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A California Plan: How California Leads Decarbonization

California's Energy Crossroads

Over the past 40 years, California has been broadly recognized as a leader in the clean energy transition. Aggressive goals and policies have driven substantial deployment of advanced clean energy technologies that others have sought to emulate. But today, California sits at a crossroads as progress in clean energy deployment has highlighted challenges to deep decarbonization at the same time as a changing climate puts new strains on the state's legacy energy infrastructure.

California's early success in renewable energy deployment is giving way to real challenges. High prices and mismatches between clean energy supply and grid demand, which result in both generation curtailments and grid shortages, illustrate key issues. At the same time, Public Safety Power Shutoffs and increasingly prevalent climate-driven disasters such as heatwaves, wildfires, floods, and drought pose new risks to the state's energy system. Together, these obstacles are driving concerns about costs, resilience and the long-term reliability of California's grid.

Fortunately, there is a path forward that builds upon the state's early successes and supports continued deployment of renewables. By incorporating new technologies, such as long-duration energy storage (LDES), it will be possible to achieve deep decarbonization of the Golden State's energy system while delivering reliability and resiliency in the face of climate threats.

The right policies and incentives can provide market signals that will accelerate the deployment of these new technologies, supporting grid stability and renewable deployment. New revenue streams for projects that promote grid resilience can provide reliable energy to California consumers. And, LDES paired with renewable energy sources, including planned offshore wind projects, can replace existing fossil fuel and nuclear generators to deliver a truly renewable future.

Setting and Meeting Goals

California's energy leadership can be traced to the 1970s when the California Energy Commission was established to confront that decade's energy crisis. As awareness of climate change grew, and the need to transition to renewables became clear, California adopted its first Renewable Portfolio Standard (RPS) in 2002. Over time, the Golden State's clean energy ambitions have become increasingly aggressive, culminating in the 2016 RPS requiring 60% of grid electricity to be produced by renewable sources by 2030 and 100% by 2045.

Though the goals have been ambitious, California's citizens and energy sector have consistently met or surpassed them. For example, while originally aiming for 33% renewable energy by 2020, the state achieved 36% that year.[1]

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Today, California's renewable energy portfolio is impressive. Solar photovoltaic (PV)'s share of California energy production went from nearly nothing in 2011 to 17% of the state's utility-scale generation in 2021. If smaller-scale production such as residential and small commercial is included, solar PV accounts for 25% of the state's total energy generation. For broader context, this represents 32% of total PV production in the United States. Wind, while a smaller proportion of clean energy than solar, now represents 8% of power generation. California also leads the U.S. in geothermal power, producing 70% of the country's total and representing 6% of California's utility-scale production.[2]

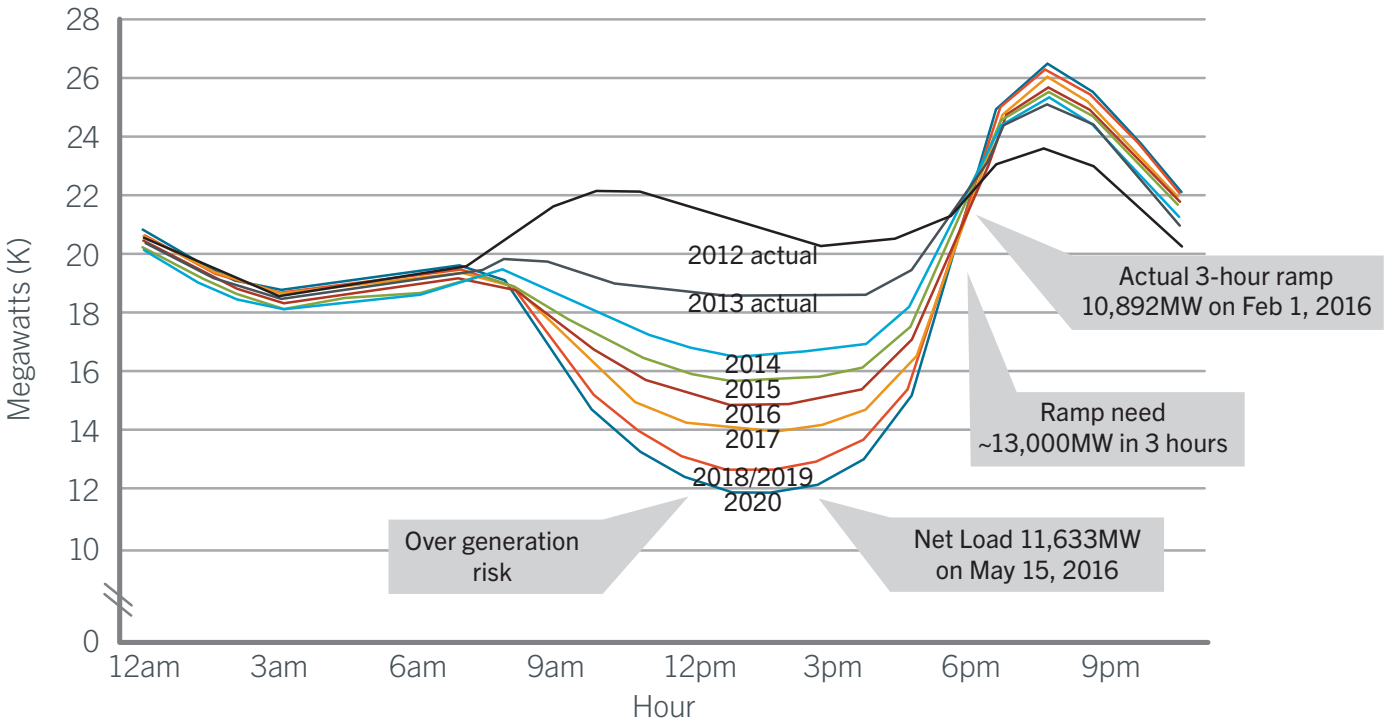
1 CMUA. Powering California's Future with Clean, Affordable and Reliable Energy. https://www.cmua.org/Files/2022_Policy_Papers/Principles_for_Clean_Energy_Success_CMUA-February_2022.pdf

