Report
2025

A BETTER DEAL FOR CALIFORNIANS:

The Rise of Battery Storage Over Gas Generation

REGENERATE CALIFORNIA (COALITION LED BY SIERRA CLUB AND CEJA) AND CEERT

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Acknowledgements

The report team — Heena Singh, Julia Rose Manriquez Dowell, Katherine Ramsey, Tyler Valdes, Roselyn Tovar, Feby Boediarto, Theo Caretto, Shana Lazerow, Maia Leroy, and Ed Smeloff — thank our coalition members and partners for their contributions and time in support of this report.

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Executive Summary

2024 marked the year of batteries, as they proved essential to grid reliability and significantly improved the efficiency of California's electricity system. Batteries have enabled the grid to operate with dramatic decreases in fossil fuel use, proving that battery storage technology can reduce the state's reliance on fossil gas plants. In 2023 and 2024, the California Independent System Operator (CAISO) reported improved system reliability with zero flex alerts—requests sent to residents asking them to voluntarily curb energy use in times of peak demand. Increased battery system availability has avoided the return of rolling blackouts that occurred in August 2020.

In addition to being a more reliable energy technology than gas plants, batteries are also significantly more cost-effective and offer great potential to improve energy affordability for ratepayers through a transition to zero-carbon energy.

Battery energy storage systems (BESS), often paired with renewable energy sources, already extend California's use of existing zero-carbon resources for hours after the sun goes down and before it rises the next morning. They are particularly valuable when energy demand is rising to its daily net peak. Historically, peak demand and evening ramping have been met with gas generation, but the rapid addition of battery storage capacity is reducing those needs while offering a cleaner, cheaper, and more versatile option. However, design of the state's reliability standards and programs, as well as interconnection process barriers, needs to be addressed to accelerate the benefits of utilizing new BESS rather than aging gas-fired power plants.

This report is a joint effort between the Center for Energy Efficiency and Renewable Technology (CEERT) and Regenerate California (Regenerate), a partnership between the California Environmental Justice Alliance (CEJA) and the Sierra Club, who share a vision to transition away from polluting gas plants to a regenerative and just clean energy economy. CEJA's member organizations include grassroots and environmental justice base-building organizations such as Communities for a Better Environment (CBE) and Central Coast Alliance United for a Sustainable Economy (CAUSE), both of which contributed to the case studies featured in the Non-Energy Impacts (NEI) section of this analysis.

This report has two aims: 1) Demonstrate the steadily decreasing cost and increasing value of battery storage in contrast with the increasing costs associated with aging and often less reliable gas-fired power plants (costs include economic as well as NEI) and 2) Address how batteries can continue to add value to the grid and ratepayers and identify what policy steps must be taken to do so.

Many fossil fuel power plants operate to serve local resource adequacy (RA) needs due to inadequate transmission capacity to the local area. These plants are frequently overdue for retirement and expensive to operate. The CAISO, together with the CPUC, identifies the amount of local RA resources that are needed to ensure there is sufficient power available within each transmission-constrained local capacity area to meet projected demand.

In a 2023 report, Regenerate analyzed the performance of nearly all gas plants in California during the 2022 heat wave.[1] The findings showed that many gas plants failed to perform at their expected capacity during the heatwave, while significantly increasing the pollution burden in nearby communities during lengthy start-ups. During extreme heat events like the one in 2022, communities living near gas-fired power plants are negatively impacted when the plants start and then ramp up, causing emissions to skyrocket. In some communities, when distribution system problems occur, customers still face power outages while suffering from toxic air pollution from their local gas plant.[2]

Key findings of this report include:

- Battery energy storage systems (BESS) represent a better investment than gas-fired power plants because of their rapid ramp-up time, low maintenance costs, and reliability.
- Gas-fired power plants present much higher non-traditional costs, referred to as Non-Energy Impacts (NEIs), than BESS, especially in environmental justice communities. These communities bear an additional burden, as more than half of California's 200 gas plants are sited in their neighborhoods—the result of decades of systemic racism and inequitable energy and land use planning.
- The many benefits of BESS, on top of their high daily dispatchability, can help lower electricity rates for Californians by squeezing out gas plants from the Resource Adequacy (RA) market.
- By replacing gas-fired generation assets in the Strategic Reliability Reserve (SRR) with BESS, California could save significant amounts while still providing reliability reserves.

1 See Regenerate California, *California's Underperforming Gas Plants: How Extreme Heat Exposes California's Flawed Plan for Energy Reliability* (2023), available at https://ceja.org/wp-content/uploads/2023/06/2023-Regenerate-Heat-Wave-Report.pdf.

2 Many EJ communities have less reliable electricity because of underinvestment in the local lower voltage distribution system. Community resiliency can be improved through the development of microgrids and resiliency hubs.

Notes on Terminology

Environmental justice (EJ) communities: These are neighborhoods most burdened and harmed by many cumulative sources of pollution and injustice, and are often working-class people of color. On a state policy level, they are referred to as Disadvantaged Communities (DACs) — the most burdened census tracts identified by CalEnviroScreen2 using over 20 indicators of environmental, health, and socio-economic burdens.

Lithium-ion batteries: Efficient, high-energy density storage systems employing lithium ions that move between electrodes to store and release energy. These systems are the most common battery energy storage systems (BESS) technology.

Load Serving Entities (LSEs): Organizations responsible for serving electricity to end-use customers, including investor-owned utilities (e.g. PG&E, SCE, and SDG&E), publicly-owned utilities, community choice aggregators, and electric service providers. LSEs are widely referred to as simply "utilities".

Peak Demand: The point in the day when electricity demand is highest across the state.

Planning Reserve Margin (PRM): A fixed percentage of capacity added to the expected demand, required to be on standby every day as a buffer so it is available in case, for example, several power lines go down at the same time. California's PRM used for 2024 and 2025 is 17%.

Resource Adequacy (RA): California's regulatory framework that ensures there are sufficient resources available on the electric grid to reliably meet demand. The RA framework was developed by the California Public Utilities Commission and mandates that all load-serving entities (LSEs) procure enough energy to maintain reliability, even during peak periods or unexpected weather events.

Slice of Day: The updated RA framework now requires LSEs to ensure enough capacity on an hour-to-hour basis. This differs from the previous framework, which used a single peak hour per month planning method, to better reflect real-time grid needs and the rise of renewable energy resources.

Strategic Reliability Reserve (SRR): In 2022, California Governor Gavin Newsom authorized Assembly Bill 205, which included a controversial $2.2 billion "Strategic Reliability Reserve" that doubled down on investments in fossil-fuel resources, including gas plants and diesel backup generation, based on an assumption about ensuring adequate power supplies when extreme heat or wildfires threaten grid reliability.

Cost Analysis

Economic Factors Impacting the Cost of Gas Generation

As gas plants age, they face cost increases from air quality compliance, increasing and variable fuel costs, and operations and maintenance. Extending the lifetime of gas plants often requires modernization to sustain operations until the plant eventually retires, making it a costly, short-term investment. As the financial outlook for these older plants worsens, obtaining the necessary investments for upgrades becomes riskier and costlier, contributing to increasing electricity costs for all ratepayers and subsidies from taxpayers.

