ERCOT and CAISO Demonstrate System Reliability Benefits of Renewables and Energy Storage

Prepared for the Center for Applied Environmental Law and Policy

under contract with

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August 6, 2025

Introduction and Background

Integrating renewable energy and storage may bring substantial benefits to electricity grids, supporting reliability and other services. These benefits are demonstrated more and more frequently as renewable energy and storage installations increase around the country. This discussion will explore two cases in particular that have recently added renewable capacity at an unprecedented rate while maintaining and even improving upon past grid reliability performance.

Since 2015, clean energy deployment in the United States has grown rapidly, posting banner years of technological advancement and significant growth driven by declining technology costs. Total capacity of solar, wind and storage has grown annually over the past decade, going from 80.1 GW in total in 2014 to 358.9 GW in total in 2024. In particular, solar and battery storage have continued to set installation records over the previous 3 years. In 2023, 27.4 GW of solar were installed in the U.S., increasing to 39.6 GW in 2024. Total installed solar capacity is close to 220 GW currently, enough to provide 7% of the nation's electricity. Battery storage capacity nearly doubled in 2024, with total installed capacity reaching about 29 GW and projected to increase to 43 GW this year. While solar and battery capacity installations continue apace, wind capacity additions have lost momentum, with 5.3 GW of new wind capacity in 2024, a significant drop from preceding years. According to the Energy Information Administration (EIA), installed wind capacity totaled 153 GW at the end of 2024.[1] The slowdown in wind capacity additions in 2024 was driven in part by a focus on repowering existing facilities and ongoing challenges related to supply chains, financing, grid interconnection and permitting.

This discussion will focus on the ways in which renewables can bolster grid reliability. For the purposes of this paper, grid reliability refers to the ability of the electricity generation and distribution system to avoid power disruptions. The Federal Energy Regulatory Commission (FERC) defines grid reliability as "the provision of an adequate, secure and stable flow of electricity as consumers may need it. In other words, when you flip the light switch, the lights turn on. The grid remains functional even during unanticipated but common system disturbances, such as loss of a source of energy generation from an energy provider or failure of some other system element. When something fails, the grid has to be able to isolate the problem and keep functioning."[2] Two primary components of grid reliability include: (1) Reliable operation, which refers to the ability of the grid to withstand sudden electrical system disturbances that can lead to blackouts, and (2) Resource adequacy, which is the ability of the electric system to meet the energy needs of electricity customers, or otherwise put, having sufficient generation to meet projected electricity demand.[3] As this discussion explores the ways in which renewable energy and batteries have strengthened grid reliability in two distinct cases, it will continually revisit these two key elements.

To date, there are two particular examples of electricity grid management that demonstrate the value of renewable energy and storage resources in maintaining grid reliability and stabilizing capacity markets. The first is the California Independent System Operator (CAISO). CAISO serves approximately 32 million customers, about 80% of all electricity demand in California, and operates a competitive wholesale electricity market and manages the reliability of its transmission grid. In managing the grid, CAISO centrally dispatches generation and coordinates the movement of wholesale electricity in California and a portion of Nevada. CAISO markets include energy (day-ahead and real-time), ancillary

[1] Energy Information Administration July 2025 Short-Term Energy Outlook, https://www.eia.gov/outlooks/steo/pdf/steo_full.pdf
[2] FERC Reliability Explainer, https://www.ferc.gov/reliability-explainer
[3] *Id.*

services, and congestion revenue rights. CAISO also operates an energy imbalance market (EIM), which currently includes CAISO and other balancing authority areas in the western United States including Arizona, Oregon, Nevada, Washington, California, Utah, Wyoming and Idaho.[4] In 2024, CAISO served 241.8 million megawatt-hours (MWh) of electric load, delivered 253.3 million MWh of electricity in total, and oversees 23 participating transmission owners and about 26,000 circuit miles of transmission lines.[5] CAISO has been steadily increasing renewable energy and energy storage on its grid while executing strategies to optimize and manage these resources, as well as managing increasing demand and meeting the state's SB100 clean energy goals.[6]

The Electric Reliability Council of Texas (ERCOT) is the second region of focus for this discussion. ERCOT serves as an independent system operator, managing the flow of electrical power to 24 million customers in Texas, representing approximately 90 percent of the state's electrical load. ERCOT operates a competitive wholesale electricity market, ensuring reliability over more than 46,000 miles of transmission lines, for approximately 550 generating units. ERCOT operates as an energy-only market with day-ahead, real-time, and ancillary services markets. It is governed by a board of directors made up of sixteen members and is subject to oversight from the Public Utilities Commission of Texas and the Texas legislature, and its members include customers, cooperatives, generators, power marketers, retail electric providers, investor-owned electric utilities (both transmission and distribution providers) and municipal-owned electric utilities. The transmission grid that the ERCOT independent system operator administers is located exclusively in the state of Texas and is not interconnected with the rest of the United States. The transmission of electric energy occurring wholly within ERCOT is not subject to the jurisdiction of the Federal Energy Regulatory Commission.[7] ERCOT is included as a case study in this discussion as increasing renewable and storage capacity and generation in Texas has played a vital role in reducing the occurrence of emergency reliability events on the grid in both summer and winter peak periods.

