PPIC

# Energy and Water

PPIC WATER POLICY CENTER

NOVEMBER 2018

## Energy and water use in California are interconnected

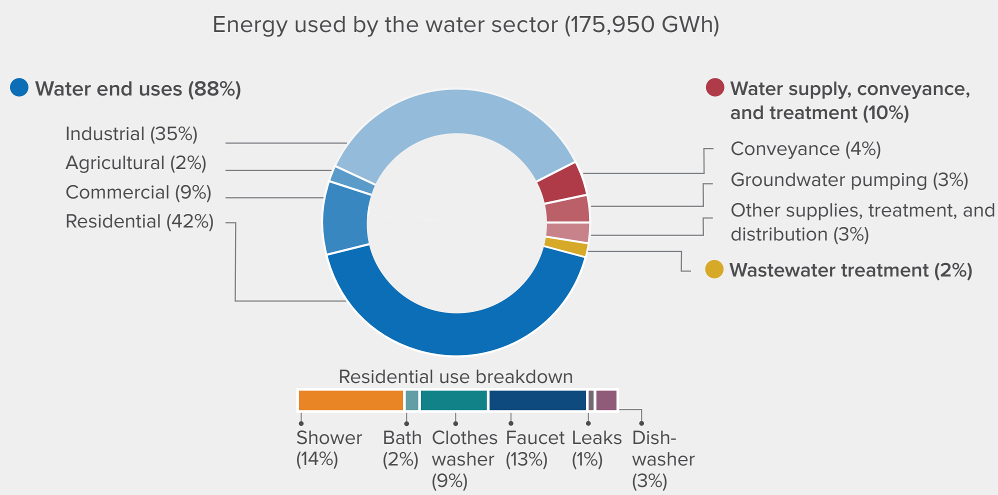
California's water system is energy intensive and may account for up to 10 percent of the state's greenhouse gas (GHG) emissions. According to the most recent estimates, approximately 20 percent of statewide electricity and 30 percent of natural gas for business and home use go to pumping, treating, and heating water. Water is also required to produce energy, including in hydropower generation, thermoelectric power plants, and oil and gas extraction.

Actions that improve water use efficiency can reduce energy consumption. Actions that improve energy efficiency can reduce impacts on water supply and quality. In contrast, some actions to boost the water sector's resilience to droughts can increase energy consumption. And measures to reduce the energy sector's water use can increase energy production costs and GHG emissions.

State policies have begun to promote managing water and energy in tandem. Some programs provide grants for efficiency, and the California Public Utilities Commission is working with utilities to quantify energy savings from water conservation. During the 2012–16 drought, the California Energy Commission (CEC) also launched an effort to reduce the energy sector's vulnerability to water shortages.

Continued population growth and a changing climate will increase pressures on water and energy supplies. To meet this challenge, California will need to continue adopting policies and technologies that improve management while being attentive to costs and trade-offs.

### MOST ENERGY CONSUMED BY CALIFORNIA'S WATER SECTOR GOES TO RESIDENTIAL USE




SOURCE: California Public Utilities Commission, *Embedded Energy in Water Studies. Study 1: Statewide and Regional Water-Energy Relationship* (prepared by GEI Consultants/Navigant Consulting, Inc., 2010).

NOTES: The figure shows total energy use by California's water sector—175,950 gigawatts per hour (GWh). It includes water-related electricity (29% of the total) and natural gas (71%), converted to equivalent measures, for 2001—the last year for which end use estimates are available. Conveyance includes the energy used in the California State Water Project, the Central Valley Project, the Colorado River Aqueduct, and several regional water systems. Groundwater pumping is for urban and farm uses. Irrigation management, such as pressurization, is an agricultural water end use. Residential end uses include energy for heating water and running appliances, but not the embedded energy for supplying or treating water.

## California's water sector is a major energy user

Although agriculture uses roughly four times more water than cities, cities use most water-related energy. End uses of water by retail customers—primarily for residential and nonfarm business purposes—make up almost 90 percent of water-related energy use. Pumping, conveying, and treating water and wastewater account for the rest. Opportunities for reducing energy use often depend on local conditions.

- **Water heating is a major energy use statewide.**
  Heating water requires a quarter of the total energy used in homes, so reducing hot water use and improving heating efficiency can significantly decrease energy consumption. Understanding behavioral factors and incentives that affect residential water use and employing data from smart metering technologies can improve conservation efforts.

- **Energy needs for delivering water vary greatly.**
  Delivering water relies on gravity in some places; in others it must be pumped. Southern California water imported from the northern part of the state is especially energy intensive because it must be pumped through the Sacramento–San Joaquin Delta and over the Tehachapi Mountains. Even within communities, large differences exist in energy required to deliver water to different neighborhoods.

