



## California



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### Overview

California is the most populous state in the nation, has the largest economy, and is second only to Texas in total energy consumption.<sup>1,2,3</sup> Although California has the world's fifth-largest economy and many energy-intensive industries, the state has one of the lowest per capita energy consumption levels in the United States.<sup>4,5,6,7</sup> California's extensive efforts to increase energy efficiency and implement alternative technologies have slowed growth in energy demand.<sup>8</sup> The state is also rich in energy resources. California leads the nation in nonhydroelectric renewable-sourced electricity generation and is among the top producers of conventional hydroelectric power.<sup>9</sup> In addition, the state has an abundant supply of crude oil and accounts for one-tenth of the U.S. crude oil refining capacity.<sup>10,11</sup>

The third-largest state by land area, California stretches two-thirds of the way up the West Coast and is more than 1,000 miles long and 500 miles wide.<sup>12</sup> With such great distances to travel, transportation dominates California's energy consumption profile.<sup>13</sup> More motor vehicles are registered and more vehicle miles are traveled in California than in any other state.<sup>14,15</sup> Commute times in California are also among the longest in the country.<sup>16</sup> In addition, the state accounts for one-fifth of the nation's jet fuel use.<sup>17</sup> Overall, the transportation sector accounts for two-fifths of state end-use energy consumption. The industrial sector, which accounts for almost one-fourth of state energy use, is the second-largest energy consumer in California, and the state leads the nation in agricultural and manufacturing gross domestic product (GDP).<sup>18</sup> The commercial and residential end-use sectors consume roughly equal amounts of the state's energy at slightly less than one-fifth each.<sup>19</sup> However, per capita energy use in California's residential sector is lower than that of any other state except Hawaii.<sup>20</sup> In most of California's more densely populated areas, the climate is dry and relatively mild.<sup>21,22</sup> More than two-fifths of state households do not use air conditioning, and about one-seventh do not use space heating.<sup>23</sup>

*Per capita residential energy use in California is lower than that of any other state except Hawaii.*

### Electricity

Renewable resources, including hydropower and small-scale (less than 1-megawatt), customer-sited solar photovoltaics (PV), supplied almost half of California's in-state electricity generation in 2018. Natural gas-fired power plants fueled more than two-fifths.<sup>24</sup> Nuclear power's share of state generation declined from almost one-fifth in 2011 to less than one-tenth in 2018, in large part because of the retirement of the San Onofre nuclear power plant in mid-2013, which left the state with only one operating commercial nuclear power plant—the two-reactor Diablo Canyon facility.<sup>25,26,27</sup>

California has the nation's second-largest conventional hydroelectric generating capacity after Washington state and is among the nation's top four hydropower producers.<sup>28,29</sup> However, hydropower's contribution is highly variable. In 2015, because of prolonged drought, hydropower supplied only about 7% of California's net generation. In 2017, hydropower's share rebounded with increased precipitation, and hydroelectric power plants provided 21% of net generation. In 2018, hydropower's share was about 13%.<sup>30,31</sup>

Fluctuations in California's hydroelectric generation and the reduction in the state's nuclear capacity and generation have been largely offset by renewable generation. Non-hydroelectric renewable technologies, such as solar, wind, geothermal, and biomass, provided about three-tenths of the state's net generation from utility-scale (greater than 1-megawatt) facilities in 2018.<sup>32</sup> There is only a small amount of coal-fired generation in California, and it is all from industrial cogeneration units. In 2018, less than 0.2% of net generation in California was fueled by coal.<sup>33,34</sup>

Expanded transmission capability has helped the Southern California electric grid compensate for the decreased nuclear generation. The Sunrise Powerlink Transmission project, which was put into service in June 2012, added approximately 800 megawatts of transmission capability to the Southern California electric grid. It was designed to link electricity generated from renewable resources in the southeastern corner of the state to San Diego.<sup>35</sup> Additional transmission projects, many aimed at improved system reliability, have come online or are in the planning and construction phase.<sup>36</sup>