Many older, less efficient gas plants typically operate during net peak evening hours (6 pm to 10 pm) and are turned off or down[3] when lower-cost renewables are available during the day. Moreover, some of the oldest plants in California are Once-Through Cooling (OTC) plants, meaning they use ocean water to cool the plant equipment. These plants include Ormond Beach Generating Station,[4] AES Alamitos, and Huntington Beach Generating Station. It should be noted that the average lifetime of gas-fired power plants ranges from 25-40 years, while plants like Ormond Beach Generating Station have been in operation since 1971. These plants are considered "emergency plants" that operate only for grid emergencies and are funded through the Strategic Reliability Reserve. These plants can take many hours to ramp up and require planning in advance to respond to a contingency event.[5] Standby generation in the wholesale market, often referred to as planning reserves, is needed during hot summer days and during major contingency events like the failure of a transmission line or when a large generator trips offline. ***California residents pay to keep these gas-fired plants available on standby in case they are needed. A key question is whether these high costs continue to be justified as new battery systems are added to the grid.***

3 Some gas-fired generators operate during midday at low levels (called Pmin) in order to be available for the evening ramp. Pmin is defined as the minimum stable load, measured in megawatts (MW), that a generating unit (or a block/module in the case of a combined cycle plant) can sustain continuously.

4 The Ormond Beach Generating Station was scheduled for retirement by the end of 2020 but received extensions through the end of 2023 (after the 2020 record heat wave) and then again through the end of 2026 to participate in the state's emergency reserve. Surrounding communities within the area who have long been burdened by the plant's pollution and negative environmental impacts joined with environmental activists to oppose the extensions, and are still fighting for its retirement.

5 If a thermal power plant has been offline for **5 days or more**, the boiler and associated systems have cooled down significantly. A cold start is time-consuming, and for larger units can take **10-20 hours or even more** to reach full operational capacity. This long duration is needed to slowly and carefully heat the boiler to avoid damage from uneven expansion and thermal stress. Combined cycle plants can ramp up more quickly and are not used in the CAISO market except during emergency conditions, which require activation of the Strategic Reliability Reserve.

How the Need for Resource Adequacy Drives Electricity Costs

California depends on the state's Resource Adequacy (RA) program to reliably keep the lights on. Load serving entities (LSEs) are responsible for delivering enough capacity to meet electrical demand through long term RA contracts with resources. Resources are then paid by the LSE and the CAISO at the locational price if they are able to deliver power for the given month. The cost of these RA resources is passed on directly to consumers through their electricity bills.

The RA Program requires LESs to show the California Public Utilities Commission (CPUC) and the the California Independent System Operator (CAISO) that they have enough resources to call on when electric demand is high or there are extreme weather events like wildfires that impact the grid.

RA costs have significantly increased in recent years, rising from $14.37 per kilowatt-month in 2023 to $26.26 per kilowatt-month in 2024.[6] Part of this cost increase comes from changes in the RA program's planning reserve margin (PRM), a buffer of additional capacity to account for uncertainties in demand forecasts as well as the immediate availability of power plants. The unavailability of some gas-fired generation for California contributed to the rolling blackouts as seen in 2020.

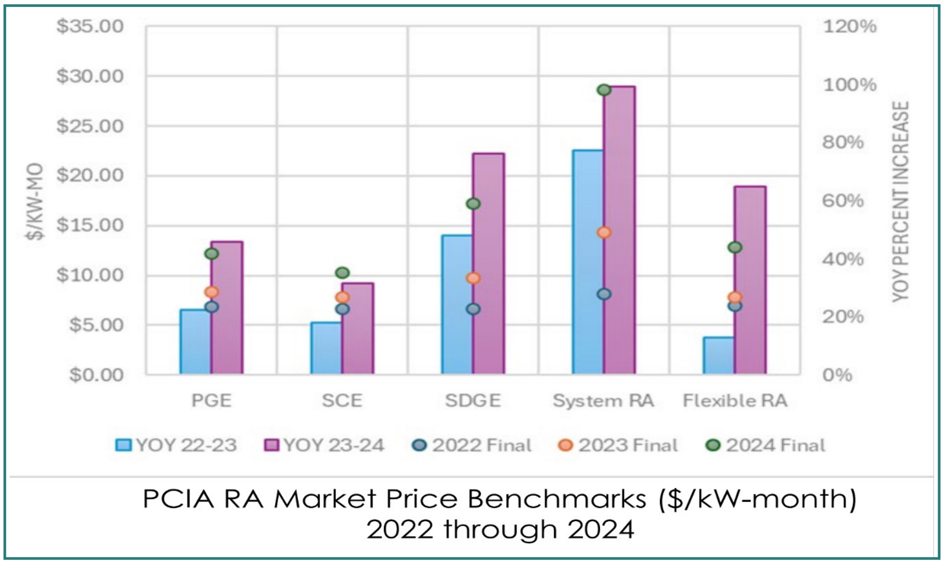
The CPUC is responsible for determining the PRM necessary to achieve a resource portfolio that meets the reliability standard of a loss of load expectation (LOLE) of 0.1, meaning demand may exceed available supply one day in ten years.[7]

To ensure the reliability of the grid and integrate a growing amount of renewable energy, CAISO utilizes three key types of capacity:		
System Capacity: This refers to the overall amount of generation capacity required across the entire CAISO area to meet the expected peak load and maintain a planning reserve margin.	**Flexible Capacity:** With the increased integration of variable renewable resources like solar and wind, the California grid experiences fluctuations in net load (customer demand minus renewable generation). Flexible capacity refers to resources that can rapidly adjust their output (ramp up or ramp down) to address these changes. This is crucial for maintaining grid stability, especially during periods of steep ramps, when solar generation declines rapidly in the late afternoon while demand remains high.	**Local Capacity:** This type of capacity addresses localized transmission constraints or reliability issues within specific geographic areas of the grid, known as Local Capacity Areas. Even if there's enough overall system capacity, a lack of local capacity can lead to reliability problems in these areas.

6 https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M553/K679/553679249.PDF.

7 The CPUC has proposed to increase the PRM from 17% in 2025 to 26.5% for the first half of 2026 and 23.5% for the later half. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M539/K999/539999171.PDF.

As more battery storage systems come online in California, they can be deployed in a way to reduce the PRM, in turn improving grid reliability and reducing RA costs. Batteries outperform gas-fired generation in flexibility and dispatchability, allowing for a lower PRM while maintaining a LOLE of 0.1 or less.



The Rising Cost of Resource Adequacy: RA prices have gone up in recent years. These costs are passed on directly to ratepayers. Transitioning the electric system from dependence on gas generation to battery energy storage systems will lower RA program costs and customer bills.

A critical aspect that needs to be taken into account for generators and batteries in the RA program is the resource availability—in other words, how likely is it that a resource is going to show up and perform when it's needed? The way megawatts are accounted for in the RA program can make some resources less attractive as an RA resource. Solar and wind power, for example, aren't always available during certain times of the day and year. This variability makes their RA capacity rating lower than what is credited to gas-fired generation.[8] Consequently, gas plants historically have been the dominant technology relied upon in the RA program because they are somewhat flexible and dispatchable. More recently, however, energy storage technologies (principally chemical batteries) are proving to be just as reliable, if not, more reliable than gas-fired generation while displacing the cost of gas storage and delivery whose well-head cost, the cost of the fuel at the point of extraction, before transportation or other downstream costs, can fluctuate significantly.

