

Powering the Future: Key Factors Influencing Solar Energy Adoption Across Hawaii, California, and Texas

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Introduction

Solar energy and battery storage technology supply clean, green, and affordable energy systems as the world moves towards renewable energy. However, local trends of solar potential, technical capability, and economic circumstances reflect different demands and opportunities for energy storage. The report examines how battery storage systems drive the adoption of solar energy in Hawaii, California, and Texas through solar qualification rates, carbon offsetting, and solar potential. Our work relies mainly on Google's Project Sunroof dataset in BigQuery, which is supported by the current energy developments in these regions. By analyzing the parameters above, we attempt to understand how different regions utilize energy storage to optimize solar energy generation and grid stability.

Storage Solutions Overview and How Battery Storage Supports Solar Adoption

Battery storage technologies play a crucial role in allowing solar energy to unlock its full potential, with geography depending on regional energy demand and the pace of technological progress. As more and more communities become reliant on solar energy, demand for low-cost, scalable, and reliable storage can only rise. Solar-plus-storage systems in Hawaii have widely depended on lithium-ion batteries, with widespread preference for lithium iron phosphate (LFP) chemistry. These batteries help stabilize the state's isolated grid and provide a steady electricity supply (Clearway Energy Group, 2023). LFP batteries have become a favorite choice because of their high safety standards and efficiency, making them a natural fit for Hawaii's ambitious goal of achieving 100% renewable energy. Since Hawaii cannot easily import or export electricity like the mainland states, having durable and dependable battery systems is essential. Due to these systems, Hawaiians now enjoy evening electricity at roughly half the cost of oil-generated power—a tremendous feat considering the state's historically high energy costs (Hawaiian Electric, 2023).

In California, some of the world's biggest battery installations have played a pioneering role. As the state increasingly incorporates renewable energy, methods for better handling when energy is available have been a high priority. Large-scale lithium-ion battery systems are today essential to the stability of California's grid and to powering its ambitious clean energy objectives. Perhaps the most significant problem they help to eliminate is the "duck curve"—the mismatch between when solar power is generated and when people use the most electricity. Without enough storage, much of the solar generation in the middle of the day would be wasted. These storage devices help capture the surplus solar energy during the day and store it when needed, like in the evening (CPUC, 2022).

In Texas, the scenario is different but no less important. The state's expansive geography and growing number of wind and solar farms render energy storage a core mechanism for keeping the grid reliable. As large as the areas of renewable projects are, so sophisticated are the methods needed to reconcile energy demand and supply. Texas battery storage units hold extra solar power when it is off-peak and provide it during peak demand hours, making higher profits for operators while keeping customers' lights burning. Further, Texas's availability of renewable resources and deregulated energy sector has made it a national hub for energy storage innovation. Utilizing fluctuating market prices, the operators can further make solar energy economically viable (ERCOT, 2023).

Across all these regions, battery storage solutions help solar power become more dependable, especially during the evening and cloudy days. Home-based battery systems are also gaining popularity, giving everyday consumers more control over energy use and costs. Programs like California's Self-Generation Incentive Program (SGIP) and Hawaii's Battery Bonus offer critical financial support, helping make solar-plus-storage options more accessible to residential and commercial users (CPUC, 2022; Hawaiian Electric, 2023).

Feasibility, Economics, and Energy Storage Potential by Region

The feasibility and economics of battery storage technologies may vary widely from location to location, depending on factors like electricity prices, government policies, and the solar energy potential of a region. Such differences unmistakably point to the fact that there is no universal solution to energy storage. In Hawaii, for example, locals endure the country's highest electricity bills, so battery storage is not only a wise choice but an essential one. New utility-scale solar-plus-storage systems now deliver energy at around \$0.09 per kilowatt-hour, significantly lower than traditional fossil fuels (Hawaiian Electric, 2023). This cost saving is no small thing for transforming Hawaii into renewables, providing utilities and consumers with an excellent motive for ditching oil. To sustain the momentum, Hawaii aims to double storage capacity by 2025, a crucial target toward 100% renewable energy (Hawaiian Electric, 2023). Battery storage investments are no longer an afterthought—these are critical to making Hawaii's clean energy dream a reality.

