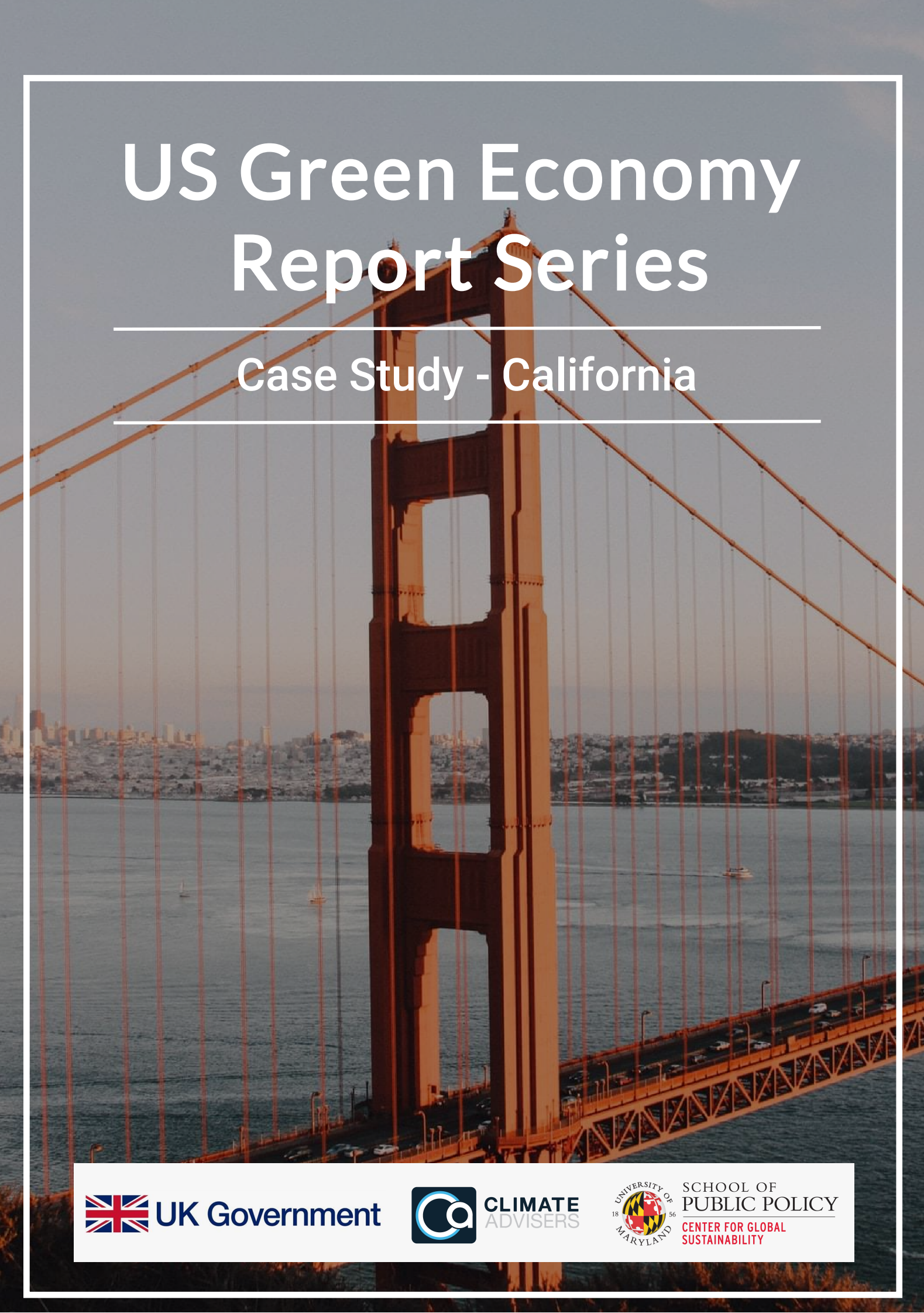
US Green Economy Report Series

Case Study - California



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CENTER FOR GLOBAL SUSTAINABILITY

California State Profile

California's Global Warming Solutions Act of 2006 established the state's trajectory toward ambitious emissions-reduction targets and the state has continually built on this law. California, considered the country's leader in climate action for decades, aimed to reach 1990 levels for greenhouse gas emissions by 2020, and is now targeting 40 percent below 1990 levels by 2030 and carbon neutrality by 2045. It established a Renewables Portfolio Standard in 2002 and subsequently accelerated this over the years as one of the most ambitious clean energy programmes in the country. California requires its electricity sector to reach clean energy targets of 60 percent of sales by 2030 and 100 percent by 2045. In the transportation sector, California is aiming for 5 million zero-emission vehicles by 2030 with 250,000 charging stations and a phase-out sales of vehicles with internal combustion engines by 2035. California's former Governor Jerry Brown was a co-founder of the US Climate Alliance, and the state is a member of 17 regional and national climate agreements. California, along with Baden-Württemberg, formed the Under2 Coalition to increase climate cooperation among subnational actors. The state also has 64 bilateral agreements with other countries. For instance, a recent Memorandum of Understanding (MOU) between California and Denmark focuses on collaboration around development of offshore wind. Another MOU, signed with Canada in 2019, aims to coordinate action between the two countries to reduce emissions, with a particular focus on clean transportation. California signed an agreement with Scotland to exchange knowledge, data and best practices on "the intersection of cultural heritage and climate action." With Democrats in charge of the governorship and the state's legislature (they have held all three since 2011), the state will likely continue to commit to meeting its various climate targets and being active in agreements and collaborations with a wide range of stakeholders.

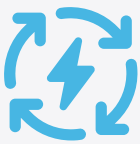
CALIFORNIA STATE GOALS

40%

cut in greenhouse gas emissions below 1990 levels by 2030, carbon neutral by 2045

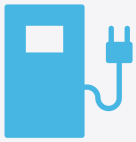
200

hydrogen fueling stations by 2025



60%

renewable energy by 2030, 100% by 2045



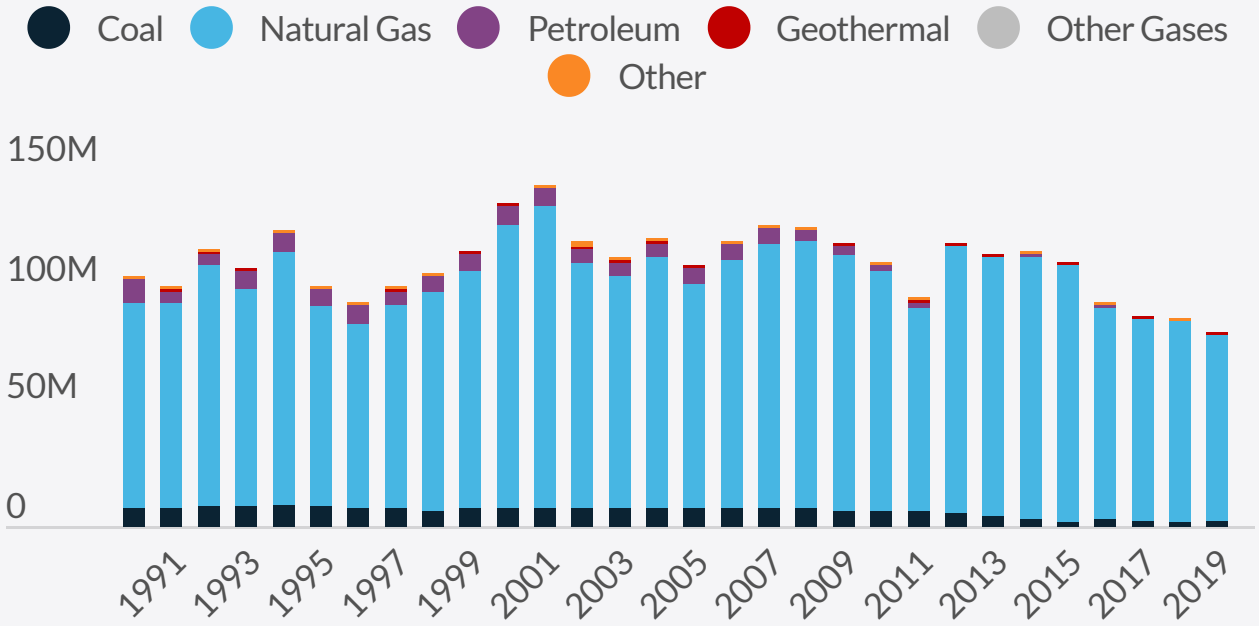
250,000

zero emission vehicle charging stations by 2025

5 MILLION

zero emission vehicles by 2030

ENERGY-RELATED GREENHOUSE GAS EMISSIONS



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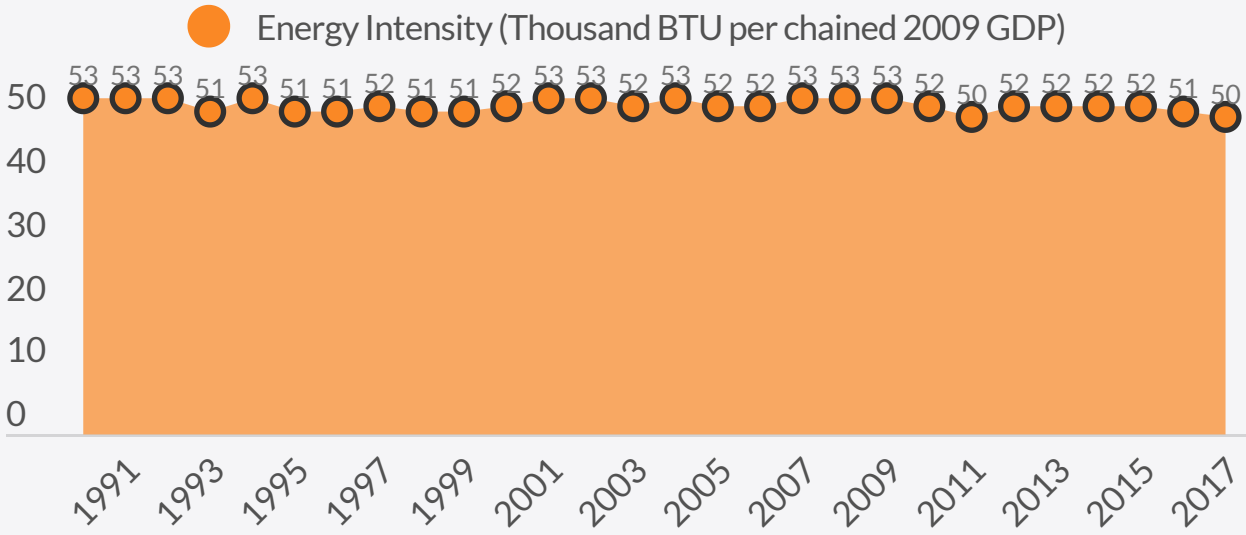
Carbon Dioxide emissions over time by energy generation source, according to the Energy Information Administration. Note: other includes non-biogenic municipal solid waste, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, and miscellaneous technologies; other Gases includes blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.

