APPENDIX A
CASE STUDIES

REO UPDATE TECHNICAL STUDY: CASE STUDIES

1. Utility-Scale Solar

1.1. Antelope Valley Solar

Project Overview

Antelope Valley Solar was one of the largest solar photovoltaic (PV) projects in the world at the time it was built, with approximately 3.8 million solar panels, generating enough electricity to power the equivalent of 75,000 homes per year. It reached full commercial operations in April 2014.

Location: Antelope Valley, in unincorporated Los Angeles County

Capacity: 242 MW

Size/Acreage: 2,100 acres

Project Life: Power purchase agreement for 25 years

Status: Operational

Annual CO2 Offset: 282,890 metric tons

Successes

- Generates electricity with no water use, no air emissions, and no waste production
- Features innovative inverters with voltage regulation and monitoring technologies, which provide more stable and continuous power, increasing the project's efficiency and reliability
- The solar panels are planned to be recycled after their lifespan

Challenges

- Fugitive dust complaints during construction; construction was halted due to air standards issue
- Local concerns about permanent disturbance to poppy fields within the project site, and potential exposure to Valley fever from fugitive dust during construction

Lessons Learned

- The project incorporated the following mitigation measures to address fugitive dust effects from ground-disturbing activities:
  - Daily watering of excavated or graded sites and soil stockpiles
  - Halted clearing, grading, and earth moving activities during high wind events (exceeding 20 mph)
  - Access routes designed to minimize travel on unimproved roadways
  - National Institute of Occupational Safety and Health (NIOSH)-approved masks provided to construction workers

References: Change 2019; CEC 2025a; Constellation Energy 2025; DOE 2017; GTM 2013; Kern County 2011; Michael Baker 2025; Power Technology 2025

Photo from Constellation Energy of Antelope Valley Solar Project

1.2. Beacon Solar

Project Overview

The Beacon Solar facility consists of over 900,000 PV solar panels, an operation and maintenance (O&M) building, as well as transmission lines to connect the solar facility with the nearby Barren Ridge Substation. It has been operational since 2017.

Location: Northwestern Mojave, near California City in eastern Kern County

Capacity: 250 MW

Size/Acreage: 2,500 acres

Project Life: 25-year power purchase agreement

Status: Operational

Annual CO2 Offset: 304,000 metric tons

Successes

- Produces enough clean energy to power over 14,000 households

Challenges

- Significant and unavoidable impacts to aesthetics, including substantial adverse effects on scenic vistas due to visibility from nearby recreational hiking trails
- Valley fever concerns from fugitive dust during construction
- Due to other proposed solar projects in the area at the time of the environmental analysis, cumulative air quality impacts during construction were determined to be significant and unavoidable
- Loss of habitat for LeConte's thrasher and loggerhead shrike, which are California Species of Special Concern

Lessons Learned

- Project was originally proposed as solar thermal technology; however, the project was configured and rescoped to solar PV because the applicant determined it was more efficient and cost effective than the solar thermal technology.
- Mitigation included measure to provide personal protective respiratory equipment to construction workers and to provide information to all construction personnel and visitors about Valley Fever to minimize their exposure.

References: CEC 2025a; Kern County 2012; LADWP 2025; USEPA 2025

Photo from Hecate Energy of Beacon Solar Project

1.3. Gemini Solar

Project Overview

Gemini Solar is a solar facility co-located with a 380-MW 4-hour battery energy storage project. Gemini is the largest co-located solar plus battery energy storage project operating in the United States. It became fully operational in 2024.

Location: Bureau of Land Management land, approximately 25 miles northeast of Las Vegas, NV

Capacity: 690 MW

Size/Acreage: Project site boundary is 7,100 acres; project infrastructure occupies less than 5,000 acres

Project Life: approximately 30 years; 25-year power purchase agreement

Status: Operational

Annual CO2 Offset: 384,000 million tons

Successes

- Generates enough reliable clean energy to power approximately 10 percent of Nevada's peak power demand
- Tribal members participated in project construction by working as equipment operators, biological monitors, cultural monitors

- Includes 380 MW of four-hour battery energy storage that will provide 1,400 MWh of electricity during night-time hours

Challenges

- Aesthetic concerns to recreationists within Valley of Fire State Park, along Bitter Springs Back Country Byway, along Old Spanish Trail Road, or anywhere within the Old Spanish National Historic Trail corridor and Arrowhead Trail
- Biological impacts to desert tortoise and rare plants

Lessons Learned

- Utilized several specific conservation techniques that represent significant new standards for solar construction in desert environments, including mitigating fugitive dust and stormwater pollution and constructing tortoise exclusion fences
- Utilized "drive and crush" method for site preparation, which preserves soil and plant root at the site. This method preserves more habitat than the "blade and grade" method, which removes all vegetation and topsoil
- Utilized the latest research and design considerations to minimize the footprint of Gemini, and ensure that local flora and fauna will continue to thrive on site with minimal impact from the solar panel installations; this approach reduced Gemini's project footprint by over 20% and reduced the need for access roads by 25% compared to traditional projects

References: BLM 2019; NS Energy 2020; Primergy 2024; USGS 2023

Figure from Primergy of Gemini Solar Project

2. Utility-Scale Wind

2.1. Alta Wind Energy Center

Project Overview

Alta Wind Energy Center consists of multiple wind projects (in 11 phases) in addition to newly approved energy storage (150 MW). The first phase was commissioned in 2011.

Location: Near Mojave (southeast Kern County)

Capacity: 1,550 MW

Size/Acreage: 3,200 acres

Project Life: 25-year power purchase agreement

Status: Operational

Annual CO2 Offset: More than 5.2 million metric tons over the next 25 years

Successes

- Largest terrestrial wind farm in the United States
- The Bureau of Land Management (BLM) approved the 150 MW Alta Wind BESS in February 2024, designed to store up to 1,200 megawatt hours produced by the existing Alta Wind Energy Center
- Project is in area zoned as "exclusive agriculture, wind energy combining;" County zoned the area to attract development of RE (both solar and wind)

Challenges

- Significant biological concerns, including impacts to special-status plants and special-status wildlife species, and cumulative threat to California condors
- Substantial noise and vibration impacts during construction would be experienced by rural residents nearest to the project
- Emissions from construction vehicles and fugitive dust would exceed thresholds established by the Eastern Kern Air Pollution Control District

Lessons Learned

- There are greater impacts and siting issues with longer gen-tie lines
- The number of wind turbine generators required may be modified to avoid a site-specific impact

References: BLM 2024; Kern County 2013 and 2025; Overview 2025; Power Technology 2014

Photo from Alta Windpower Development

2.2. Ocotillo Wind

Project Overview

Ocotillo Wind uses 112 American-made Siemens Gamesa 2.3 MW wind turbines to provide electricity to power the needs of about 300,000 Californians yearly. The facility's output is sold to San Diego Gas & Electric through a 20-year power purchase agreement. It has been in operation since 2012.