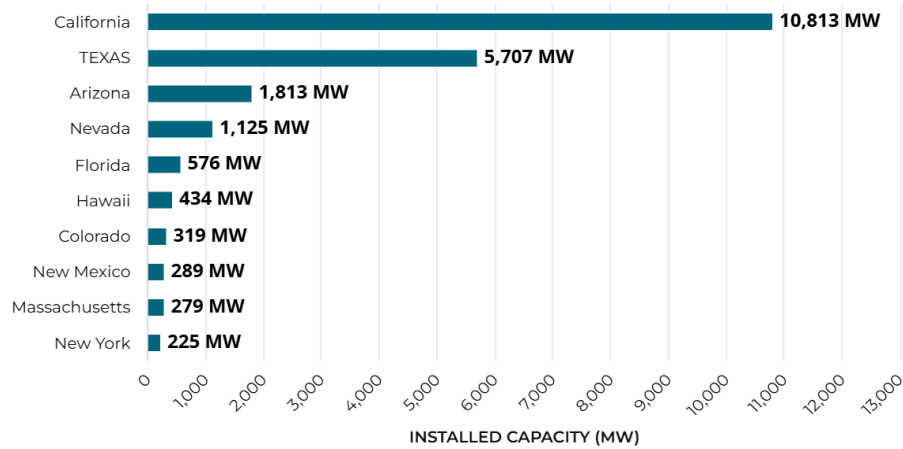
California follows the same success story, but on a much grander scale. In achieving more than 10 gigawatts of utility-scale battery storage capacity, California has illustrated how important strong economic and policy support can be to scaling new technologies. State programs like the Self-Generation Incentive Program (SGIP) have rendered solar-plus-storage systems within reach for residential and commercial properties. With these programs, energy storage is not just a big-utility affair—it is something that all regular homeowners can also participate in (CPUC, 2022). The state's level of solar installations and high consumer interest in energy storage have helped create a robust market that keeps growing. Battery storage in California is becoming nearly as ubiquitous as solar panels themselves.

The scene is still building in Texas, but the potential is enormous. The state's open spaces and growing number of solar and wind farms provide an ideal battery storage for large-scale settings. With Texas having such an energy market deregulated and in many cases volatile, there are real opportunities for battery systems to buy low when energy is plentiful and sell high when prices are highest. With such a mechanism to quickly respond to price spikes, storage systems immensely benefit the grid. Already, gigawatt-hours of newly proposed battery installations are queued up to be added to the grid, showing Texas is dedicated to adding storage and its ability for renewable power (ERCOT, 2023). As much land as there is to spare, as well as sun and wind to collect, the state is in an excellent position to become a prime energy storage location nationally.

Beyond the central states, battery storage is equally important to increasing grid stability, especially in remote and rural areas. Where reliable electricity availability cannot always be taken for granted, energy storage units are a welcome backup. Microgrids powered by renewables and batteries enable clean, steady power to areas that otherwise suffer from routine shutdowns. This added reliability boosts local energy security, public health, and economic development opportunities (DOE, 2022). As technologies continue to develop and prices fall, these types of storage expansion to rural and underserved areas will increase exponentially.

Plot 1: Battery Storage by State, August 2024 (Gonzalez, 2024)

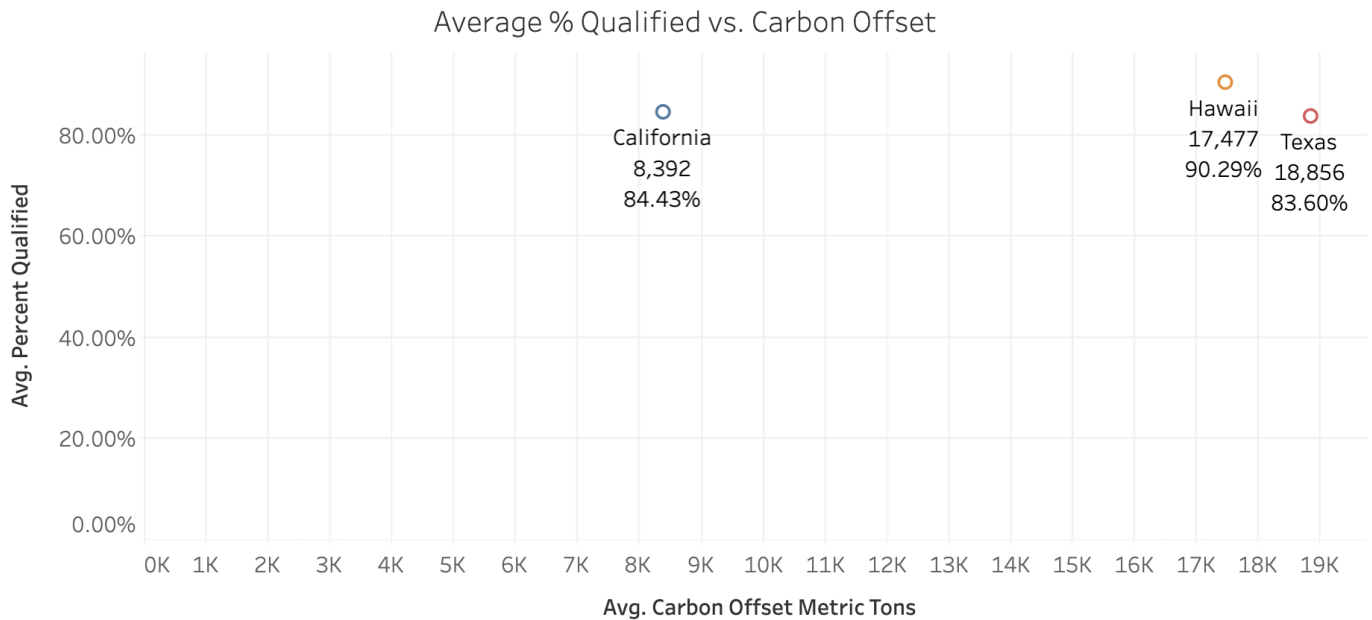
EXHIBIT 2: TOP 10 STATES WITH THE MOST INSTALLED BATTERY STORAGE CAPACITY, SEPTEMBER 2024 (MW)