ENERGY INTENSITY OVER TIME



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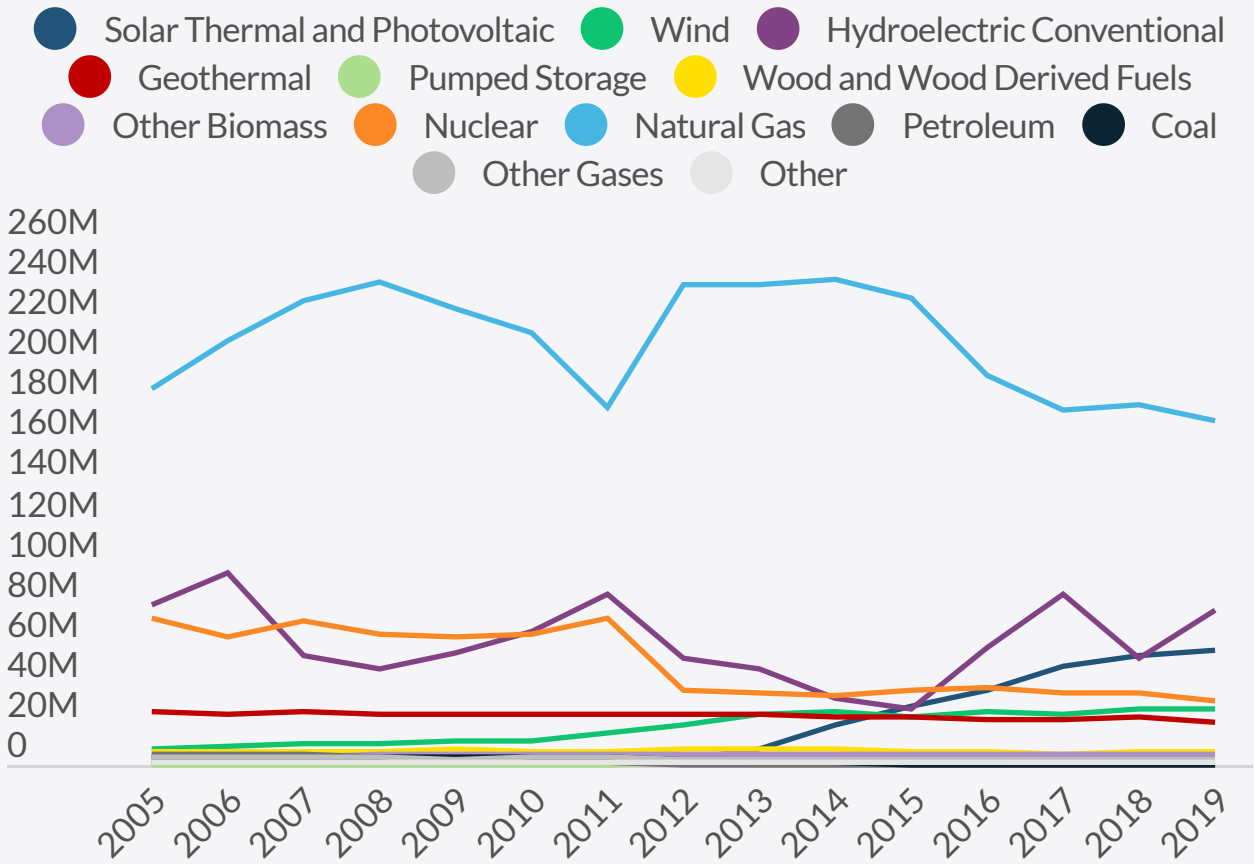
Source: Energy Information Administration

ELECTRICITY GENERATION BY SOURCE



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Generation over time, according to the Energy Information Administration. Note: other includes non-biogenic municipal solid waste, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, and miscellaneous technologies; other Gases includes blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.

ENERGY FACTS AND FIGURES

ENERGY LOSSES	1,605,577	BBTU
ELECTRICITY PRICES	48.70	USD per MBTU
ENERGY PER GDP	2.89	Thousand BTU per 2012 USD
CONSUMPTION PER CAPITA	199.50	MBTU
NET-INTERSTATE FLOW	865,712	BBTU

Facts and figures, according to the Energy Information Administration. Note: negative net interstate flow of electricity and associated losses indicates flow out of state.

CALIFORNIA'S LARGEST GENERATING PLANTS

Largest generation facilities by capacity, according to the Energy Information Administration

2,240 MW

Nuclear: Diablo Canyon

1,491 MW

Natural gas: Ormond Beach

1,675 MW

Pumped storage: Castaic

1,212 MW

Pumped storage: Helms Pumped Storage

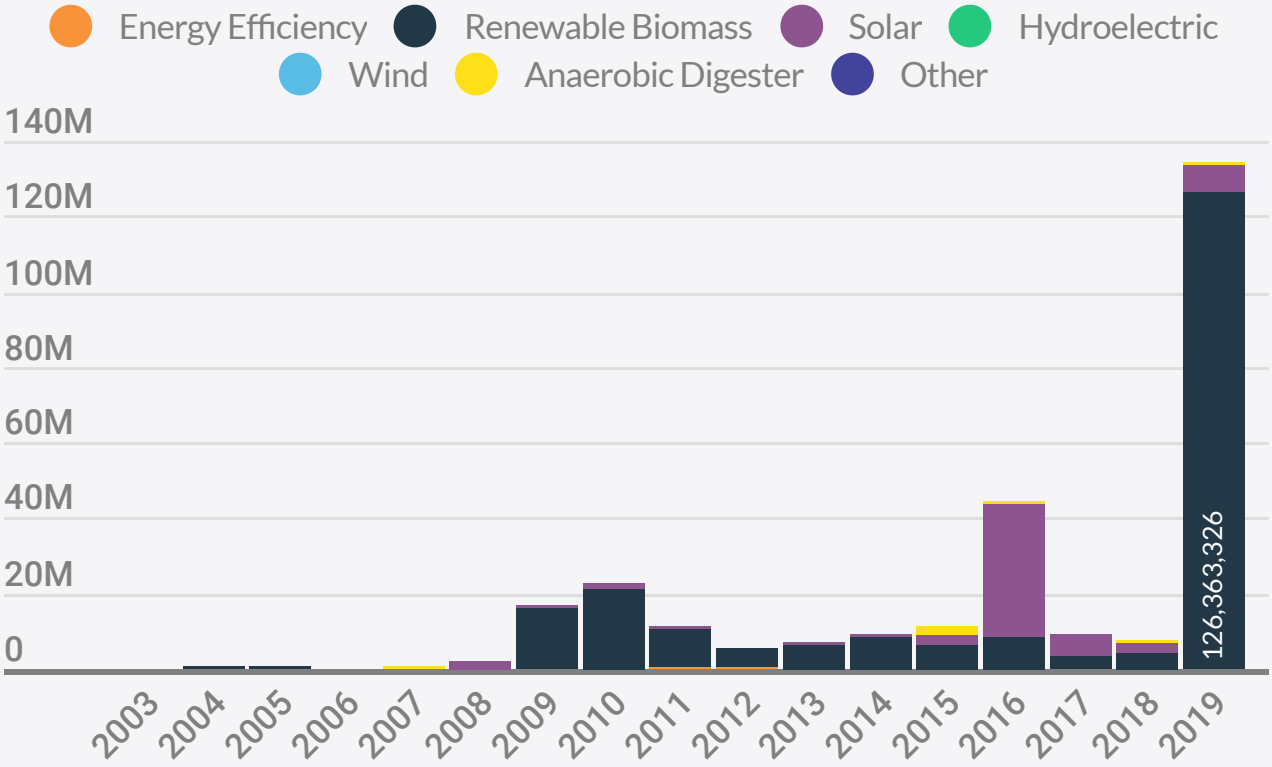
1,600 MW

Natural gas: Haynes

1,152 MW

Natural gas: AES Alamitos LLC

PUBLIC INVESTMENT BY GENERATION TYPE (DOA)



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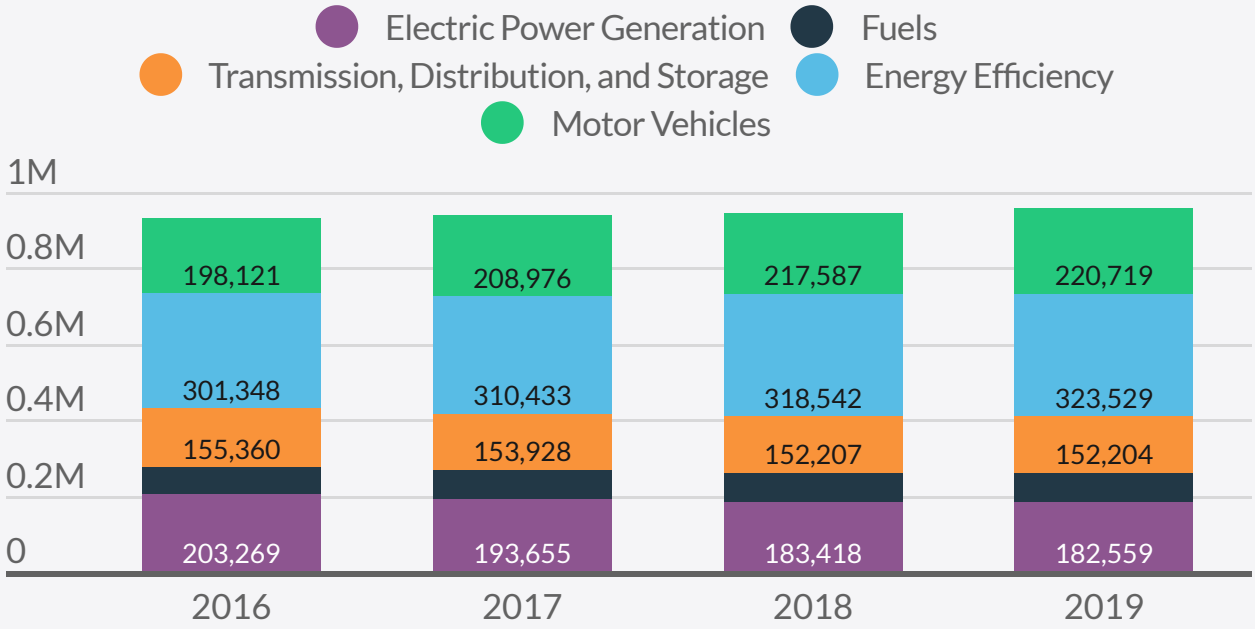
Public investment by energy type from 2002 to 2020, according to the United States Department of Agriculture. Data includes all investments made through Department of Agriculture programs.