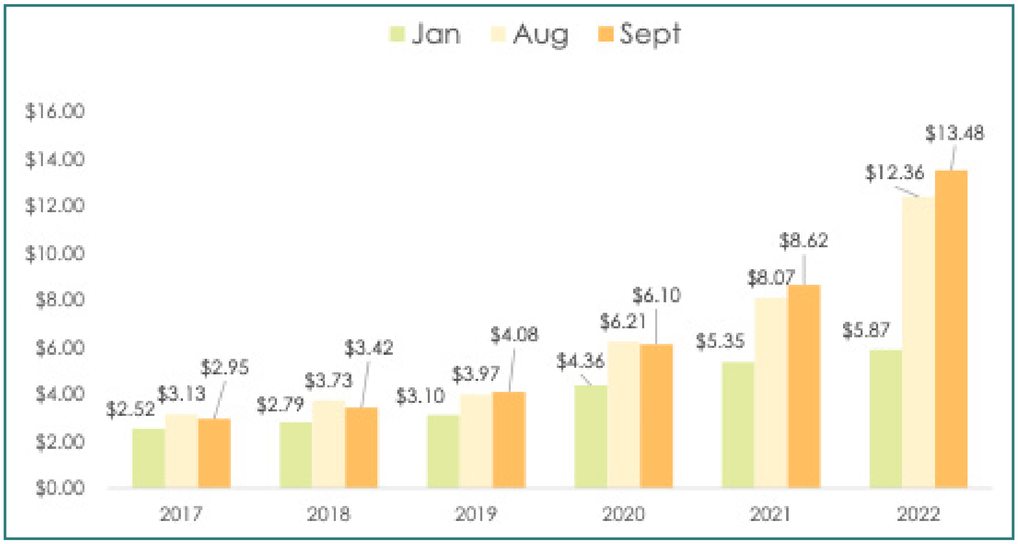
Calculating Battery Storage Cost for the RA Program

In addition to emitting harmful pollution, gas-fired power plants contribute significantly to rising electricity costs for ratepayers across California. Residential electricity rates for California's three major investor-owned utilities increased from 48% to 67% between 2019 and 2023.[9] Wildfire-related costs are the most cited source of these increases, but it is important to recognize the major contributions from other components. For example, the cost of energy capacity contracts has increased significantly in recent years.

8 Some gas-fired generators are also not available when called upon despite getting paid to be available. The CPUC is attempting to de-rate fossil generation based on how it has performed in the past.

9 Song, Sharon. FOX KTVU2. California's power rates are second highest in the U.S., soaring bills projected to continue (January 9, 2025), available at https://www.ktvu.com/news/california-has-nations-second-highest-power-rates-soaring-bills-projected-continue.

Expensive contracts with gas plants are typically justified for assuring reliability, but at a significant cost to ratepayers. Utilities and other load-serving entities regularly sign capacity contracts with gas plants to meet both system and local RA requirements to ensure that those plants will be available if needed to meet demand. Those capacity costs at both the system and local level have varied in recent years. The 2022 CPUC Resource Adequacy Report—the most recent public information on California's capacity costs—showed that the 2022 weighted average system price for system capacity was $7.64/kW-month and the weighted average system price for local RA was $7.70/kW-month.[10] The 85th percentile of RA contracts indicated that many contracts were much higher, reaching prices of $10.50/kW-month for system capacity and $13.00/kW-month for local capacity.[11] Prices for September capacity represent the most expensive of the year, where RA resources received a weighted average price of $13.48/kW-month with the 85th percentile of contracts reaching $30.00/kW-month. As a point of comparison, these September RA prices reflect a **357% increase** from the September 2017 weighted average.



Weighted Average Price of System RA ($/kW-month): From 2017-2022, the average price of system RA has increased significantly, especially during the high-demand months of August and September.

These RA capacity costs represent the amount of money that utilities pay for resources just to stay online and be available. If and when an RA resource is deployed, the utilities pay for the energy, which includes the costs of the fuel and variable generation costs. These fuel and variable operating costs are in addition to the contracts. All of these costs then get passed down to ratepayers.

Actual capacity contract terms are kept confidential, and CPUC reports represent the limited public information on capacity prices and which power resources account for the bulk of these contracts. Battery storage deployment has been significant in recent years, contributing to the capacity available for the RA program capacity. Still, most of the net qualifying capacity necessary for the RA program continues to come from gas plants. ***Transitioning the electric system from dependence on gas generation to battery energy storage systems will lower RA program costs and customer bills.***

10 California Public Utilities Commission. *2022 Resource Adequacy Report* (May 2024), Table 7.

11 *Id.*

Battery storage systems offer a more equitable and cost-effective alternative to keeping unneeded gas plants available. By storing excess solar energy and discharging it during peak periods, batteries can reduce reliance on high-cost peaker plants and fuel price volatility. When paired with local solar and implemented at scale, battery storage can improve grid reliability and lower energy costs. In a 2023 report, the California Energy Commission (CEC) found that energy storage could cost-effectively displace reliance on existing gas plants while also supporting bulk grid decarbonization and environmental justice.[12] In analyzing local capacity requirements, the CEC research team demonstrated that energy storage could cost-effectively maintain local capacity requirements while reducing the need to retain gas plants in disadvantaged communities.[13]

Huge quantities of energy storage systems have come online and received RA contracts in recent years. Across California, battery storage capacity grew from about 500 MW in 2020 to 11,200 MW in June 2024,[14] but only a portion of that capacity received RA contracts.[15] As more battery systems come online, they will further contribute to RA contracts and reduce reliance on existing gas systems.

The levelized cost of new energy storage ranges from $170-296/MWh, with a total installed cost average of $0.76-1.57/MW.[16] As RA prices increase, the incentive to develop additional energy storage projects will also increase, and gas plants will find it harder to compete. By displacing gas plants for capacity contracts, battery storage projects will represent better value to California ratepayers and reduce pollution across the state.

Slice of Day: Reforming Resource Adequacy To Reflect Battery Storage Reliability

Even if the cost of RA capacity increases, gas plants that are reaching their retirement age may still be able to obtain RA contracts that delay their retirement based on steady revenue streams for staying on standby. However, if more batteries can overcome barriers to connecting to the transmission grid, as discussed in the Addressing Interconnection, Permitting, and Local Reliability Constraints section, then the price of RA capacity should fall and force the economic closure of more gas-fired generation. Also important to lowering the cost of electricity is the opportunity to leverage available solar and wind energy to charge battery storage systems that can be discharged later in the day. Savings to ratepayers can be achieved by lowering RA capacity prices for BESS because they also earn revenue through daily energy arbitrage, meaning the batteries are charged when electricity prices are low and discharged when prices are higher, allowing storage operators to profit while also balancing supply and demand on the grid.

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12 Go, Roderick et al. California Energy Commission. ***Assessing the Value of Long-Duration Energy Storage in California*** (Dec. 2023), p.2, available at https://www.energy.ca.gov/sites/default/files/2024-01/CEC-500-2024-003.pdf.

13 Id. at 28.

14 CAISO, Special Report on Battery Storage (2023), available at https://www.caiso.com/documents/2023-special-report-on-battery-storage-jul-16-2024.pdf.

15 *Id*. at 28.