Location: Near the towns of Ocotillo and No Mirage on public land (BLM) and a small portion under the jurisdiction of Imperial County

Capacity: 265 MW

Size/Acreage: 10,151 acres

Project Life: 30 years

Status: Operational

Annual CO2 Offset: 360,000 metric tons

Successes

- Completed construction in less than 1 year
- Land set aside for cultural resources (2,285 acres) as a result of extensive tribal consultation on the federal side during the NEPA environmental review process
- Partners with the Imperial Valley Community Foundation (IVCF) to contribute millions of dollars to support community, cultural, environmental, and youth causes

Challenges

- Technical issues (broken turbine blades; tower collapse) temporarily halted project multiple times
- Residents were concerned about potential health effects of low-frequency sound and electric and magnetic fields
- Several Native American tribes opposed the project due to its location in an important cultural area; hundreds of cultural resource sites were recorded during the surveys
- Environmental groups were concerned about the project's effect on natural resources, including effects on sensitive species and the natural desert landscapes
- Visual impacts were a concern due to the project's visibility from nearby communities, Anza-Borrego Desert State Park, Wilderness Areas, and Interstate 8

Lessons Learned

- Early stakeholder engagement can improve the project, reduce environmental impacts, and avoid conflicts with resources
- Stakeholder input from interested Native American Tribes resulted in a modified layout of the turbines to avoid impacts to cultural resources
- Some wind turbine technologies are compatible with OHV use
- Technical difficulties during operations can result in halting the project; it is critical for the applicant and agencies to work together to provide oversight and to keep stakeholders informed in order to get the project back online

References: Sawyer 2021; Pattern Energy 2025

Figure from Pattern Energy Group

2.3. Mesa Wind Repower

Project Overview

The repowering of Mesa Wind includes removal of approximately 460 legacy turbines and installation of 8 new wind turbine generators. The legacy turbine foundations will remain in place until the site is decommissioned.

Location: 11 miles northwest of Palm Springs, CA

Capacity: 27 MW

Size/Acreage: 20 acres

Project Life: 30 years

Status: Operational; minor construction ongoing (e.g., for roads)

Annual CO2 Offset: 2,800 metric tons

Successes

- The repower did not change the interconnection nor require a repowered interconnection line

Challenges

- Increased collision risk to birds and bats
- Public concerns that criteria pollutant emissions were underestimated
- Public concerns of increased exposure to Valley Fever from fugitive dust during construction
- Public concerns of fire risk and that mitigation measures may not be adequate
- Public concerns that the Project could be visible from the Pacific Crest Trail, obstructing natural views

Lessons Learned

- Repowering Mesa Wind site minimizes ground disturbance; 30% of the temporary disturbance areas (e.g., access roads and work areas) were located in areas already disturbed by the existing wind project
- The O&M building remains in the same location and all substation work for the repower was completed within the existing substation fence
- Good example of how evolving technologies can help meet energy needs while allowing for more efficient use of public lands

References: Brookfield Renewable 2025; CEC 2025a; Riverside County 2021a and 2021b; USEPA 2025;

Figure from Brookfield Renewable

3. Distributed Generation Solar

3.1. Palmdale Water District

Project Overview

The Palmdale Water District's (PWD) new solar plan for their water treatment plant would include decommissioning of the almost 20-year-old wind turbine and installation of two new solar projects and a BESS. The project would assist with rising energy costs.

Location: Solar projects would be located at PWD Headquarters (2029 East Avenue Q, Palmdale) and at a 6-million-gallon tank site (641 East Avenue S, Palmdale)

Capacity: Each solar project will be capable of producing between 2 and 5 MW

Size/Acreage: 34 acres (both sites combined)

Project Life: 25 years

Status: Approved; not yet built

Successes

- Will potentially save up to $16.5 million in energy costs for PWD in the next 25 years
- Combined solar project with BESS
- Replacing an existing wind turbine with newer/more efficient technology

Challenges

- Dust control
- Biological concerns (e.g., habitat for San Joaquin Pocket mouse, Mohave ground squirrel, Crotch bumble bee, Monarch butterfly, Joshua tree, and burrowing owl)

Lessons Learned

- Distributed solar can help mitigate rising energy costs, which are increasingly a burden on PWD's revenue

References: Gatlin 2022; PWD 2022a and 2022b

3.2. Point Reyes Farmstead Cheese Co

Project Overview

Point Reyes Farmstead Cheese Company, a dairy farm and creamery, had SunPower dealer, Sunlight Electric, install solar on the roofs of the company's Petaluma creamery and packaging building and cold storage warehouse. It has been operational since 2021.

Location: Petaluma, CA

Capacity: 217 kW

Size/Acreage: 11,000 ft^2

Project Life: 25-year warranty on solar panels, with a projected project life of 40 years

Status: Operational

Annual CO2 Offset: 550,000 pounds

Successes

- System is projected to pay for itself in six years
- Complements other sustainable initiatives at their farm (e.g., methane-powered renewable energy, composting, water reuse and recycling system)
- Enables Point Reyes to reduce electricity costs by approximately 56%

Challenges

- During the Covid-19 pandemic, when production capacity dipped to 50%, electricity bills topped $100,000 annually for the facility; solar panels were a good solution to this problem, but had a large upfront cost

Lessons Learned

- Expansion of the cheese production is electricity-intensive. Solar has been a good solution for their needs while expanding operations.

References: Point Reyes Farmstead 2021 and 2022; SunPower 2013

Figure from Point Reyes Farmstead Cheese Company

4. Distributed Generation Wind

4.1. Palmdale Water District

Project Overview

The PWD 237-foot-tall wind turbine produced energy for the water treatment plant for almost 20 years, reducing the energy costs for PWD.

Location: Leslie O. Carter Treatment Plant in Palmdale, CA

Capacity: 950 kW

Project Life: 20 years

Status: Decommissioned

Successes

- The installation of this renewable energy source paid for itself in cost savings less than halfway through its life

Challenges

- Finding parts and qualified technicians for repairs was difficult
- Needed maintenance at 12.5 years to upgrade turbine mechanics

Lessons Learned

- The wind turbine, installed in 2004, saved the District 30-50% on power costs when the treatment plant was running. During some years, the turbine saved PWD up to $100,000
- PWD is replacing the wind turbine with distributed solar; the retirement is timely because finding parts and qualified technicians for repairs have been very difficult
- The wind turbine afforded the community (i.e., the PWD rate payers) a cost savings tool, while also promoting innovation in renewable energy production and clean air

References: Gatlin 2022; PWD 2016 and 2022a

Figure from Palmdale Water District of their 237-foot tall wind turbine

4.2. Bogle Vineyards

Project Overview

Bogle Vineyards was proposed as a single wind turbine to be used to power the Bogle wine production facility.