TRADITIONAL ENERGY SECTOR JOBS



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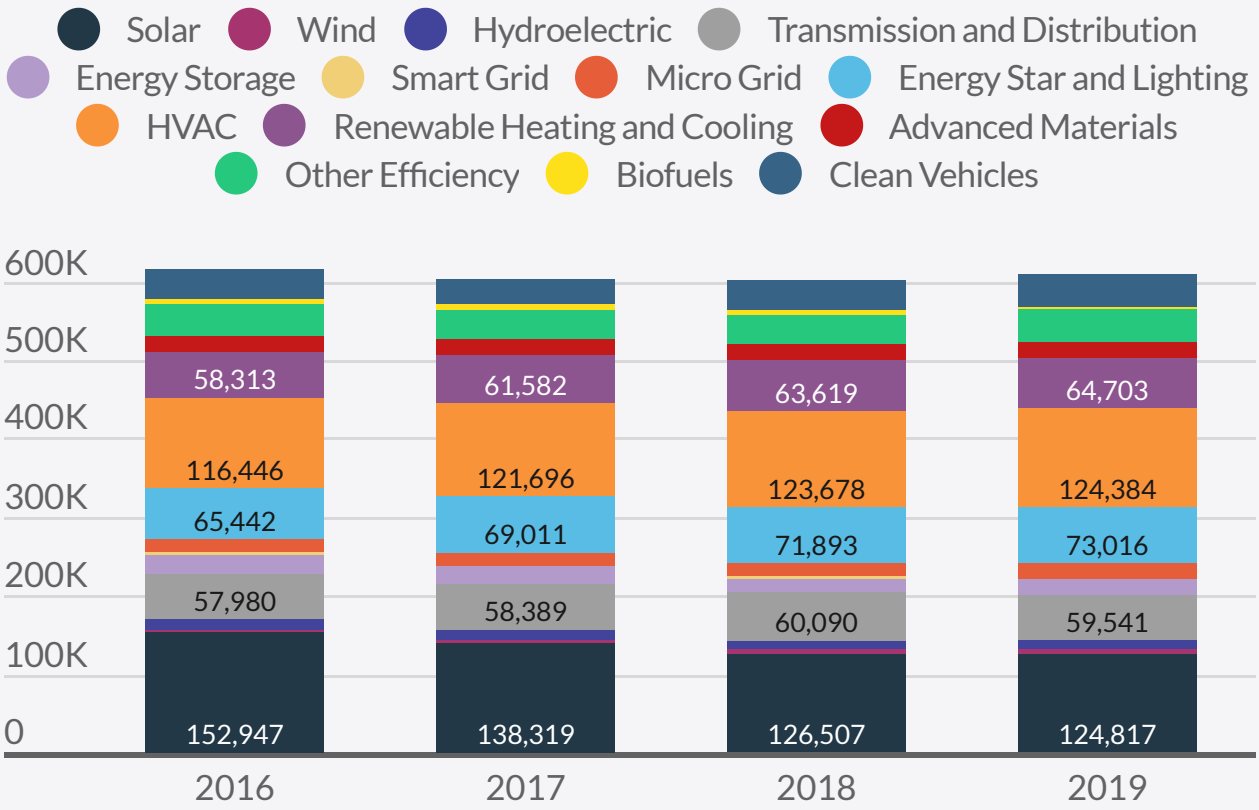
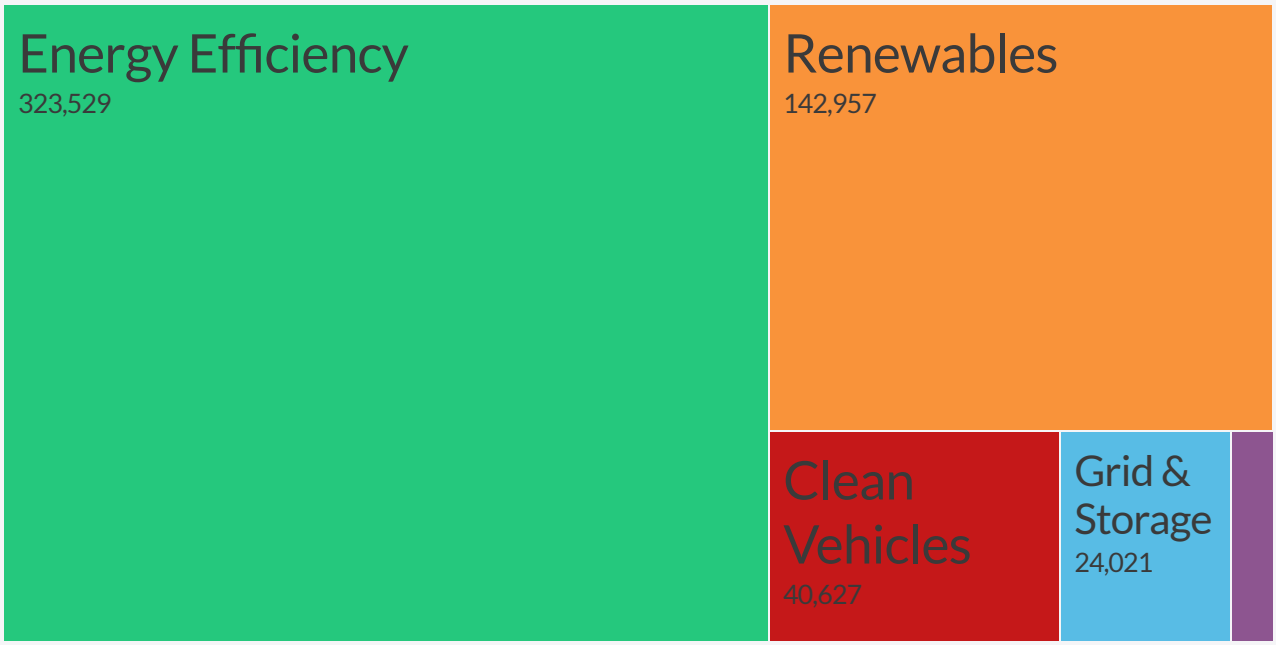
Traditional energy sector jobs over time, according the United States Energy and Employment Report (USEER).

CLEAN ENERGY JOBS



Clean energy jobs over time by type, according to the USEER. See Appendix for definitions and methodology.

OVERVIEW OF CLEAN ENERGY JOBS BY CATEGORY



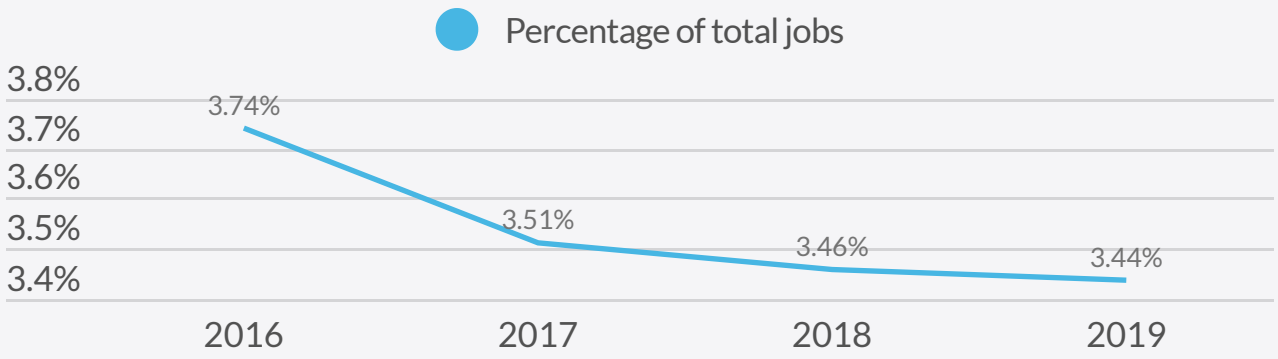
Clean energy jobs over time by technology, according to E2 Clean Jobs America.

CLEAN ENERGY COMPENSATION

Average state clean energy wage	$27.49
Percent above/below median state wage	29.2%
#1 most difficult to hire occupation	Management
#2 most difficult to hire occupation	Sales, marketing, or customer service

Clean energy jobs compensation and hiring, according to E2 Clean Jobs America and the USEER.

CLEAN ENERGY JOBS AS PERCENTAGE OF OVERALL JOBS



Clean energy jobs as a percentage of Bureau of Labor Statistics employment total numbers.

ELECTRIC VEHICLES

California is ranked 1st according to the ACEEE EV Scorecard, indicating high prioritisation of EV policies, practices and investments. It was the first state to have a Zero Emissions Vehicle (ZEV) Standard, which mandates a certain percentage of all new vehicles sold to be ZEVs. Governor Newsom recently took this a step further and signed an executive order mandating that all new cars sold be zero-emission by 2035. The California Air Resources Board (CARB) has issued a similar mandate for medium- and heavy-duty trucks. The state has a long list of EV policies and incentives, but its headline initiative is the ZEV Program administered by CARB, which includes funding for charging infrastructure and rebates for buyers of EVs. There are also several other programmes administered by utilities and municipalities, which range from discounted power rates for vehicle charging to vehicle rebates. EVs accounted for 7.84 percent of vehicle sales in California in 2018. There are 256,800 EVs registered and 12,487 charging stations in the state, and the state has set a goal of 1.5 million ZEVs by 2025 and 5 million by 2030. Looking forward, Governor Newsom has proposed $1.5 billion in additional funding to assist individuals and businesses in buying EVs, which shows that the potential for ZEVs in California will likely continue to improve.

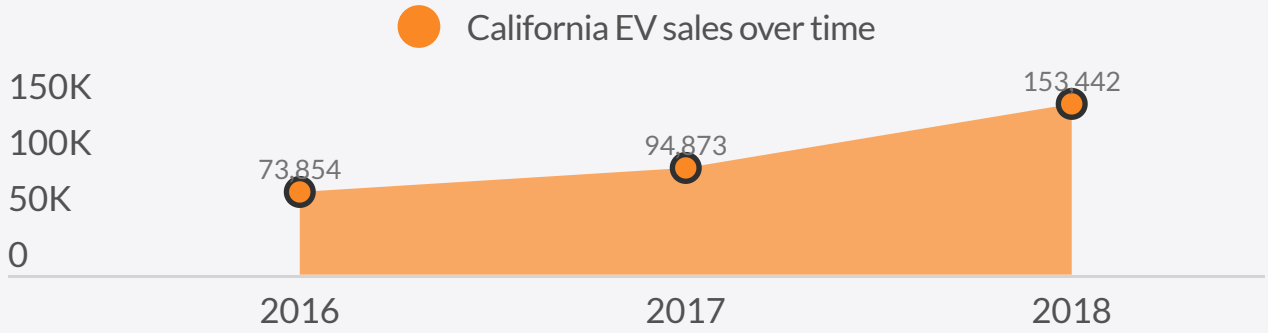
Key Players: California Air Resources Board (CARB), The California Energy Commission (CEC), California Public Utilities Commission (CPUC), California Environmental Protection Agency, Tesla, ChargePoint, Electrify America, and Volta Charging

ELECTRIC VEHICLE FACTS AND FIGURES

National rank based on EV sales	1
Percentage of national EV sales	46.8%
Market share within state	7.8%
Market share within state (year over year growth)	56%
EV sales as a percentage of motor vehicle sales	4.7%
Number of people per charging station	7,942
Number of people per charging station (rank)	5
EV Fuel Cost per eGallon (2018)	$1.72
EV Fuel Cost per eGallon (% above/below national average)	36%
Fuel cost savings per gallon versus gasoline	$1.74
Most popular EV (search volume)	Tesla Model S

Electric vehicle quick facts based on data from EVAdoption.

ELECTRIC VEHICLE SALES OVER TIME



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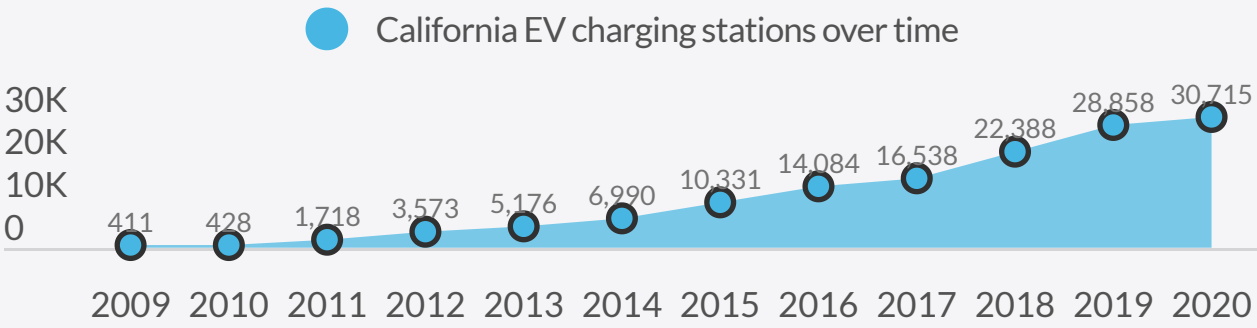
Electric vehicle sales over time, according to EVAdoption.