California System Operator (CAISO)

The California Independent System Operator (CAISO) is actively taking steps to integrate increasing amounts of renewable energy onto the grid in accordance with SB100 while maintaining system reliability. With SB100 guiding the state toward a carbon-free power grid, CAISO projects that over 165,000 MW of new solar, wind, and battery resources need to be built through 2045 to meet both increasing electric demand and state GHG reduction targets.[8] CAISO has seen a continuing trend of clean energy growth in 2025, including record-setting solar generation and battery storage.

Figure 1. CAISO capacity mix by fuel type and year[9]

[4] Federal Energy Regulatory Commission, https://www.ferc.gov/industries-data/electric/electric-power-markets/caiso

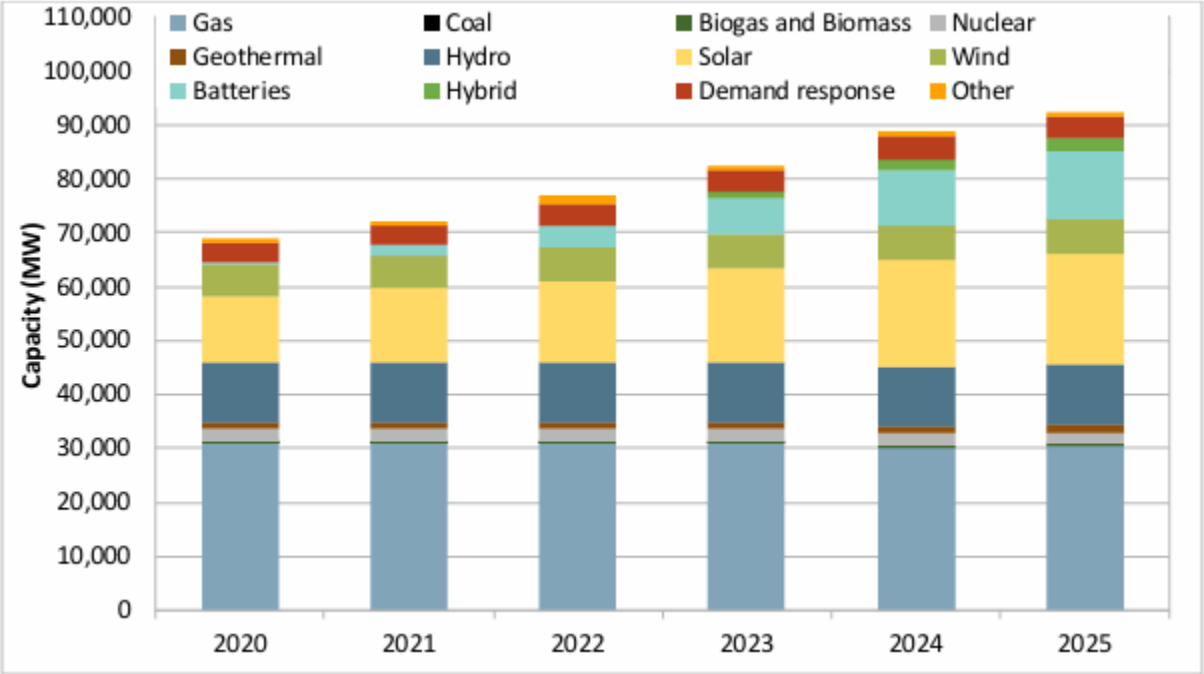
[5] CAISO June 2025 Key Statistics, https://www.caiso.com/documents/key-statistics-jun-2025.pdf

[6] SB 100 in California established a landmark policy requiring renewable energy and zero-carbon resources to supply 100 percent of retail electric sales by 2045. https://www.energy.ca.gov/sb100

[7] Federal Energy Regulatory Commission, https://www.ferc.gov/industries-data/electric/electric-power-markets/ercot

[8] CAISO Special Report on Battery Storage, https://www.caiso.com/documents/2024-special-report-on-battery-storage-may-29-2025.pdf

[9] CAISO Special Report on Battery Storage, https://www.caiso.com/documents/2024-special-report-on-battery-storage-may-29-2025.pdf (see page 9)



To keep on track with the goals of SB100 while keeping the grid reliable in the face of (projected) rising electricity demand, CAISO is focused on key resources and actions. The primary strategies in place to achieve renewable energy targets and maintain system reliability include continued clean energy expansion, battery storage, demand response, and various grid modernization, planning and collaborative approaches.

Renewable Energy. Currently, as of June 2025, installed renewable resources in CAISO totaled 32,994 MW, comprised of[10]:

- Solar: 21,240 MW
- Wind: 8,373 MW
- Small hydro: 1,146 MW
- Geothermal: 1,505 MW
- Biofuels: 730 MW

In 2024, California added a record of nearly 7,000 MW of new clean energy capacity, marking the largest single-year increase in state history and the third consecutive year of unprecedented growth.[11] This growth trend suggests that California is in a strong position to further clean energy expansion. More than

[10] CAISO June 2025 Key Statistics, https://www.caiso.com/documents/key-statistics-jun-2025.pdf

[11] CAISO Energy Matters Blog, Managing the July 2024 Heat Wave with our Partners in California and the West, https://www.caiso.com/about/news/energy-matters-blog/managing-the-july-2024-heat-wave-with-our-partners-in-california-and-the-west. In July 2024, CAISO maintained grid reliability during a prolonged heat wave, which made July 2024 the hottest month recorded in California's history. CAISO was successful in maintaining grid reliability by leveraging its new clean energy resources, battery storage, demand response programs and enhancing coordination with state agencies. The CAISO grid also exported energy to neighboring states facing similar challenges from the heat event.