Description: This plot displays the distribution of battery storage capacities across Hawaii, California, and Texas.

California leads the charge with the highest installed capacity, followed by Texas and Hawaii. California's extensive infrastructure allows it to deploy large utility-scale projects, while Texas benefits from deregulated energy markets, enabling better storage optimization. With its isolated grid system, Hawaii faces challenges but shows steady growth in storage installations, which are crucial for stabilizing its renewable energy grid.

Plot 2: Solar Qualification Rates and Carbon Offsets by State

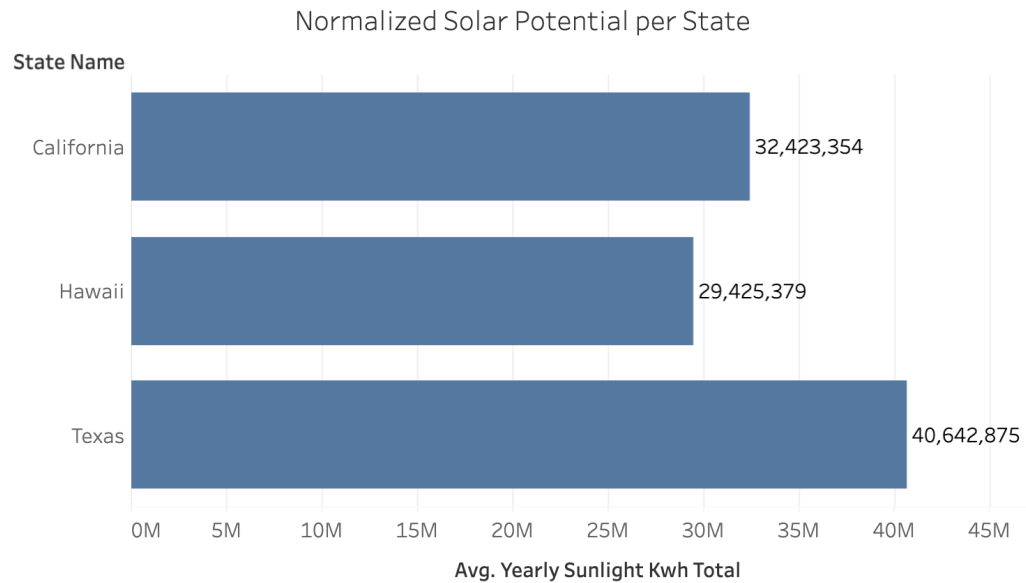


Description: This plot compares solar qualification rates and carbon offsets for Hawaii, California, and Texas.

California's moderate % qualification rate of 84.43% contrasts with its moderate carbon offset of 8,392 metric tons. With a lower qualification rate of 83.60%, Texas outperforms California in carbon offset at 18,856 metric tons due

to its larger land area and more extensive solar installations. Despite having the highest qualification rate at 90.20%, Hawaii has a lower carbon offset of 17,477 metric tons, likely due to its smaller installations and limited land area.

Plot 3: Solar Potential per State: Analyzing Total and Normalized Energy Output

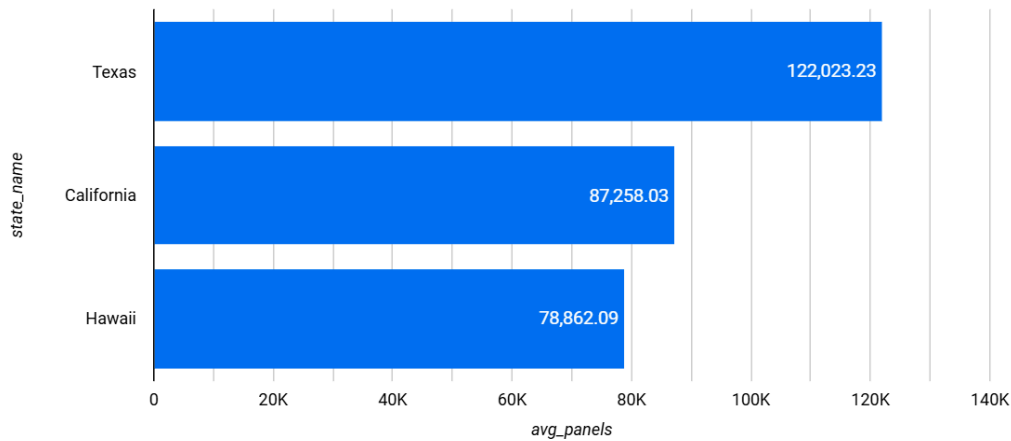


Description: This plot compares the total and normalized solar potential across Hawaii, California, and Texas.

