Through the Valley of Death: Taking Emerging Seasonal Energy Storage Technologies from Research and Development through Deployment

Select Committee on California's Clean Energy Economy
Assemblymember Bill Quirk, Chair

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California State Capitol, Room 4202

BACKGROUND

Overview

In 2018, California set an ambitious goal of decarbonizing the electric grid by 2045. As the grid becomes increasingly reliant on renewable energy sources, seasonal variation in solar and wind power generation will need to be addressed in order to have a reliable energy supply. Renewable energy in California is likely to be overgenerated in the spring and early summer months and is not likely to meet demand in the winter months. Seasonal energy storage could ensure grid reliability by storing energy for days, weeks, or even months for later use. However, many seasonal energy storage technologies are currently in the research and development stage and have yet to make it through the challenging phase of commercialization, colloquially known as the "valley of death." Scaling up and deploying these emerging technologies can require years to decades, so ensuring that cost-effective seasonal storage will be available in time to meet the 2045 goals set by SB 100 represents both technical and policy challenges.

The goals for this informational hearing are to:

1) Hear an overview of the needs of a zero-carbon grid, the role of seasonal energy storage, and the emerging technologies for seasonal energy storage;

2) Discuss the challenges of commercializing seasonal energy storage technologies; and,

3) Discuss the existing state and federal efforts to develop and deploy seasonal energy storage technologies.

Seasonal Energy Storage (SES): A Necessity for the Zero-Carbon Grid

With SB 100 (De León, Chapter 312, Statutes of 2018), California adopted the goal of meeting all of the state's retail electricity supply needs with renewable and zero-carbon sources by the end of 2045. Achieving this goal while maintaining energy affordability and reliability will be both a technical and a policy challenge. However, California has already come a long way, shifting the energy power mix from 11% renewables in 2002 to 36% renewables in 2019.

A major challenge in achieving a zero-carbon grid lies in matching renewable energy supply with energy demand. Solar and wind energy sources are weather dependent, so power generation can vary and exhibit daily and seasonal patterns that do not coincide with energy demand. When renewable energy production exceeds demand, production is scaled back or "curtailed" to match demand unless it can be stored for later use. This overgeneration frequently occurs in the spring when energy demand is low but weather patterns drive a high supply of energy from hydropower, solar, and wind resources. When energy demand exceeds renewable energy production (e.g. during peak demand later in the summer), California currently relies largely on natural gas plants to meet that demand.

Seasonal energy storage (SES) could play a key role in the zero-carbon grid by storing energy for days, weeks, or months to make energy available when demand exceeds production. This storage can be used to take advantage of times where renewable energy generation exceeds demand and can be used to compensate for seasonal variability or longer-term supply disruption.

The field of SES is rapidly diversifying with new technologies and production capacity is increasing. These technologies can be broadly categorized to include mechanical (e.g. compressed air); electrochemical (e.g. flow batteries); chemical (e.g. hydrogen); and thermal (e.g. molten salts) technologies.

There is exciting potential for new seasonal, grid-scale storage technology adoption including systems such as hydrogen, innovative batteries, and compressed air. For example, hydrogen could be generated using electrolysis during times when renewable energy is available and stored for use as a fuel or for re-electrification through fuel cells during the winter. However, a study by the National Renewable Energy Laboratory, forecast that hydrogen would be a cost-effective method for storage of up to two weeks by the 2050-2070 time frame. Many of these technologies are still in the research and development (R&D) stage, so significant resources will be required to ensure that cost-effective seasonal energy storage solutions are available in time to meet the 2045 goal of a zero-carbon grid.

Commercializing SES Emerging Technologies

The U.S. is a world leader in scientific research, but technologies must transition from the R&D stage through to deployment in order to build sufficient energy storage capacity for a reliable, zero-carbon grid. In order to be scaled up and deployed, technologies undergo commercialization to turn prototypes into fully realized, commercially available products. Commercialization requires significant investments and long timelines, but government grants often only apply to R&D and the risk of developing novel technologies can deter private investors. This phase is called the "valley of death" because many promising technologies do not receive enough investment to bridge the gap between R&D and deployment.

The challenges of technology commercialization are particularly pronounced for SES technologies because they rely on complex hardware and can be expensive to develop and implement. In addition, markets do not value energy storage in the same way as energy

production, despite the many benefits that energy storage can provide to the grid. These factors can disincentivize private investment in energy storage technologies.

The State and Federal Government's Role in Scaling up SES Technologies in Time for 2045

State and federal governments can aid in the commercialization of technologies by providing funding opportunities to energy storage demonstration and development projects and by enacting policies that create a viable market for energy storage. Many of these initiatives include energy storage projects that provide short-duration storage that is best suited for addressing daily variation in energy supply as well as long-duration or seasonal energy storage projects.

At the state level, the California Energy Commission (CEC) has funded over 30 energy storage demonstration projects since 2010. These projects vary widely in location, technology employed, and size. By funding these demonstration projects, CEC is working to provide data in field conditions that can help reduce costs and inform which technologies are suitable for specific storage applications. In addition, CEC's Electric Program Investment Charge (EPIC) Program has funded research to assess different scenarios for the deployment of long-duration storage to meet the state's mandates to decarbonize the electricity sector by 2045.

The state has also taken legislative action to advance the deployment of energy storage, including the passage of AB 2514 (Skinner, Chapter 469, Statutes of 2010). This bill resulted in the California Public Utilities Commission decision for energy storage procurement targets for each of the investor-owned utilities totaling 1,325 MW to be completed by the end of 2020 and implemented by 2024.

Funding and research from the U.S. Department of Energy (DOE) also contributes to the development and deployment of energy storage technologies. National Laboratories including Sandia National Laboratory have been instrumental in creating energy storage technology through programs that focused on developing battery technology in addition to renewable energy technology. In July 2021, DOE announced the Long Duration Storage Energy Earthshot, which established a target to reduce the cost of grid-scale energy storage by 90% for systems that deliver ten or more hours of duration within the decade. DOE's Advanced Research Projects Agency-Energy (ARPA-E) program funds energy storage R&D that is too risky for private investment through the Duration Addition to Electricity Storage (DAYS) program. Further, the Seeding Critical Advances for Leading Energy technologies with Untapped Potential (SCALEUP) program supports the scaling of high-risk and potentially disruptive new technologies across a range of energy applications. While efforts are currently underway to fund energy storage R&D, more investment will be needed to bring down the cost, increase the capabilities of storage technology, and scale up emerging energy storage technologies. Funding for both R&D and scaling up technology can help to ensure that California is prepared to have a reliable, zero-carbon grid.