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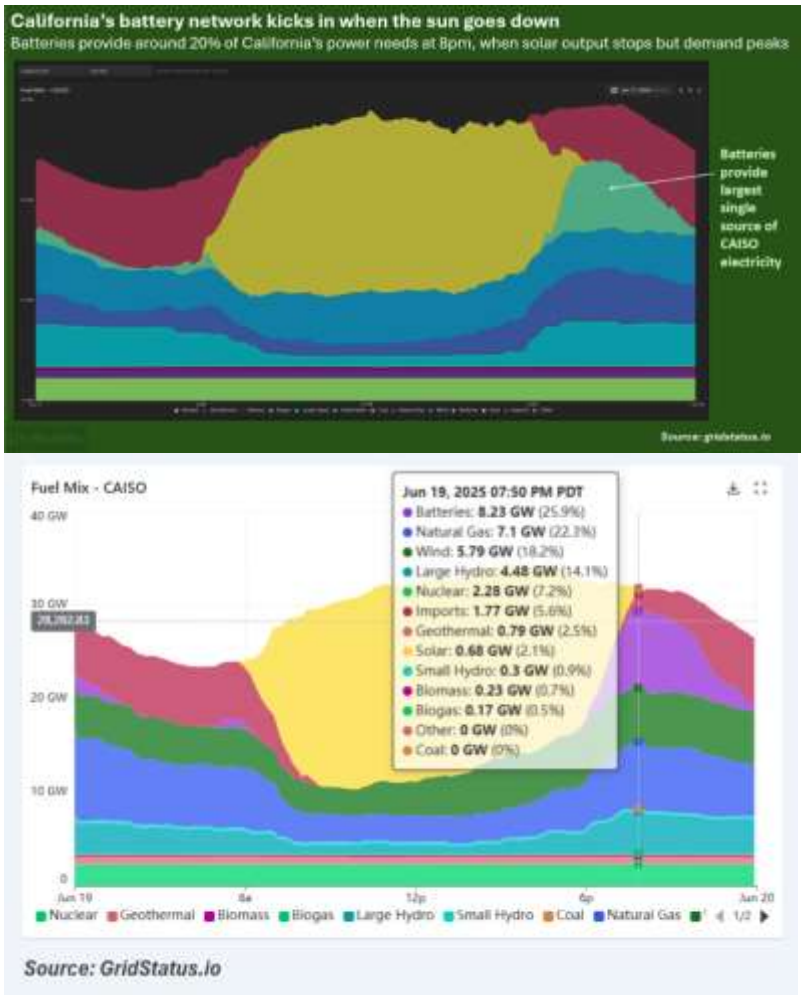
California as a best-practice example for energy storage deployment: Lessons for the EU

California has emerged as an excellent example of the impact and benefits of energy storage on the energy grid, where it is enabling that large scale integration of renewables, bringing down energy costs, and increasing grid stability. This was made possible by setting clear targets for energy storage deployment, enhanced market design, streamlined permitting, and strategic investments. These can be taken as best practice examples to be shared and recommended to EU and national policymakers, to increase the deployment of energy storage and Long Duration Energy Storage (LDES), furthering the clean transition, and increasing energy security, reliability, and affordability in Europe. This article provides an in-depth look at California's large-scale energy storage deployment, highlighting the key benefits and the strategic steps that enabled its success. It offers practical recommendations for how similar approaches can be adapted and implemented across European. The analysis also features an exclusive interview with David Hochschild, Chair of the California Energy Commission, offering first-hand perspectives on policy, innovation, and lessons learned.

California showcasing the benefits of energy storage on the grid

California has the highest capacity of installed energy storage of any US state by far, with around 13,000MW, which is around **42% of all battery storage capacity in the US** as of early 2025 (Reuters). With sufficient energy storage on the grid, the California Independent System Operator (CAISO) can make full use of renewable energy source, while avoiding renewable curtailment and storing excess generation for off-peak hours. With 21,000 MW of solar capacity and around 12,400 MW of battery capacity, CAISO has been able to provide **100% clean energy during peak supply on 239 days in a one-year period**, between April 2024 to April 2025. Moreover, for certain periods in the system demand peak in the early evening, battery storage is already the largest single source of electricity, supplying 20% of the systems electricity during peak consumption periods in June 2024, and increasing to 26% (8.23 GW) in June 2025 (Reuters).