75,000 MW of new clean energy is expected to be in operation by 2040.[12] Over 20,000 MW of clean energy projects are currently under contract and in development, planned for operation by 2030.[13] Additionally, California has reached a number of significant clean energy milestones. In 2023, 67% of California's retail electricity sales came from renewable and zero-carbon electricity generation, including solar, wind, hydro, nuclear, geothermal and biomass, compared with 61% in 2022 and 41% in 2013.[14] This makes the state the largest economy in the world to reach this amount of clean energy generation over the course of one year.[15]

Frequent record-setting renewable generation and battery-related occurrences demonstrate that grid operators can continue to manage growing amounts of renewable resources reliably and efficiently. For instance:

- In April 2024, the ISO set a record of serving 117% of total system demand with renewables in one five-minute interval[16], compared with 103.5% in April 2023 and 107% in June 2023
- The average total system demand served by renewables across all five-minute intervals was almost 52% in April 2025, compared with 49% in April 2024 and 43% in April 2023[17]
- In 2024, there were 70 days between March 1 and May 31 when renewables – including solar, wind, and small hydropower plants – served 100% of consumer demand for parts of each day. During 54 of those days, solar and wind alone at times served 100% of consumer demand.[18]
- As of the end of June 2025, CAISO has 13,250 MW of installed grid-scale battery storage capacity, nearly triple the capacity it had in 2023.[19]

The pace of clean energy development in California has reduced emissions throughout the economy by 20% from 2000 levels, with the power sector accounting for the majority of these reductions.[20] Over the same period, the state's gross domestic product (GDP) grew by 78%. The unprecedented growth in clean

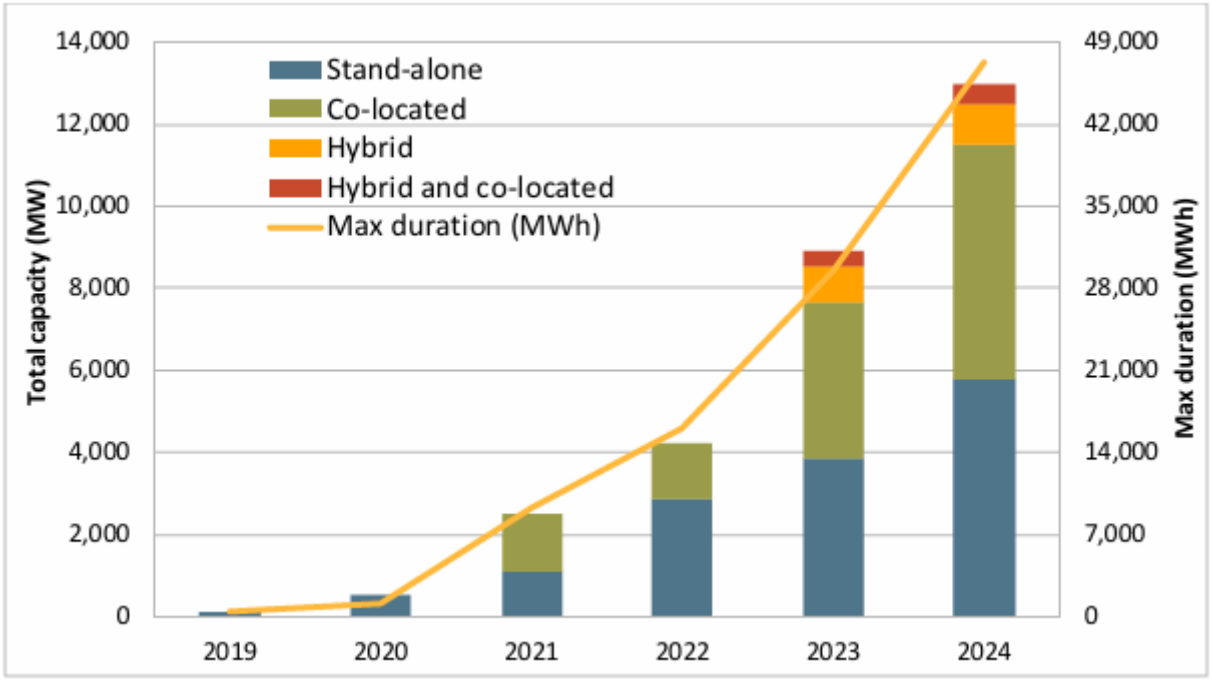
[12] Governor Gavin Newsom, New data shows California is adding more clean energy capacity to the grid faster than ever before, https://www.gov.ca.gov/2025/06/04/new-data-shows-california-is-adding-more-clean-energy-capacity-to-the-grid-faster-than-ever-before/
[13] *Id.*
[14] Governor Gavin Newsom, In historic first, California powered by two-thirds clean energy – becoming largest economy in the world to achieve milestone, https://www.gov.ca.gov/2025/07/14/in-historic-first-california-powered-by-two-thirds-clean-energy-becoming-largest-economy-in-the-world-to-achieve-milestone/
[15] *Id.*
[16] CAISO April 2024 Monthly Renewables Performance Report, https://www.caiso.com/documents/monthlyrenewablesperformancereport-apr2024.html
[17] CAISO April 2025 Monthly Renewables Performance Report, https://www.caiso.com/documents/monthly-renewables-performance-report-april-2025.html
[18] CAISO Energy Matters Blog, New renewables records – what they mean for the grid and its carbon-free future, https://www.caiso.com/about/news/energy-matters-blog/new-renewables-records-what-they-mean-for-the-grid-and-its-carbon-free-future
[19] CAISO June 2025 Key Statistics, https://www.caiso.com/documents/key-statistics-jun-2025.pdf
[20] Governor Gavin Newsom, In historic first, California powered by two-thirds clean energy – becoming largest economy in the world to achieve milestone, https://www.gov.ca.gov/2025/07/14/in-historic-first-california-powered-by-two-thirds-clean-energy-becoming-largest-economy-in-the-world-to-achieve-milestone/