In 2018, almost one-third of California's electricity supply came from generating facilities outside the state.<sup>37</sup> From 2013 to 2017, California was the nation's largest importer of electricity from other states.<sup>38</sup> In 2018, more than half of the power delivered to California from states in the Pacific Northwest was from renewable energy sources, including from large federal hydropower facilities. States in the Southwest delivered power generated from coal, renewable resources, natural gas, and nuclear energy. Slightly more than one-fourth of the southwestern power came from renewables, including from hydroelectric power plants, and another one-sixth came from coal-fired power plants.<sup>39</sup> Electricity supplied from out-of-state coal-fired power plants has decreased following the enactment of a state law in 2006 that requires California utilities to limit new long-term financial investments in base-load generation to only those power plants that meet California emissions performance standards. Essentially all of California's imports of coal-fired generation are projected to end by 2026.<sup>40</sup> In 2018, almost all the coal-fueled electricity generation consumed in the state was imported, and coal-fired generation from all sources provided less than 4% of California's power supply.<sup>41</sup>

*Almost one-third of California's electricity comes from outside the state.*

In 2003, California adopted an Energy Action Plan (EAP) to ensure the availability of adequate, reliable, and reasonably priced electric power and natural gas supplies. The plan also called for increased energy conservation and efficiency, new in-state generation facilities, and upgraded and expanded electricity transmission and distribution infrastructure. In 2005, a second EAP (EAP II) was adopted with additional environmental goals to mitigate California's contributions to climate change, and a 2008 update focused on policies that support California's goal to reduce greenhouse gas emissions.<sup>42,43</sup>

Although California has the second-highest electricity retail sales in the nation, after Texas, it has the lowest retail sales per capita.<sup>44</sup> The commercial sector accounts for almost half of all retail sales. The residential sector, where more than one-fourth of California households use electricity for home heating, accounts for slightly more than one-third of sales.<sup>45</sup> Almost all the rest of retail sales of electricity in the state are to the industrial sector. A small amount goes to the transportation sector.<sup>46</sup> California has provided incentives to increase

the use of non-carbon-emitting vehicles, and, by the end of 2018, California drivers owned almost 500,000 electric and plug-in hybrid vehicles.<sup>47</sup> In 2019, nearly one-fourth of the nation's electric vehicle charging stations were in California.<sup>48</sup>

## Renewable energy

California is among the top states in the nation in electricity generation from renewable resources. In 2018, the state was second, after Washington, in total utility-scale electricity generation from all renewable resources, including hydroelectric power. California typically leads the nation in generation from solar, geothermal, and biomass energy. In 2018, the state was also the nation's fourth-largest producer of electricity from conventional hydroelectric power and the fifth-largest producer from wind energy.<sup>49</sup>

One of California's largest renewable resources is solar energy and, in 2014, the state became the first in the nation to get more than 5% of its utility-scale electricity generation from solar energy.<sup>50</sup> California's greatest solar resource is in the state's southeastern deserts where all of its solar thermal facilities and largest solar PV plants are located. However, solar PV facilities are also located throughout the state.<sup>51,52,53</sup> In 2018, utility-scale solar PV and solar thermal facilities together provided about one-seventh of California's net generation. When small-scale generation is included, solar energy provided nearly one-fifth of the state's net generation. In all, California produces more than two-fifths of U.S. total solar PV electricity. More than two-thirds of the nation's utility-scale solar thermal electricity generation also occurs in California.<sup>54</sup> By the end of 2018, California had about 12,000 megawatts of utility-scale solar power capacity, more than any other state, and, including small-scale, customer-sited generation, the state had about 20,000 megawatts of installed solar capacity.<sup>55</sup> The California Solar Initiative uses rebates and grants to encourage Californians to install solar power systems on the rooftops of their homes and businesses.<sup>56</sup> Additionally, the state's 2019 building energy efficiency standards require solar PV systems on all new homes built in 2020 and later.<sup>57</sup>

*California is the top producer of electricity from solar, geothermal, and biomass energy in the nation.*

California is the top producer of electricity from geothermal resources and accounts for almost three-fourths of the nation's utility-scale electricity generation from geothermal energy. About 2,730 megawatts of capacity are installed at 43 operating geothermal power plants located in the state.<sup>58,59</sup> Four areas of California have substantial geothermal resources—the coastal mountain ranges north of San Francisco, volcanic areas of north-central California, near the Salton Sea in southern California, and along the state's eastern border with Nevada.<sup>60</sup> The Geysers, located in the Mayacamas Mountains north of San Francisco, is the largest complex of geothermal power plants in the world and has about 725 megawatts of installed capacity.<sup>61</sup>

