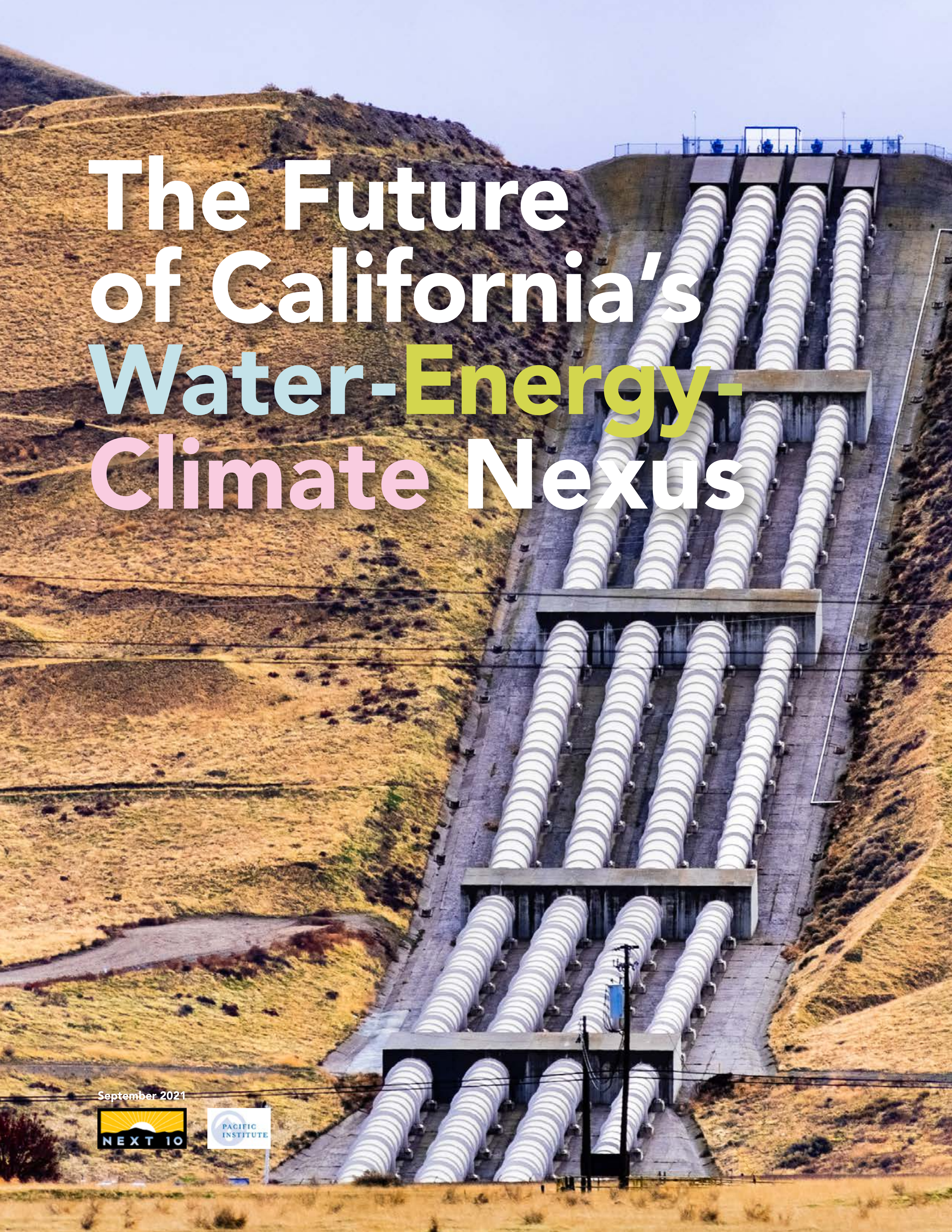

The Future of California's Water-Energy-Climate Nexus

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Next 10 is focused on innovation and the intersection between the economy, the environment, and quality of life issues for all Californians. We provide critical data to help inform the state's efforts to grow the economy and reduce greenhouse gas emissions. Next 10 was founded in 2003 by businessman and philanthropist F. Noel Perry.

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1. EXECUTIVE SUMMARY

Water and energy are inextricably linked in California and, as one resource faces constraints or challenges, so does the other. With the state looking to both reach its climate change goals and decarbonize its economy through a transition to 100 percent clean energy, water will play an integral role. Water is a key input for energy production, and energy is integral to all aspects of water management and use in California—including collection, treatment, heating, and wastewater management. Prior studies have estimated that about 20 percent of California's total statewide electricity use, a third of non-power plant natural gas consumption, and 88 billion gallons of diesel consumption are related to water—from collection and treatment to use and wastewater management—with a large share associated with heating water. These interdependencies between water and energy supplies are commonly referred to as the water-energy nexus.