energy has strengthened the reliability of the grid, advanced the state's climate and energy goals and continues to deliver climate, public health and economic benefits.[21]

Battery Storage. Battery storage has emerged as a significant resource on the CAISO system, and has become the fastest growing resource type in the CAISO capacity mix.[22] Batteries are playing an increasingly important role in maintaining flexibility and resilience of the power grid. Batteries charge during hours when renewable energy is plentiful and discharge or dispatch later during the hours of low or no renewable generation. As of early 2025, total battery storage capacity in CAISO has reached over 15,700 MW, currently made up primarily of 4-hour Lithium-ion batteries. This storage capacity supports reliability during peak periods like summer evenings, especially when demand for electricity is high and solar generation is low or declining. CAISO projects that battery storage capacity on the system must reach at least 58,000 MW across the CAISO footprint by 2045 to support the growth and renewables expansion expected under SB100.[23]

Battery storage capacity increased from about 500 MW in 2020 to over 15,000 MW in 2025 in the CAISO balancing area. Over half of this capacity is paired with solar or wind generation, either sharing a point of interconnection under the co-located model or as a single hybrid resource.[24]

Figure 2. Active battery capacity in CAISO balancing area (2019-2024)[25]



[21] Governor Gavin Newsom, In historic first, California powered by two-thirds clean energy – becoming largest economy in the world to achieve milestone, https://www.gov.ca.gov/2025/07/14/in-historic-first-california-powered-by-two-thirds-clean-energy-becoming-largest-economy-in-the-world-to-achieve-milestone/

[22] CAISO 2024 Special Report on Battery Storage, https://www.caiso.com/documents/2024-special-report-on-battery-storage-may-29-2025.pdf

[23] *Id.*

[24] *Id.*

[25] *Id.*

As the amount of battery storage on the California grid has grown exponentially over the last five to six years, the storage fleet has played a more important role in balancing the power grid during extreme weather events. Battery storage is expected to be a vital resource in maintaining grid reliability as renewable energy capacity increases. CAISO also continues to refine market rules to ensure that batteries are dispatched according to the reliability needs of the grid in an effort to further maximize the value of battery storage.[26]

Demand Response. Demand response refers to programs and policies involving customer participation that are designed to reduce electricity consumption during peak demand periods, with the objectives of supporting grid reliability and stability and reducing energy costs. CAISO relies on demand response as a critical resource for maintaining grid reliability and managing electricity supply. Residential, commercial, agricultural and industrial customers can elect to participate in demand response programs offered by the investor-owned utilities (IOUs), Community Choice Aggregators (CCAs), Aggregators or Demand Response Providers and receive financial incentives or reduce their energy bills. For example, one such program is time-of-use rates (TOU).[27] Well-executed demand response programs are expected to provide the following benefits to California homes and businesses:

- Avoiding the construction of new power plants and transmission infrastructure;
- Avoiding the purchase of high-priced energy, lowering the overall cost of electricity;
- Providing greater reliability to the grid, which helps prevent blackouts;
- Avoiding the consumption of fossil fuels, leading to lower greenhouse gas and public health emissions;
- Harnessing or integrating renewable energy by reducing afternoon curtailment or evening system ramp.[28]

A recent success of California's demand response programs demonstrating the value of DR to grid reliability occurred during the September 2022 heatwave that affected the entire state. The electric grid experienced record high demand for electricity. Residents and businesses reduced and shifted electricity use in accordance with DR program incentives. California state government facilities participated as well, shedding 209 MW of load over the nine-day period. These DR program customer actions have been vital to reducing energy usage at peak times and preventing blackouts and energy shortages.[29]

Resource Adequacy Planning. CAISO has a mandatory resource adequacy program to ensure there are enough resources to meet the grid's demands in real time and that the grid is able to handle the variability of the renewable resources and other factors that could affect the energy supply. For example, CAISO collaborates with other regional operators to improve grid reliability and reduce costs by sharing excess energy and coordinating grid operations, leading to better forecasting, resource allocation and overall grid stability.[30]