Location: 4.5 miles southwest of the town of Clarksburg in Yolo County, CA

Capacity: 1.6 MW

Size/Acreage: Southwest corner of a 60-acre property

Status: Yolo County approved the wind turbine, but it was never constructed; applicant installed a solar PV system

Annual CO2 Offset: 450,000 tons (solar PV)

Successes

- The winery pivoted to a solar project, reducing their carbon output by more than 450,000 tons per year

Challenges

- Yolo Audubon Society filed a lawsuit together with Tuleyome, a nonprofit conservation organization, and a group of local landowners against Yolo County and the Board of Supervisors challenging the county's approval of a wind turbine development on Bogle Vineyards. The County had determined that no environmental impact report was needed and used a Mitigated Negative Declaration for the project's CEQA clearance

- The public raised concerns about impacts to birds, noise, and potential conflicts with low-flying aircraft (i.e., crop duster planes)

Lessons Learned

- Initially an MND was prepared for the project, but after public protest, Yolo County prepared an EIR for the project's CEQA clearance
- Distributed wind generation requires less acres than distributed solar generation for the same output; acreage requirements have implications when evaluating impacts on agricultural lands (e.g., farmland conversion, loss of high quality soils, conflicts with land preservation contracts)

References: Bogle 2019; Dowling 2018; Ternus-Bellamy 2014; Yolo Bird Alliance 2024; Yolo County 2017

Visual simulation of wind turbine from Bogle Wind Turbine Project EIR

5. Community Choice Aggregation

5.1. Sonoma Clean Power

Project Overview

Sonoma Clean Power (SCP) became California's second Community Choice Aggregator (CCA) in 2014, and today generates power for 87% of all homes and businesses in Sonoma and Mendocino counties. SCP is the default power generation provider in the area; if customers opens a new PG&E account in Sonoma County or Mendocino County, they will automatically receive electric generation service from SCP unless they choose to opt out. SCP and PG&E work together to provide electricity to customers.

Successes

- 2024 marked 10 years of delivering clean, affordable, and locally sourced energy to its communities
- Generates energy for 87% of all homes and businesses in Sonoma and Mendocino counties
- Passed more than $100 million in direct savings to its more than 500,000 customers
- Since 2014, SCP's power purchase agreements have directly supported new development of more than 195 MW of renewable energy and storage facilities in California, including 6 MW of solar projects in Sonoma and Mendocino counties

Challenges

- Public perception was a minor implementation challenge in the first year of the program, particularly among the business community, citing concerns about power reliability. Though only five percent of total customers opted out of SCP in 2014, 80 percent of the program's opt-outs were from business customers

Lessons Learned

- SCP ensures that there is enough energy on the grid to meet customer needs, and PG&E maintains the poles and transmission lines that bring the electricity to customers' homes and businesses
- Public outreach may be helpful to educate potential customers of the benefits and to change negative public perceptions
- Over the past 10 years, SCP saved its customers millions of dollars through lower rates and avoided fees. The majority of these customers are PG&E rate payers

References: Cal CCA 2025a; Moore 2014

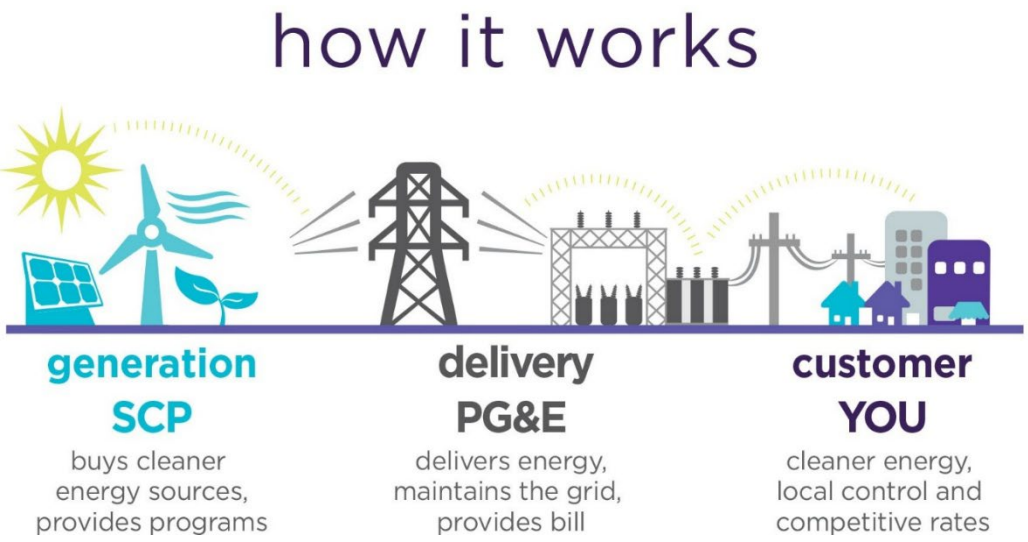

Figure from Sonoma Clean Power showing flow and delivery of electricity

5.2. Clean Power Alliance

Project Overview

Clean Power Alliance (CPA) is a non-profit community choice aggregation available in Los Angeles and Ventura Counties since 2018.

Successes

- Available in unincorporated Los Angeles County and the cities of: Agoura Hills, Alhambra, Arcadia, Beverly Hills, Calabasas, Carson, Claremont, Culver City, Downey, Hawaiian Gardens, Hawthorne, Hermosa Beach, Malibu, Manhattan Beach, Monrovia, Paramount, Redondo Beach, Rolling Hills Estates, Santa Monica, Sierra Madre, South Pasadena, Temple City, West Hollywood, Westlake Village, and Whittier
- Available in unincorporated Ventura County and the cities of: Camarillo, Moorpark, Ojai, Oxnard, Santa Paula, Simi Valley, Thousand Oaks, and Ventura
- CPA has more customers on 100% green energy rates than any other electricity provider in the nation
- Offers options of three tiers: 40% clean energy, 50% clean energy, and 100% clean energy

Challenges

- Only available in SCE service areas; cannot use in the LADWP service area

Lessons Learned

- Revenues are reinvested back into the community, creating jobs and establishing programs like the Power Response Program, Power Ready Program, Community Solar, Community Benefits Grants, and public EV Charging incentives
- Uses existing transmission and distribution electric infrastructure to deliver power to customers thereby avoiding the need for siting of new infrastructure