*The Geysers in northern California is the largest complex of geothermal power plants in the world.*

California also leads the nation in utility-scale electricity generation from biomass.<sup>62</sup> Two-thirds of California's biomass generating capacity is at the state's 30 power plants fueled by wood and wood waste.<sup>63</sup> Additionally, two wood pellet manufacturing facilities in California have the ability to produce about 140,000 tons of pellets per year. Wood pellets, made mainly from recycled wood waste, are used for heating and for electricity generation.<sup>64</sup>

California routinely has produced more than 5% of the electricity generated at U.S. utility-scale wind farms.<sup>65</sup> In 2018, the state ranked fifth in the nation behind Texas, Oklahoma, Iowa, and Kansas.<sup>66</sup> California's wind power potential is widespread, especially along the state's many mountain crests, as well as in northern California coastal areas both onshore and offshore.<sup>67</sup> Six major wind resource areas and many smaller wind sites have been identified in the state.<sup>68</sup> By the end of the third quarter of 2019, California had more than 5,800 megawatts of installed wind capacity.<sup>69</sup>

Environmental concerns have led to several state policy initiatives that reduce greenhouse gas (GHG) emissions. California enacted the Global Warming Solutions Act of 2006, which set a goal for the reduction of the state's GHG emissions to 1990 levels by 2020 and to 80% of 1990 levels by 2050.<sup>70</sup> California has already exceeded the 2020 goal.<sup>71</sup> To minimize the costs of pollution controls, a system for trading emissions allowances, known as cap-and-trade, was created. The cap-and-trade program set statewide limits on the sources responsible for about 85% of California's GHG emissions.<sup>72</sup> California's Low Carbon Fuel Standard, issued in January 2007, called for a reduction in the carbon intensity of the state's transportation fuels. The standard requires fossil fuel substitutes that demonstrate lower lifecycle GHG emissions than the fuels they replace.<sup>73</sup> A number of alternative processes have been identified that reduce the levels of GHG emissions in the production of ethanol, biodiesel, and renewable diesel.<sup>74</sup> There are about a half dozen ethanol production plants in the state, but California consumes more than one-tenth of the nation's fuel ethanol supply, which is seven times more than the state produces.<sup>75,76,77</sup> California also produces biodiesel from 10 plants that have a combined capacity of nearly 90 million gallons per year, which is far less than the amount consumed in the state.<sup>78,79</sup>

The California renewable portfolio standard (RPS), implemented in 2002 and revised several times since then, requires that 33% of retail sales of electricity in California come from eligible renewable resources by 2020, 60% by 2030, and 100% by 2045.<sup>80</sup> In 2018, an estimated 34% of the state's electricity retail sales were generated from renewables.<sup>81</sup> The state requires that retail electricity suppliers disclose the fuel sources used to generate the power they supply as well as the GHG emissions intensity of those sources.<sup>82</sup> California includes cost-effective energy-efficiency as a resource that can be used to meet the state's clean energy targets. In addition to the RPS, California created an energy-efficiency resource standard. The standard's goal is to lower electricity and natural gas consumption through increased energy efficiency and reduced demand. Targets were set for each of the state's three natural gas utilities and three large investor-owned electric utilities.<sup>83</sup>

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## Petroleum

California has the fifth-largest share of U.S. crude oil reserves and is the seventh-largest producer of crude oil in the nation.<sup>84,85</sup> Reservoirs in the geologic basins along California's Pacific Coast, including the Los Angeles basin, and in the state's Central Valley contain major crude oil reserves. The most prolific oil-producing area in the state is the San Joaquin Basin in the southern half of the Central Valley.<sup>86,87</sup> Several of the nation's largest oil fields, as ranked by reserves, are located there.<sup>88</sup> Overall, California's crude oil production has declined during the past 30 years, but the state remains one of the top producers of crude oil in the nation, accounting for about 4% of total U.S. production in 2018.<sup>89,90</sup>