16 Lazard Levelized Cost of Energy+, June 2024 (Lazard assumes 60% debt at 8% interest and 40% equity at 12% cost).

The many benefits of BESS, on top of their high daily dispatchability, can help lower electricity rates for Californians by squeezing out gas plants from the RA market. However, the old RA framework was built around assuring the availability of sufficient gas generation to meet the annual peak demand. That framework is changing with the adoption of a "Slice of Day" design for the RA program, which can enable market entry for more flexible battery resources as well as demand response measures. The CPUC will fully implement the Slice of Day methodology in 2025. Still missing from the revised framework is a strategy for reducing the need for gas-fired plants in local sub-areas, due to the deliverability constraints of the transmission system.

Legacy RA Framework:	Slice of Day Framework:
• **Typically assessed grid conditions for one peak demand hour annually** • **Limited assessment of risks of capacity during net peak (during and after sunset) and other non-peak hours (cold mornings)** • **Resources demonstrating availability during a single peak hour earn RA capacity credits, regardless of performance across other hours** • **Can be misaligned with energy markets (e.g. low RA credits for energy arbitrage to high demand periods)** • **Limits qualifying capacity and development of BESS with durations less than 4 hours** • **Lower RA payments assigned to qualifying BESS despite their better performance and flexibility**	• **Assesses grid conditions across 24 hourly slices of the most stressed days for each month** • **More detailed assessment of grid conditions offers a more accurate representation of future needs** • **Capacity credits are assigned based on resources' availability for each of the 24-hour slices per day** • **Better integration with energy market modeling** • **Qualifying capacity captures hour-by-hour reliability of BESS as assigned by procuring load-serving entities (LSEs)** • **Flexible scheduling of RA contribution incentivizes LSEs to be procured for periods when most needed**

Currently, most commercial batteries, especially lithium-ion-based systems, provide four hours of discharge at maximum capacity. Four-hour batteries have become the standard since the older CPUC RA framework mandated that battery resources be capable of providing at least four hours of continuous output to be eligible for RA capacity credits. It is the full fleet of batteries that is important for system reliability; the current fleet capacity is now around 40 gigawatt hours, which can be deployed daily based on market pricing. RA counting rules are changing as the Slice of Day RA program design is put in place. The Slice of Day program will allow batteries of varying capacity to get capacity credit to meet the load profile of individual load-serving entities.

Some LSEs may see a higher RA value for 1-hour or shorter duration batteries, while others may prefer 4-hour or longer duration batteries. The Slice of Day approach to capacity accreditation will permit a more flexible approach to battery procurement. As noted previously, the actual daily dispatch of the batteries will be determined through bids submitted into the wholesale power market.

The complexities of varying battery systems will be better accounted for under the Slice of Day RA framework. However, storage technologies with a multi-day discharge duration are at a disadvantage in a framework that focuses solely on daily charging and discharging.

Addressing Interconnection, Permitting, and Local Reliability Constraints

The deployment rate of BESS depends on interconnection to the transmission grid. Despite the rapid expansion in battery storage capacity that California has seen in recent years, the pace of deployment will slow because of grid interconnection challenges, consisting of overcrowded queues, delays in interconnection studies, rising costs of deliverability upgrades, and permitting hurdles.

The CAISO has seen extraordinarily high numbers of interconnection requests for BESS in recent years, leading to significant backlogs. In response, the CAISO recently reformed the way it prioritizes interconnection studies through the Interconnection Process Enhancements (IPE) initiative.[17]

The IPE aims to expedite the interconnection approval process to reduce regulatory delay of interconnection agreements. However, many BESS projects are still experiencing delays in obtaining permits and, in some parts of the state, are awaiting transmission deliverability upgrades. These delays can impact the procurement strategies of LSEs and result in their continued reliance on existing gas-fired capacity to meet their RA requirements.

A major challenge for the development of renewable energy and battery storage is the time it takes to expand and upgrade the transmission system. Even before the influx of interconnection applications requiring network upgrades, the CPUC encountered significant delays in approving transmission project permits. Several policy initiatives have recently attempted to address the CPUC permitting bottleneck, including an update to General Order 131 (now in its fifth form, G.O. 131-E) and efficient renewable energy project review at the CEC.

Transmission constraints, areas on the grid with limited ability to receive power during certain conditions, limit the number of available interconnection sites that do not require network upgrades. Under the RA program, LSEs are required to ensure a maintained capacity in transmission-constrained sub-areas of the CAISO grid.

17 The final set of reforms was just approved on April 9, 2025 at the Board of Governors meeting. https://stakeholdercenter.caiso.com/StakeholderInitiatives/Interconnection-process-enhancements-2023.

These areas, also called local reliability areas, frequently have already limited locations where additional capacity can be built. As load growth occurs, limited transmission poses significant challenges for generation to flow into these areas. To qualify for local RA contracts, battery systems must be able to operate for the length of time when transmission is constrained to these subareas. If the deliverability of energy needed to charge the batteries located in a subarea is insufficient, then the battery cannot qualify for the RA program.

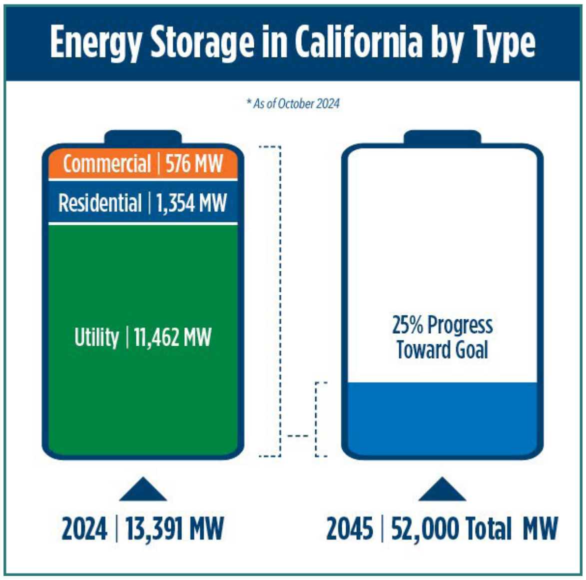
The Strategic Reliability Reserve

Since the Strategic Reliability Reserve (SRR) was established in 2022, Californians have paid several billion dollars to keep large, environmentally damaging gas plants online, even when state water law would have otherwise required them to retire. The California Legislature established the SRR to buy emergency backup generation that could be used for reliability during extreme weather events, such as summer heat waves, when demand is extremely high across the entire western United States. The SRR is overseen by two entities: the California Energy Commission (CEC) and the California Department of Water Resources (DWR).

Since 2010, California law has required utilities to retire once-through cooling (OTC) gas-fired power plants by 2020 or adopt new cooling methods due to the harmful impacts of the technology on water quality and marine ecosystems. Implementation of this policy has been delayed for certain gas plants, whose operations have been extended.

In 2022, the State Water Board further extended the compliance date for eliminating three of the state's once-through-cooling (OTC) gas-fired power plants—Ormond Beach Generating Station, AES Alamitos, and Huntington Beach Generating Station—to December 31, 2026. The Board also extended the life of the Scattergood Generating Station, another OTC gas plant, to December 31, 2029. This was the second time the compliance date was extended for these plants despite outcry from local communities and environmental justice advocates. These aged plants have a combined capacity of approximately 3 GW—enough to power about 2.3 million homes—and were removed from the wholesale energy market to be placed into the SRR, shifting funding from ratepayers to taxpayers, with the intent to only be called upon during the summers of 2024, 2025, and 2026. The DWR has invested the overwhelming bulk of legislatively appropriated funds for the extended operations of these expensive and polluting OTC plants.