References: Cal CCA 2025b; CPA 2025

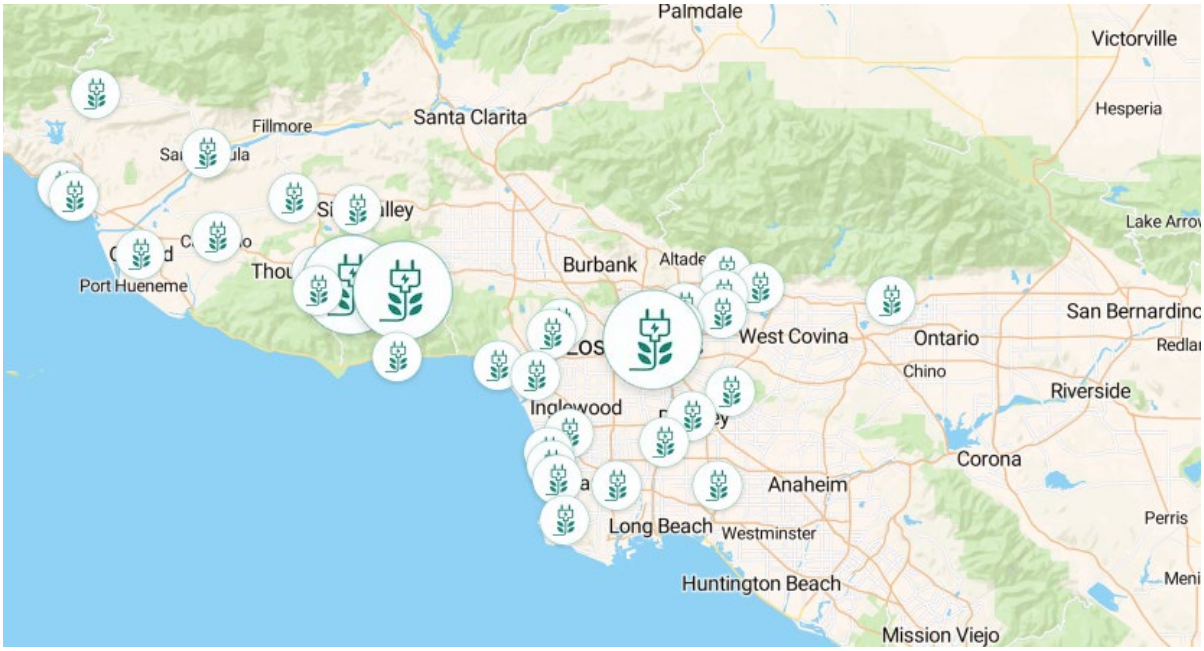

Figure from Clean Power Alliance showing CPA service areas

6. Energy Storage Systems

6.1. Moss Landing Energy Storage Facility

Project Overview

Moss Landing BESS facility is currently the world's largest lithium-ion BESS. It has been operational since 2020. It is located at the Moss Landing Power Plant on the California coast in Moss Landing.

Location: Monterey County, CA

Capacity: 750 MW

Project Life: Phase III under 15-year term

Status: Operational

Successes

- Siting at an existing power plant allowed the BESS facility to connect to an existing power plant grid, and provided sufficient land space to site a battery storage system
- Currently, the largest BESS by megawatt-hours output

Challenges

- Poor public perception on BESS systems due to four thermal runaway[1] incidents, resulting in fires
- High levels of heavy metals were found at nearby estuary after the most recent BESS-induced 2025 fire, with potential effects on habitats of several endangered and threatened species such as the southern sea otter, the Santa Cruz long-toed salamander and the California brown pelican

Lessons Learned

- The batteries are housed within the turbine hall of the existing/decommissioned Moss Landing Power Plant, which are not designed to contain thermal runaway. This repurposing (adaptive reuse) of an existing building for a BESS facility has not occurred at any other BESS site
- Purpose-built buildings with fire barriers would be more successful, such as in the case of Gateway project fire in San Diego (see 6.2, below)
- Phase 1 system which burned in the fire was powered with nickel manganese cobalt (NMC) batteries, which are known to be more reactive than the lithium iron phosphate (LFP) batteries used in the majority of BESS installed today
- On January 23, 2025, the State of California Legislature proposed AB 303: Battery Energy Safety & Accountability Act due to multiple BESS fire incidents, including at the Moss Landing facility. This legislation, if adopted, will affect all future BESS siting in the State

References: Addis 2025; Colthorpe 2023 and 2025; CPUC 2025; Harter 2025; Marks 2025

[1] Thermal runaway is one of the primary risks related to lithium-ion batteries. It is a phenomenon in which the lithium-ion cell enters an uncontrollable, self-heating state. Thermal runaway can result in: ejection of gas, shrapnel and/or particulates (violent cell venting), extremely high temperatures, smoke, fire. https://ul.org/research-updates/what-is-thermal-runaway/

Figure from LG Energy Solution

6.2. Gateway Energy Storage

Project Overview

Gateway Energy is a lithium-ion battery storage system in San Diego County, operating next to the Pio Pico and Otay Mesa natural gas-fired power stations.

Location: Otay Mesa, CA

Capacity: 250 MW

Size/Acreage: 4 acres

Project Life: 15-year power purchase agreement with SCE

Status: Operational

Successes

- Enhances grid reliability and reduces customer energy costs

Challenges

- 2024 fire at facility lasted over a week. Resultant toxic gas from the fire made access to the site an issue for firefighters. After the fire was contained, the fire re-ignited multiple times. The building and roof suffered major damage
- 2024 fire required evacuations of nearby areas, including local businesses
- Contributed to poor public perception due to fire risk and safety issues

Lessons Learned

- CEC staff visited the site to inspect the building after the May 2024 fire because CEC has jurisdiction over all thermal power generation facilities over 50 MWs (i.e., Pio Pico and Otay Mesa Power Plants sites where the BESS facilities are located). CEC concluded that the BESS "failed safely." Equipment worked as planned, the fire department was sufficiently trained in emergency response, and there were no injuries to onsite staff, the firefighters, or the public.
- The 2024 fire incident illustrates the challenges of putting out a fire from a grid-scale BESS that is housed inside a dedicated and enclosed building.

References: CAISO 2020; CEC 2025b; JRMA 2025; Sanderson 2024

Figure from JRMA showing the Gateway Energy Storage facility

6.3. East Road Storage Project

Project Overview

Form Energy will build a 5-MW multi-day iron-air energy storage system at the site of a Pacific Gas and Electric Company (PG&E) electric substation. This will be the first multi-day energy storage project in the state.