2 Energy Information Administration. State Profile: California. https://www.eia.gov/state/analysis.php?sid=CA

The Duck Curve: Timing Mismatch Between Supply and Demand Grows

On May 8, 2022, California achieved an important milestone. For a short period of time during peak renewables production, the state's utility power grid ran entirely on renewable power for the first time. While this was an exciting development, many challenges remain to powering the grid with renewable energy 24/7.

Renewable energy sources are variable by nature. Given California's reliance upon solar generation, the state's renewable energy production peaks in the early afternoon before the sun begins to set. However, demand reaches its peak in the late afternoon and evening as the heat of the day continues to build and people return home from work. The graph of power production over the course of a day illustrates timing imbalance between peak demand and solar power generation. This graph is referred to as the duck curve. Without energy storage capacity, excess renewable energy produced before peak demand cannot be accommodated by the grid and is curtailed. And when demand spikes late in the afternoon, fossil-fired natural gas and diesel generators ramp up to fill the gap.



Typical Spring Day

Duck curve evolution shows sharp ramp needs and overgeneration risk. Source: CAISO

Energy Storage in California: Bridging the Duck Curve for 24/7 Clean Energy

Currently, the majority of energy storage in California is provided by pumped hydro – nearly 4,000 MW of capacity. The non-hydro energy storage pipeline in California consists of over 1,500 MW of projects approved by the California Public Utilities Commission, with approximately one third of those already in operation.[3] Most non-hydro energy storage projects to date have relied upon 2-4 hour lithium-ion batteries which can help in some applications, but which do not have the duration to fully bridge the gap between supply and demand in late afternoon and evening hours.

In addition to inadequate duration, lithium-ion batteries have many operational drawbacks. The risk of fire, dramatically illustrated by the Moss Landing fire in September 2022, makes them ill-suited for installation near populated areas. Limitations on daily cycling reduce the ability of lithium-ion storage systems to meet both capacity and grid service demands. And, the technology's supply chain is problematic; a heavy reliance upon resources dominated by China has been identified by the U.S. Department of Energy as a potential national security weakness.[4]

Energy storage policy in California began to develop in 2010 when the legislature, acknowledging the importance of the technology, commissioned a report to set targets for storage. The result was a 2013 procurement target of 1,325 MW by 2020 with the state's three largest utilities required to develop strategies for implementation.[5]

While current four-hour storage can help, for the grid to rely entirely upon renewable energy, storage will need to last longer. Long-duration energy storage (LDES), with durations of 6-10+ hours, will be essential for achieving California's goal of 100% renewable energy by 2045.

3 California Public Utilities Commission. Energy Storage. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/energy-storage

4 U.S. Department of Energy. "Securing America's Clean Energy Supply Chain." https://www.energy.gov/policy/securing-americas-clean-energy-supply-chain

5 California Public Utilities Commission. Energy Storage. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/energy-storage

Climate Impacts Strain the System

It is clear that climate change is a liability for energy infrastructure. The deadliest fire in California history, the Camp Fire, occurred when power lines ignited dry foliage amid high winds which then carried the fire into the city of Paradise. Aging powerlines are believed to have started several other fires as well, including the Dixie Fire in 2021 (the second largest in state history) and the McKinney Fire in 2022. Outdated energy infrastructure and climate change-fueled drought have proven to be a disastrous combination for California.