ELECTRIC VEHICLE CHARGING STATIONS OVER TIME



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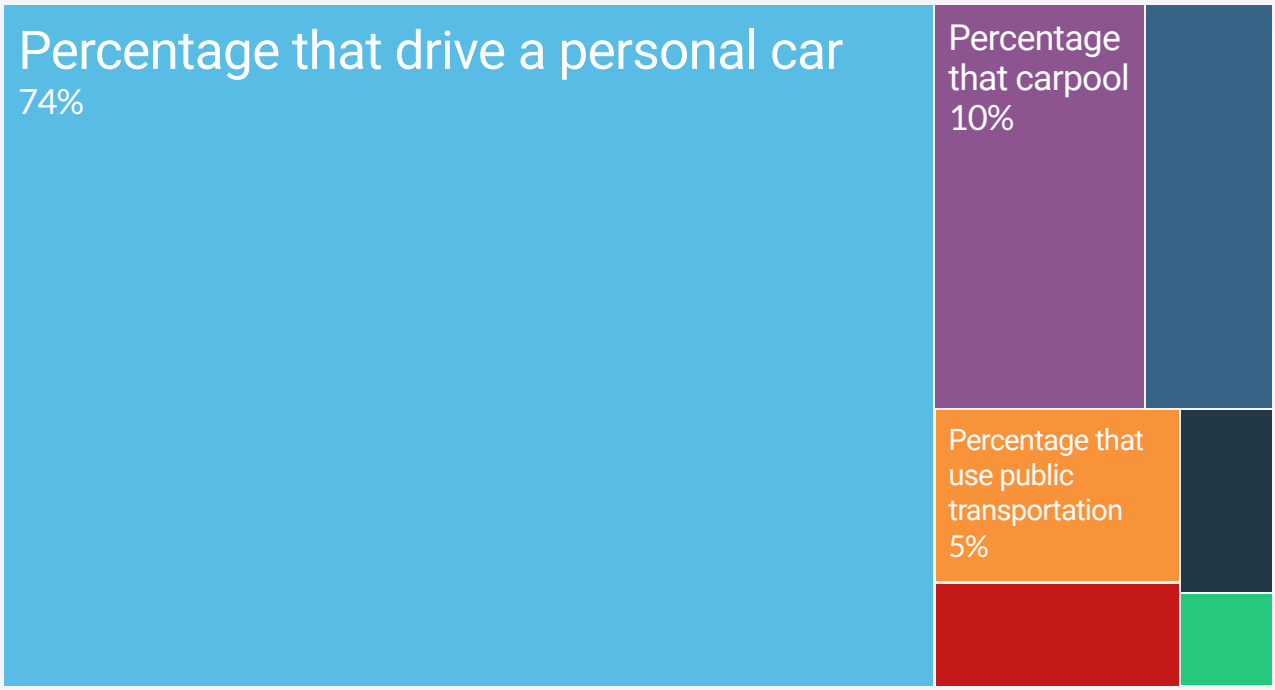
Charging stations over time, according to the United States Department of Energy's Alternative Fuels Data Center.

ELECTRIC VEHICLE LAWS AND INCENTIVES

	Strength	Number	Compared to National Average
Number of EV laws & incentives	High	118	700%
Number of HEV laws & incentives	High	12	483%
Number of PHEV laws & incentives	High	107	705%
Number of NEV laws & incentives	High	3	189%
Number of fuel economy/efficiency laws & incentives	High	7	505%

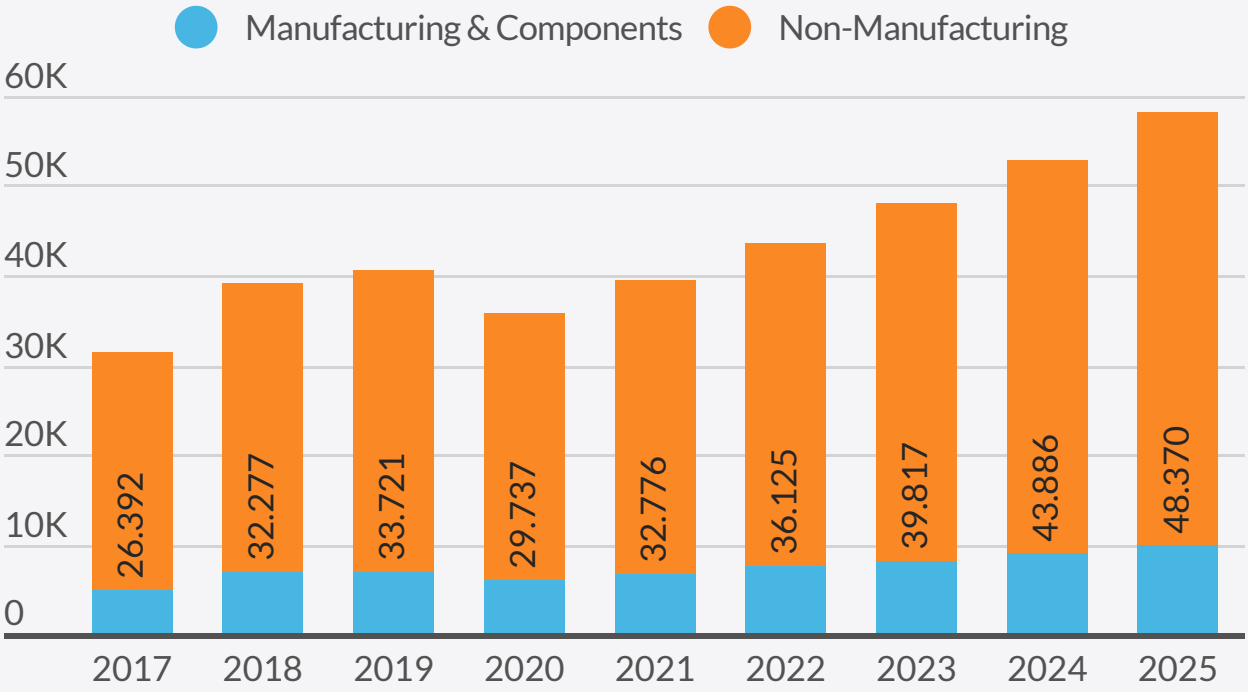
Quantity of state laws and incentives on electric vehicles, in comparison to national average, according to the Alternative Fuels Data Center.

PROFILE OF A CALIFORNIA COMMUTER



State commuter dynamics, according to the United States Department of Commerce, Bureau of Census.

PROJECTED CLEAN VEHICLE JOBS (2020-2025)



Methodology: Percentage of manufacturing jobs by state (NAICS codes 3361,3362,3363) of total motor vehicle jobs was applied to total clean vehicle jobs by state (E2) to determine the break down. Forecast based on projected clean vehicles miles travelled. More detail in the Appendix.

ENERGY EFFICIENCY

California is ranked 1st on ACEEE's 2020 State Energy Efficiency Scorecard, reflecting the state's leadership in energy efficiency efforts. The state has 97 financial incentives for energy efficiency, including multiple active PACE financing programmes, the Statewide Energy Efficiency Program (SWEEP), the Energy Partnership Program, the Bright Schools Program and more. The state's Assembly Bill 1103 requires benchmarking energy usage in state, commercial and residential buildings on ENERGY STAR Portfolio Manager. Major state-funded facilities are also expected to meet aggressive energy and water efficiency targets, which are consistently updated to reach higher ambition. California has several research and development institutions focused on energy efficiency, including the California Energy Commission's Energy Research and Development programme, Electric Program Investment Charge and the Natural Gas Research and Development Fund.

Key Players: Bear Valley Electric Service, Liberty Utilities, PacifiCorp, Pacific Gas & Electric Company, San Diego Gas & Electric Company, Southern California Edison Company, Sacramento Municipal Utility District, Los Angeles Department of Water and Power

ENERGY EFFICIENCY RANKINGS BY CATEGORY

1

Energy Efficiency Rank

4

Utilities Rank

1

Government Rank

2

Transportation Rank

2

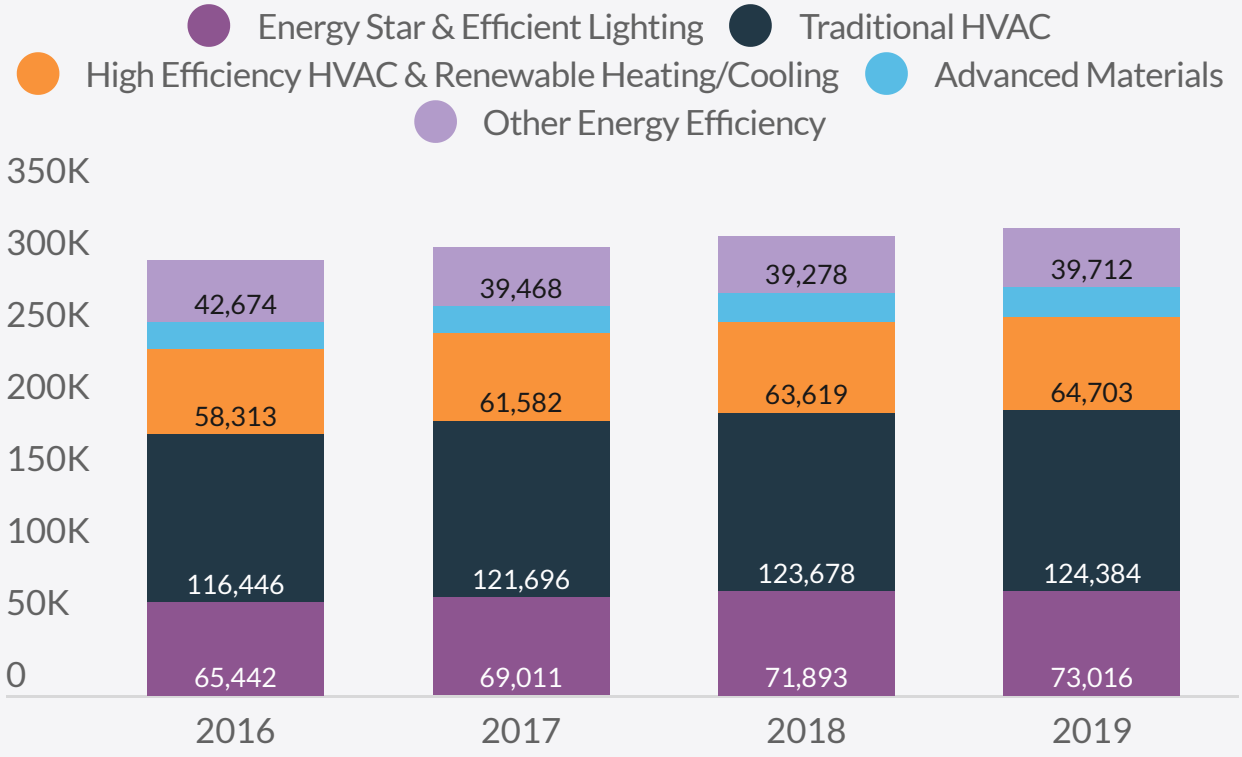
Buildings Rank

1

Appliances Rank

Each component of energy efficiency was evaluated by state by the American Council for an Energy-Efficient Economy, which is the basis for these national rankings. The ACEEE monitors state policies and programs, which feed into an assessment of 32 energy efficiency metrics.

