CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Non-Lithium Energy Storage Technologies

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Outline

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- Introduction to CESA
- Growth of Energy Storage and Estimates of Future Need
- Why Lithium-Ion Batteries Dominate Current Energy Storage Capacity
- Overview of Non-Lithium Technologies
  - Often referred to as long-duration energy storage (LDES) since Li batteries are generally more cost effective at shorter durations
- CPUC Energy Resource Procurement Decisions Driving LDES Deployment

About CESA

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CESA, founded in 2009, is a nonprofit trade association advocating for energy storage as a key resource to achieve a more affordable, efficient, reliable, safe, and sustainable electric power system.

CESA has approximately 80 members consisting of manufacturers, developers, energy safety experts, and legal firms.

We represent utility-scale and customer-sited energy storage and technologies including lithium-ion batteries and a wide range of non-lithium energy storage technologies.

CESA's Non-Lithium Storage Members

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Advanced Compressed Air

HYDROSTOR

Non-Lithium Static Chemical Batteries

e-zinc

Form energy

INLYTE ENERGY

Flow Chemical Batteries

BASF We create chemistry

cmblu

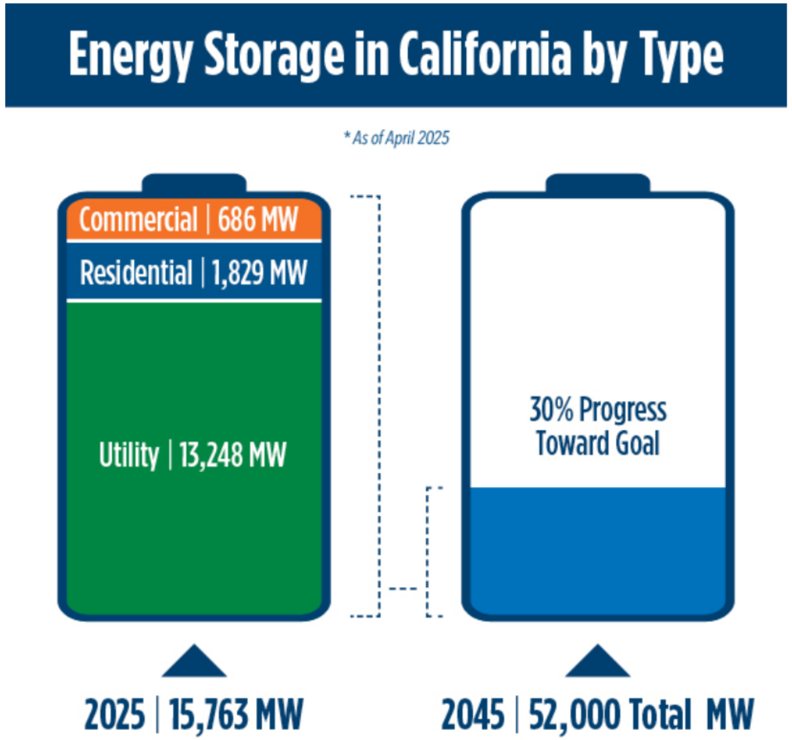
H2

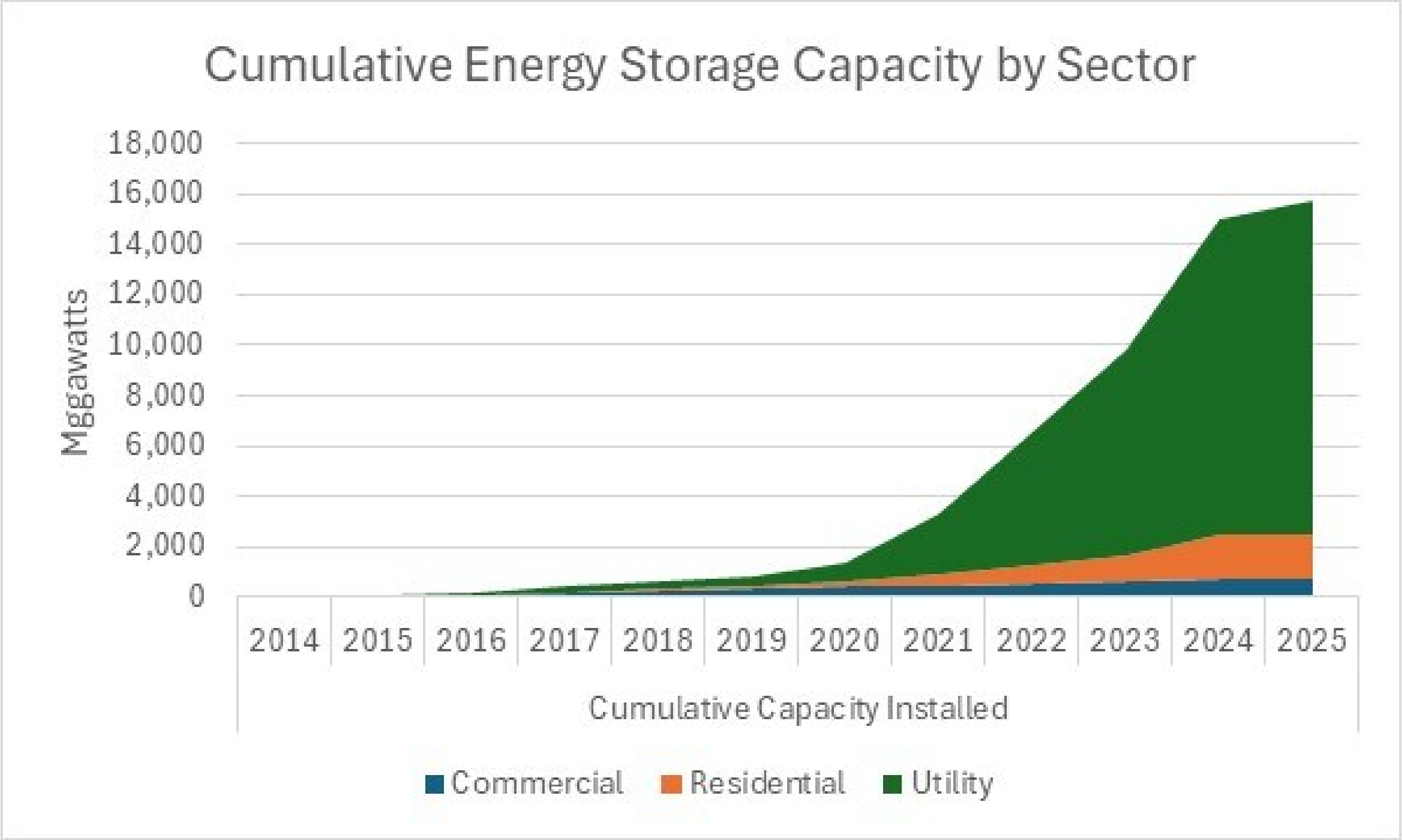
NGK

QUINO ENERGY

SUMITOMO ELECTRIC

Growth of Energy Storage in California



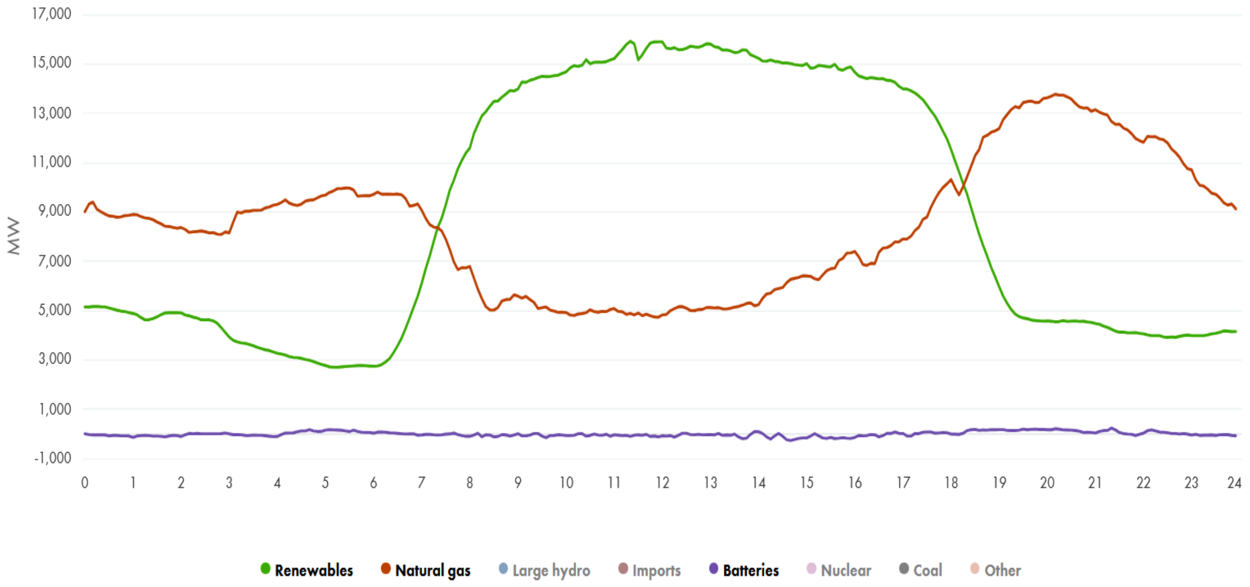


Source: California Energy Commission, "California Energy Storage System Survey." https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/california-energy-storage-system-survey