- **Groundwater pumping also requires energy.**
  Pumping water from wells to supply both farms and cities requires energy. During the latest drought, farmers significantly increased groundwater pumping to replace lost surface water supplies. Especially in the San Joaquin Valley, long-term groundwater depletion has increased energy use because water must be pumped from greater depths. Implementing the 2014 Sustainable Groundwater Management Act is expected to stabilize groundwater levels and energy used for pumping over the long term.

- **Some new water sources are energy intensive.**
  To increase the reliability of water supplies, many urban agencies are investing in local sources, including recycled wastewater, stormwater, and desalination. These sources generally use more energy than local surface and groundwater supplies. But they can reduce water's total energy footprint if they displace more energy-intensive imported water—a possibility in Southern California.

- **Water-efficient irrigation technologies can increase energy use.**
  Improving irrigation system efficiency decreases the amount of water applied to fields. These upgrades can reduce the energy required to pump groundwater or to import water from other regions. But these technologies are often pressurized, requiring additional energy. And they enable expansion of acreage farmed, increasing both water and energy use.

- **Water conservation can be a cost-effective way to save energy.**
  One study found that the 25 percent urban water savings achieved during the latest drought resulted in 11 percent more electricity savings than electricity conservation programs run by energy utilities during the same period, at comparable cost.

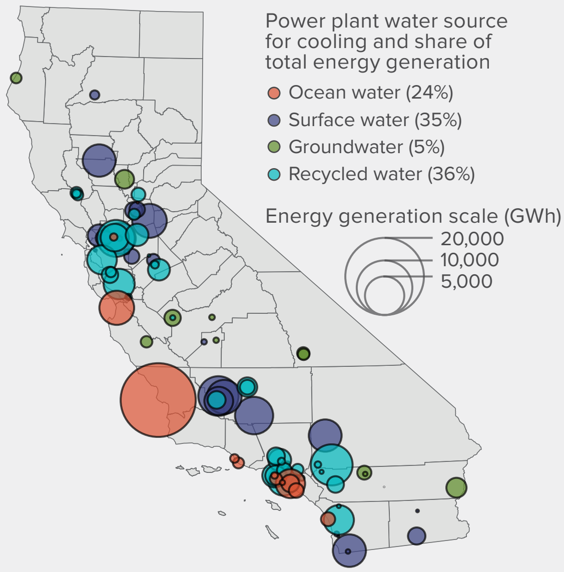
## Energy production requires reliable water supplies

California's in-state electricity generation includes thermoelectric (roughly 70%), hydropower (7% to 22% depending on precipitation and snowpack), and a growing share of other renewable sources, particularly solar and wind (up from 3% in 2010 to 18% in 2017). Thermoelectric and hydropower are highly dependent on water; solar photovoltaic and wind energy systems require little or no water—except in their manufacturing. Extracting oil and gas can also cause issues in water supply and quality.

- **Coastal power plants are changing water use to lessen environmental impacts.**
  These plants historically used "once-through cooling" systems, which take water from the ocean, circulate it through the plant's pipes to absorb heat, and discharge it back into the sea. To reduce harm to aquatic life, in 2010 the State Water Board announced that this practice must end. The "closed-cycle wet cooling" and "dry cooling" power systems being introduced now use less water and recycle it multiple times. These changes help protect ocean ecosystems, but the upgrades are expensive. Sometimes—especially with dry cooling—they are less efficient, raising other environmental concerns, such as air quality and GHG emissions.

- **Inland thermoelectric plants can be vulnerable to drought.**
  Most inland plants already use closed-cycle wet cooling systems. During the latest drought, some Central Valley plants that rely on surface water were at risk of shortages. The California Energy Commission is encouraging the industry to develop drought contingency plans and switch to more reliable recycled water supplies, already the cooling source for 36 percent of the state's power production.

**MOST THERMOELECTRIC GENERATION IN CALIFORNIA RELIES ON RECYCLED WATER OR SEAWATER**




SOURCE: Authors' calculations using data from the California Energy Commission.

NOTES: The map shows thermoelectric power plants—including nuclear, natural gas, geothermal, and biomass—with an installed capacity of more than 75 megawatts per hour. Bubble size represents the actual energy generated in 2015, and color represents the primary source of water used for cooling. The largest coastal plant, the Diablo Canyon nuclear power plant, generated 9.5 percent of all in-state electricity in 2015. It is slated to close by 2025.

