www.gov.ca.gov/wp-content/uploads/2020/08/8.17.20-EO-N-74-20.pdf
[22] From both their Haynes Unit 1 and Scattergood natural gas-fired plants, totaling 300-600 MW; pg. 69 *Final Root Cause Analysis* (citation 3)
[23] Specifically September 6th and 7th
[24] Pg. 36; *Final Root Cause Analysis* (citation 3)
[25] Data request to CAISO from the Committee on Communication Outreach during 2020 Heat Events; April 20, 2021

demonstrate how a collective response could be called upon should the state require it. As a result, one of the recommendations from the RCA was to formalize this collective response, directing the CEC, in coordination with the Governor's Office, CPUC, and CAISO, to develop a Contingency Plan that draws from actions taken statewide during August 16-20 to address future unanticipated shortfalls.

As noted in the RCA, "the Contingency Plan will lay out a process to sequence emergency measures in rank order to minimize environmental, equity, and safety impacts. The measures will include: load flexibility and conservation from large users, moving demand to microgrids and back-up generation (including emergency use of diesel generation that the three large electric IOUs own or have under contract for use in major emergencies such as wildfire prevention and wildfire or earthquake response), and temporarily increase the capacity of existing generation resources." It is this Committee's understanding that the CEC is still working on establishing the Contingency Plan prior to summer 2021. Articulating such a plan could add an additional level of protection should circumstances lead to further electricity tightening this upcoming summer.

Looking Over the Horizon – Ensuring Reliability Beyond 2021. While the events of August 2020 call for an urgent response to ensure similar rotating outages do not happen again, many of the solutions take long-term planning and development. Power plants are not built overnight. Similarly, accurately forecasting and planning for what should even be built to address climate events remains uncertain; historical averages are likely to become less predictive and previously-considered-extreme events are likely to grow more common under climate change.

In California, these larger climate events are occurring alongside ambitious renewable energy integration. Over the next decade, the state is expected to retire both the Diablo Canyon nuclear facility (~2300 MW) and a fleet of once-through-cooling power plants (~10,000 MW remaining in 2019[26]) and replace these resources with clean energy. Additionally, the state established the policy goal of meeting all retail electricity supply with a mix of RPS-eligible and zero-carbon resources by December 31, 2045, for a total of 100 percent clean energy.[27] This supply-side goal is running parallel to changes in demand anticipated with deep decarbonization efforts in the transportation and building sectors. These changes could lead to more prevalent and complex challenges beyond what was experienced in the summer of 2020. Our grid planning and operations will need to evolve to meet these challenges. As demonstrated last August, focusing on single worst-case events may no longer be predictive, but rather a risk-based, multiple scenario approach may better capture the realities of our future.

[26] CEC blog "Once-Through Cooling Power Plant Phase Out in Progress"; May 20, 2019. http://calenergycommission.blogspot.com/2019/05/once-through-cooling-power-plant-phase.html
[27] SB 100, De Leon, Chapter 312, Statutes of 2018.

Despite these challenges, our ambitious goals are feasible. On May 6th, 2021, California's grid ran on nearly 95% renewable energy.[28] This brief glimpse into the state's future lasted for four seconds, but still demonstrated our potential. Moreover, California's policies are not occurring in isolation. Many western states are adopting clean energy standards. California, for the foreseeable future, will be strongly import-dependent, with roughly a quarter to a third of our resource mix imported from our neighbors. These changes suggest more coordination western-wide will be necessary and beneficial to ensure reliability of our electric system.

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[28] Sammy Roth; "California just hit 95% renewable energy. Will other states come along for the ride?" *LA Times*; April 29, 2021.

Appendix A – Useful Terminology

Understanding the following terms and concepts is helpful to understand the conditions surrounding the 2020 outages. These acronyms are used throughout this paper:

Balancing Area Authority (BAA) are entities who manage the actual operation of the electric system. Many BAAs in the United States are electric utilities that have taken on the balancing responsibilities for the portion of the power system served by their load. A BAA ensures, in real time, that electricity system demand and supply are finely balanced. This balance is needed to maintain the safe and reliable operation of the power system. In California, approximately 80% of the load is served by the CAISO BAA.

The California Energy Commission (CEC), formally the Energy Resources Conservation and Development Commission, has many electricity planning and policy functions, including forecasting electricity and natural gas demand, investing in energy innovation, setting the state's appliance and building energy efficiency standards, and planning for and directing state response to energy emergencies. Among the CEC's key responsibilities is the preparation and adoption of electricity demand forecasts for the CAISO. As part of its Integrated Energy Policy Report process and in consultation with the joint entities, the CEC develops a set of forecasts to support the needs of CAISO transmission planning, CPUC Integrated Resources Planning, and CPUC and CAISO resource adequacy.