This not only allows for the maximised use of renewables, it also helps to avoid curtailment. Much of the electricity stored and discharged would otherwise have been curtailed, being wasted and costing grid operators and consumers more. During the first five months of 2025, 11.5% of California's solar generation was curtailed to maintain grid balance, down from 13% over the same period in 2024, despite an 18% increase in total solar production in that time (ESS news, 2025). On 29 March , a day with particularly high curtailment, over 58,000 MWh of solar, and over 6,100 MWh of wind was curtailed, however according to CAISO data, this would have been 67% higher without storage, as batteries absorbed 38,897 MWh of electricity that day.

All of this leads to more practical and consumer level benefits, as it **makes electricity cheaper**. According to the California Energy Commission (CEC) grid scale batteries have generated $11.5 million in net market value, by charging when prices are low at midday and discharging during evening peaks. This also reduced wholesale price volatility by smoothing out the midday to evening supply and demand differences, with reductions of $100/MWh at peak price and an increase of $15/MWh at price lows observed in the CAISO system. Furthermore, it helps displace the need for natural gas. According to S&P Global (2024), CAISO connected battery peaker plants which displaced nearly 30% of

monthly demand for natural gas peaking generation in spring 2024, and an estimated 30 billion cubic feet (Bcf) of natural gas through the first 8 months of 2024, roughly equivalent to $66.3 million of natural gas. These factors benefit consumers through smoother and lower electricity prices, support grid operators and utilities by reducing price volatility and reliance on peaker plants, and lower overall system costs by decreasing gas consumption and improving the efficiency of renewable energy use.

Energy storage also plays a crucial role in grid stability, and this is having a clear effect in California. In his presentation at the International Flow Battery Forum 2025, David Hochschild, Chair of the California Energy Commission, explained that the summer of 2024 was the hottest summer on record in California, leading to the largest energy demand on record. Despite this, there were no grid outages, or even any flex alerts (the alert sent when there is risk of an outage) and this is largely due to energy storage, which is performing exceptionally well. The benefits California has gained from adding so much battery storage to the grid are enormous and will continue to grow as the state continues to increase its storage capacity.

How California enabled storage to flourish

California has proven to be an inspiring example of how grids should look, but how did they do it? **It started with setting a clear target and timeline to achieve it**. This was done in California in 2010 with Assembly Bill 2514, which required the California Public Utilities Commission (CPUC) to set **mandatory energy storage procurement targets**, which also included a precise definition of energy storage systems. This allows for predictability and long - term planning for the grid operators, ensuring smooth installation and integration. The CPUC initially mandated 1,825 MW by 2020, which was easily met and even exceeded. The state now has targets for **100% clean energy by 2045,** and has already achieved over 60%. It is well understood how important the role of battery storage now is, and it is continuing to grow significantly, with 16 GW added in the last 6 years, and a **new ambitious goal to reach 50 GW by 2045**. More recently, a new target has been set specifically for long-duration energy storage (LDES), of 2 GW of LDES to be deployed by 2037, including 1 GW of at least 12-hour storage and 1 GW of multi day storage.

The next step California took was to enhance the market opportunities for battery storage. This first included structured market participation, allowing storage assets to participate in multiple market roles simultaneously, paving the way for cost effective stacked revenue streams, and expanding the use cases for batteries. Following this, the Energy Storage Enhancements initiative was introduced, bringing advanced modelling for state of charge constraints when participating in ancillary services, and adjusted bidding rules, with bid cost recovery protections, and a specific model for co-located solar plus storage financing. There were also further incentive programs for residential and self-generation storage, leading to a considerable rise in behind the meter battery storage. Finally, along with the previously mentioned LDES procurement targets, a 2023 Assembly Bill also introduced a **state-level central procurement mechanism, which includes LDES battery storage**, moving beyond utility level procurement and delivering scale and investment confidence by reducing project risk. This has so far

resulted in two LDES procurements, for 1 GW of 12-hour LDES, and 1 GW of multi-day LDES to be operation by 2033.