Location: Redwood Valley, Mendocino County, CA

Capacity: 5 MW of 100-hour, iron-air, energy storage

Size/Acreage: Approximately 5 acres

Project Life: Approximately 5 years

Status: Project is permitted and expected to be operational fourth quarter of 2025

Successes

- This multi-day storage project would have a large storage capacity, allowing it to charge and discharge electricity for extended periods of time
- Less expensive to discharge iron-air batteries than lithium-ion batteries

Challenges

- Many utilities are hesitant to switch from lithium-ion systems that are energy efficient but only discharge for a few hours to multiday batteries
- Compared with fossil fuels, long-duration batteries are still relatively expensive
- Iron-air battery technology has to compete with lithium-ion, which has become the default technology for storing renewable energy because companies are mass-producing them for the electric vehicle market

Lessons Learned

- Lithium-ion technology is not suitable for all energy storage applications; more long-duration energy storage is needed, allowing other technologies to enter the market
- Iron-air batteries are not currently efficient; return is about 40% of the energy used to charge it, which is an improvement over earlier iron-air battery technologies

References: C&EN 2025; CEC 2023; Form Energy 2023

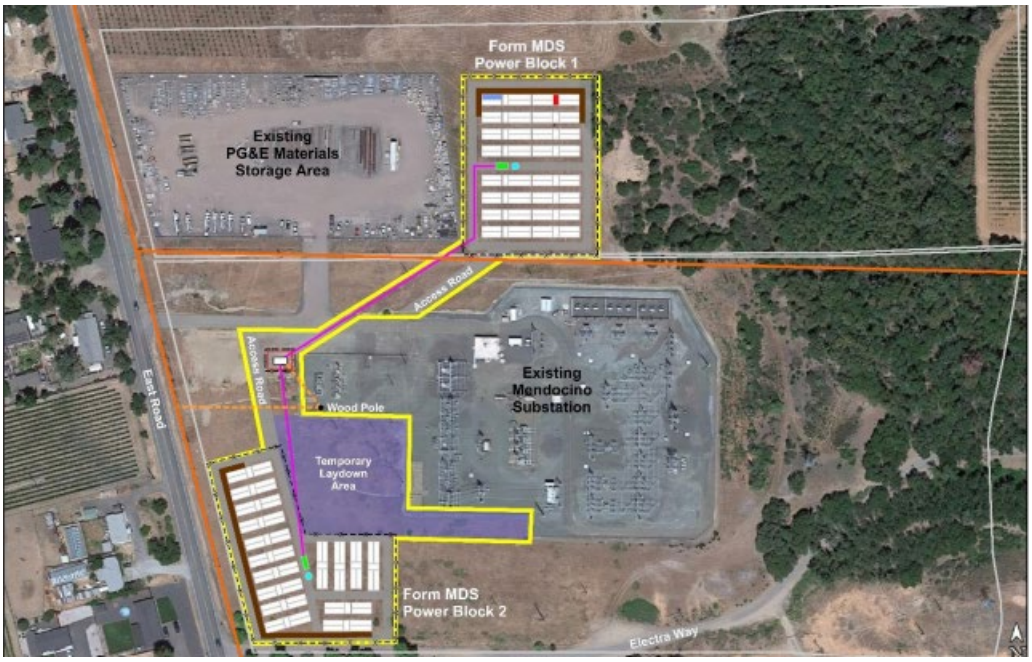

Figure from California Energy Commission showing the project location

6.4. Beacon Liquified Air Energy Storage

Project Overview

The Beacon liquified air energy storage (LAES) project was a proposed pilot project that would allow LADWP to evaluate the compatibility of this long duration energy storage technology with the electricity grid. The pilot project was proposed to provide up to 50 MW of storage with a discharge of up to 10 hours. An LAES system converts electrical energy to a cryogenic fluid storage medium, which is stored in low-pressure thermally insulated tanks, and converted back to electrical energy through a thermodynamic power cycle.

Location: North of California City in Kern County, CA

Capacity: 50 MW

Size/Acreage: Approximately 4.5 acres

Project Life: Approximately 30 years

Status: Withdrawn

Successes

- The LAES project would have been located on a disturbed site owned by LADWP that is adjacent to the Beacon Collector Substation
- The LAES project would have connected directly to an existing 230-kV transmission line that also connects to the Beacon Collector Substation
- Electricity generated by the nearby Beason Solar Power Project would have been stored on-site via the LAES system, allowing for deployment into the grid by LADWP as needed

Challenges

- Technology is too expensive to be feasible and has only been deployed outside of the U.S.
- LAES large-scale units pose a major visual intrusion on the high desert landscape
- LAES unit heights may create issues with the FAA and the military due to flight paths
- An LAES system has a large electricity loss of 40-50%
- Requires very large storage tanks, typically 100 feet in height

Lessons Learned

- If a new LAES project is sited as a minor accessory structure at an existing electrical facility (e.g., substation), the project could be categorically exempt from CEQA

References: LADWP 2021; Vecchi et al. 2021

Figure from European Association for Storage of Energy of a LAES plant

7. Green Hydrogen

7.1. Plug Green Hydrogen Production in Georgia

Project Overview

Plug Power began operations at the largest electrolytic liquid hydrogen production facility in the U.S. in 2024. The site contains eight 5-MW electrolyzers[2] that create clean hydrogen fuel by separating water into hydrogen and oxygen. Liquid hydrogen fuel is used for several applications that include fuel cell electric vehicle fleets, material handling operations, and stationary power applications.

Location: Woodbine, GA

Capacity: 15 metric tons of liquefied hydrogen daily

Size/Acreage: 20 acres

Status: Operational

Successes

- The facility features the largest operating proton exchange membrane (PEM) electrolyzer deployment in the U.S.

Challenges

- Hydrogen fuel introduces a fire and explosion risk
- The Plug facility's water usage exceeded the developer's original predicted water use, leading to the need for withdrawal of groundwater. These additional water requirements are currently under permit review by Georgia Department of Natural Resources

Lessons Learned

- High water use has caused public concerns; Plug is trying to reduce the water consumption at production facilities to lessen dependency on resources, which would decrease operational cost and mitigate potential reputational concerns with water usage
- Plug plans to invest in more water treatment plants near current and future production facilities to address the risk of water scarcity by using recycled water
- The current energy market is still heavily influenced by demand for fossil fuels, leading to little incentives for green hydrogen

References: Daldrup et al. 2024; Darby 2021; Leimbach 2024; Plug 2024; S&B 2024; Wolfe 2024

[2] An electrolyzer is a device that uses electricity to split water or other components into their constituent elements through electrolysis. In the case of water electrolysis, an electrolyzer uses an electric current to split water molecules into hydrogen and oxygen gases. The hydrogen gas can be stored as either compressed gas or liquefied. The oxygen created is released back into the air or captured and stored to supply to other industrial processes (https://www.accelerazero.com/news/what-is-an-electrolyzer-and-what-is-it-used-for)

Figure from S&B

7.2. Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES)

Project Overview

The Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) is a statewide (California) public-private partnership dedicated to advancing the hydrogen economy. In 2024, the Department of Energy provided 1.2 billion in federal funding, which will be used towards projects such as decarbonizing ports, adding fuel-cell electric trucks and busses, and developing infrastructure for hydrogen transport and use.