The California Independent System Operator (CAISO) is a private nonprofit public benefit corporation and the only independent grid operator in the electrically interconnected western grid. The CAISO is the Balancing Authority that oversees the reliability of approximately 80% of California's electricity demand and a small portion of Nevada. The remaining 20% is served by publicly-owned utilities such as the Los Angeles Department of Water and Power and Sacramento Municipal Utility District, which operate separate transmission and distribution systems. The CAISO manages the high-voltage transmission system and operates wholesale electricity markets for entities within its system and across a wider Western footprint via an Energy Imbalance Market (EIM). The CAISO performs its functions under a tariff approved by the Federal Energy Regulatory Commission (FERC) and reliability standards set by the Western Electricity Coordinating Council (WECC) and the North American Electric Reliability Corporation (NERC). Approximately, sixty percent of the power supplied in the United States is managed by such regional transmission organizations or independent system operators.

The California Public Utilities Commission (CPUC) has many regulatory responsibilities for energy, telecommunications, water, transportation, and safety in California. Relevant to this paper, the CPUC sets reliability requirements for the load-serving entities (LSEs) that participate in the CAISO markets and comprise the majority of the CAISO footprint. Electricity utilities regulated by the CPUC represent approximately 80% of the electricity demand in California and 91% of the electricity demand in the CAISO system. The CPUC's reliability (termed resource adequacy) requirements are set based on the peak demand shown in the CEC's demand forecast,

plus a planning reserve margin (PRM) of 15%.[29] The PRM is comprised of a 6% requirement to meet grid operating contingency reserves, as required by the WECC reliability rules, and a 9% contingency to account for unplanned plant outages and higher-than-average peak electricity demand.

Capacity generally refers to the rated output of the plant when operating at maximum output. Capacity is typically measured in terms of a kilowatt (kW), megawatt (MW), or gigawatt (GW) rating. Rated capacity may also be referred to as "nameplate capacity" or "peak capacity." This may be further distinguished as the "net capacity" of the plant after plant parasitic loads have been considered, which are subtracted from the "gross capacity."

Capacity factor is a measure of how much energy is produced by a plant compared to its maximum output. It is measured as a percentage, generally by dividing the total energy produced during some period of time by the amount of energy it would have produced if it ran at full output over that period of time.

Capacity value refers to the contribution of a power plant to reliably meet demand. Capacity value is the contribution that a plant makes toward the planning reserve margin. The capacity value (or capacity credit) is measured either in terms of physical capacity (kW, MW, or GW) or the fraction of its nameplate capacity. Thus, a plant with a nameplate capacity of 150 MW could have a capacity value of 75 MW or 50%.

Convergence bidding is a form of financial energy trading used to converge day-ahead and real-time pricing. Under normal conditions, when there is sufficient supply, convergence bidding plays an important role in aligning loads and resources for the next day. These are financial trades; no physical electricity is ever delivered. The theory behind convergence bidding is that it creates a controlled avenue for arbitrage, increases market efficiency, and may assist in reliability. Convergence bidding is not permitted at the interties; only physical export bids are permitted there.

Intertie is an interconnection point on the electric grid permitting passage of current between two or more electric utility systems.

Load-serving entity (LSE), as defined in Public Utilities Code § 380, means an electrical corporation (such as PG&E, SCE, or SDG&E), and electric service provider, or a community choice aggregator. LSEs do <u>not</u> describe municipal or publicly-owned utilities, load-serving the State Water Project, or behind-the-meter resources such as rooftop solar.

Net Qualifying Capacity (NQC) describes the amount of capacity from each resource that can be counted towards meeting Resource Adequacy (RA) requirements in the CPUC's RA program. Each year, CPUC staff work with the CAISO to publish NQC lists for each resource. The qualifying capacity (QC) of each resource is set by the specific methodology. Then, if the QC is not fully deliverable – meaning unable to output generation to aggregate CAISO load – then the

QC is adjusted downwards to its deliverable capacity resulting in the NQC. In most cases, a resource is fully deliverable and there is no difference between QC and NQC.

Resource Adequacy (RA), in its simplest terms, is just a regulatory construct developed to ensure that there will be sufficient resources available to serve electric demand under all but the most extreme conditions. In the wake of the California Electricity Crisis of 2000-01, the state determined that it was necessary to develop a system that would prevent the kind of power shortages, extreme price spikes, and rolling blackouts that occurred during that turbulent period. The Legislature adopted the requirement for RA which requires the CPUC, in cooperation with the CAISO, to adopt a program that would require all retail LSEs to "maintain physical generating capacity and electrical demand response adequate to meet its load requirements, including, but not limited to, peak demand and planning and operating reserves."