In response to these dangerous conditions, the state's utility companies have begun to periodically institute Public Safety Power Shutoffs (PSPS) when conditions make grid-related fire disasters most likely. Heatwaves have also strained the capacity of the grid as widespread use of air-conditioning created record energy demand, leading to brownouts and a risk of blackouts, most notably in 2020.

In addition, the long-term drought – believed to be the worst the region has experienced in more than a thousand years – has reduced the production of hydroelectric power. Reduced water levels in reservoirs at hydroelectric power stations are estimated to have decreased power output potential by nearly 50% in 2021 and 2022.[6, 7]

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Whether it's wildfires, heatwaves, flood, or drought, energy reliability and availability are at the core of some of the worst ongoing climate disasters in California. The grid needs to adapt to remain resilient and reliable in the face of a changing climate.

Short Term Fixes Give Way to Long Term Solutions

In the short term, maintaining grid reliability will require extreme measures just to keep the lights on. The recent five year extension of the Diablo Canyon nuclear facility's operating certificate, a stark policy reversal on the part of the Newsom Administration, will ease the short term crunch but comes at a steep cost - $1.4 billion.[8]

While some legacy assets and voluntary demand reduction campaigns will be necessary in the short term, there is an opportunity to rapidly deploy new systems and technologies that can quickly improve community resilience and expand clean energy generation. Microgrids, local power grids that may be fully or partially detached from the broader grid, can be relatively quick to implement and provide resilience to remote areas and areas prone to PSPS events. They generally consist of a renewable energy source such as solar or wind paired with LDES, creating a self-sufficient clean energy system.

And, to ensure the state is on the right path for long-term decarbonization and success, CAISO should take immediate action to reform the interconnection queue and prioritize clean energy projects that are likely to be built and which have a storage component. The current backlog in the CAISO interconnection queue adds years to the development timeline of new clean energy projects, increases costs for developers, and slows progress.

6 EIA. Drought effects on hydroelectricity generation in western U.S. differed by region in 2021. https://www.eia.gov/todayinenergy/detail.php?id=51839

7 S&P Global. California hydro generation to be half of average this summer. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/052622-california-hydro-generation-to-be-half-of-average-this-summer-eia-analysis

8 Lopez, Nadia. (Sep. 1, 2022). Cal Matters. Diablo Canyon: Nuke plant a step closer to staying open longer. https://calmatters.org/environment/2022/09/diablo-canyon-legislature-california/

The Long Term: Driving Decarbonization and Energy Storage Development in California

California cannot rely solely upon legacy assets or voluntary demand curtailment to build a reliable, sustainable energy future. If the state's ambitious targets are to be met, the state will have to move forward in ways that are **better, faster, and smarter** to continue to lead the global clean energy transition.

Better

To drive the clean energy transition forward, it is critical that policy creates market conditions that will deliver a decarbonized grid and avoid unintended consequences. For example, recent reforms to Net Energy Metering standards (NEM 3.0) may have the unintended effect of discouraging new residential solar deployment. By reducing compensation for solar projects that lack storage, the state is effectively placing the burden of deploying grid storage onto individual homeowners.

This is an inefficient way to add needed storage capacity and threatens continued successful deployment of rooftop solar. Instead of this, CPUC should consider regulations that incentivize standalone solar while also creating opportunities for distribution-level LDES to capture and deploy excess solar as needed.

The recent Federal Energy Regulatory Commission (FERC) order 2222 helps achieve this goal. By instructing regional grid operators to incorporate Distributed Energy Resources (DERs), which can include distribution-level storage, into the market, DERs are able to earn revenue by providing decentralized storage.

Deploying LDES to maintain strong support for residential solar and utility-scale renewables promotes a more rapid energy transition while ensuring grid stability. It is estimated that in order to meet its targets, California will need 2-11GW of energy storage by 2030 and 45-55GW by 2045, 5GW of which will need to be LDES.[9] Compare this to the previously stated roughly 1,500MW approved and 500MW currently installed.[10]

Faster

The need is immediate, and speed matters. California must move quickly to meet ambitious targets for clean energy while ensuring reliable and affordable energy for consumers.

Fortunately, the Federal Inflation Reduction Act (IRA) provides a blueprint that states can emulate. For example, the IRA includes Investment Tax Credits (ITCs) for clean energy technologies, including energy storage, with additional incentives for domestically manufactured products. ITCs improve project economics and can accelerate the deployment of new technologies, allowing them to achieve economies of scale.

9 California Energy Storage Alliance and Strategen. Long Duration Energy Storage for California's Clean, Reliable Grid.

10 California Public Utilities Commission. Energy Storage. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/energy-storage

Industry experience with wind and solar demonstrates that, with the right incentives, new technologies can be deployed quickly. By stacking a state-level ITC for energy storage on top of those contained in the IRA, **California can cement its leadership role in clean energy** while driving growth and cost-down in the LDES industry.