Environmental Value of Energy Storage

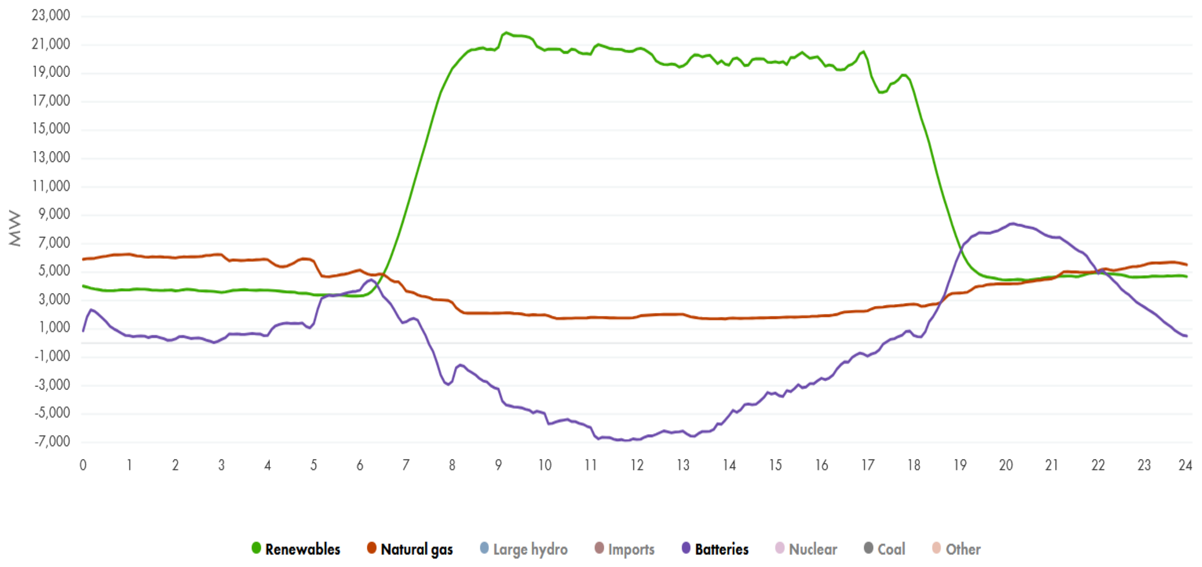
Renewable, Natural Gas, and Battery Supply

April 29, 2021



Renewable Natural Gas, and Battery Supply

April 29, 2025



Reliability Value of Energy Storage

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Year	Peak Load, MW	Blackouts	Flex Alerts	Energy Storage, MW
2020	47,121	2	5	763
2022	52,061	0	11	3,465
2024	48,323	0	0	9,883

At the end of 2026, California will retire 3,700 MW of old gas-fired turbines that use sea water for cooling.

Another 2,200 MW of nuclear capacity at Diablo Canyon is scheduled to go offline in 2030.

The Increasing Need for LDES

- Nearly all utility-scale energy storage procured to date consists of facilities that can discharge for four hours, the minimum required by CPUC rules.
- As reliance on dispatchable gas-fired resources declines and the share of variable energy sources grows, longer durations of storage are needed to maintain grid reliability.
- Some non-lithium storage technologies become more cost competitive with lithium-ion batteries at longer durations.