ENERGY EFFICIENCY JOBS BY CATEGORY



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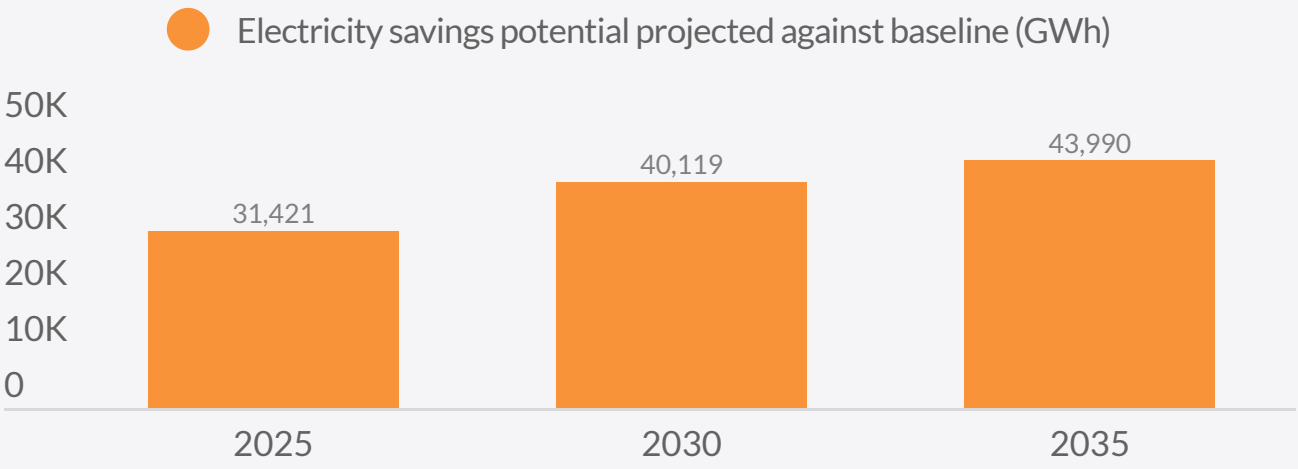
Categories of energy efficiency jobs, according to the United States Energy and Employment Report.

ENERGY EFFICIENCY ELECTRICITY SAVINGS POTENTIAL PROJECTED AGAINST BASELINE



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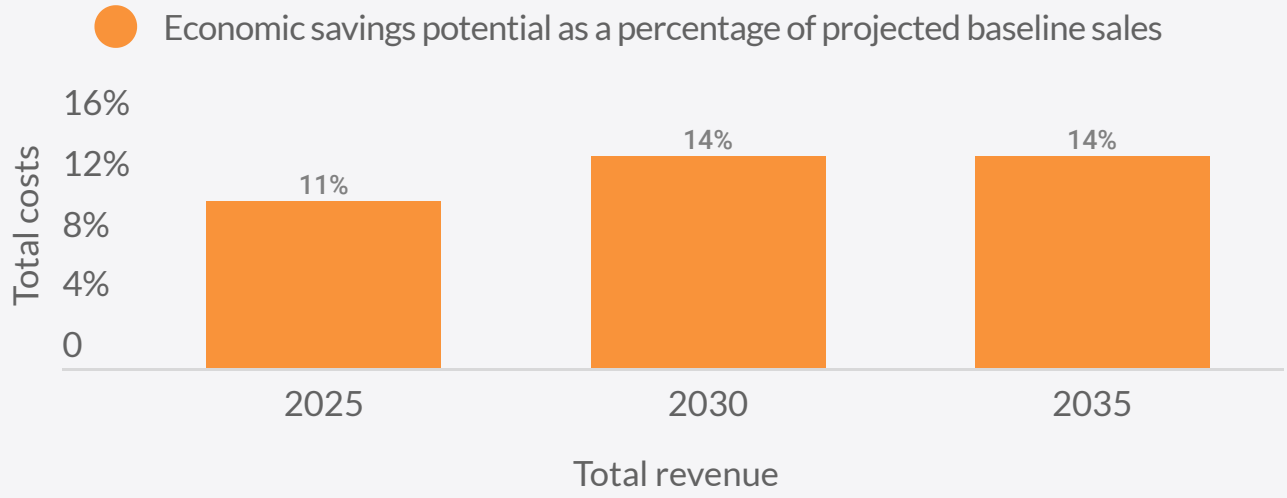
Electricity savings projected by the the United States Office of Energy Efficiency and Renewable Energy.

ENERGY EFFICIENCY ECONOMIC SAVINGS POTENTIAL AS A PERCENTAGE OF BASELINE SALES



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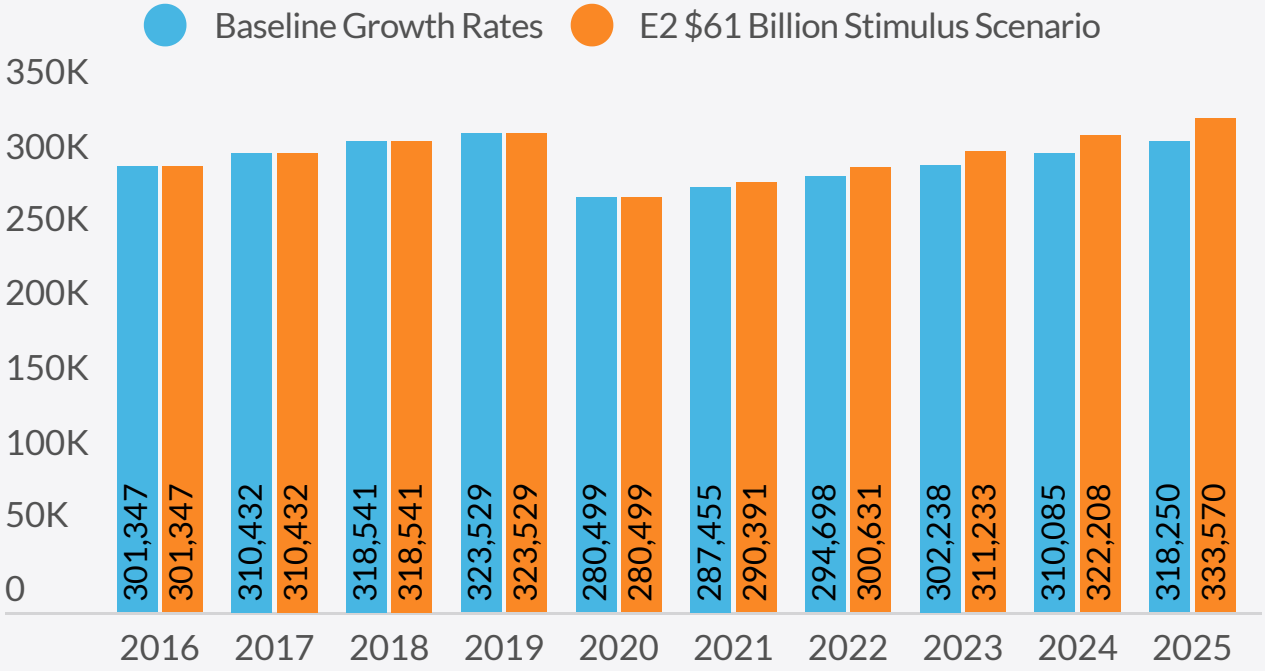
Electricity savings projected by the the United States Office of Energy Efficiency and Renewable Energy.

PROJECTED ENERGY EFFICIENCY EMPLOYMENT



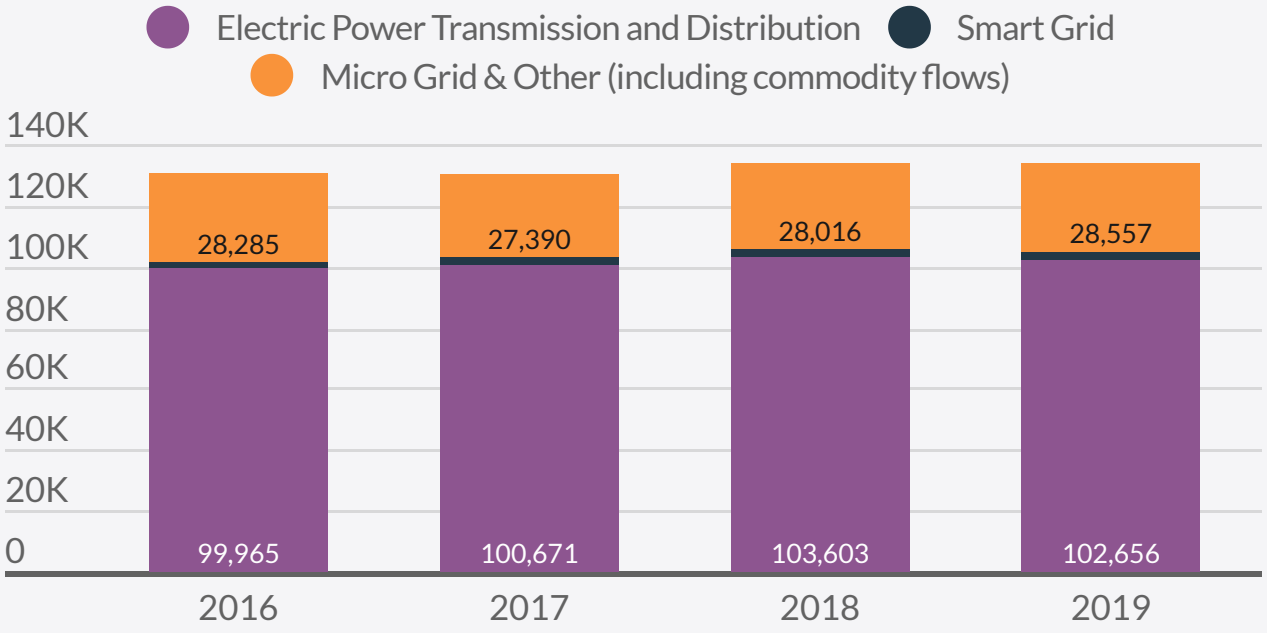
Methodology: US Energy & Employment actuals for ENERGY STAR and efficient lighting, traditional HVAC, high efficiency HVAC and renewable heating and cooling, advanced materials and other energy efficiency. Current growth rates use historic compound annual growth rate, while the E2 $61 Billion stimulus scenario uses growth rates based on projected impacts of a federal stimulus bill. Both cases adjust for COVID-19 job loss actuals in 2020. Additional detail in the Appendix.

GRID MODERNISATION

California ranks 1st in the 2018 Grid Modernization Index, based on state policy support, customer engagement and degree of grid operations investment. The state focuses on grid modernisation in its energy plan and runs an active programme to enable customer data access. Approximately 83 percent of customers use smart meters in California, primarily driven by a statewide policy requiring smart meters. Wildfires in the state have spotlighted the need for grid improvements, and the state's annual report documents progress made on distribution resource plans, microgrids and demand response. As of 2019 Q2, utilities in California proposed $14.2 billion in spending across 17 grid modernisation proceedings. In 2020, 60 bills relating to energy infrastructure and regulations were introduced, of which 3 were enacted, 1 was vetoed and 7 were passed by one chamber. With regards to demand response, California enrols 1,546,067 customers, helping to save 4,854 MWh. As it stands, Climate Advisers anticipates above-average growth in this sector due to the strong investment and policy environment in California.

