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Energy and Water

PPIC WATER POLICY CENTER

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Energy and water use in California are interconnected

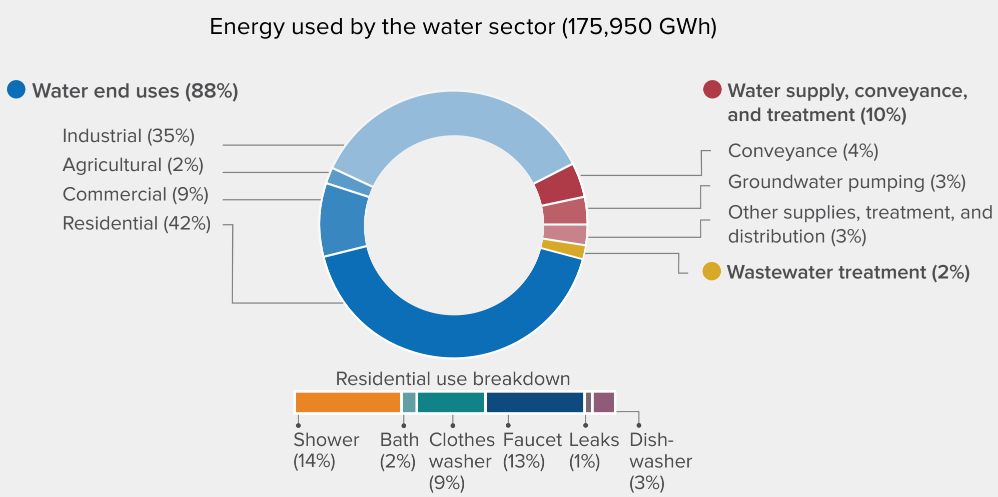
California's water system is energy intensive, accounting for nearly 10 percent of the state's greenhouse gas (GHG) emissions. According to the most recent estimates, approximately 20 percent of statewide electricity use—and 30 percent of business and home use of natural gas—goes to pumping, treating, and heating water. Water is also required for the production of energy. Hydropower generation, thermoelectric power plants, and oil and gas extraction all use water.

Actions that improve water-use efficiency can reduce energy use. Actions that improve energy efficiency can, in turn, reduce energy sector impacts on water supply and quality. In contrast, some actions to boost the water sector's resilience to droughts can increase energy use. And measures to reduce the energy sector's water use can make energy production more costly.

State policies—including efforts to reduce GHG emissions—have begun to promote managing water and energy in tandem. Some state programs provide grants for water and energy efficiency programs, and the California Public Utilities Commission (CPUC) is working with utilities to quantify energy savings from water conservation. During the latest 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 place increasing pressure on water and energy supplies. To meet this challenge, California will need to continue adopting policies and technologies that improve water and energy management, while being attentive to potential 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). The figure 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 system management, such as pressurization, is an agricultural water end use. Residential end uses include energy used in heating water and running appliances, but not the embedded energy for supplying or treating water.

California's water sector is a large energy user

Although California's agriculture uses roughly four times more water than cities, cities use most water-related energy. End uses of water—especially for water heating—make up almost 90 percent of the total. Pumping, conveying, and treating water and wastewater make up the remainder. Opportunities for reducing energy use often depend on local conditions.

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

- **… but energy needs for conveyance vary by region.**
  Delivering water relies on gravity in some regions; in others it must be pumped to its destination. 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.

- **Groundwater pumping also requires energy.**
  Energy is used to pump water from wells to supply both farms and cities. During the latest drought, farmers significantly increased groundwater use to make up for surface water shortages. This roughly doubled their energy consumption compared to pre-drought conditions. Long-term groundwater depletion—especially in the San Joaquin Valley—has increased farm energy use because water has to be pumped from greater depths.

- **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 and desalination of brackish groundwater and seawater. These sources generally use more energy than traditional 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 also increase energy use.**
  Improving irrigation system efficiency decreases the amount of water applied to fields. These upgrades can reduce energy used 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.

Energy production requires reliable water supplies

California's in-state electricity portfolio includes thermoelectric power (roughly 70%), hydropower (7% to 22% depending on precipitation), and a growing share of other renewable sources, particularly solar and wind power (up from 3% in 2010 to 14% in 2015). Thermoelectric power and hydropower are highly dependent on water. Extracting oil and gas also raises issues of water supply and quality.