Federal assessments of California's offshore areas indicate the potential for large, undiscovered recoverable crude oil resources in the federally administered Outer Continental Shelf (OCS).<sup>91</sup> Concerns about the cumulative impacts and risks of offshore oil and natural gas development after the 1969 Santa Barbara oil spill resulted in state legislation that imposed a permanent moratorium on offshore oil and natural gas leasing in state waters.<sup>92</sup> Congress imposed a federal moratorium on oil and natural gas leasing in California federal waters in 1982. The federal moratorium expired in 2008.<sup>93</sup> No offshore California federal lease sales have occurred since then and none were included in the current 2017-22 U.S. Department of the Interior lease sale schedule, but some have been proposed in a draft 2019-24 schedule.<sup>94,95</sup>

California ranks third in the nation in petroleum refining capacity, after Texas and Louisiana, and the state accounts for one-tenth of the total U.S. refining capacity.<sup>96</sup> A network of crude oil pipelines connects California's oil production to the state's refining centers, which are located primarily in the Central Valley, the Los Angeles area, and the San Francisco Bay area.<sup>97</sup> California refiners also process large volumes of foreign and Alaskan crude oil received at the state's ports. As crude oil production in California and Alaska has declined, California refineries have become increasingly dependent on imports from other countries to meet the state's needs.<sup>98,99</sup> Led by Saudi Arabia, Ecuador, and Colombia, foreign suppliers now provide more than half of the crude oil refined in California.<sup>100,101</sup>

Many of California's largest refineries are highly sophisticated and can process a wide variety of crude oil types. To meet state environmental regulations, California refineries are configured to produce cleaner fuels, including reformulated motor gasoline and low-sulfur diesel. Refineries in the state often operate at or near maximum capacity because of the

high demand for those petroleum products.<sup>102</sup> California requires that all motorists use, at a minimum, a specific blend of motor gasoline called CaRFG (California Reformulated Gasoline) as part of an overall program to reduce emissions from motor vehicles.<sup>103</sup> When unplanned refinery outages occur, the lack of CaRFG deliveries available by interstate pipelines means replacement supplies must be brought in by marine tanker from refineries in the state of Washington or on the U.S. Gulf Coast. Refineries in several other countries can also supply CaRFG. Locating and transporting replacement motor gasoline that conforms to California's unique fuel specifications from overseas can take several weeks.<sup>104</sup>

California is the second-largest consumer of petroleum products in the nation and the largest consumer of motor gasoline and jet fuel. Almost nine-tenths of the petroleum consumed in the state is used in the transportation sector.<sup>105,106</sup> The industrial sector, the second-largest petroleum-consuming sector, uses less than one-eighth of the petroleum consumed in the state. The commercial sector accounts for about 2% of petroleum use, and the residential sector consumes less than 1%.<sup>107</sup> Fewer than 1 in 25 California households heat with petroleum products; most of those use hydrocarbon gas liquids (HGL) such as propane.<sup>108</sup>

*California is the largest consumer of motor gasoline and jet fuel in the nation.*

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## Natural gas

California accounts for less than 1% of total U.S. natural gas reserves and production.<sup>109,110</sup> As with crude oil, California's natural gas production has experienced a gradual decline in the past three decades.<sup>111</sup> The state's reserves and production are located primarily in geologic basins in the northern Central Valley. Some natural gas fields are also located in the southern Central Valley, in coastal areas in northern California, and offshore along the Southern California coast.<sup>112</sup>

California's natural gas output equals about one-tenth of state demand.<sup>113,114</sup> Almost two-thirds of California households use natural gas for home heating, and almost half of the state's utility-scale electricity generation is fueled by natural gas.<sup>115,116</sup> Several interstate natural gas pipelines enter the state from Arizona, Nevada, and Oregon and bring natural gas into California from the Southwest, and from the Rocky Mountain region, as well as from western Canada.<sup>117</sup> Almost all the natural gas delivered to California is used in the state or is placed in storage. Some natural gas is exported to Mexico, and a much smaller amount is liquefied and shipped by cryogenic container to Hawaii.<sup>118,119,120</sup>