Texas has the highest total solar potential at 40,642,875 kWh, driven by its vast land area and numerous installations. California, while second in total solar potential at 32,423,354 kWh, maximizes its infrastructure for optimal output. With the smallest land area, Hawaii shows lower total potential but benefits from higher efficiency due to strong solar adoption policies and smaller installation footprints.

Plot 4: Average Number of Panels by State

Average Number of Panels by State

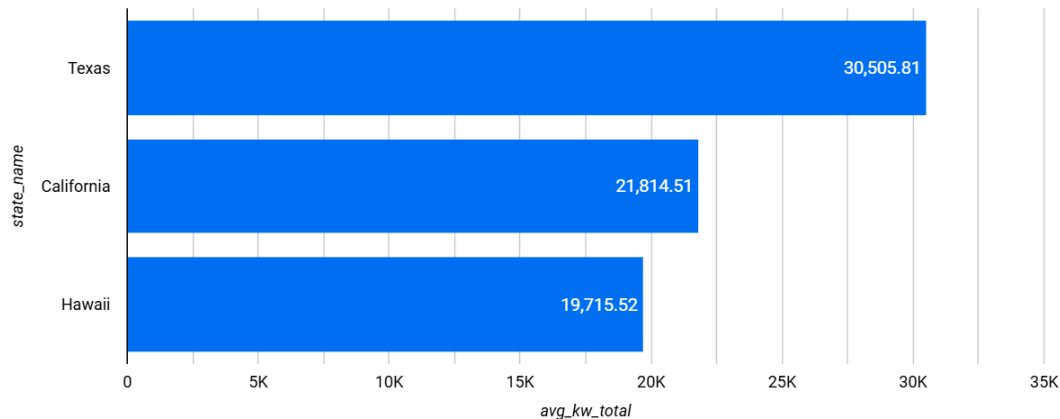


Description: This plot compares the average number of solar panels per census tract in Texas, California, and Hawaii.

Texas stands out with approximately 122,023 panels on average, far exceeding California's 87,258 and Hawaii's 78,862. This substantial difference may be due to Texas's expansive land availability and greater investment in solar infrastructure, enabling higher installation rates across larger rooftops and open areas. These regional disparities reflect broader economic and infrastructural factors that influence solar adoption across the U.S. [9]

Plot 5: Average Solar Potential (kW) by State

Average Solar Potential (kW) by State



Description: This plot shows the average solar potential in kilowatts (kW) per tract across the three states.

Texas again ranks highest with an average of 30,505.81 kW, followed by California at 21,814.51 kW and Hawaii at 19,715.52 kW. Despite Hawaii's high percentage of qualified rooftops, its lower overall solar potential is likely attributed to spatial constraints and smaller rooftops typical of island regions. In contrast, Texas benefits from land-scale and favorable solar capacity development conditions [9].

Comparison with Mega Batteries and Solar Energy Qualification Rates and Carbon Offsets

Mega batteries, such as Tesla's Megapack, are large storage systems that store renewable energy generated during peak production and release it when there is off-peak demand. They benefit from economies of scale, centralized control, and lower per-kWh costs than small systems, which makes them very efficient for grid reliability and stability. Mega batteries are highly suitable for frequency regulation and peak shaving, providing valuable services for grid management in high renewables penetration regions (Southern California Edison, 2020).

On the other hand, traditional storage systems offer local resilience. They are smaller and designed for home and business use. They enable customers to save on electricity bills and enjoy backup power during outages. State incentives through rebates and tax credits render such systems accessible to homeowners and firms (CPUC, 2022).

Conclusion

Battery storage is crucial in advancing solar energy adoption across Hawaii, California, and Texas. Despite regional differences in technology, economics, and solar potential, energy storage is key to overcoming the challenges of intermittent solar power and ensuring reliable, cost-effective electricity. While mega batteries offer large-scale solutions to grid stability and optimization of solar energy, traditional storage systems contribute to localized energy resilience. By continuing to invest in energy storage technologies and modernizing transmission infrastructure, these regions can maximize their solar potential and work toward achieving their renewable energy goals.

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