Key Players: CAISO, California Public Utilities Commission, Pacific Gas and Electric Company, Southern California Edison Company, San Diego Gas and Electric, California Center for Sustainable Energy

GRID JOBS BY CATEGORY OVER TIME



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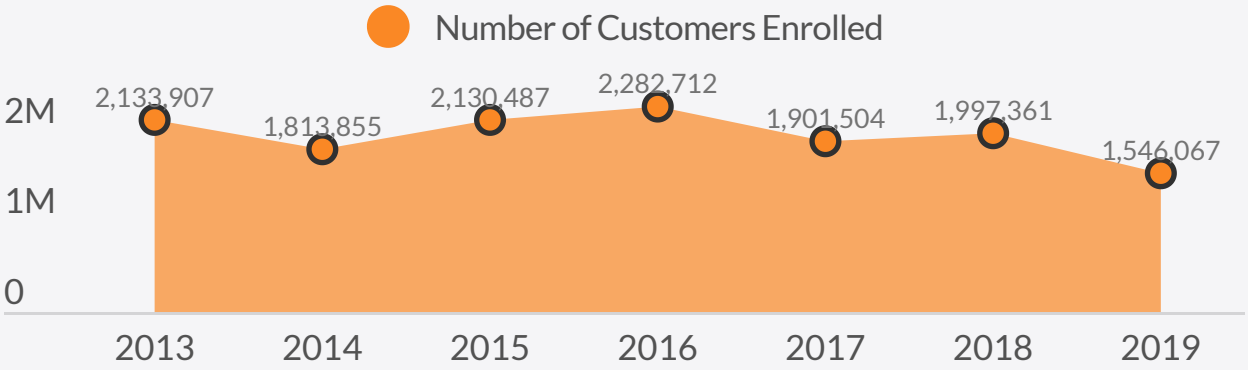
Categories of grid-related jobs, according to the United States Energy and Employment Report.

DEMAND RESPONSE ENROLLMENT AND INCENTIVES



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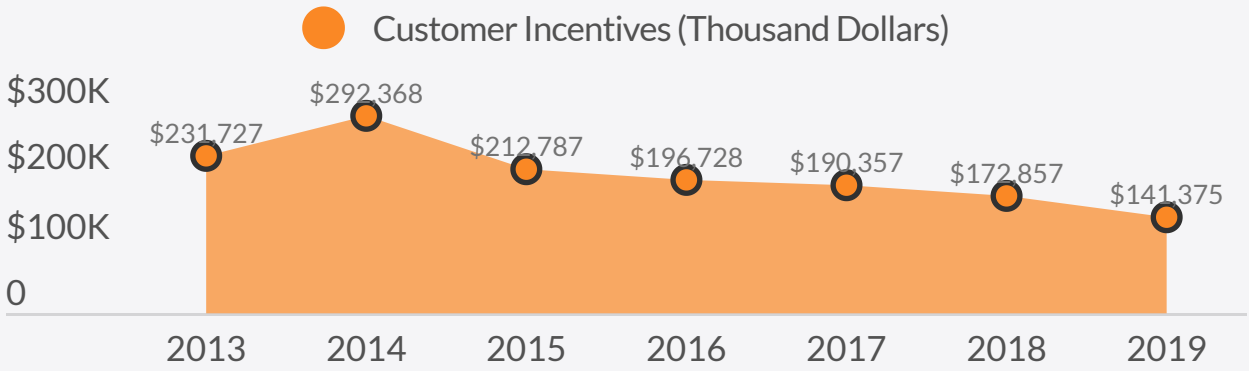

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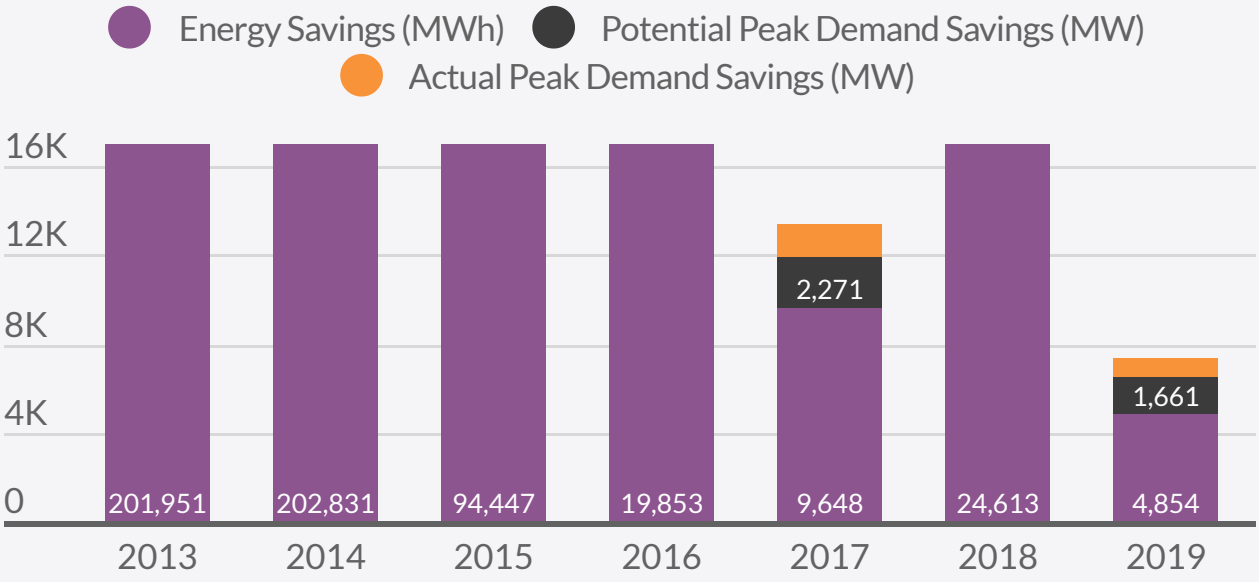
Enrollment and incentive data sourced from the Energy Information Administration.

DEMAND RESPONSE ENERGY SAVINGS OVER TIME



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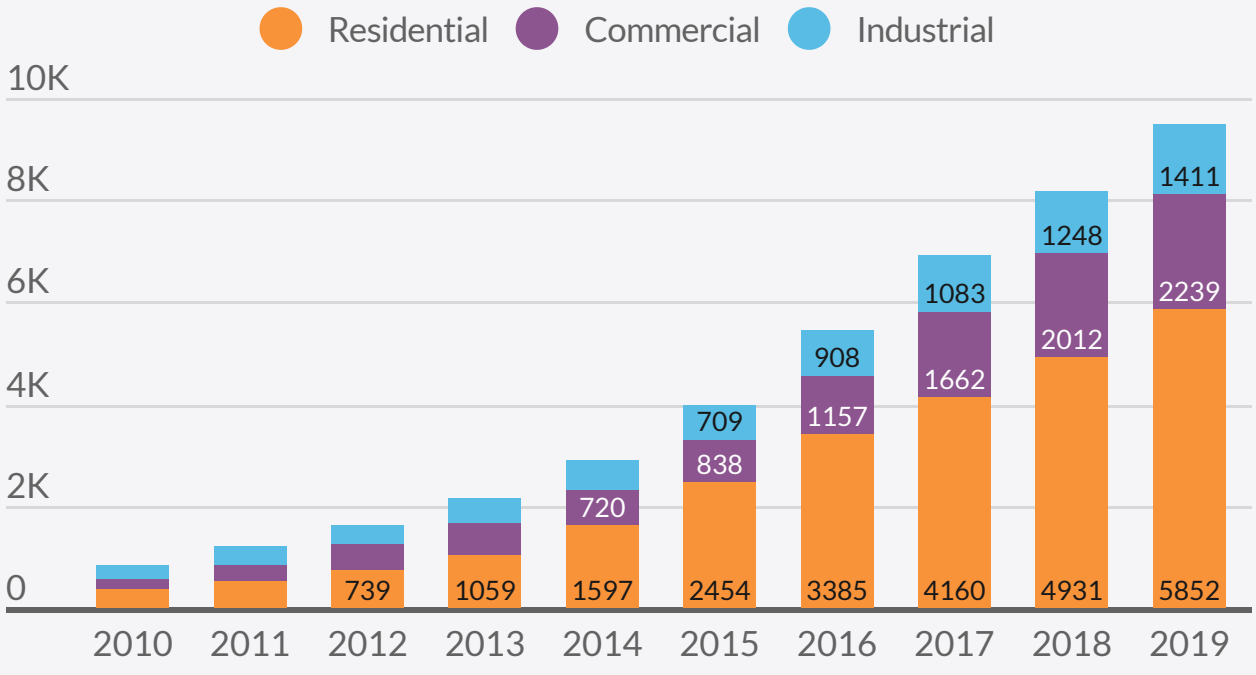
Demand response savings data sourced from the Energy Information Administration.

DISTRIBUTED GENERATION: NET METERING CAPACITY



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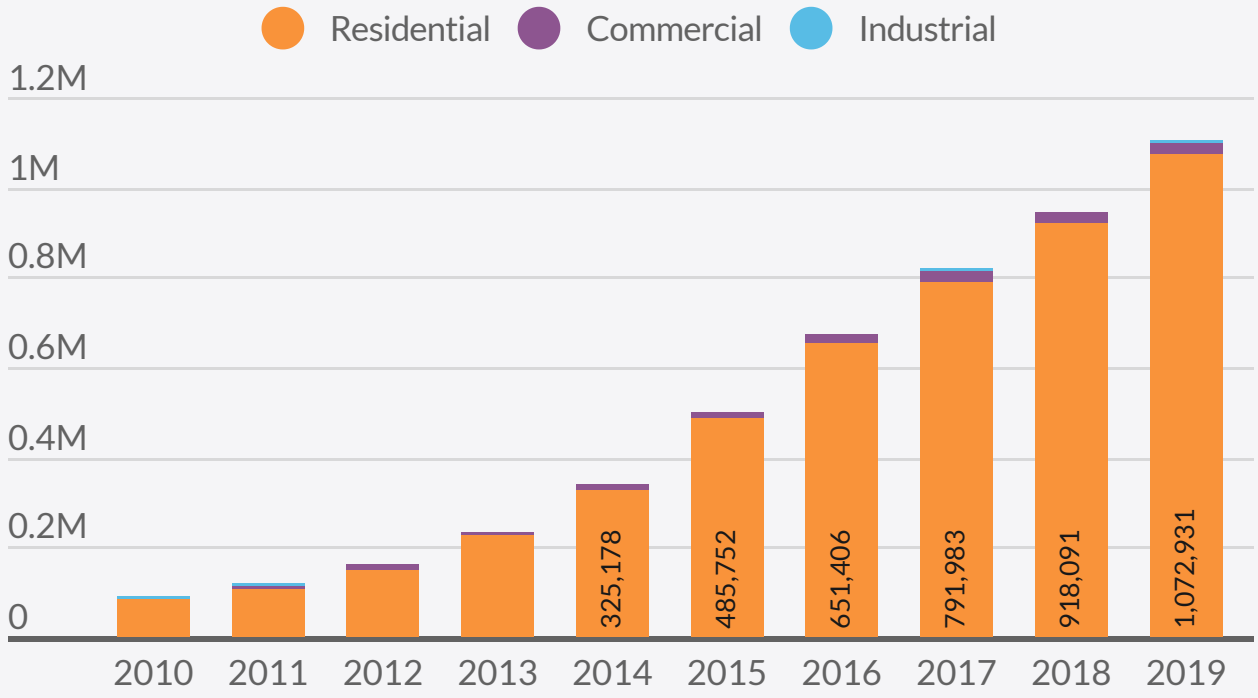
Net metering capacity over time sourced from the Energy Information Administration.

DISTRIBUTED GENERATION: NET METERING CUSTOMERS



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Number of net metering customers sourced from the Energy Information Administration.