California has 14 natural gas storage reservoirs in 12 storage fields.<sup>121,122</sup> Together those fields have a natural gas storage capacity of about 600 billion cubic feet.<sup>123</sup> Between October 2015 and February 2016, a natural gas leak at the Aliso Canyon natural gas storage facility in Los Angeles County released about 6 billion cubic feet of methane into the atmosphere.<sup>124</sup> As a result of the incident, new rules covering the management of natural gas storage facilities were put in place at the state level. The new state rules mandate the creation of approved risk assessment and emergency response plans and put in place new testing, monitoring, and data management requirements.<sup>125</sup>

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## Coal

California does not have any coal reserves or production and has phased out almost all use of coal for electricity generation.<sup>126,127</sup> In 2018, coal fueled less than 0.2% of the in-state utility-scale net generation, and all of that power was generated at industrial facilities.<sup>128</sup> Most of the coal consumed in California arrives by rail from mines in Utah. A much smaller amount arrives from Colorado.<sup>129</sup> More than three times as much coal is exported through California ports as is consumed in the state.<sup>130,131</sup>

## Energy on tribal lands

California has the largest Native American population in the nation.<sup>132</sup> The state is home to more than 100 federally recognized tribal groups.<sup>133</sup> Although tribal areas are spread throughout the state, they account for less than 1% of the state's land area.<sup>134,135</sup> Many of the tribal lands are small, including the nation's smallest reservation, the 1.32-acre Pit River Tribe cemetery.<sup>136</sup> The largest is the Hoopa Valley Reservation in northern California's Humboldt County. Two-thirds of that reservation's almost 144-square-mile area is commercial timberland.<sup>137</sup> The Colorado River Tribe Reservation, which straddles the Colorado River and the California-Arizona border, covers about 420 square miles, although only about 67 square miles of its area is within California.<sup>138</sup>

California's diverse geography gives tribes access to a variety of renewable energy resources. In 2005, the Campo Kumeyaay Nation in Southern California leased land for the development of a utility-scale wind project, one of the first on tribal land.<sup>139</sup> The Ramona Band of Cahuilla is one of the first reservations in the nation to become independent of the regional electric grid. They established a microgrid for an eco-tourism project and met the project's energy needs with renewable resources.<sup>140</sup> In 2015, the Bear River Band of the Rohnerville Rancheria in Northern California became the first California tribe to install a hybrid solar, wind, and advanced energy storage microgrid for power generation.<sup>141</sup> The Agua Caliente Band of Cahuilla Indians, whose 31,610-acre reservation includes 6,700 acres in the city of Palm Springs, is working on the development of a combined wind and solar project.<sup>142,143</sup>

Other California reservations are in areas of abundant biomass potential. The Blue Lake Rancheria Tribe in Humboldt County uses wood waste from timber harvesting to fuel a first-of-its-kind biogas fuel-cell system.<sup>144</sup> In 2016, as part of the construction of its microgrid, the members of the Blue Lake Rancheria installed a 500-kilowatt solar array, and, in 2017, their microgrid became operational.<sup>145,146</sup> In 2019, the Rancheria welcomed the broader community, about 10,000 people, or 10% of the county's population, to use their power system during the widespread wildfire-related utility power shutoffs in northwest Humboldt County. Although county residents had no power, the Rancheria did because of its microgrid.<sup>147</sup> In addition to the tribes that have abundant solar, wind, and biomass resources, some California tribal lands have geothermal electricity generation potential, particularly in three areas—the Imperial Valley in southern California, the Geysers area in northern California, and along the state's eastern border.<sup>148</sup>

California tribes often have been among the U.S. tribes selected to receive funding from the U.S. Department of Energy (DOE) for deployment of energy infrastructure projects on tribal lands.<sup>149</sup> In 2018, three tribes received grants for projects that included installation of rooftop solar panels on single-family homes, installation of solar PV at a tribally owned fish hatchery in northern California, and installation of a hybrid solar PV-battery storage-liquid propane microgrid system.<sup>150</sup> In 2019, three more California tribes received funding from the DOE for tribal energy projects—one to expand an electrical distribution and battery storage system, another to integrate solar PV with diesel-fueled generation in a microgrid, and a third to install a parking lot canopy solar PV system.<sup>151</sup>

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## Endnotes

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