National Center for Sustainable Transportation

POLICY BRIEF

Grid Energy Storage Assessment for Select Vehicle Electrification Scenarios

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Issue

California has set aggressive vehicle electrification goals to achieve its greenhouse gas (GHG) reduction targets. The state is also integrating renewable energy into the electric grid under the Renewables Portfolio Standard (RPS). Increasing electricity demand from electric vehicles, combined with increasing power generation from variable renewable energy sources like solar and wind, will require significantly increased electrical energy storage capabilities, such as batteries and pumped hydroelectric storage. Assessing long-term energy storage needs and deploying the necessary infrastructure will be critical for maintaining future grid reliability.

Researchers at the University of California, Riverside analyzed several scenarios using the California Public Utilities Commission's Resolve power system planning model to understand how vehicle electrification, renewable energy standards, and GHG reduction goals affect California's mid- to long-term energy storage needs. The scenarios assumed 3.5–5 million electric vehicles on the road and an RPS target of 50% or 60% in 2030, and 8.7–13.4 million electric vehicles and an 80% RPS by 2042. The scenarios also considered annual GHG caps on the electricity sector of 30, 42, and 99 million metric tonnes (MMT). These caps were based on electricity sector planning targets set by the California Air Resources Board to help the state realize its economy-wide GHG reduction goals.

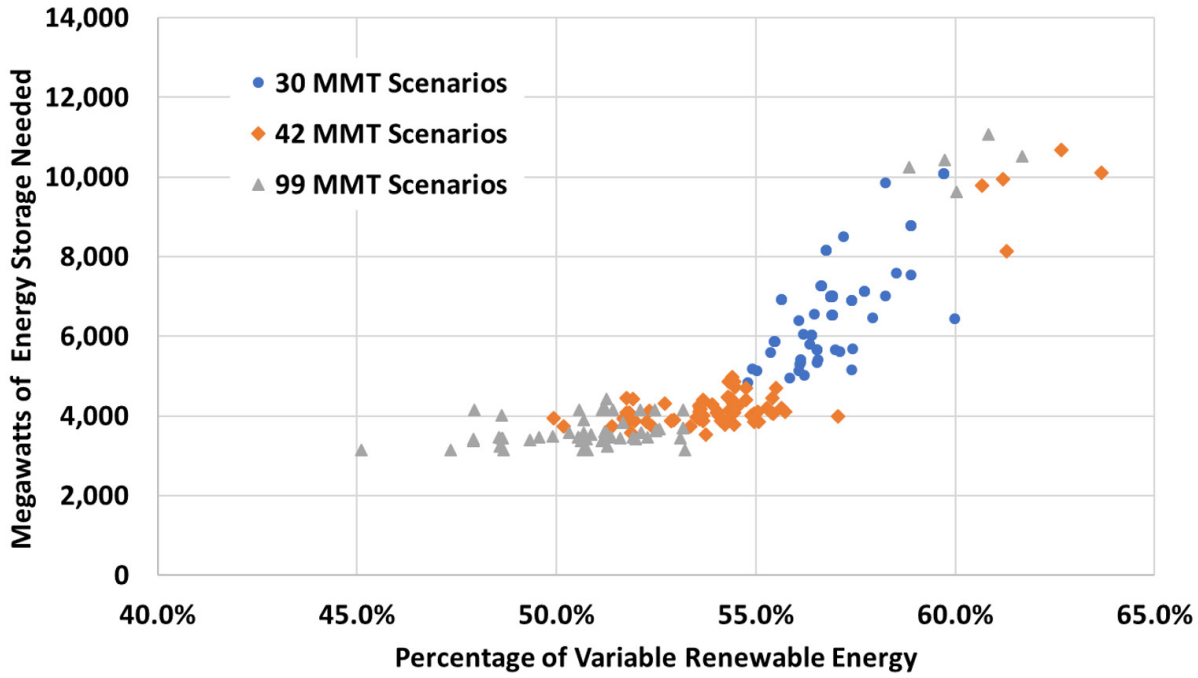

Figure 1. Electrical energy storage needs under different scenarios based on the percentage of variable renewable energy in California's grid capacity

Key Research Findings

California's energy storage capacity requirements are heavily influenced by electricity sector GHG emission caps and the RPS. The scenario analysis shows that a high RPS target and limits on the grid's GHG emissions drive up energy storage needs far more than the number of electric vehicles on the road. Storage needs increase significantly once variable renewable energy (solar and wind) make up more than 55% of the grid's capacity (Figure 1). Other factors influencing energy storage capacity requirements include demand response and electric vehicle charging flexibility.

The California grid's renewable power mix has a relatively small impact on energy storage requirements under these scenarios. The scenarios considered different mixes of renewable energy resources, including a grid dominated by solar energy, one dominated by wind energy, and balanced mixes of the two sources. The analysis showed that energy storage requirements are more heavily influenced by electricity sector GHG caps than the mix of solar and wind. The renewable energy mix only had a meaningful impact in scenarios with a 30 MMT emissions cap, with higher solar-to-wind ratios requiring more energy storage.

The 80% RPS scenarios require three-to-five times higher energy storage capacities than the average values reported in peer reviewed literature. Anticipated energy storage needs for the 50% RPS scenarios are within the range of prior research. The high energy storage requirement of the 80% RPS scenarios is primarily driven by the GHG caps imposed on the scenarios. Multiple grid management techniques, including advanced demand response and electrical energy storage, will be required to achieve the renewable energy and GHG targets simultaneously.

Converting excess renewable electricity into hydrogen (the "power-to-gas" pathway) can help mitigate electricity curtailment losses while reducing battery storage needs. Besides being a long-term energy storage option, hydrogen has the added benefit of serving as a zero-emission transportation fuel. Estimates suggest California could produce 12,000 gigawatt-hours of excess electricity by 2030, enough to produce 243 million kilograms of hydrogen. The most viable storage approaches must be identified to realize the potential benefits of hydrogen storage. Incorporating both conventional and hydrogen energy storage systems as part of future generating plants can help reduce curtailment and increase the flexibility and resiliency of the electric grid.

More Information

This policy brief is drawn from "Grid Energy Storage Assessment for Select Fleet Electrification Scenarios," a report from the National Center for Sustainable Transportation, authored by Arun S.K. Raju and Alexander Vu of the University of California, Riverside. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/electric-fleet-adoption-strategies-addressing-storage-and-infrastructure-needs.

For more information about the findings presented in this brief, please contact Arun S.K. Raju at arun@engr.ucr.edu.

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