Other states have successfully created similar state-level ITCs for diffuse storage. Maryland has set aside funds for an individual income tax credit for residential and commercial energy storage,[11] and Connecticut has instituted a similar program to benefit residential, commercial, and industrial energy consumers who install storage.[12]

Furthermore, new technologies like LDES should be given at least the same support as legacy technologies. Though California did allocate $140 million in the 2022-2023 state budget for innovative energy storage projects, this was only a fraction of what was originally proposed. And, when compared to the $1.4 billion in additional support being allocated to Diablo Canyon, a single power plant, the contrast is stark. Only when there is a truly level playing field where clean energy technologies receive the same kinds of support as legacy technologies will it be possible to decisively pivot toward the sustainable, decarbonized energy system we need.

11 Maryland Energy Administration. Maryland Energy Storage Income Tax Credit – Tax Year 2023. https://energy.maryland.gov/business/Pages/EnergyStorage.aspx

12 Connecticut Department of Energy and Environmental Protection Public Utilities Regulatory Authority. Energy Storage Solutions. https://portal.ct.gov/PURA/Electric/Office-of-Technical-and-Regulatory-Analysis/Clean-Energy-Programs/Energy-Storage-Solutions-Program

13 Lopez, Nadia. Cal Matters. Dec. 6, 2022. First-ever California offshore wind auction nets $757 million. https://calmatters.org/environment/2022/12/california-offshore-wind/

After Diablo Canyon – Offshore Wind and LDES

The postponement of the decommissioning of Diablo Canyon will help to stave off severe capacity shortfalls for several years, however it does not present a long-term solution. As California looks ahead, developing a post-Diablo Canyon future, powered by clean energy, will be critical to achieving the state's energy goals.

To meet this gap in generation capacity, in 2022, California turned its eyes offshore. In the first such lease sale on the West Coast, the U.S. Bureau of Ocean Energy Management leased 373,268 acres off the coast of California to several developers for the construction of offshore wind facilities. It is estimated that these lease areas have the potential to deliver up to 4.5 GW of installed capacity.[13]

The generation profile of offshore wind differs from that of solar, however the importance of LDES to maximize renewable generation and provide clean energy 24/7 remains the same. Offshore wind projects developed off of California are expected to have capacity factors ranging from 40-80%, indicating strong potential for LDES to bridge gaps when wind generation varies.

Diablo Canyon is slated for decommissioning just as new wind farms are expected to come online. Leveraging transmission infrastructure at the Diablo Canyon site by adding gigawatts of LDES and maximizing offshore wind utilization provides an exciting opportunity for California to continue to lead the world in implementing cutting edge clean energy technologies.

Smarter

Going forward, California must organize electricity markets in a way that creates the right incentives to deliver reliable, resilient, low-carbon energy. This means getting the prices right so that LDES and other emerging technologies can receive value for the services they provide.

LDES technologies don't just store energy. Increasingly, it is recognized that these technologies can provide valuable grid ancillary services such as voltage regulation, spinning reserve and in some cases, black start capability. LDES assets should have opportunities to realize revenue for the system-level value they deliver. In addition, capacity markets must evolve to include and prioritize LDES assets that can provide 8+ hours of storage – enough to provide power even through extended peak demand periods.

In addition, reforming wholesale energy markets to require that price signals for Independent Power Producers (IPPs) reflect real time grid needs will both support grid stability by reducing periods of oversupply and provide long-term economic opportunity for IPPs to take advantage of arbitrage opportunities with LDES.

Finally, to help mitigate the effects of climate change on California's communities, revenue streams for generators and storage asset owners who provide resilience, especially those in at-risk areas, need to be created. Location-based grid capacity and ancillary service revenue opportunities must be created for storage or generation assets that can keep the lights on in areas that are subject to PSPS events.

Conclusion

California sits at an energy crossroads. As dissatisfaction with high energy prices and unreliability grows, turning back to legacy fossil and nuclear resources and counting on voluntary programs may have some appeal.

But, from this crossroads is a tremendous opportunity: An opportunity to reaffirm the Golden State's leadership position in clean energy by accelerating the deployment of advanced clean energy technologies to achieve deep decarbonization with reliable clean energy.

Aggressive short-term actions will give way to long term solutions that include evolving market mechanisms and providing appropriate support for new technologies, creating the conditions for California to drive innovation and advancement of new technologies, including LDES.

As more LDES is deployed, the average duration of new grid-connected storage projects will increase, improving the utilization of variable renewable energy production and rapidly reducing emissions.

If we get the policy right, California will not only meet its clean energy goals, but continue to drive the clean energy transition and lead the world towards a clean energy future. ■

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