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[26] CAISO Energy Matters Blog, New renewables records – what they mean for the grid and its carbon-free future, https://www.caiso.com/about/news/energy-matters-blog/new-renewables-records-what-they-mean-for-the-grid-and-its-carbon-free-future

[27] CAISO, Managing the Evolving Grid, https://www.caiso.com/about/our-business/managing-the-evolving-grid

[28] California Public Utilities Commission, Demand Response (DR), https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr

[29] CAISO Summer Market Performance Report for September 2022, https://www.caiso.com/Documents/SummerMarketPerformanceReportforSeptember2022.pdf

[30] CAISO Regional Collaboration, https://www.caiso.com/about/our-business/regional-collaboration

CAISO's initiatives to facilitate resource adequacy planning are designed to enhance grid reliability by optimizing the scheduling and dispatch of storage resources, especially during evening hours when demand typically peaks and renewable resource supply begins to decline. CAISO has also implemented a "Slice of Day" framework for resource adequacy. This program requires load serving entities (LSEs) to demonstrate that they have enough capacity to meet the hourly electricity demand level for the day within the month that contains the hour with the highest coincident peak load forecast. Previously, resource adequacy was demonstrated on a monthly peak hour basis. The shift to daily peak load hour ensures grid reliability, especially with the increasing proportion of load served by renewable energy and batteries.[31]

Grid Modernization. CAISO is investing in smart grid technologies and advanced grid management systems to improve visibility, control and flexibility of the grid while enabling better forecasting, integration and management of renewable energy sources. In addition to infrastructure and transmission investments, CAISO is also engaging in reforming the interconnection queue and processes, incorporating more diverse renewable generation types including geothermal, and establishing a preparedness program to offer capacity on an emergency basis.[32]

California's approach has shown that a clean energy future is compatible with grid stability and reliability. In 2024, for the first time ever, California achieved 100 percent clean energy in the California ISO service area every three out of five days as the California ISO system reached 100 percent clean electricity for a period of the day on 219 different days.[33] Solar energy output hit a peak of 19,600 MW, and battery discharges topped 8,000 MW in October 2024, demonstrating the effectiveness of recent investment and coordination. At the beginning of summer 2025, the CAISO grid was well-positioned and capable of handling summer peak demand as well as potential extreme weather events driven by climate change, due to high clean energy deployment levels, battery storage expansion, and strategic efforts to build up energy reserves through planning and grid modernization.

Electric Reliability Council of Texas (ERCOT)

The rate of wind and solar capacity installations in Texas has increased dramatically in recent years. Wind capacity increased 37% from 28,373 MW in 2019 to 38,911 MW in 2024, with generation from wind increasing 46% from 76,708 MWh to 111,744 MWh over the same period. Solar capacity grew 627% between 2019 and 2024, reaching 27,157 MW by the end of 2024. Solar generation increased 996%, from 4,398 MWh in 2019 to 48,222 MWh in 2024. Storage capacity also increased significantly, from 363 MW in 2019 to 9,863 MW in 2024, or 2,617%. Renewable energy served approximately 35% of Texas's total electricity demand in 2024. In particular, battery storage injected 4,000 MW during critical evening ramp hours, preventing outages and stabilizing frequency on the grid. Grid reliability remained strong, with no Energy Emergency Alerts triggered throughout the year despite extreme weather and record peaks.[34]

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[31] CAISO RA Processes and CPUC's Slice of Day, file:///C:/Users/starl/Downloads/Updated-White-Paper-Resource-Adequacy-Processes-CPUCs-Slice-of-Day-Oct-14-2024.pdf

[32] CAISO 2025 Summer Loads and Resources Assessment Overview, https://www.caiso.com/content/summer-loads-resources-assessment/2025/index.html

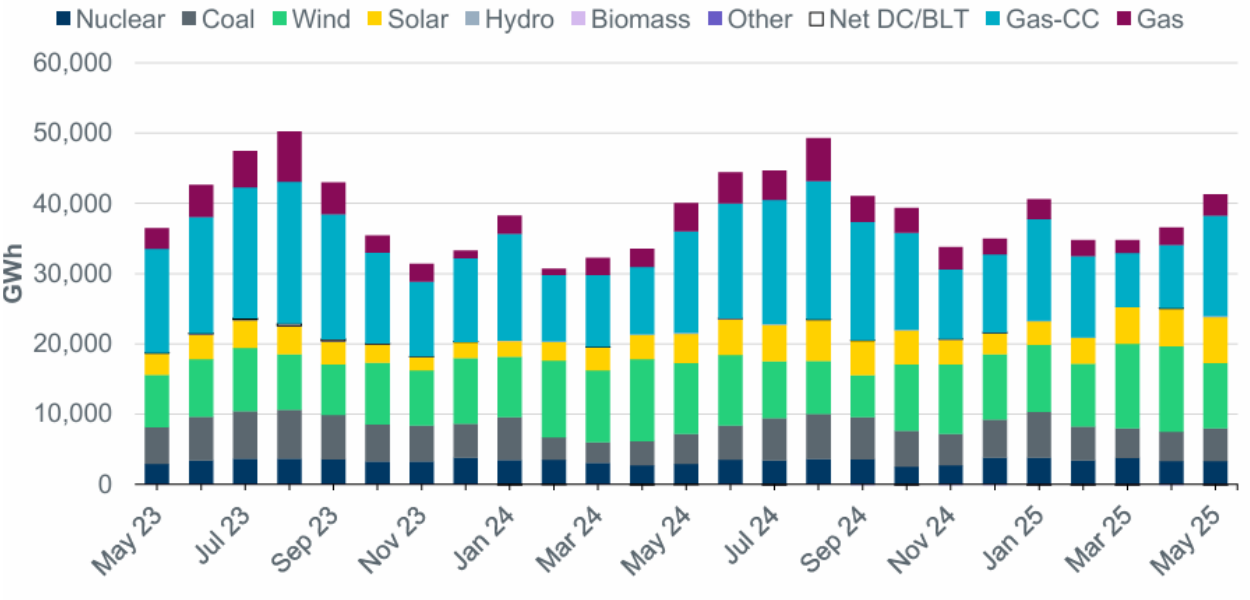
[33] California Energy Commission, https://www.energy.ca.gov/data-reports/clean-energy-serving-california/estimated-california-iso-clean-energy-days