Location: Projects to be located throughout California, including locations at the Ports of Los Angeles, Long Beach, and Oakland; major power plants in Northern and Southern California; Lancaster, CA; and on the reservation of the Rincon Band of Luiseño Indians in Valley Center, CA

Status: Under development

Annual CO2 Offset: Goal of 2 million metric tons total

Successes

- ARCHES received 1.2 billion in federal funding towards the development of a hydrogen hub
- ARCHES will require that at least 40% of the benefits from its projects flow to California's disadvantaged communities
- ARCHES promises to include organized labor, cities and local governments, tribal nations, communities and environmental justice organizations in its governance and decision-making

Challenges

- There are public concerns as follows:
  - Participants of the ARCHES network are subject to non-disclosure rules
  - Lack of public information on what projects are being funded
  - Lack of general updates and communication with the public
- Funding is subject to change under new federal administration laws and funding freeze starting in 2025

Lessons Learned

- Explosion in electrolysis system in a commercial facility occurred due to sludge deposits in the electrolyte passages. Investigation found that the explosion could be prevented by a continuous gas analyzer test of oxygen and hydrogen product purity. This incident illustrated the need for more widespread use of hydrogen analyzers, which shuts off the electrolyzer if hydrogen purity falls below critical values.
- Small volume of hydrogen gas was released at a production facility while fixing a hydrogen leakage. Hydrogen should be vented out of the system to create an inert atmosphere before working on system tubing and joints.
- Certain metals are highly sensitive to Hydrogen Embrittlement. Before any metal or material is used for hydrogen production and storage, it must be subjected to Hydrogen Embrittlement susceptibility testing.

References: ARCHES 2024 and 2025; H2tools 2025; Hy Responder 2023; Newsom 2024; OCED 2024; Schou 2025; St. John 2024; UCI 2020

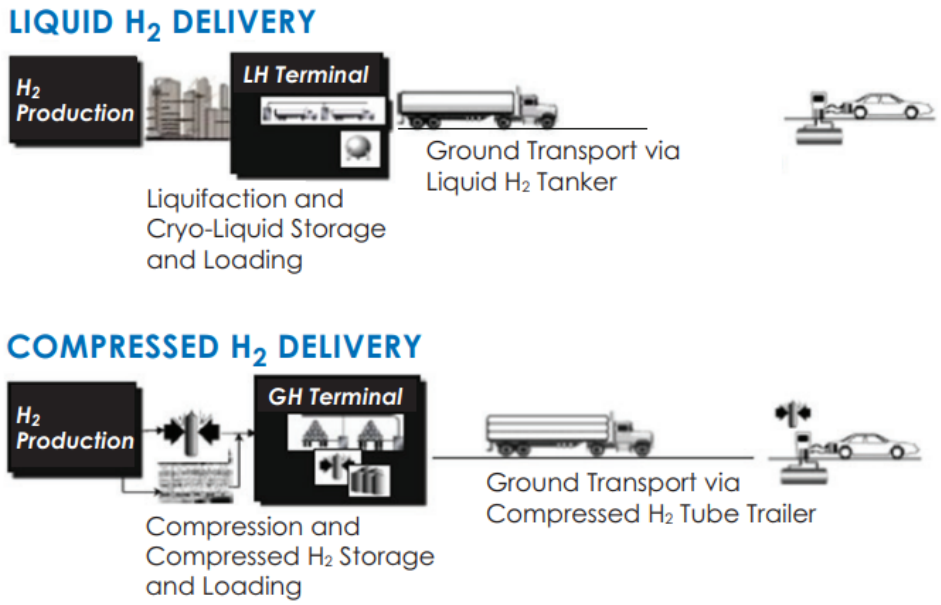

Figure from University of California Irvine, Renewable Hydrogen Production Roadmap for California

References

Addis, Dawn. 2025. AB 303: Battery Energy Safety and Accountability Act. February 4, 2025. [online]: https://a30.asmdc.org/sites/a30.asmdc.org/files/2025-03/AB303-Fact-Sheet-030525.pdf

ARCHES. 2024. California's renewable hydrogen hub officially launches. July 24, 2024. [online]: https://archesh2.org/arches-officially-launches/

_____. 2025. Alliance for Renewable Clean Hydrogen Energy Systems. Accessed March 21, 2025. [online]: https://archesh2.org/wp-content/uploads/2024/03/ARCHES-Mission-and-Principles-1.pdf

BLM (U.S. Department of the Interior Bureau of Land Management). 2019. Gemini Solar Project. Final Resource Management Plan Amendment and Environmental Impact Statement. December 2019. [online]: https://eplanning.blm.gov/public_projects/nepa/100498/20010717/250013741/GeminiSolarProject_RMPA_FEIS_Vol_I.pdf

_____. 2024. BLM approves Alta Wind Battery Energy Storage project in California. Accessed March 18, 2025. [online]: https://www.blm.gov/press-release/blm-approves-alta-wind-battery-energy-storage-project-california

Bogle (Bogle Family Vineyards). 2019. Being Sustainable: Going Beyond Green in the Vineyard. July 3, 2019. [online]: https://boglewinery.com/newsletters/being-sustainable-going-beyond-green-in-the-vineyard/

Brookfield Renewable. 2025. Mesa Re-Power. Accessed March 18, 2025. [online]: https://mesarepower.brookfieldusprojects.com/

CAISO (California Independent System Operator). 2020. Largest battery storage system in US connects to California ISO grid. July 13, 2020. [online]: https://www.caiso.com/Documents/LargestBatteryStorageSysteminUSConnectstoCaliforniaISOGrid.pdf

C&EN (Chemical & Engineering News). 2025. The search for long-duration energy storage. February 21, 2025. [online]: https://cen.acs.org/energy/energy-storage-/search-long-duration-energy-storage/103/i5

Cal CCA (California Community Choice Association). 2025a. Sonoma Clean Power Celebrates 10 Years of Providing Clean Energy to Sonoma and Mendocino Counties. Accessed March 19, 2025. [online]: https://cal-cca.org/sonoma-clean-power-celebrates-10-years-of-providing-clean-energy-to-sonoma-and-mendocino-counties/

_____. 2025b. Community Choice Aggregation (CCA) Service Areas. Accessed March 19, 2025. [online]: https://cal-cca.org/wp-content/uploads/2023/12/CCA-Service-Area.pdf

CEC (California Energy Commission). 2025a. Quarterly Fuel and Energy Report (QFER) Power Plant Annual Generation. Accessed March 3, 2025. [online]: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/quarterly-fuel-and-energy-report-qfer-1

_____. 2025b. Pages from Darden Clean Energy Project Staff Assessment – BESS Safety. Docket Number 24-OPT-02. TN #262083

_____. 2023. Initial Study and Proposed Mitigated Negative Declaration. East Road Storage. December 2023. [online]: https://www.energy.ca.gov/sites/default/files/2023-10/CEC-500-2023-055-D.pdf

Change. 2019. Save the AV Poppies. Accessed March 18, 2025. [online]: https://www.change.org/p/savetheavpoppies-from-being-destroyed-by-solar-farms

Colthorpe, Andy. 2023. Moss Landing: World's biggest battery storage project is now 3GWh capacity. August 2, 2023. [online]: https://www.energy-storage.news/moss-landing-worlds-biggest-battery-storage-project-is-now-3gwh-capacity/