- **Hydropower generation is also vulnerable to drought and a warming climate.**

Hydropower production relies on water in rivers and reservoirs. Between 2001 and 2017, in-state hydropower supplied an average of 15 percent of all electricity used, but this share was halved at the height of the latest drought. As the climate warms, loss of snowpack and increased winter runoff will likely reduce high-elevation hydropower in summer when electricity demand is highest.

- **Growth of renewables decreases the electricity sector's reliance on water.**

Senate Bill 100, enacted in 2018, requires that all of the state's electricity come from renewable and carbon-free resources by 2045. This bill also updates the 2030 target for renewable resources, from 50 to 60 percent. Although some renewables also need water—especially geothermal and concentrated solar power plants—shifting toward renewables will decrease the energy sector's overall water dependence.

- **Oil and gas production can affect water quality and local supplies.**

California is the nation's fourth-largest oil producing state, and it also produces some natural gas. To aid extraction, water is injected into wells. During this process, many wells also produce water mixed with oil and drilling fluids, which must be disposed of or treated. As of 2014, well owners must report water volumes used and produced. In 2016, oil and gas production used 5,100 acre-feet (af) of water and produced approximately 50,000 af. Roughly 8,500 of that met standards for domestic or irrigation use.

## Looking ahead

California has been a pioneer in recognizing the nexus between water and energy. But it is still in the early stages of understanding synergies and trade-offs in managing the two sectors to benefit the economy and environment and meet climate policy goals.

**Update estimates of the energy for water end uses.** Much has changed in California's water sector over the past decade. Per capita urban water use has fallen considerably, and at least some of the more recent water savings are likely to persist. Updating estimates of water-related energy can help target effective actions.

**Evaluate the benefits of water conservation and more energy-efficient water systems.** To guide water and energy planning, the state should assess the costs and benefits of various options from both water and energy perspectives. For example, reducing the energy used to heat water may be an inexpensive way to reduce GHG emissions.

**Recognize trade-offs of new water and energy technologies.** To avoid unintended consequences, policymakers and managers need to anticipate such trade-offs. For instance, some new water sources can improve supply reliability but increase energy loads. Water-saving energy technologies like closed-cycle cooling can benefit aquatic habitat but increase costs and emissions.

**Reduce the energy system's vulnerability to drought and a changing climate.** The latest drought's combination of record warm temperatures, low snowpack, and reduced rainfall has provided a window into the future. State and energy-industry officials should continue efforts to understand and reduce the power grid's vulnerability to future droughts and a warming climate. Accommodating shifts in the timing of runoff and greater fluctuations in hydropower production will be essential.

**Explore synergies in water operations and power grid management.** As California increases the use of renewable energy, it will need to accommodate more variable supplies within its power grid. It may help to shift the timing of water heating, pumping, and treatment to periods when renewable sources are more available. With "pumped storage" systems, reservoirs can also act as a battery for excess renewable energy by storing water and converting it to hydropower when other renewables are less available.

**Manage the quality and supply of water in oil and gas extraction.** The reporting requirements on water use and production by oil and gas wells are an important first step to understand the water impacts of this sector. Better understanding of these water quality issues—including opportunities for safe disposal and safe reuse—is the next priority.


## CONTACT A PPIC EXPERT

**Alvar Escriva-Bou**
escriva@ppic.org

**Ellen Hanak**
hanak@ppic.org

## CONTACT THE RESEARCH NETWORK

Newsha Ajami, newsha@stanford.edu
David Jassby, jassby@ucla.edu
Katrina Jessoe, kkjessoe@ucdavis.edu
Jay Lund, jrlund@ucdavis.edu
Edward Spang, esspang@ucdavis.edu
Joshua Viers, jviers@ucmerced.edu
Robert Wilkinson, wilkinson@bren.ucsb.edu


## READ MORE

- CLIMATE CHANGE AND WATER
- THE COLORADO RIVER
- ENERGY AND WATER
- MANAGING DROUGHTS
- PAYING FOR WATER
- PREPARING FOR FLOODS
- PROTECTING HEADWATERS
- PROVIDING SAFE DRINKING WATER
- THE SACRAMENTO–SAN JOAQUIN DELTA
- STORING WATER
- WATER FOR CITIES
- WATER FOR THE ENVIRONMENT
- WATER FOR FARMS

*This series is supported by the annual sponsors of the PPIC Water Policy Center.*



Public Policy Institute of California
500 Washington Street, Suite 600
San Francisco, CA 94111
T 415.291.4400 F 415.291.4401
**PPIC.ORG/WATER**

PPIC Sacramento Center
Senator Office Building
1121 L Street, Suite 801
Sacramento, CA 95814
T 916.440.1120 F 916.440.1121

PPIC | PUBLIC POLICY INSTITUTE OF CALIFORNIA