In 2024, the OTC plants were not needed to provide reliability resources. This positive development comes in large part due to BESS capacity reaching 9,070 MW in July 2024, enabling the CAISO to manage peak summer load conditions during several heat waves without having to issue any energy alerts.[18] As of October 2024, energy storage capacity totals 13,391 MW with 11,462 MW directly responsive to CAISO market prices, further reducing the need for gas-fired power plants, including the OTC plants in the SRR.[19]



As of October 2024, California had 13,391 MW of energy storage on the grid. In order to reach the state's 2045 goal, it is estimated that California will need 52,000 MW.

Benefits and Barriers of Replacing Gas Generation with BESS

The operational flexibility of BESS offers multiple advantages in comparison to gas-fired generation. Because of their near-instantaneous ramp-up time[20] batteries are capable of rapidly injecting power to maintain the grid's 60 Hz frequency when components fail or load increases. This fast response to frequency disturbances is important to enabling more renewable energy resources to operate in a competitive energy market, since it fills the gap when solar energy drops off at the end of the day or when wind power fluctuates. The slower response time of gas peaker plants, in contrast, makes them more costly to use for frequency regulation or as contingency reserves. For instance, gas plants are less able to keep up with batteries when transmission corridors are unexpectedly shut down or demand spikes in unexpected ways, particularly during extreme heat events and wildfires. Much of California's electric grid relies on inverter-based battery systems, which convert direct current (DC) to alternate current (AC), and can be used to provide reactive power when charging, discharging, or standing idle. Reactive power is needed to stabilize voltage, increasing reliability on portions of the grid when lines fail or demand exceeds expectations. Gas plants, on the other hand, can only provide reactive power when they are on and spinning, which requires burning methane gas. When left unadjusted, large voltage drops can damage customer equipment and can trigger local outages. The following table compares the cost, efficiency, and impacts of batteries and gas turbines. Notably, batteries are faster and more scalable than gas turbines, contributing to their cost effectiveness.

18 The CAISO alert system has transitioned to align with the North American Electric Reliability Corporation's (NERC) Energy Emergency Alert system, ensuring consistency with alerts used by other grid operators in the Western Electricity Coordinating Council. A Flex Alert is a proactive, voluntary call to consumers to conserve electricity. It's typically issued when CAISO anticipates that electricity supply might not meet high demand.

19 The CEC's California Energy Storage System Survey https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/california-energy-storage-system-survey.

20 Battery storage systems take just milliseconds to discharge to the grid; this comes in comparison to the hours (sometimes more than 12) that gas plants can take to ramp-up to full capacity. https://www.eia.gov/todayinenergy/detail.php?id=45956.

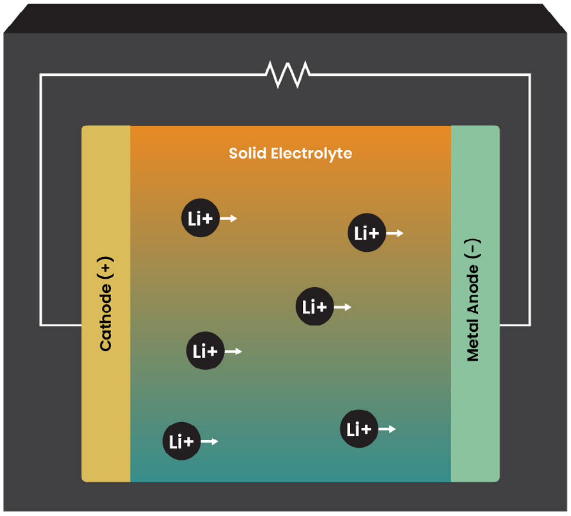
Batteries vs. Gas Generation: A Comparison

Feature	Batteries	Gas Generation
Response Time	Extremely fast (milliseconds), providing near-instantaneous power.	Slower, requiring time to start up and ramp to full power (sometimes 10-20+ hours).
Frequency Response	Can quickly inject or absorb power to stabilize grid frequency.	Slower than batteries.
Load Following	Highly flexible and can quickly adjust output to match changes in demand.	Ramping speed is slower.
Operating Reserves	Excellent for short-duration reserves. Can provide rapid injections of power during sudden outages. Long Duration Energy Storage (LDES) is an emerging technology that can provide power for longer periods.	Good for sustained reserves. Can provide power for longer periods if there are no compliance restraints.
Planning Reserves	Becoming increasingly viable, especially when paired with renewable energy sources.	Traditionally a primary source of planning reserves, ensuring capacity during peak demand.
Environmental Impact	Zero direct emissions.	Significant emissions, contributing to air pollution and greenhouse gas emissions.
Scalability	Highly scalable, with modular systems that can be deployed at various sizes.	Scalability is limited by the size of individual turbine units.
Fuel Flexibility	Relies on stored electrical energy. Can be charged from various sources, including renewables.	Relies on methane gas or other fossil fuels.
Location Flexibility	Highly flexible. Can be deployed in various locations, including urban areas.	Requires access to fuel pipelines or storage, limiting location flexibility.
Cost	Requires large capital investment, but low operating costs contribute to their cost effectiveness.	Lower upfront capital costs, but higher operating costs due to fuel consumption.
Grid Stabilization	Excellent for providing grid stabilization services, such as voltage support and inertia.	Can provide grid stability, but not with the same agility as batteries.

Batteries on the Market Today

1. Solid-State Batteries (SSBs)

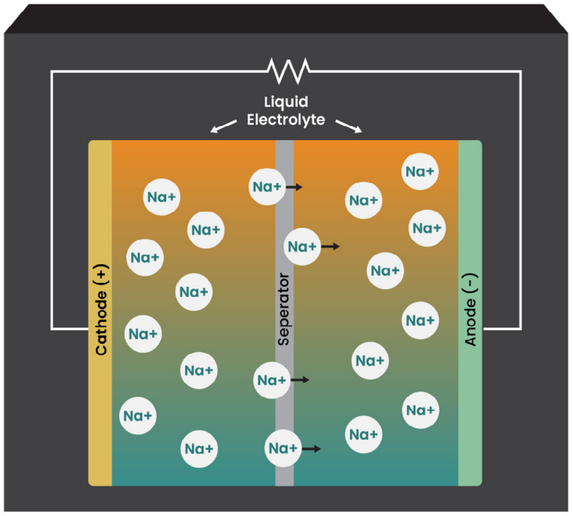
Solid-State Batteries



- **Key Characteristics:** Replace the liquid or gel electrolyte of conventional Li-ion batteries with a solid material (e.g., ceramic, sulfide, polymer). This inherently improves safety, as it eliminates the risk of leaks and reduces the chance of thermal runaway. They also promise higher energy density, longer cycle life, and faster charging times.
- **Typical Charging/Discharging Times:** Can benefit from rapid charging to obtain a full charge, depending on the specific chemistry and application design. The solid electrolyte supports quicker ion transfer.
- **Commercial Status:** Largely in research and development (R&D) with some early pilot projects and limited commercialization in niche, high-value applications. Automotive companies are heavily investing, with prototypes expected in EVs by 2027 and broader commercialization for EVs and potentially grid storage in the 2027-2030 timeframe.