ENERGY STORAGE

Installed Capacity: California leads in the utility-scale energy storage market. California currently has 252.5 MW of battery storage and 3,807.1 MW of hydroelectric pumped storage installed, the largest of which are the 351-MW Helms Pumped Storage Project operated by the Pacific Gas & Electric Co. and the 40-MW Vista Energy Storage System operated by Vista Energy Storage LLC. There are 45 battery storage projects and 8 pumped hydroelectric projects in the state.

Policies: The California Public Utilities Commission (CPUC) adopted a mandatory procurement target for energy storage of 1,325 MW by 2020. The target is to be reviewed and increased every two years. In order to advance the growth of storage in the state, in January 2018, the CPUC issued 11 rules that direct utilities to integrate the economic value of energy storage in their resource planning. In 2019, the CPUC issued Decision 19-09-043, which requires utilities to include storage when modelling effective load carrying capabilities (ELCC) values that are used in the bid ranking and selection process. California has several financial incentives for energy storage, including the $378 million Self-Generation Incentive Program (SGIP) for customer-sited energy storage projects from 2017-21 and net metering for facilities with energy storage. A report from the California Energy Storage Alliance, published late last year, said that for California to meet its 2045 clean electricity goal, the state needs 45-55 GW of storage capacity, an indication of how much investment the state will need.

Project Pipeline: California has 2,845.6 MW of planned battery projects in place, the largest of which include a 300-MW Slate Hybrid owned and operated by RE Slate LLC and a 300-MW Dynegy-Moss Landing Power Plant Hybrid owned and operated by Dynegy-Moss Landing LLC.

Key Players: California Public Utilities Commission (CPUC), Pacific Gas & Electric (PG&E), Vista Energy Storage LLC, Southern California Edison (SCE), EDF Renewables Distributed Solutions, Inc., Advanced Microgrid Solutions, San Diego Gas & Electric Co., Los Angeles Department of Water & Power, California Department of Water Resources, U.S. Bureau of Reclamation, VESI Pomona Energy Storage, Inc., Tesla, Inc.

ENERGY STORAGE: POLICIES AND CAPACITY INSTALLED

4,060 MW

Capacity installed

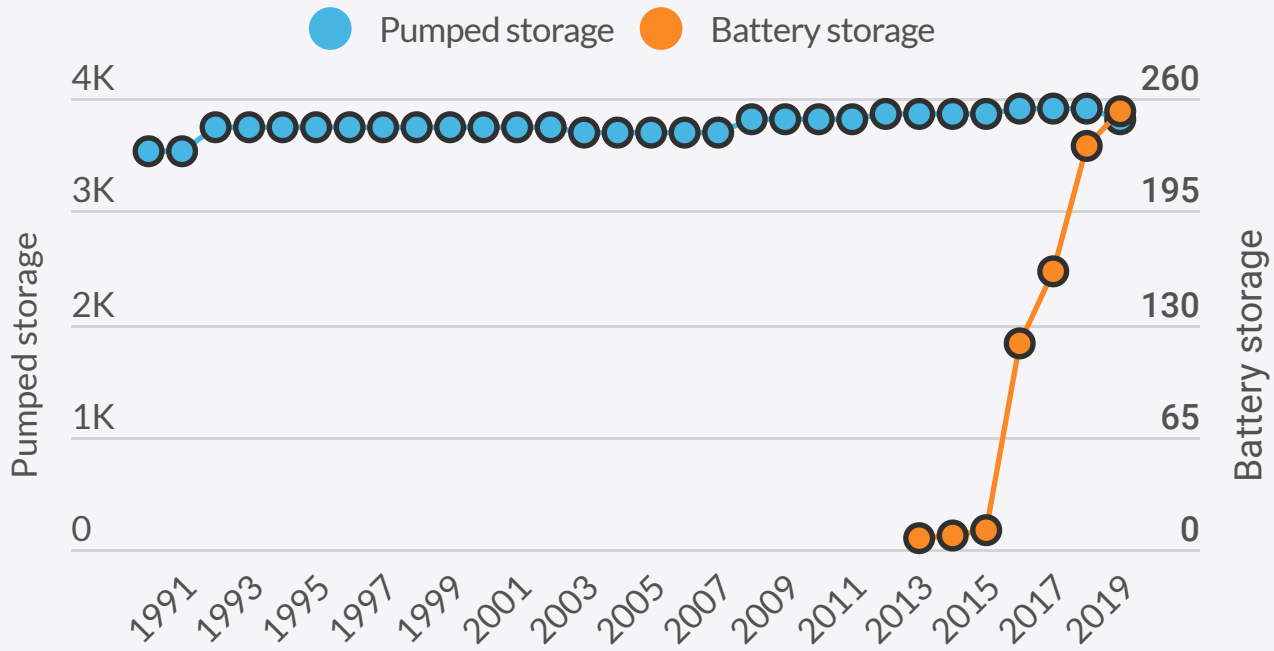
18,571

Energy storage jobs

	Yes/No
Procurement Targets	Yes
Regulatory Requirements	Yes
Demonstration Programs	No
Financial Incentives	Yes
Consumer Protection	No

Targets, policies and incentives maintained by the Pacific Northwest National Laboratory through the United States Department of Energy. Capacity installed sourced from EIA and jobs from USEER.

CALIFORNIA CURRENT ENERGY STORAGE CAPACITY



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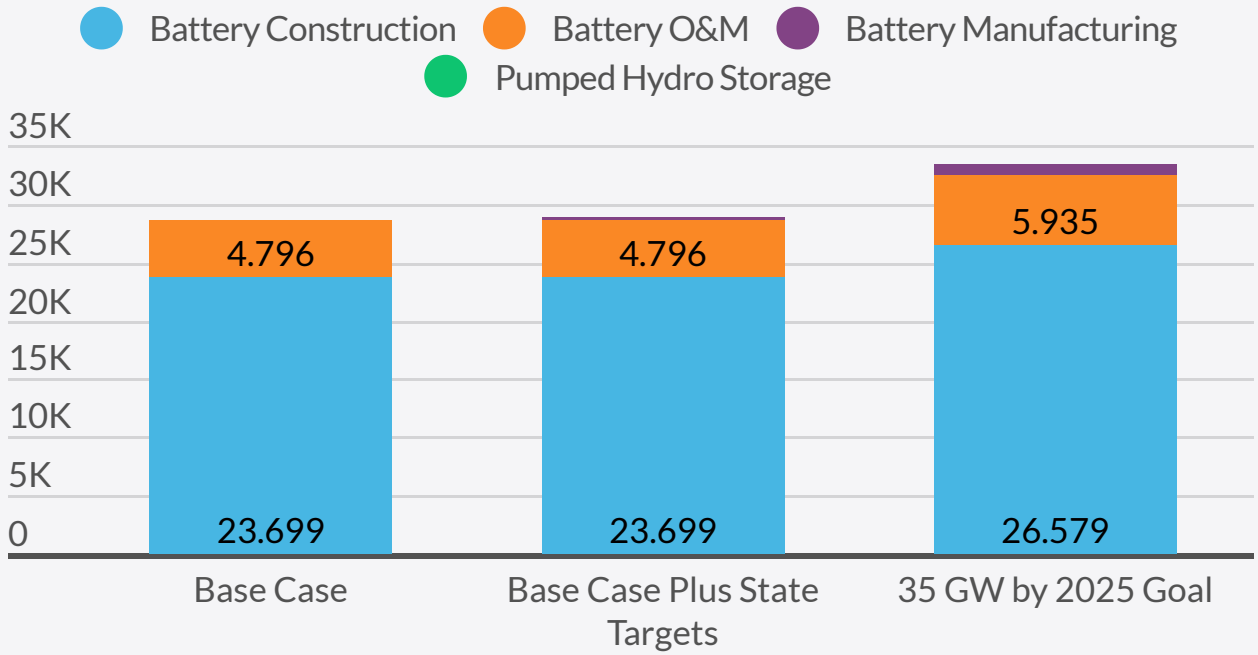
Energy storage generation capacity over time available through the Energy Information Administration.

PROJECTED ENERGY STORAGE FTE ADDITIONS (2021-2025)



Methodology: Battery construction, battery O&M, and Pumped Hydro Storage jobs per MW rates based on historical data and Navigant estimates through 2025; manufacturing based on NAICS 335911 with manual adjustments. Base case capacity forecasts from the EIA pipeline; base case plus state targets includes announced state targets and the 35 GW by 2025 goal is based on an Energy Storage Association vision report. Additional information available in the Appendix.

WASTE TO ENERGY

Biogas: California is ranked 1st nationally for biogas production potential with an estimated 116.22 billion cubic feet of renewable methane per year. The highest potential is in manure (901 systems), food waste (246 systems), wastewater (120 systems) and landfill (27 systems). These systems would result in a combined 3.88 billion in capital investments, 32,342 construction jobs and 2,148 permanent jobs. Furthermore, estimated emissions reductions would be equivalent to having 11.47 million fewer cars on the road. California currently operates 156 wastewater, 77 landfill, 38 manure and 30 food waste biogas systems.

Transport: The state offers a range of incentives and some of the strongest laws and regulations in the nation. California imposes a Low Carbon Fuel Standard (LCFS), Low Emission Vehicle (LEV) Standards and other associated regulations and restrictions on fleet emissions reduction and mobile source emissions. The state imposes requirements on its own purchases: At least 3 percent of bulk transportation fuel purchases should come from low carbon fuels and 50 percent of the state's purchased vehicles should be zero-emission vehicles (ZEVs). California also offers incentives for alternative fuels and alternative fuel vehicles, such as through parking programmes. All initiatives are mapped through the California Transportation Plan, the California Sustainable Freight Action Plan and a biannual Integrated Energy Policy Report from the California Energy Commission.

Biomass: California is 2nd in the country in utility-scale generation from biomass sources (Georgia being first), with two-thirds of its total biomass generation capacity coming from 30 power plants fueled by wood and wood waste. Almost 3 percent of the state's in-state electricity generation came from biomass in 2019, with the 86 total biomass power plants holding an installed capacity of 1,289 MW.