The CPUC and CAISO have adopted a series of decisions over the years to develop the RA program as it exists today. While some other markets in the US, such as PJM and the New England ISO, operate centrally cleared capacity markets, California's market is bilateral, based on individual transactions between LSEs and resource owners. At the most basic level, LSEs are required to own or contract with sufficient resources to meet their share of the CAISO system's peak demand, plus a planning reserve margin ("PRM") of 15%.[29] This "System" RA obligation ensures that those resources will be available to serve CAISO demand when needed. A (supply or demand) resource that commits to providing RA undertakes a "must-offer" obligation to bid or self-schedule its capacity into the CAISO market. The actual dispatch of resources to meet load in real-time is performed on an economic basis, with the lowest (variable) cost resources committed first. Thus, an RA resource must be offered into the market, but it may not be dispatched to serve load if there are cheaper non-RA resource bids available. The RA program also requires each LSE to procure a certain amount of its RA from "Local" resources that are sited in certain load pockets where supply is needed due to insufficient transmission to serve the entire load (e.g., SF Bay Area, LA Basin, San Diego, etc.). Finally, as one means of dealing with the so-called duck curve problem, each LSE must procure a certain amount of its RA from "Flexible" resources that can ramp up or down on short notice to meet variations in load and intermittent energy production.

[29] A recent decision by the CPUC increased the PRM to 17.5% for 2021 and 2022 in response to the outages experienced last summer. The action is reflected in D.21-03-056, adopted March 25,2021 and available at https://docs.cpuc.ca.gov/publisheddocs/published/g000/m373/k745/373745051.pdf

Appendix B – Resource Performance

As mentioned previously, extreme heat can negatively impact generation resulting in losses in operating capacity for certain resources. As part of the Final RCA, the CAISO, CPUC, and CEC evaluated how specific resource types performed during the August and September extreme heat waves. The additional analysis and potential improvements are provided below for each resource type.[30]

- **Natural gas** – under very high temperatures, reduced efficiency and capacity is not uncommon for the natural gas fleet. During the August 2020 events, high temperatures and dispatch stressed multiple sub-systems of natural gas power plants resulting in power loss.[31] On December 2, 2020, the CEC, in collaboration and coordination with the CPUC and CAISO, hosted a workshop to highlight a range of options for incremental upgrades at existing natural gas power plants, in an effort to increase their capacities to help address potential generation supply concerns for summer 2021 and beyond. The workshop highlighted several projects that add up to 100 MW of additional capacity that could be available for summer 2021. Since the workshop, the CPUC has been coordinating with the generators to realize this potential. The CEC has already reviewed and approved multiple requests for software and equipment improvements for these projects, and additional requests are expected prior to summer.[32]

- **Imports** – In total, import bids received in the day-ahead market were between 40-50% higher than imports under RA obligations, which indicates that the CAISO was relying on imports that did not have an actual contract obligating it to offer resources into the CAISO market. In addition to the rule changes the CPUC made to the RA program with regard to imports for RA year 2021, the CPUC may consider additional changes to current import requirements.

- **Hydro and pumped storage** – California hydro conditions for summer 2020 were below normal. RA hydro resources provided above their RA amounts and various hydro resources across the state managed their pumping and usage schedules to improve grid reliability. Summer 2021 is likewise anticipated to be a below normal for hydro. There should be increased coordination by communicating as early as possible the need for additional energy or active pump management ahead of stressed grid conditions.

[30] Reprinted from pg. 58-60 in *Final Root Cause Analysis* (citation 3)
[31] CEC "Lead Commissioner Workshop - Incremental Efficiency Improvements to Natural Gas Power-Plants for Electric System Reliability and Resiliency"; December 2, 2020. https://efiling.energy.ca.gov/GetDocument.aspx?tn=235827
[32] CAISO, CPUC, & CEC Report to Assembly Committee on Utilities and Energy; "Combined Energy Resource Planning & Procurement Actions"; April 2021.

- **Solar and wind** – In August 2020, high clouds caused by a storm covering large parts of California as well as smoke from active fires during the high heat events reduced large-scale and behind-the-meter solar generation on some days. The CPUC has improved the methods for estimating the reliability MW value of solar and wind over the years, but the reliability value of intermittent resources is still over-estimated during the net peak hour. Improvements to the RA program should account for time-dependent capabilities of intermittent resources.

- **Demand response** – While a significant portion of emergency demand response programs (reliability demand response resources or RDRR) provided load reductions when emergencies were called, the total amount did not approach the amount of demand response credited against RA requirements and shown as RA to the CAISO. Some, but not all of this difference, is the result of the credited amounts including a "gross up" that the CPUC applies to demand response resources consisting of approximately 10% for avoiding transmission and distribution losses, and 15% for avoided planning reserve margin procurement for customers who agree to drop load in grid emergencies. Additional analysis is needed to understand the discrepancy between credited and shown RA amounts, the amount of resources bid into the day-ahead and real-time markets, and performance of dispatched demand response.

- **Battery storage** – During the mid-August events and in early September, there were approximately 200 MW of RA battery storage resources in the CAISO market. It is difficult to draw specific conclusions about fleet performance from such a small sample size. However, the CAISO is anticipating ten times that amount of battery storage on its system by August 1, 2021.[33] The CAISO should continue to track and understand the collective behavior of the battery storage fleet and work with storage providers to effectively incentivize and align storage charge and discharge behavior with the reliability needs of the system.

[33] Or 2,000 MW; CAISO News Release; "California ISO prepares for surge in grid-scale energy storage: Stakeholder initiative will drive cutting edge solutions for storage integration"; April 28, 2021