2. Sodium-Ion Batteries (Na-ion)

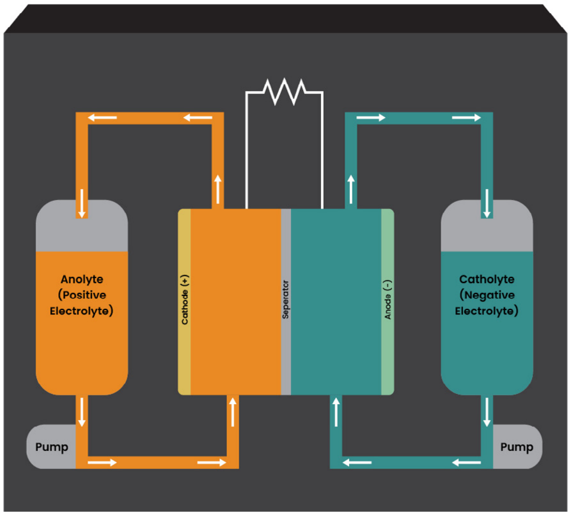
Sodium-Ion Batteries



- **Key Characteristics:** Utilize sodium ions (Na+) instead of lithium ions for charge transfer. Sodium is far more abundant and cheaper than lithium (e.g., found in sea salt and the Earth's crust), making it a more sustainable and cost-effective alternative.
- **Typical Charging/Discharging Times:** Generally supports fast charging and discharging, similar to Li-ion. Capable of faster bursts for frequency regulation.
  Can handle deep discharges.
- **Commercial Status:** In early commercialization and pilot deployment, particularly for stationary energy storage. Companies are launching grid-scale Na-ion products. Production is expected to grow significantly, capturing a notable market share by 2029.

3. Flow Batteries (Redox Flow Batteries - RFBs)

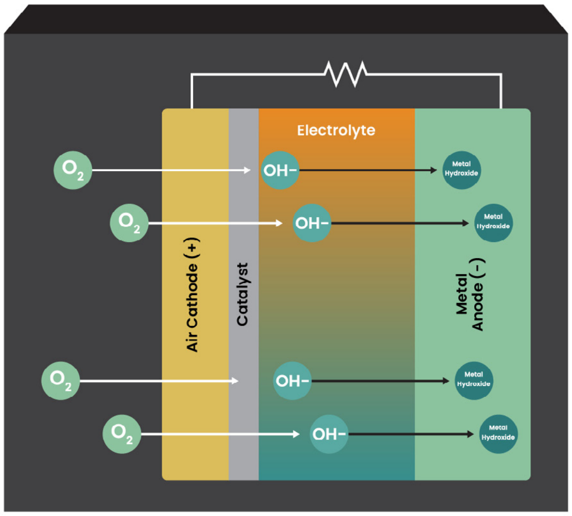
Flow Batteries



- **Key Characteristics:** Store energy in liquid electrolytes contained in external tanks, separated from the power conversion components (the "stack"). Energy capacity (tank size) is decoupled from power output (stack size), allowing for flexible scaling. Different chemistries are used, with Vanadium Redox Flow Batteries (VRFBs) being the most mature.
- **Typical Charging/Discharging Times:** Excel at longer-duration storage, typically 4-12+ hours, and can even store energy for days. They can also provide rapid response for ancillary services.
- **Commercial Status:** Vanadium flow batteries are fully commercialized and widely deployed for grid-scale applications, with significant installations worldwide. Other chemistries like zinc-bromine and iron-based flow batteries are in pilot deployment and early commercial stages.

4. Metal-Air Batteries (e.g., Iron-Air, Zinc-Air)

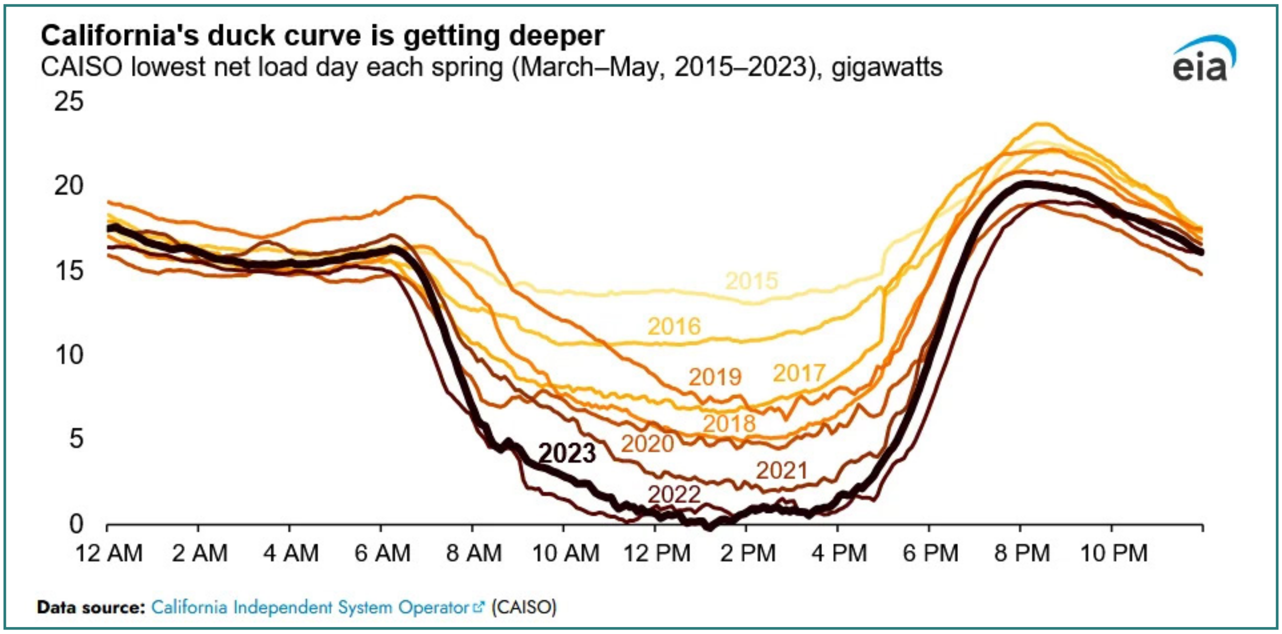
Metal-Air Batteries



- **Key Characteristics:** These batteries use oxygen from the air as a reactant at the cathode, while the anode is made of a metal (iron, zinc, aluminum, etc.). This chemistry allows for very high theoretical energy densities because the oxygen reactant doesn't need to be stored within the battery itself.
- **Typical Charging/Discharging Times:** Can offer very long-duration storage, with some iron-air systems targeting 100+ hours of discharge. Charging times can vary.
- **Commercial Status:** Generally in advanced R&D and pilot phases. Companies are actively developing and piloting iron-air batteries for long-duration grid storage. Zinc-air batteries are commercially available as non-rechargeable batteries for hearing aids and other small devices. Rechargeable zinc-air for grid scale is still under development, focusing on improving cycle life and efficiency.

As the technologies develop, longer-duration BESS, such as those with eight or more hours of duration, may turn out to be cost-effective in a well-balanced portfolio. However, they will need to demonstrate their performance before they are widely deployed. These longer-duration technologies may use chemistries other than lithium-ion. For example, flow batteries, which store energy in liquid electrolyte tanks that flow through a reactor, may offer up to 10 or more hours of duration and longer lifespans (stemming from higher cycle counts, or the number of full charge-discharge cycles a battery can undergo before capacity significantly degrades). However, some technologies may have a larger land-use footprint and offer lower power-to-energy ratios.[21] Profitable applications of flow batteries could include microgrids in rural or fire-prone areas since they utilize non-flammable, water-based electrolytes, or, like lithium-ion batteries, can assist with solar shifting during the evening peak.