_____. 2025. Fire at Moss Landing Energy Storage Facility: What we know so far. January 24, 2025. [online]: https://www.energy-storage.news/fire-at-moss-landing-energy-storage-facility-what-we-know-so-far/

Constellation Energy. 2025. One of the Largest Solar Facilities in the United States. Accessed March 18, 2025. [online]: https://www.constellationenergy.com/our-company/locations/location-sites/antelope-valley-solar-ranch-one.html

CPA (Clean Power Alliance). 2025. We work together to bring you access to the most sustainable energy available. Accessed March 19, 2025. [online]: https://cleanpoweralliance.org/

CPUC (California Public Utilities Commission). 2025. CPUC Issues Proposal to Enhance Safety of Battery Energy Storage Facilities. January 27, 2025. [online]: https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-issues-proposal-to-enhance-safety-of-battery-energy-storage-facilities

Daldrup, Till; Sherwood, Daniel; Koppelman, Sam; Gibbons, Nick. Plug Power Failure Part I: Critical DOE Loan at Risk Die to False Water Data, Cash Crunch, and Stalled Expansions as Hostile Trump Administration Looms. Impoco, Jim, Ed. December 4, 2024. [online]: https://hntrbrk.com/plug-1/

Darby, Betty. 2021. Camden County: History Shapes the Future. October 31, 2021. [online]: https://www.georgiatrend.com/2021/10/31/our-state-camden-county-history-shapes-the-future/

DOE (U.S. Department of Energy). 2017. Antelope Valley Solar Ranch. Accessed March 18, 2025. [online]: https://www.energy.gov/lpo/antelope-valley-solar-ranch

Dowling, Sarah. 2018. Yolo supervisors approve Bogle wind turbine. Updated August 30, 2018. [online]: https://www.dailydemocrat.com/2014/03/29/yolo-supervisors-approve-bogle-wind-turbine/amp/

Form Energy. 2023. Form Energy awarded $30M grant from the California Energy Commission to deploy first multi-day energy storage project in California. December 13, 2023. [online]: https://formenergy.com/form-energy-awarded-30m-grant-from-the-california-energy-commission-to-deploy-first-multi-day-energy-storage-project-in-california/

Gatlin, Allison. 2022. PWD replacing windmill power with solar. December 2022. [online]: https://www.avpress.com/news/pwd-replacing-windmill-power-with-solar/article_d5d76d6c-7b5e-11ed-8aee-1f1fe502ce41.html

GTM (Green Tech Media). 2013. Construction Halted at First Solar's 230 MW Antelope Valley Site. Accessed March 18, 2025. [online]: https://www.greentechmedia.com/articles/read/construction-halted-at-first-solars-230-mw-antelope-valley-site

Harter, Clara. 2025. 'Extremely disturbing': High levels of heavy metals at Monterey estuary after lithium battery site fire. January 29, 2025. [online]: https://www.latimes.com/california/story/2025-01-29/heavy-metals-found-in-monterey-estuary-after-moss-landing-lithium-battery-fire

H2 Tools. 2025. Lessons Learned. Accessed March 28, 2025. [online]: https://h2tools.org/lessons

Hy Responder (Hy Responder Consortium). 2023. Compatibility of hydrogen with different materials. February. Online: https://hyresponder.eu/wp-content/uploads/2021/06/Lecture-4-slides.pdf

JRMA. 2025. Gateway Battery Storage. Accessed March 20, 2025. [online]: https://www.jrma.com/projectsdetails/gateway-battery-storage

Kern County. 2011. Draft Environmental Impact Report. Antelope Valley Solar (PP 10242). April 2011. [online]: https://psbweb.kerncounty.com/planning/pdfs/eirs/av_solar/av_solar_deir.pdf

_____. 2012. Draft Environmental Impact Report. Beacon Photovoltaic Project by Beacon Solar LLC. July 2012. [online]: https://psbweb.kerncounty.com/planning/pdfs/eirs/beacon_solar/deir-v1_120700_209595-09.pdf

_____. 2013. Kern County Planning Commission Board of Supervisors Staff Report. January 22, 2013. [online]: https://psbweb.kerncounty.com/planning/pdfs/eirs/AltaEast/alta_east_wind_bos_sr_012213.pdf

_____. 2025. Kern County GIS. Accessed March 18, 2025. [online]: https://maps.kerncounty.com/H5/index.html?viewer=KCPublic

LADWP (Los Angeles Department of Water & Power). 2025. LADWP Begins Construction on Major Solar Project that Will Deliver 300 MW of Solar Power to Los Angeles. Accessed March 18, 2025. [online]: https://www.ladwpnews.com/ladwp-begins-construction-on-major-solar-project-that-will-deliver-300-mw-of-solar-power-to-los-angeles/

_____. 2021. Withdrawn Per Lead: Beacon Liquified Air Energy Storage Project. January 28, 2021. [online]: https://ceqanet.opr.ca.gov/2021010343/2

Leimbach, Sydney. 2024. Plug Power Commences Green Hydrogen Production at Georgia Facility. January 29, 2024. [online]: https://www.environmentenergyleader.com/stories/plug-power-commences-green-hydrogen-production-at-georgia-facility,742

Marks, Aaron. 2025. For energy storage fire safety, will perception become reality? February 13, 2025. [online]: https://www.energy-storage.news/for-energy-storage-fire-safety-will-perception-become-reality/

Michael Baker (Michael Baker International). 2025. Antelope Valley Solar Ranch 1. Accessed March 18, 2025. [online]: https://mbakerintl.com/en/project/antelope-valley-solar-ranch-1

Moore, Derek. 2014. Some customers opting out of Sonoma Clean Power. March 19, 2014. [online]: https://www.pressdemocrat.com/article/news/some-customers-opting-out-of-sonoma-clean-power/

Newsom, Gavin. 2024. California launches world-leading Hydrogen Hub. July 17, 2024. [online]: https://www.gov.ca.gov/2024/07/17/california-launches-world-leading-hydrogen-hub/

NS Energy. 2020. Gemini Solar Project. Accessed March 18, 2025. [online]: https://www.nsenergybusiness.com/projects/gemini-solar-project/?cf-view

OCED (Office of Clean Energy Demonstration). 2024. Regional Clean Hydrogen Hubs Program California Hydrogen Hub (ARCHES). Accessed March 21, 2025. [online]: https://www.energy.gov/sites/default/files/2024-07/H2Hubs%20ARCHES_Award%20Fact%20Sheet.pdf

Overview. 2025. Alta Wind Energy Center. Accessed March 18, 2025. [online]: https://www.overview.com/overviews/alta-wind-energy-center

Pattern Energy. 2025. Ocotillo Wind. Accessed March 18, 2025. [online]: https://patternenergy.com/projects/ocotillo-wind/