On the R&D side, **California is investing significantly in LDES demonstration projects.** In 2022, the **CEC approved $273 million in non-lithium LDES demonstration funding, awarding 10 different projects, with durations from 8 hours to 100 hours, and 1MW to 40MW system sizes.** The use cases for these projects include 3 microgrids for native American tribes, 2 projects for military bases, 2 for utilities, and the remaining projects for a hospital, industrial facility, and a testing and evaluation facility. There are 6 different non-lithium technologies being demonstrated, including 3 different chemistries for flow batteries; vanadium, iron, and zinc bromine. One of these projects, the Viejas Enterprise Microgrid for the Kumeyaay tribal lands is the largest vanadium flow battery in North America, with a 10 MWh AC-coupled vanadium flow battery system co-located with 15 MWp PV. Another project will provide backup power to the Camp Pendleton military base during outages, while engaging with energy markets when the grid is up, with a 2-phase installation combining for 50 MW / 400 MWh. Not only do these projects add LDES capacity, they also demonstrate viable use cases and technologies for LDES, providing further data to support the uptake of LDES and flow batteries specifically.

As a final point, California has been able to **fast track storage deployment by removing administrative burdens with interconnection process reforms**. This has allowed for new storage projects to be commissioned exceptionally fast, far outpacing connection permitting timelines in most EU member states. CAISO manages the grid interconnection process through annual cluster studies, grouping projects for streamlined review. This process included **fast track pathways for energy storage projects that meet certain financial readiness criteria**, and battery only priority zones, where preferred zones for battery siting are identified where existing infrastructure can integrate new storage capacity with minimal upgrades. Streamlined permitting also extends to the local level, where **uniform permitting guidelines for energy storage have been adopted by local governments, in some cases reducing permitting timelines to under 90 days**.

The CPUC also directs utilities to develop interconnection hosting capacity maps, and proactively upgrade grid infrastructure in zones where high storage deployment is expected, which reduced bottlenecks and allows for faster approvals. It is important to note that **many of these reforms were driven by urgency, in response to significant grid stressing events such as wildfires and heatwaves**. Temporary waivers on environmental reviews and permitting timelines for grid critical storage projects helped to fast track 2 GW of storage capacity in 2022 alone, in response to a grid reliability crisis the previous summer. This also reflects the value of storage on the grid however, as the proven benefits and shorter development time meant that energy storage was the chosen solution to the emergency, rather than more traditional fossil fuels.

Lessons and recommendations for Europe

California has become a global leader in energy storage through the methods outlined above, and the EU could achieve similar results by taking inspiration from these policies. Naturally, the approach must be different considering the EU is not a single centralised state with a single centralised energy regulator, but these best practices can be a blueprint to be adapted at EU or member state level to accelerate deployment.

1. Binding energy storage targets

The European Commission could include binding **national energy storage targets in revisions to the Electricity Market Design or National Energy and Climate Plans (NECPs), including a specific target for LDES**. LDES capacity mandates could be complemented with a scheme inspired by California's central procurement mechanism, enabling member state level or cross-border regional LDES procurement hubs. This could align with European energy grid markets (i.e. Iberian Peninsula, Nordic region, Baltic Sea region, etc.) and significantly boost European grid resilience. This would need to be complimented with capacity remuneration mechanisms for these regional areas, adjusted to be competitive with fossil fuel peakers. National regulatory authorities (NRAs) could ensure compliance of energy storage targets at the transmission system operator (TSO) and distribution system operator (DSO) level, while ENTSO-E and regional coordination centres could oversee the regional LDES capacity procurements.