[34] Texas Reliability Entity (Texas RE), 2024 Reliability Performance and Regional Risk Assessment: https://poweralliance.org/2025/07/03/new-texas-reliability-report-shows-renewables-and-storage-powering-a-reliable-affordable-future/. Renewable energy served 34.8% of Texas' total electricity demand in 2024. Solar generation rose by 996% and battery storage by 2,617% over the past five years. Battery storage injected over

While solar energy has exhibited strong growth with projections for significant additional capacity installations in Texas, battery energy storage systems (BESS) are the fastest-growing technology in ERCOT's energy mix and will be increasingly critical to maintaining system reliability. Acting as both load and generation, BESS charge when power is plentiful and cheap and demand is low, and discharge when power is expensive and demand is high. From 2020, installed BESS capacity in ERCOT has grown nineteen-fold to about 4,000 MW as of January 2024. Solar, the second-fastest growing generation technology, increased 4.5-fold over the same period, from 4 GW to 22 GW.[35] With solar generation increasingly powering the grid during the day, greater BESS capacity (along with flexible gas generation) will be needed for the ERCOT grid to manage large ramping requirements in the evenings and maintain reliability. Batteries are also increasingly providing ancillary services to the ERCOT grid which help maintain grid reliability conditions and provide backup power while reducing costs. BESS have also provided critical support to the grid during extreme weather events.

Alongside these generation and technology shifts, electricity demand has also surged in the ERCOT footprint. Monthly energy generation increased by 3% year-over-year to 41,181 GWh in May 2025, compared to 39,974 GWh the previous year.[36] This is the case for many historical monthly year-on-year comparisons over the past year.

Figure 3. Monthly Energy Generation by Fuel Type, May 2023-May 2025[37]



4,000 MW during critical evening ramp hours, helping prevent outages and stabilize frequency. Grid reliability remained strong, with no Energy Emergency Alerts triggered in 2024 despite extreme weather and record peaks.

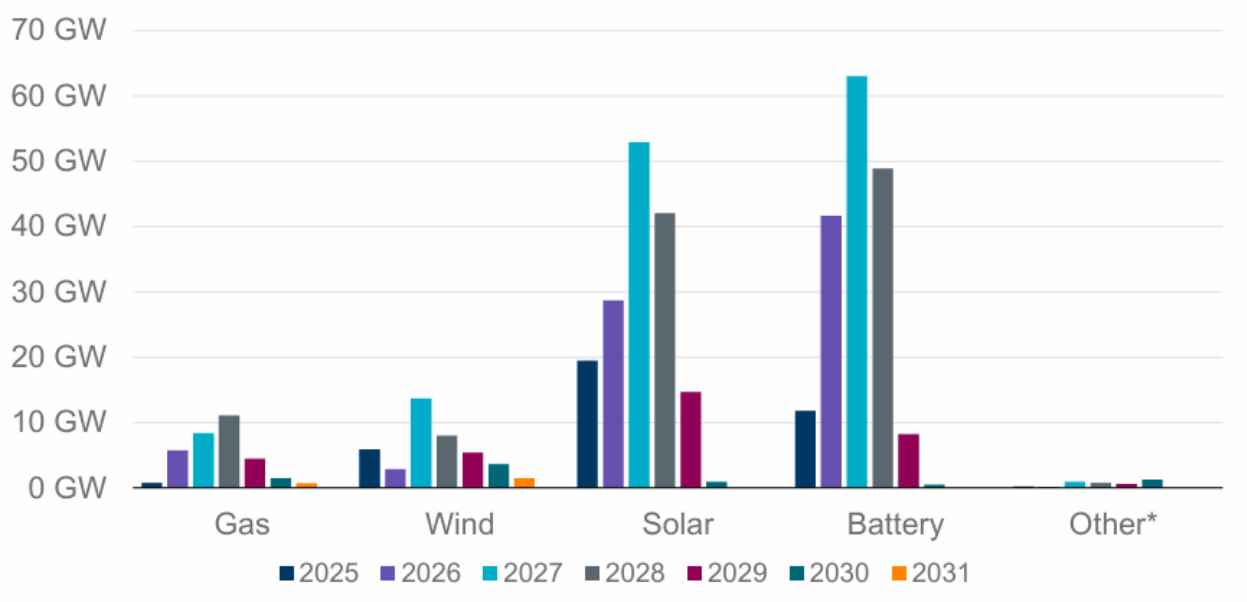
[35] Role of Battery Energy Storage Systems (BESS) in the ERCOT Market, Auroral Energy Systems (page 2): https://go.auroraer.com/l/885013/2024-05-21/n4rl6/885013/1716308186gOCcibDh/Eolian_Role_of_Batteries_in_ERCOT_Final_Public_v2__1_.pdf