TABLE E.S.1 Estimated Urban Water-Related Energy and Greenhouse Gas (GHG) Impacts, 2015-2035

Change from 2015-2035	Declining Per-Capita Demand Scenario (Low-Case)	2015 Constant Per-Capita Demand Scenario (Mid-Case)	Water Supplier Projections Scenario (High-Case)
Urban Water Demand	-17%	+24%	+44%
Water-Related Electricity Use	-19%	+21%	+40%
Water-Related Natural Gas Use	-16%	+25%	+45%
GHG Emissions From Urban Water-Related Energy Use	-41%	-12%	+2%

Many factors affect California's water demand and supply portfolio, and the implications of multiple, ongoing changes to the state's water resources on future energy use are not well understood. California has experienced a dramatic decoupling between water use and growth over the last 40 years. Total urban demand has declined, particularly since 2005, despite continued population and economic growth due to end-use efficiency improvements and less water-intensive commercial and industrial activities. At the same time, urban water suppliers are pursuing local water supply options, many of which are more energy-intensive than traditional water sources but still less energy-intensive than imported water. Agricultural water use has remained relatively flat since the 1980s despite a significant increase in the economic value of crop production. Agriculture, however, is particularly dependent on unsustainable groundwater extraction, and pumping has become increasingly energy-intensive as groundwater levels have fallen around the state. Climate change, with impacts on water availability, quality, and demand, may accelerate these trends.

Water and energy trends in California also affect greenhouse gas (GHG) emissions for the state. In California, electricity generation—the main energy source for the provision and treatment of water—is undergoing structural reform to decarbonize and reduce its GHG intensity. There are also state programs and policies to incentivize switching to electric water heating, which is the most energy-intensive end-use of water and is still largely done using natural gas water heaters. While these policies and incentives help limit the energy- and carbon-intensity of the state's water sector, as droughts worsened by climate change continue to place constraints on both water supply and quality—both the energy- and carbon-intensity related to water are in danger of increasing. These complex interactions between changing water supply and demand trends, grid decarbonization, and electrification of water heaters will affect California's water-related GHG emissions.

In this analysis, the report authors evaluated the combined impact of emerging trends on California's water (including population growth, climate change, and policies to promote water efficiency and alternative water supplies) and electricity (including generation decarbonization) on the state's water-related energy and GHG footprints from 2015 to 2035. The latest available (2015) water demand and supply data from water suppliers and state water agencies were used to develop various scenarios of future water resources and to estimate associated energy and GHG emissions out to 2035. Key findings from the study, summarized in Tables ES.1 and ES.2, include:

Urban Findings:

- **If urban per-capita water demand is maintained at current (2015) levels, statewide urban water demand would increase 24 percent (1.3 million acre-feet, or MAF) between 2015 and 2035 with population growth.** This "mid-case" scenario would result in a 21 percent increase in annual water-related electricity use (from about 30,000 GWh to 36,000 GWh) and a 25 percent increase in annual natural gas use for water heating (from about 150,000,000 to 190,000,000 MMBtu).
- **If per-capita water demand increases to levels consistent with urban water suppliers' projections (a "high-case" scenario), urban water demand would increase by 44 percent (2.4 MAF) between 2015 and 2035,**

TABLE E.S.2 Estimated Central Valley Agricultural Water-Related Energy and Greenhouse Gas (GHG) Impacts, 2015-2035

Change from 2015-2035	Low Ag Water Use Scenario	Mid Ag Water Use Scenario	High Ag Water Use Scenario
Agricultural Water Supply Delivered	-3%	-2%	-5%
Water-Related Electricity Use	-5%	-4%	-6%
GHG Emissions From Agricultural Water-Related Energy Use	-62%	-62%	-62%

resulting in a 40 percent and 45 percent increase in related electricity and natural gas use, respectively. As the state replaces fossil fuel generators with more renewable resources, the GHG intensity (greenhouse gases emitted per unit of energy produced) of California's electricity is expected to decline, and consequently GHG emissions associated with urban water-related energy use (electricity and natural gas) are projected to decrease about 12 percent in the mid-case scenario. However, in the high-case scenario, GHG emissions increase two percent because growing natural gas use offsets some of the impact of decarbonization in the electricity sector.