Key Players: California Bioenergy, Anaergia, Calgren/Maas Energy Works, 4Creeks Inc., Western Governors Association, Biomass Crop Assistance Program (Project Area 8), California Biomass Energy Alliance

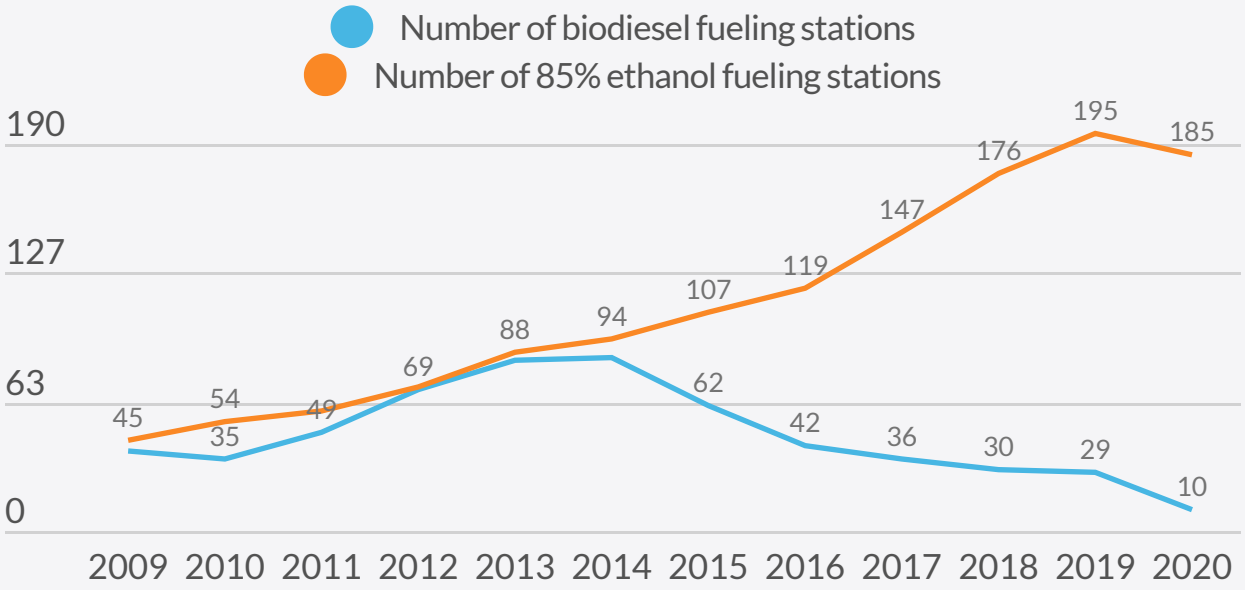
WASTE TO ENERGY: BIOMETHANE POTENTIAL

Biomethane Type	Output (Tonnes/Year)	National Rank
Methane Emissions from Landfills	422,557	1st
Biogas Generation Potential from Wastewater	221,757	1st
Biogas Generation Potential from Industrial, Commercial and Institutional Organic Waste	140,412	1st
Biogas Generation Potential from Animal Waste	321,786	1st

Biomethane generation potential and biomass feedstocks, according to the National Renewable Energy Laboratory's Biofuels Atlas..

WASTE TO ENERGY: BIOFUEL LAWS AND INFRASTRUCTURE

	Strength	Number	Compared to National Average
Number of biodiesel laws & incentives	High	14	140%
Number of ethanol laws & incentives	High	13	138%



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Fueling stations and applicable laws and incentives, according to the United States Department of Energy's Alternative Fuels Data Center.

WASTE TO ENERGY: CAPACITY BY PLANT TYPE

Biopower Plant Type	Production Capacity (MW)	National rank
Landfill Gas	308	1st
Municipal Solid Waste	57	12th
Wood/Wood Waste Biomass	759	1st
Other Waste Biomass	118	3rd
Co-Firing Biomass	6	14th

Production capacities, according to the National Renewable Energy Laboratory's Biofuels Atlas.

HYDROGEN

With 50 policies and incentives on the books, California is the country's leader in hydrogen fueling infrastructure, policy and practices. The state has 44 fuelling stations and 7,883 hydrogen-powered cars on the road and plans to have 200 hydrogen retail filling stations by 2025. The California Energy Commission is spending $20 million annually on hydrogen infrastructure. Between 37 percent and 44 percent of hydrogen used for transportation in California is renewable. Looking forward, Governor Newsom has proposed a COVID recovery bill which includes $1.5 billion in incentives for the purchase of electric or hydrogen vehicles and to invest in the construction of additional infrastructure. Outside of transportation, the state's hydrogen potential extends to storage, heating and cooling.

Key Players: California Air Resources Board (CARB), The California Energy Commission (CEC), California Public Utilities Commission (CPUC), California Environmental Protection Agency, California Hydrogen Business Council, SunLine, Royal Dutch Shell, Toyota Motor, and California Fuel Cell Partnership

HYDROGEN PRODUCTION POTENTIAL NATIONAL RANKING

5th

Rank of hydrogen production potential in the wind sector

11th

Rank of hydrogen production potential in the solar sector

5th

Hydrogen production potential in the biomass sector

9th

Hydrogen production potential across renewable technologies

Hydrogen potential, according to the National Renewable Energy Laboratory's Hydrogen Demand and Resource Analysis Atlas.

HYDROGEN PRODUCTION COST AND RANK BY PROCESS

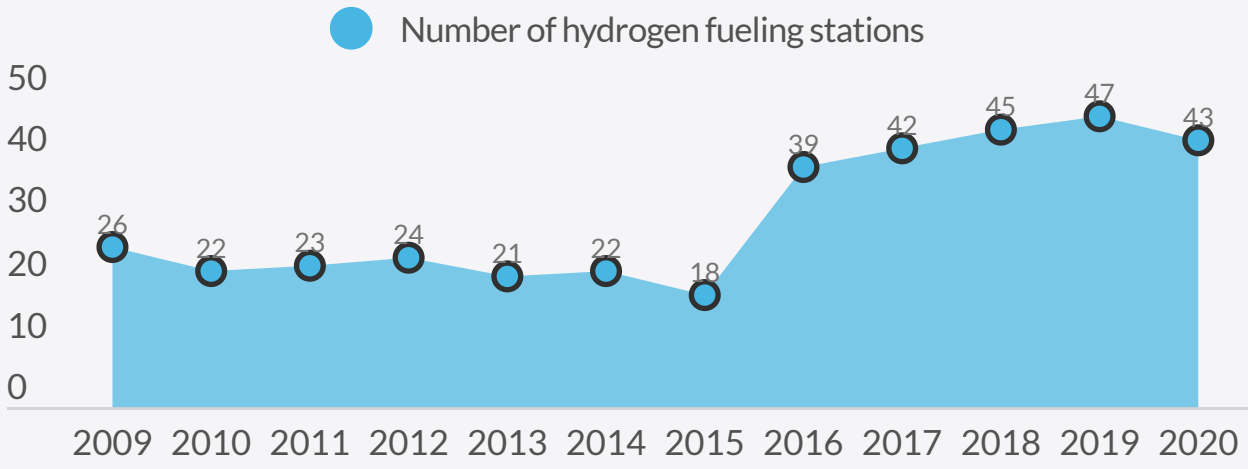
Hydrogen Electrolysis Costs	USD/kg	Rank (Low to High)
Commercial	584	34th
Industrial	494	34th
Residential	578	32nd

Hydrogen Steam Methane Reforming Costs	USD/kg	Rank (Low to High)
Commercial	251	28th
Industrial	244	27th
Residential	263	27th

Hydrogen costs, according to the National Renewable Energy Laboratory's Hydrogen Demand and Resource Analysis Atlas.

HYDROGEN FUELING STATION POLICY AND INFRASTRUCTURE

	Strength	Number	Compared to National Average
Number of hydrogen fuel laws & incentives	High	50	801%



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Fueling stations over time and state laws and incentives, according to the United States Department of Energy's Alternative Fuels Data Center.

GREEN CONSULTANCY

In California, there are currently 12,820 environmental consultants employed, earning an average salary of $87,080.

California's renewable energy consultancy sector is promised strong growth by the state's renewable energy potential of 21,984,738 GWh, driven primarily by rural utility-scale PV and concentrating solar power. California ranks 5th in the nation for renewable energy potential, which represents significant opportunity for green consulting projects and assessments.

Key proposed projects in the state include a major solar PV facility to be run by SE Athos I, along with two large battery facilities to be operated by RE Slate and Dynegy-Moss Landing. Given the state's ambitious climate policies and major technical potential, Climate Advisers expects above-average growth in California's green consulting sector.

CARBON CAPTURE, UTILISATION, AND STORAGE

The cornerstone of CCUS policy in California is the California Air Resources Board's (CARB) Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard adopted in 2019. This and other policy incentives in California mean that up to 20 metric tonnes per year could be captured and stored profitably. CCUS could reduce CO2 emissions in the state by up to 15 percent. The state's SB 100, which established a mandate for 100 percent clean energy by 2045, allows for CCUS, but the established state cap-and-trade program does not provide an official pathway. Although California's geology provides an abundance of opportunities for storage, there are currently no operational CCUS projects in the state, though there are 5 in various states of development. The furthest along is a retrofit of the Elk Hills Natural Gas Power Plant, where engineering planning is complete, but construction has not yet begun. The others range from a retrofit of biomass power plant to a range of biofuel projects. However, without meaningful incentives on the horizon, the outlook for the industry remains mixed.

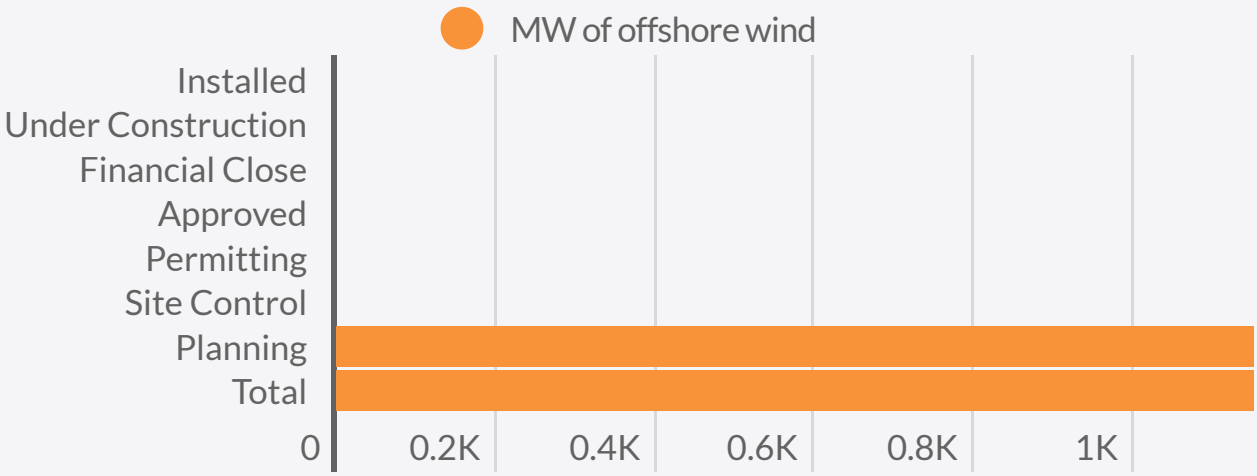
Key Players: Clean Energy System, California Resources Corporation, Oil and Gas Climate Initiative (OGCI), Electric Power Research Institute and California Air Resources Board (CARB)

OFFSHORE WIND

Despite enormous wind potential in the central and northern areas of California's coast, California's offshore wind projects lag behind its East Coast peers. The California Public Utilities Commission estimates that around 7 GW of offshore wind, equivalent to 9 percent of total California's power-producing capacity, could contribute to California's target of carbon-free power generation by 2045. One barrier to offshore wind development in California is the reduced areas available for lease on the central coast because of conflicts with U.S. military operations. Developers argue that these areas are not adequately large enough to create a viable offshore wind industry and reach production targets. Another barrier to offshore wind development is California's coastal water depths. Many states on the East Coast have the natural advantage of shallow waters suitable for offshore wind foundation installation. California's continental shelf drops off steeply, making the installation of fixed foundations more challenging. Floating offshore wind technologies, as they become more commercially viable, could play a key role in California's offshore wind industry. The NREL estimates that 10 GW of offshore wind could generate around $20 billion for California's economy and create 14,890 construction jobs by 2050.

Key Players: EDP Renewables, Principle Power Inc (PPI), Trident Winds; EnBW, Clean Energy States Alliance (CESA), California Wind Energy Association (CalWEA), California Energy Commission (CEC), California Offshore Wind Energy Gateway (COWEG), Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL), Bureau of Ocean and Energy Management (BOEM), 25x25 Alliance

OFFSHORE WIND PROJECT PIPELINE STATUS



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Offshore wind pipeline sourced from the Office of Energy Efficiency and Renewable Energy 2018 Wind Technologies Market Report.