[36] ERCOT Monthly Operational Review (May 2025), June 17, 2025. https://www.ercot.com/files/docs/2025/06/17/ERCOT-Monthly-Operational-Overview-May-2025.pdf

[37] *Id.*

At the same time, the mix of new resources being added has dramatically shifted in favor of solar and storage capacity, with additions of gas and wind capacity slowing. This trend is projected to continue over the next five years.

Figure 4. ERCOT Interconnection Queue Capacity by Fuel Type[38]



In addition, on the demand side, ERCOT is currently tracking approximately 156 GW of large loads seeking interconnection through 2030. This is an increase of nearly 250% over the December 2024 large load interconnection queue.[39]

Despite record-breaking electricity demand, a rapidly evolving resource mix, and an unprecedented surge in data center and industrial electricity demand growth, the Texas grid has been notably reliable and resilient in large part due to the contributions of renewable energy and battery storage.

In Texas, grid reliability in summer and winter months must be achieved by addressing differing stressors to the system, as the two seasons pose unique challenges. Summer peak demand is generally more predictable and consistently higher than winter peak demand, while unpredictable winter weather is more likely to cause unforeseen demand spikes. The system must also manage the risk of outages during periods of extreme cold temperatures, as in recent years as winter storms have caused significant outages due to equipment failures and fuel shortages at power plants. These outages, most notably in February 2021, have clearly identified vulnerabilities in the grid's infrastructure.[40]

Summer Reliability and the Role of Renewables and Batteries. ERCOT performed well over the 2024 summer specifically because of the combination of solar, storage and wind, and to a lesser extent gas

[38] *Id.* The ERCOT Resource Adequacy page contains more detail by zone: https://www.ercot.com/gridinfo/resource
[39] ERCOT Monthly Operational Review, June 17, 2025, https://www.ercot.com/files/docs/2025/06/17/ERCOT-Monthly-Operational-Overview-May-2025.pdf (see page 9)
[40] A full discussion of grid performance during all winter weather events, including Winter Storm Uri of February 2021 and other specific weather events that impacted grid reliability is beyond the scope of this discussion. ERCOT has published a report focused on Winter Storm Elliott of December 2022 that includes references and comparisons to Winter Storm Uri along with best practices and lessons learned. See ERCOT official document: https://www.ercot.com/files/docs/2023/03/27/December-2022-Cold-Weather-Operations-Public-Report.pdf

facilities. Record-setting heat and consecutive days of triple digit temperatures across most of the state in August 2024 drove record peak demand. At the same time, record-setting solar generation levels kept supply matched with demand throughout the peak midday hours and wholesale electricity prices remained low because solar is the cheapest source of electricity on the grid today. Batteries discharged during net load hours (also at record-levels), which prevented rolling outages and other emergency load reduction measures. The substantial contribution of solar and storage on Texas's 2024 peak summer day had four impacts on the system's ability to serve demand safely and reliably:

- Solar significantly contributed to meeting peak demand;
- Solar shifted the period of highest risk to the evening;
- Storage provided a meaningful contribution to the evening demand, enabled by solar generation;
- Solar (and wind) increased the availability of off-peak energy for storage charging.

To further illustrate the value of renewable energy on the Texas grid, Aurora Energy Research prepared an analysis[41] for the Texas Association of Business exploring various scenarios for meeting ERCOT's growing energy and peak demand requirements through the remainder of this decade.[42] The report shows that restrictions on wind and solar development in Texas could increase wholesale power prices by 14% over the next 10 years, translating to a 10% increase in household energy bills. Restricted renewables development will also cause capacity shortfalls resulting in up to 3.1 GW of load shed in an extreme heat weather event, leaving 620,000 homes without electricity.[43] The Aurora analysis underscored the importance of renewable energy in meeting expected load growth this decade while moderating electricity prices and improving system reliability.

Winter Reliability and the Important Role of Battery Storage. Winter peak demand can present different challenges than summer peak because winter peak load commonly begins early in the morning and lasts for a longer period. This pattern is mismatched with the time that solar power is most available, and also does not match as well with the one- to two-hour discharge capacity of current battery storage resources within the ERCOT service area. Common occurrences and risks that ERCOT has faced during past extreme cold weather events include: loss of production from natural gas wells, natural gas processing facilities experience reduced or total loss off natural gas receipts due to production declines leading to reduced output into pipelines, pipeline operators in certain regions may be faced with reduced production volumes, increased demand for gas, and unplanned compressor facility outages.