Another example of long-duration BESS is iron-air batteries, which convert iron into rust, releasing electrons through oxidation, and offer 100 or more hours of energy storage while being relatively low-cost and made of abundant resources. A downside to this technology is its low energy conversion efficiency; current iron-air batteries only have a turnaround efficiency rating of around 50-60% (in comparison to the 90%+ efficiency for lithium-ion batteries). This means longer charging time and the loss of nearly half of the input energy.[22]



This is famously known as the "duck curve", referring to a dip in demand during the day (when solar power is plentiful) followed by the evening peak (when solar drops at sunset). The "belly" of the duck offers prime time and capacity for batteries to charge before meeting the evening's high demand.

21 DOE Flow Batteries Technology Assessment https://www.energy.gov/sites/default/files/2023-07/Technology%20Strategy%20Assessment%20-%20Flow%20Batteries.pdf.

22 "Will Iron-Air Batteries Revolutionize Renewable Energy Storage?" E+E Leader https://www.environmentenergyleader.com/stories/will-iron-air-batteries-revolutionize-renewable-energy-storage,48339.

Their significantly long duration, despite low efficiency, makes this technology an attractive option for emergency backup, such as that needed during heat waves and outages. It could be a suitable asset for inclusion in the Strategic Reliability Reserve since it could not compete as an RA resource with daily must-offer obligations to the CAISO.

The use of "zero-carbon" hydrogen has been proposed as a longer-term solution for electricity storage. The conversion of gas-fired generation to use a blend of methane and hydrogen is not cost-effective anywhere on a commercial scale, particularly when using "green" hydrogen produced via electrolysis. While it can leverage existing infrastructure, the economic feasibility faces significant challenges due to the high cost of green hydrogen production and the efficiency losses associated with its conversion and combustion.

The combustion of hydrogen produces significant air pollution, primarily nitrogen oxides (NOx). Leaks of hydrogen can have an indirect warming effect by impacting other greenhouse gases in the atmosphere.

Non-Energy Impacts: The True Costs For Communities

The costs of gas plants compared to those of battery storage systems extend beyond traditional economic factors to social costs that cannot be overlooked in cost-benefit analyses. Gas plants also expose communities across California to air and water pollution, energy insecurity, blackouts, and the resulting public health impacts and medical costs. These non-energy impacts are not considered in most regulatory analyses and overlook the externalities of gas plants. There are over 200 gas plants[23] in the state of California, and over half are located in environmental justice (EJ) communities. These are neighborhoods most burdened and harmed by many cumulative sources of pollution and injustice, and are often working-class people of color. This is not a coincidence but rather the result of institutionalized and systemic environmental racism.[24]

Non-Energy Impact

In addition to the capital costs and operations and maintenance costs associated with energy projects, it is necessary to consider the non-energy impacts (NEIs), a project's impacts to communities and the environment that are not directly associated with the costs and benefits of the energy they provide. Historically, NEIs have not been considered in the state's planning process to decide which resources to build and procure. However, many communities and activists have been advocating for NEIs to be considered in resource planning, so that decisions take into account social and environmental costs, in addition to direct economic impacts.

23 https://www.ucs.org/sites/default/files/attach/2018/07/Turning-Down-Natural-Gas-California-fact-sheet.pdf.

24 Nature Energy. Historical red-lining is associated with fossil fuel power plant siting and present-day inequalities in air pollutant emissions, https://www.nature.com/articles/s41560-022-01162-y.

Gas-fired power plants produce an array of NEIs, including the release of harmful pollutants, such as carbon dioxide (CO_2), into surrounding communities. CO_2 is a prominent greenhouse gas that is the biggest contributor to climate change.[25] CO_2 emissions and their impacts on our climate, environment, and health are NEIs that will cost billions of dollars.[26] When these additional factors are taken into account, it becomes even clearer that the costs associated with maintaining reliance on gas plants significantly outweigh the benefits.

In addition to climate change pollutants, gas plants emit fine particulate matter ($PM_{2.5}$) and oxides of nitrogen (NOx). $PM_{2.5}$ is closely correlated with decreased lung function, more frequent emergency department visits, additional hospitalization, and increased morbidity.[27] NOx also causes smog, which has serious lung and cardiovascular impacts and increased mortality.[28] These health impacts result in increased medical bills, which are an additional cost that communities living near gas plants have to shoulder. ***A report from 2020 found that U.S. residents pay $820 billion in health expenses due to burning fossil fuels and climate change.***[29]

Transitioning away from fossil fuels to clean energy paired with battery storage not only avoids these costs but also offers resilience in the face of climate disasters such as extreme heat, wildfires, and high winds. Behind-the-meter (BTM) batteries with microgrid capabilities offer communities a backup source to turn off or on when there is a power outage. Because many low-income residents and EJ communities have a more difficult time recovering from environmental, economic, and social hardships, batteries are a critical planning tool to raise resilience and preparation.

Many gas plants in EJ communities persist due to grid constraints, such as outdated transmission and distribution lines that lack the capacity to accommodate alternative energy resources. This aging equipment is a result of decades of underinvestment in these communities. These grid constraints also prevent local clean energy resources from coming online to replace the energy supplied by gas plants, perpetuating a cycle of extraction and harm, with communities bearing the brunt.

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25 https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide.

26 https://nca2023.globalchange.gov/. Under California's Greenhouse Gas program, many of these power plants do not even report their CO_2 emissions to the state, let alone contribute to the Climate Credit. See 17 Cal.Code Regulations § 95812(c)(2)(a).

27 American Lung Association, *Particle Pollution*, https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/particle-pollution.

28 American Lung Association, *Health Impacts of Pollution*, https://www.lung.org/research/sota/health-risks.

29 https://www.nrdc.org/press-releases/report-health-costs-climate-change-and-fossil-fuel-pollution- tops-820-billion-year.

Batteries present an opportunity to disrupt this cycle. Front-of-the-meter (FTM) resources, such as solar and storage, can be built close to load centers, eliminating the need for costly transmission upgrades, shortening interconnection queues, and reducing costs for ratepayers. When combined with community solar, batteries can provide benefits to multiple residents and create an alternate, clean energy system. During power outages, batteries paired with microgrid technology can also continue operating independently from the utility grid (also known as "islanding mode"), providing much needed electricity to neighborhoods during emergencies such as the 2022 heat wave.

Case Study: Proposed Puente Power Plant Replaced with Battery Energy Storage

CAUSE members celebrate the defeat of proposed Puente Power Plant in Oxnard, 2017.
Image Source: California Environmental Justice Alliance

In 2014, NRG Energy won a contract to build a new gas plant, the Puente Power Plant (Puente), in Oxnard, CA, to support Southern California Edison (SCE) in providing reliable power locally in the event of a grid emergency. Oxnard is a working-class, primarily Latine neighborhood with many polluting industrial sites located in close proximity, including the Ormond Beach Generating Station, the Halaco Superfund site, and the Port of Hueneme. The Central Coast Alliance United for a Sustainable Economy (CAUSE), a local advocacy organization and member of Regenerate California, led the opposition against Puente and encouraged the City of Oxnard to block the project with local ordinances. Despite vocal opposition from CAUSE and community members, the California Public Utilities Commission (CPUC) approved the project, leaving the next round of decision-making to the California Energy Commission (CEC). In 2017, however, CAUSE, Sierra Club, and allies were able to prompt the CAISO to study potential alternatives. CAISO determined that battery storage paired with renewables could replace the emergency power that Puente would have provided in a grid emergency. The CEC rejected Puente and instead selected a 100MW, 400 MWh BESS from Strata Clean Energy, which became the Ventura Energy Storage Facility in El Rio. The facility can provide power for up to four hours for the entire City of Oxnard (over 50,000 households or 200,000 people).