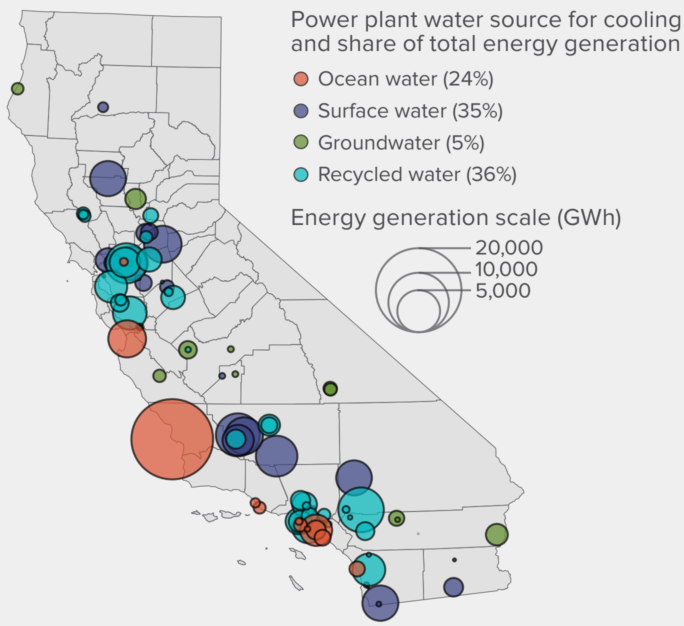
- **Coastal power plants are changing water use to lessen environmental impacts.**
  These coastal plants historically used "once-through cooling" systems, which take water from the ocean, circulate it through the plant's pipes to absorb heat, and discharge it back into the sea. In 2010, the State Water Board announced that this practice must be discontinued to reduce its harmful effects on aquatic life. The "closed-cycle wet cooling" and "dry cooling" power systems being introduced use less water and recycle it multiple times. While these changes help to preserve the ocean environment, upgrading the plants is expensive.

- **Inland thermoelectric plants are 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 CEC is encouraging the industry to develop drought contingency plans and to switch to more reliable recycled water supplies, already the cooling source for 36 percent of power production.

- **Hydropower generation is also vulnerable to drought and a warming climate.**
  Hydropower production relies on water in rivers and reservoirs. Between 2000 and 2015, in-state hydropower supplied an average of 15 percent of all electricity used, but this share was halved during the latest drought. As the climate warms, loss of snowpack and increased winter runoff will diminish high-elevation hydropower generation in summer months when demand is highest.

- **Growth of renewables will decrease the electricity sector's reliance on water.**
  Senate Bill 350, enacted in 2015, requires that half of the state's electricity come from renewable resources by 2030—up from a 33 percent target for 2020. Although some renewables also need water—especially geothermal and concentrated solar power plants—this shift will decrease the energy sector's overall water dependence.

MOST THERMOELECTRIC GENERATION IN CALIFORNIA RELIES ON RECYCLED WATER OR SEAWATER



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

NOTES: The map presents the thermoelectric power plants—including nuclear, natural gas, geothermal, and biomass—with installed capacity over 75 megawatts per hour. The size of the bubbles represents the actual energy generated in 2015, and the 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.

- **Oil and gas production can impact water quality and local supplies.**
  California is the nation's third largest oil-producing state, with 6 percent of US production in 2015. It also produces some natural gas (0.7% of US output). As part of the extraction process, water is injected into wells—more than 55,000 around the state. During the extraction, many wells also produce water that is mixed with oil and drilling fluids. This water must be disposed of or treated. A 2014 law requires well owners to report water volumes used and produced. In 2015 they reported using 5,600 acre-feet (af) of surface water and groundwater (less than 0.2% of all freshwater used by the urban and farm sectors). The production process yielded more than 80,000 af of water, roughly 13,000 of which 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 in water end uses. Much has changed in California's water sector since 2001, when the most recent estimates of energy in water end uses were made. Even before the latest drought, per capita urban water use had fallen considerably, and at least some of the more recent water savings are likely to persist. Updating the profile 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. As an example, reducing the energy used in heating 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 water supply reliability but increase energy loads, and water-saving energy technologies like closed-cycle cooling can benefit aquatic habitat but increase costs.

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. Shifting the timing of some water supply and treatment operations to periods when renewable sources provide higher shares of energy supply may help in this process.

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

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.

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