During winter events, battery storage has provided critical support to the system, providing ancillary services to maintain grid conditions and provide backup power while steadily reducing the costs of these

[41] Aurora Energy Research, Texas Consumers Face 10% Increase in Power Bills and Higher Reliability Risks without Rnewables Expansion, https://auroraer.com/company/press-room/texas-consumers-face-10-increase-in-power-bills-and-higher-reliability-risks-without-renewables-expansion-aurora-energy-research-finds

[42] ERCOT's most recent 2025-2029 Capacity, Demand and Reserves (CDR) report includes scenarios that test the impacts of timing differences in load and supply growth. The ERCOT CDR report is a snapshot of potential supply resource availability and demand over the next five years. Its primary purpose is to provide potential future planning reserve margins that are expected to be available for resource adequacy when demand is highest during the summer (June through September) and winter seasons (December through February). The CDR forecasts that summer peak load could increase by 56% from 90,472 MW in 2025 to 140,872 MW in 2029. https://www.ercot.com/files/docs/2025/02/12/CapacityDemandandReservesReport_December2024.pdf

[43] Aurora Energy Research, Texas Consumers Face 10% Increase in Power Bills and Higher Reliability Risks without Rnewables Expansion, https://auroraer.com/company/press-room/texas-consumers-face-10-increase-in-power-bills-and-higher-reliability-risks-without-renewables-expansion-aurora-energy-research-finds

services. During Winter Storm Elliott in December 2022, for example, BESS has provided capacity in ancillary services which freed up the equivalent of 3 GW of natural gas capacity to provide critical energy to customers. From January 13-14, 2024, when the ERCOT grid experienced very low wind generation and high load driven by freezing temperatures, BESS committed an hourly average of 2.8 GW of capacity every hour to Ancillary Services, allowing least-cost natural gas combined cycle facilities to generate for wholesale markets.[44] Similarly, on January 16, 2024, through freezing temperatures and peak winter demand in the morning hours, BESS saved $77M in day-ahead system costs by providing 2.5 GW of Ancillary Services, directly enabling gas generation to participate in the energy markets and helping to keep prices low for Texas consumers. Between January 15-16, 2024, BESS saved a total of $750M in costs to the day-ahead market, keeping costs low while simultaneously maintaining grid reliability.[45]

Solar generation and storage capacity in ERCOT have afforded grid stability and reliability, enabling the system to more easily serve peak demand on hot summer days, as well as keeping energy prices low. Still, ERCOT faces increasing load forecasts due to a growing manufacturing base, electrification, population and economic growth, more extreme weather events as well as expected constraints on the pace of renewable additions, which may require planning foresight or other market adjustments to preserve optimal reliability and grid performance.

Key Takeaways on Reliability Benefits of Renewables and Storage in CAISO and ERCOT

(1) Battery storage has proven to be a valuable resource in addressing intermittency challenges of renewable resources when they arise. Storage may also be a viable and more cost-effective substitution for gas plants in providing ancillary services. Battery storage resources on the grid in both CAISO and ERCOT have been effective at smoothing the peaks and valleys that renewable generation is sometimes subject to, enabling a more stable and predictable power supply.

(2) Renewable energy has been shown to enhance grid reliability in ERCOT and CAISO by diversifying the resource mix and providing capacity contributions. Renewable energy could also lower the cost of generation, potentially leading to reduced electricity bills for consumers.

(3) As demonstrated in CAISO and ERCOT, renewable energy and battery storage resources can work together to achieve greater reliability through:

- Improved grid stability, by balancing the variable nature of renewables with the dispatchable energy from storage;
- Increased grid flexibility, by providing flexible resources to manage challenges like high demand, extreme weather conditions, and transmission interruptions.

[44] Aurora Energy Research, Role of Battery Energy Storage Systems (BESS) in the ERCOT Market, https://go.auroraer.com/l/885013/2024-05-21/n4rl6/885013/1716308186gOCcibDh/Eolian_Role_of_Batteries_in_ERCOT_Final_Public_v2__1_.pdf (see page 10)

[45] *Id.*

Conclusions

CAISO and Texas present two case studies of successfully and effectively managing renewable energy on an electricity grid while maintaining, and even improving, grid reliability. In the case of CAISO, rapid renewable energy expansion and growth in battery storage installations along with enhanced coordination with state government and smart planning with partners in California and throughout the West have prevented power disruptions through extreme heat and weather events. In Texas, rapidly increasing wind, solar and storage capacity on the grid has performed well in supporting grid flexibility and maintaining grid stability during peak summer and winter hours. Renewables and storage have also demonstrated value in providing ancillary services and facilitating greater renewable integration. Moreover, the combination of renewable energy and battery storage has been shown to keep electricity costs low for households and businesses. CAISO and ERCOT are exemplary in maximizing the value of the accelerated pace of renewables and battery storage additions to support grid reliability and flexibility through implementing policies and market mechanisms. These two case studies serve as models for other RTOs or ISOs on integrating unprecedented renewable capacity and battery storage increases, and managing these resources to optimize grid performance and strengthen reliability.