Battery Safety for Communities

While batteries can offer many benefits for communities, it's still a technology that needs to be designed and implemented with safety in mind. The Moss Landing battery fires in January and February of 2025 are a reminder of the importance of safety considerations that need to be in place when planning, designing, and operating battery storage systems.

Regenerate California supports batteries in communities as long as safety requirements are met. Regenerate California advocates for the following requirements for all battery storage projects:

- **Ensuring Environmental Review:** Battery projects must undergo environmental review under the California Environmental Quality Act (CEQA), including a thorough Environmental Impact Report (EIR). Emerging and less-proven technologies must not be deployed without first completing a comprehensive assessment of potential health, safety, and environmental risks. Strong environmental review is essential to identify and prevent harms before battery storage projects are built, ensure that siting decisions prioritize community and environmental health, and give frontline communities a meaningful voice in shaping the projects that affect them.
- **Community-Centered Fire and Emergency Safety Protections:** Battery projects must be designed and operated with strong protections against fires, toxic releases, and system failures, which pose serious risks to nearby communities. At a minimum, projects must comply with California's General Order 167 requirements,[30] including the development of thorough Emergency Response Action Plans (ERAPs). They must also follow federal best practices for preventing thermal runaway, assessing toxic emissions risk, and coordinating emergency response with local departments. Projects should adopt additional safeguards informed by community input to ensure that emergency planning and response protocols reflect specific local needs and conditions.
- **Battery Life Cycle Accountability:** Battery projects should be responsible for minimizing environmental and community harms prior to, during, and after a system's usable life, including material sourcing, manufacturing, operation, decommissioning, and final disposal. Developers must also track and publicly share adequate data on materials used, land and water impacts, emissions, and waste, so communities, especially those already overburdened, have clear access to information and can hold projects accountable.

30 California Public Utilities Commission, *CPUC Sets New Safety Standards and Enhances Oversight of Emergency Plans for Battery Energy Storage Facilities*, https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-sets-new-safety-standards-and-enhances-oversight-of-emergency-plans.

Case Study: BESS After Moss Landing

In January and February 2025, two significant fires erupted at the **Moss Landing Energy Storage Facility** in Santa Cruz County. Expert analysis suggests the fires might be unique due to the specific battery technology used (Nickel Manganese Cobalt, known to be more reactive than the more common Lithium Iron Phosphate), the facility's design (some parts pre-dated current fire codes), and a history of prior safety events at the site. The January and February 2025 fires led to investigations and a proposal by the California Public Utilities Commission to enhance safety standards for battery energy storage facilities statewide. This proposal includes enforcing Senate Bill 1383, granting the CPUC greater oversight. The industry is emphasizing adherence to UL9540 and UL1973 certification and third-party quality assurance to mitigate risks at other battery storage facilities.

Case Study: Wilmington Resident Navigating Pollution and Rising Energy Costs

Community Voice: Maria Serafin[31]

Maria Serafin is a member of Communities for a Better Environment (CBE) who has lived in Wilmington for over 25 years, raising her family surrounded by refineries, oil drilling, port pollution, and a gas power plant. Wilmington residents experience some of the worst air quality in the nation. Living near one of Los Angeles Department of Water and Power's (LADWP) four in-basin power plants, Harbor Generating Station, Maria faces rising electricity bills as well as serious health impacts due to constant exposure to pollution.

> *"Every two months the energy bill arrives, and each time it's more and more. It gets to the point where you say: do I pay this bill, pay rent, or buy food? We're paying for the electricity service of other neighborhoods. The gas power plant is right here, polluting our air day and night, but that electricity goes somewhere else. Why are we breathing the pollution but not getting the benefits? Why are we paying for their electricity with our health and our wallets?"*

31 Maria Serafin's quotes are drawn from an interview conducted by Communities for a Better Environment (CBE) in 2024. The original interview is in Spanish and was translated to English and edited for clarity.

Maria's advocacy is driven by her son's asthma - a condition she links directly to local pollution:

> *"My son has asthma. He didn't have it before, but he had an asthma attack. It's awful to see a child carry an inhaler because he can't run or do what any normal child would be able to do. That's my biggest motivation to raise my voice for him and for all the kids whose moms can't speak up."*

Maria calls for systemic change not just in energy policy, but in how communities are respected and supported:

> *"We have a right to breathe clean air. We deserve parks, trees, and spaces where kids can play without carrying an inhaler. I invite these companies to buy a house here and live with us, so they can see what we go through every day."*

Recommendations

Reduce dependence on gas generation

1. **The CPUC should refine the Resource Adequacy program to develop cost-effective clean resources where they're needed**, including locationally-targeted procurement, a possible reduction in the planning reserve margin (PRM) enabled by the better recognition of BESS technologies' additional value.
2. **The CPUC should ensure that the new Slice of Day design of the RA program addresses the diversity of BESS projects and technologies**, recognizing their ability to shape demand curves and store available energy from additional renewable generation. These RA program refinements should support the development of renewable generation paired with battery storage, particularly in local capacity areas currently reliant on gas plants.
3. **The Governor's Office, the CPUC, and the CAISO should include an actionable strategy for reducing dependence on gas-fired plants** in local areas and sub-areas, due to deliverability constraints of the transmission system.

Increase battery storage and renewable energy

4. **The CPUC and the CAISO should closely coordinate to ensure that transmission expansion is compatible with increased deployment of BESS in currently constrained areas.**

Priority should be given in the upcoming CPUC Integrated Resource Planning (IRP) proceeding to resolving local reliability constraints and procuring battery storage and renewable energy for local capacity areas currently reliant on gas plants.

5. **State decision makers should consider further policy reforms that address the significant delays faced by most renewable energy and BESS projects.** It will be critical to reduce the lengthy timelines for transmission and distribution upgrades necessary for moving away from fossil fuel generation and decarbonizing the grid.
6. **The Governor's Office, the CPUC, and the CEC should cease further investments into expensive, gas-fired plants and support the procurement of additional battery storage.** Funding for the Strategic Reliability Reserve should be shifted from maintaining fossil fuel infrastructure to deploying cleaner battery storage systems, such as under the Distributed Electricity Backup Assets (DEBA) and Demand Side Grid Support (DSGS) programs administered by the CEC.
7. **The California State Water Resources Control Board and the CEC should not extend contracts for Once-Through-Cooling (OTC) gas plants,** including the Ormond Beach Generating Station's Units 1 and 2; the Alamitos Energy Center's Units 3, 4, and 5; and the Huntington Beach Energy Project's Unit 2 which are all scheduled to retire on December 31, 2026.

Reject false solutions

8. **LADWP should explore alternative local energy solutions, such as BESS**, instead of retrofitting gas-fired power plants with hydrogen, which can expose communities to air pollution and safety risks.

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