Estimates of LDES Need by 2045

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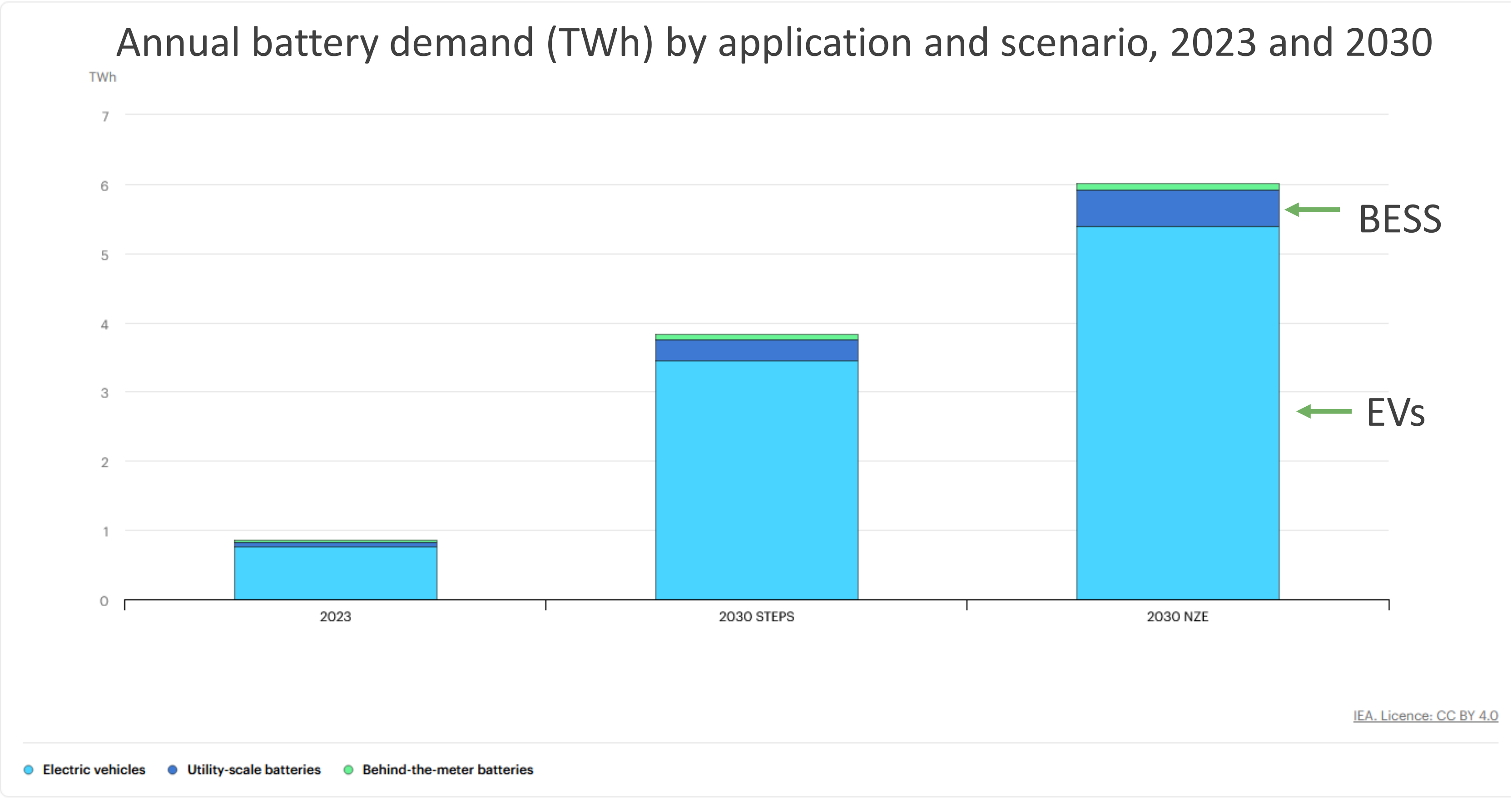
- The official projection of resources need to meet the statewide 100% net zero GHG target by 2045 is the 2021 SB 100 Joint Agency Report.
  - Pumped hydro (8-hour) was the only LDES candidate resource. Given geographic constraints, the model was limited to only 4 GW, which the model fully deployed.
- A 2023 analysis from the CPUC found a need for 17 GW of 8-hour LDES for the CAISO territory (which excludes LA and Sacramento).
- A 2023 CEC report produced by Form Energy and E3 modeled 12, 24, 48, and 100-hour LDES needed for the CAISO territory. Results depended largely on assumptions about gas-plant retirements and LDES costs.
  - 5 GW with no gas retirement
  - 11 GW to 18 GW with economic gas retirement
  - 13 GW to 27 GW to eliminate all in-state gas-fired resources
  - 37 GW to eliminate all GHGs, including imports, from CAISO electricity supply

Why Lithium-Ion Chemistries Are Dominant



Li-ion batteries performance and durability have improved while costs declined 90% from 2010 to 2023 due to demand for consumer goods, BESS, and EVs driving R&D and economies of scale.

Of the nearly 16,000 MW of operating energy storage in CA, about 10-20 MW are non-lithium technologies.