Plug Power. 2024. ESG Report 2023. Accessed March 21, 2025. [online]: https://www.plugpower.com/wp-content/uploads/2024/04/2023-ESG-Report-Final_5-5Optimized-04252024.pdf

Point Reyes Farmstead (Point Reyes Farmstead Cheese Co.). 2021. A Family Farm with Solar and Sustainable Practices. Accessed March 19, 2025. [online]: https://pointreyescheese.com/blogs/the-blog/a-family-farm-with-solar-and-sustainable-practices?srsltid=AfmBOoovtLVGPwpgwcPRngG4JGDYkI7zzMarmKC_8fuTB1SetI9YZHEt

_____. 2022. LinkedIn post. Accessed March 19, 2025. [online]: https://www.linkedin.com/posts/point-reyes-farmstead-cheese-co_weve-gone-solar-as-part-of-our-ongoing-activity-6836340315012657152-TJJ8/

Power Technology. 2025. Antelope Valley Solar Ranch One, Los Angeles County. Accessed March 18, 2025. [online]: https://www.power-technology.com/projects/antelope-valley-solar-ranch-one-los-angeles-county/

_____. 2014. Alta Wind Energy Center (AWEC), California. Accessed March 18, 2025. [online]: https://www.power-technology.com/projects/alta-wind-energy-center-awec-california/

Primergy. 2024. Gemini Solar + Storage. Accessed March 18, 2025. [online]: https://www.primergygemini.com

PWD (Palmdale Water District). 2022a. PWD to Expand Use of Solar Power, Decommission Wind Turbine. December 2022. [online]: https://www.palmdalewater.org/wp-content/uploads/2022/12/PWD_Press_Release_Turbine_2022.pdf

_____. 2022b. Draft Initial Study and Mitigated Negative Declaration. Palmdale Water District Solar Energy Project. November 2022. [online]: https://files.ceqanet.opr.ca.gov/282955-1/attachment/81ktVhVsvskjLoOvebIyUTIf3xA_ANt0qpe8lLs7PfQhbu5vddkPKsCmqxvhmpm3QxfEmVGxM_J-uKt-0

_____. 2016. Press Release- Back to the Future: Lake Palmdale Wind Turbine gets Rejuvenated. December 19, 2016. [online]: https://www.palmdalewater.org/back-to-the-future-lake-palmdale-wind-turbine-gets-rejuvenated/#:~:text=Since%20its%20establishment%20in%202004%2C%20the%20Palmdale,to%20cut%20annual%20energy%20costs%20in%20half

S&B. 2024. S&B Completes Green Hydrogen Plant. March 7, 2024. [online]: https://www.sbec.com/About/Company-News/--SB-Completes-Green-Hydrogen-Plant-/

Sanderson, Cosmo. 2024. Fire burns for five days at huge lithium-ion energy storage facility. May 20, 2024. [online]: https://www.rechargenews.com/energy-transition/fire-burns-for-five-days-at-huge-lithium-ion-energy-storage-facility/2-1-1646389

Schou, Nicholas. 2025. Hydrogen Hub on Hold. February 4, 2025. [online]: https://redcanarycollective.org/magazine/trump-doe-freeze-hydrogen-hub-california-port/

St. John, Jeff. 2024. One year in, US clean hydrogen hubs face questions – and have few answers. October 16, 2024. [online]: https://www.canarymedia.com/articles/hydrogen/one-year-in-us-clean-hydrogen-hubs-face-questions-and-have-few-answers

Riverside County. 2021a. Final Environmental Assessment/Initial Study Alta Mesa Wind Project. February, 2021. [online]: https://planning.rctlma.org/sites/g/files/aldnop416/files/migrated/Portals-14-Postings-AltaMesa-Final-IS-MND.pdf

_____. 2021b. Alta Mesa Wind Project EA-IS Response to Comments. February 2021. [online]: https://planning.rctlma.org/sites/g/files/aldnop416/files/migrated/Portals-14-Alta-20Mesa-20EA-IS-20Response-20to-20Comments-2002-05-21-To-20RivCo.pdf

Sawyer, Abigail. 2021. BLM Shuts Down Ocotillo Wind After Second Tower Collapse in Five Years. News Data Article. Accessed March 18, 2025. [online]: https://www.newsdata.com/california_energy_markets/regional_roundup/blm-shuts-down-ocotillo-wind-after-second-tower-collapse-in-five-years/article_bf4a86ca-22d5-11ec-92cd-e7a1eee0a6ac.html

SunPower (SunPower Corporation). 2013. SunPower Module 40-year Useful Life. Accessed March 27, 2025. [online]: https://assets.ctfassets.net/k6ot5nj1c6f9/30PSEWq6zx5pe3NwzesOLn/5a3336e7e05ce37e1607b9bedf00557f/wp-sunpower-module-40-year-useful-life__1_.pdf

Ternus-Bellamy, Anne. 2014. Supervisors OK wind turbine for Bogle vineyards. March 25, 2014. [online]: https://www.davisenterprise.com/news/county_government/supervisors-ok-wind-turbine-for-bogle-vineyards/article_27907749-fa52-5de7-be53-c28785764916.html

UCI (University of California Irvine). 2020. Renewable Hydrogen Production Roadmap for California. June 2020. [online]: https://www.apep.uci.edu/PDF_White_Papers/Renewable_Hydrogen_Production_Roadmap_For_California_061920_11am.pdf

USEPA (U.S. Environmental Protection Agency). 2025. Greenhouse Gas Equivalencies Calculator. Accessed March 27, 2025. [online]: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results

USGS (U.S. Geological Survey). 2023. The Gemini Solar Project uses the “Drive and Crush” method to preserve soil and plant roots. Accessed March 18, 2025. [online]: https://www.usgs.gov/media/images/gemini-solar-project-uses-drive-and-crush-method-preserve-soil-and-plant-roots

Vecchi, A., Li, Y., Mancarella, P., Sciacovelli, A. 2021. Liquid air energy storage (LAES): A review on technology state-of-the-art, integration pathways and future perspectives. Advances in Applied Energy; Vol. 3. [online]: https://www.sciencedirect.com/science/article/pii/S2666792421000391?via%3Dihub

Wolfe, Wes. 2024. Plug Power seeks 1.1M gallons of groundwater. July 20, 2024. [online]: https://www.tribune-georgian.com/local-news-newsletter/plug-power-seeks-11m-gallons-groundwater

Yolo Bird Alliance. 2024. Wind Turbine Development at Bogle Vineyards. Accessed March 19, 2025. [online]: https://yolobirdalliance.org/wind-turbine-development-bogle-vineyards/

Yolo County (Yolo County Department of Community Services). 2017. Draft Environmental Impact Report Bogle Wind Turbine Project. March 2017. [online]: https://www.yolocounty.gov/home/showpublisheddocument/41032/636240664465370000