2. Clarified and accessible market rules for storage

Reducing the barriers to energy storage deployment can be facilitated by enabling revenue certainty This could begin with updating EU network codes to formally define energy storage as both a consumer and a generator, resolving the double-charging issue and enabling participation across multiple market layers to allow for revenue stacking. Harmonised metering and settlement standards could be promoted to allow simplified participation across member state borders. Capacity remuneration mechanisms and market differentiated by use case to ensure LDES is on level footing with short term flexibility, including specific recognition in market design and long-term contracts, from 10-20 years in the case of California. The 2024 Electricity Market Design reform addresses some of these issues, but further member state level implementation guidance could strengthen its progress, particularly for LDES.

3. EU funding for capacity procurement

While the EU already has several funding streams to support battery innovation, there is no EU wide support mechanism for commercial deployment or capacity procurement. Taking inspiration from California's LDES demonstration funding, the EU could use existing funding streams to **provide funds to market ready solutions like flow batteries to fill capacity needs and address grid vulnerabilities.** This could also bridge the gap between innovation funding and market deployment, **ensuring technologies can be demonstrated, verified and connected to the grid.**

4. Streamlining grid connections and permitting

Energy storage in Europe often suffers from prolonged permitting and queue management delays, and while permitting process varies widely between member states, permitting can generally take several years, in some cases exceeding 10 years. Adapting permitting review processes to fast-track projects deemed commercially mature, and critical to grid stability can help, especially if coordinated with grid planning and proactive grid infrastructure upgrades. The identification of zones where limited grid upgrades are needed further enables faster integration of streamlined projects, and even more so if projects such as hybrid co-location with peakers and renewable energy sources would not necessitate a new grid connection.

Conclusion and interview

By setting clear targets and enabling conditions such as inclusive market access, streamlined grid planning, and public funding, the EU can foster a robust energy storage sector. California offers a compelling example of best practices and the wide-ranging benefits that follow. Adopting similar measures in EU regulation can enhance grid resilience, reduce fossil fuel dependence, and lower energy costs.
Chair of the California Energy Commission David Hochschild was happy to share the results of his states energy storage efforts, and encouraged Europe to take full advantage of energy storage technology, starting with setting clear and ambitions targets. Read the full interview below.

Full transcript of interview with Chair of the California Energy Commission, David Hochschild:
"I'm really proud to be here at this flow battery conference because battery energy storage is going to be critical for our future to support reliable a reliable grid and to help decarbonise our society and flow batteries and long duration storage play a particularly important role as they can provide that storage for a longer period of time, up to 100 hours in some cases.
So I'm here sharing a little about our experience in California where we have deployed 16 gigawatts of battery storage over the last 6 years, and it's helped our grid to get to 2/3 clean energy and it's helped support reliability, we have a really reliable grid in California and energy storage is big part of the reason why it has been.

One thing I'll say, I do hope Europe really leans into this technology and sets bold aggressive goals to get to energy storage targets. I think that will unlock really important investment and innovation that can help improve reliability and decarbonisation for all the European electric grid.

Top 3 recommendations for Europe; I would say number 1, to establish a formal goal. I don't think you get anywhere without goals. Everything we're doing in California, the fact that we're getting 2/3 of our electricity from clean energy, that's because we established a law to get to 100% clean energy with these stage grades and we're following that and doing the same thing with energy storage where we have a 50-gigawatt goal by 2045, we've done 16, and that provides a lot of certainty.

So setting a goal is important and I think investing in research and development is really important to encourage innovation and get the costs down and to create some industrial policy. The chemistries can do a lot of good in terms of job creation here in Europe.

And I think the final thing is around making the process of interconnecting and constructing these systems as friction free as it possibly can be. To reduce all of the barriers so that we're achieving not just technology innovation but process innovation to get these resources connected to the grid quickly."

– David Hochschild, Interview by David Twomey and Jesse Terry, 24 June, 2025.

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