IEA (2024), Paris https://www.iea.org/data-and-statistics/charts/annual-battery-demand-by-application-and-scenario-2023-and-2030, Licence: CC BY 4.0

Current Advantages of Li-ion Batteries

- Low cost driven by a decade of massive investment
- High round-trip efficiency (the % of energy discharged for every unit of energy used to charge the battery) of 85%-90%
- Excellent energy density (energy stored per unit of mass or volume)
- Significant improvements in durability (performance degrades more slowly in newer products)
- Faster response than some flow batteries and mechanical storage
- However, Li-ion becomes less cost-effective at longer durations, where lower round-trip efficiencies are offset by lower upfront costs

Overview of LDES Technologies

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Electricity can be stored in four ways:

- Electrochemically – using chemical processes to store and release electricity
- Chemically – producing synthetic fuels (e.g. H2) for combustion/oxidation
- Mechanically – compressing gases, elevating mass
- Thermally – heating salts, metals, or other materials

Electrochemical batteries can be further divided into flow and non-flow (static electrolyte) variants.

Non-Flow Chemical Batteries

- These storage technologies use a static electrolyte like common Li-ion or lead-acid batteries or with electrolytes based on different metals for longer duration.
- Storage durations range from 6 to 100 hours.
- Round-trip efficiencies range from 50 to 85%.
- Non-Li chemistries expected to last 15 to 25 years.
- CESA members make batteries using iron, zinc, or combination of iron and sulfur.

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Flow Batteries

Characteristics	Flow Batteries	Li-ion Batteries
Active Material	Electrolyte fluid in large tanks	Nanoscale solid materials
Ideal Use Cases	4hr - 24 hr renewable storage, ancillary services, peak shaving, resiliency	10 min - 4 hr ancillary services, peak shaving, frequency regulation
Response Time	milliseconds	microseconds
SOC Range	100% *electrolyte dependent	80%
Installed Cost Global Average	$444,000/MWh (BNEF)	$304,000/MWh (BNEF)
Battery Lifetime	20+ years	15-25 years
Supply Chain	Domestic *electrolyte dependent	International

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Mechanical Storage

- Mechanical storage systems store potential energy via elevating mass (pumped hydro or lifting solid mass on cables) or compressing gases (compressed air, liquid air, liquid CO2).
- Storage duration ranges from 8 to 24 hours.
- Round-trip efficiencies of 50 to 75%.
- Expected lifetimes range from 40 to 60 years.
- Hydrostor developing a 500 MW advanced compressed air energy storage system in Kern County.

CPUC Procurement Orders Regarding LDES

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- Following the brief blackouts in the summer of 2020, the CPUC issued a decision in 2021 ordering the utilities and community choice providers to procure 11,500 MW of qualifying capacity to come online between 2023 and 2028.
  - "Qualifying capacity" means the amount of capacity a given resource can reliably provide at times of highest grid need.
- Of the 11,500 MW, 1,000 MW was reserved for long-duration energy storage, defined as resources capable of delivering at least hours of discharge at their rated capacities.
- It was largely assumed that non-lithium storage technologies would be more competitive at this duration.
- From available data it appears that lithium-ion projects have won most of the contracts for this capacity.

Examples of Recent LDES Procurement

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- A consortium of Community Choice providers has executed contracts for over 100 MW of 8-hour lithium-ion batteries.
  - Of the 98 offers received, 56 were for lithium-ion projects, and lithium-ion accounted for the top 10 highest-scoring projects, ranked by such factors as contract price, project value, developer experience, technology viability and environmental attributes.
- SCE has executed a contract for 400 MW of 8-hour Li-ion capacity.
- Central Coast Community Energy has signed a contract for 200 MW of 8-hour advanced compressed air energy storage from Hydrostor. The project is designed for 500 MW of total capacity.
- SMUD has executed an agreement with ESS (iron flow) for 4 MW with an option to increase to as much as 200 MW.

Longer-Term Drivers of Non-Lithium Storage Procurement

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- A 2023 law (AB 1373) authorized the CPUC to *request* centralized procurement of certain "long lead-time" resources (e.g., offshore wind, geothermal, long-duration energy storage) to be procured by the Dept of Water Resources with cost allocated to all CPUC-jurisdictional utilities and community choice programs.
- In August 2024, the CPUC adopted a decision recommending that DWR issue solicitations for 1,000 MW of 12+hour ES and 1,000 of "multi-day" ES. The decision specified that Li-ion technologies are ineligible.
- These resources are expected to come online between 2031 and 2037.
- There are approximately 12,000 MW of energy storage under contract with online dates from 2025 through 2028 to meet reliability and environmental goals. The vast majority is likely to be Li-ion.

Summary

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- Lithium-ion batteries account for the vast majority of energy storage capacity deployed to date.
- Lithium-ion technology will continue to dominate energy storage deployment for the next 5 to 10 years.
- As the California grid incorporates higher shares of variable renewable energy, longer duration storage will be necessary.
- In the medium to longer term, non-lithium energy storage technologies will play a larger role in California's energy portfolio.

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