- **The authors found that more comprehensive water conservation and efficiency efforts in urban California could reduce water-related electricity usage by 19 percent, natural gas use by 16 percent, and GHG emissions by 41 percent cumulatively between 2015 and 2035.** Because indoor residential water use is the most energy-intensive subsector (driven by high energy requirements for end-use, treatment, and wastewater treatment), water conservation and efficiency improvements for this subsector could dramatically decrease the energy use and GHG emissions that would result from the mid- and high-case scenarios.
- **While the total annual electricity use related to urban water use increases in the mid-case scenario, the average energy intensity of water—the total electricity used per unit of water used—decreases by two percent between 2015 and 2035.** This decrease is driven in part by a shift away from energy-intensive imported water toward alternative local water sources, including brackish desalination (+7,000% increase in supply between 2015 and 2035 from the current low levels), potable recycled water (+300% increase in supply between 2015 and 2035), and captured stormwater (+19,000% in supply between 2015 and 2035). The shares of these alternative sources among the statewide urban water supply portfolio remain relatively small in this scenario but have important implications for total energy use because they are less energy-intensive than imported water in most regions of California, especially in Southern California.

Agricultural Findings:

- **Central Valley agricultural water use under the mid-case scenario is projected to decline by two percent, or 0.3 MAF, between 2015 (23.4 MAF) and 2035 (23 MAF).** This decline is driven by the state's projection that urban population growth will encroach on agricultural lands. Under this scenario, the associated electricity use decreases four percent (from 14,200 to 13,600 GWh), and GHG emissions decrease about 60 percent.[1] The proportionally larger reduction in electricity usage compared to water use is due to expected reductions in supply from relatively energy-intensive water sources, such as imported water. Likewise, the proportionally larger reduction in GHG emissions is due to statewide efforts to decarbonize its electricity generation. Climate change is assumed to have minimal impacts on agricultural water use by 2035 across all of the scenarios; however, changes in temperature, precipitation, and evapotranspiration are likely to have a much larger effect on both supply availability and irrigation demand toward the end of century.

1 These GHG emissions are entirely from electricity because natural gas agricultural use was not calculated.

- **There are also large uncertainties in the future energy use of Central Valley agriculture because of its dependence on groundwater, which the state has mandated through the Sustainable Groundwater Management Act (SGMA) to reach sustainable levels by 2040.** If pumping volumes are maintained at current levels and groundwater depths drop to the proposed minimum thresholds (levels of groundwater beyond which any reduction would cause undesirable effects in the basin), the authors estimate agricultural water system energy intensity would increase by 20 percent and six percent for the San Joaquin and Tulare regions, respectively. This would increase overall energy use for agricultural water in the San Joaquin and Tulare regions by about 16 percent by 2035. Permitting groundwater levels to rise can reduce the magnitude of the increase, as can improvements in pump efficiency. Likewise, shifting the timing of energy usage to coincide with times of renewable electricity generation could reduce the impact on GHG emissions.

Cross-Cutting Findings:

- **Overall, urban water efficiency improvements have the largest beneficial effect on California's water-related energy use and GHG emissions because urban water is much more energy-intensive than agricultural water.** Even though Central Valley agricultural water use is projected to be almost three times that of the urban sector by 2035, agriculture's water-related electricity usage is about half, primarily because irrigation is less energy-intensive than water treatment and heating for urban end-uses. In the mid-case, the energy intensity and total GHG emissions related to urban water statewide are about 9 times that of Central Valley's agricultural water (5,400 kWh/AF and 14 million tons CO_2 for urban water, compared to 600 kWh/AF and 1.4 million tons CO_2 for agricultural water by 2035). GHG emissions from other aspects of the agricultural sector are not included in this assessment.
- **Water-related GHG emissions are driven by the pace of California's electricity decarbonization and end-use electrification.** The increasing share of renewables in the generation portfolio is estimated to effectively minimize the electricity component of these GHG emissions. Natural gas usage, mostly for heating water in residential and non-residential settings, is projected in the mid- and high-case scenarios to rise, which could cause GHG emissions from urban water use to increase overall. Therefore, there is an opportunity for water-energy partnerships to promote the electrification of water-end uses (water heaters) to reduce the state's GHG footprint.

Policy Recommendations:

The report authors identify specific water policies that could play an important role in helping the state meet energy and GHG goals:

- Expand urban water conservation and efficiency efforts;
- Accelerate water heater electrification;
- Maintain groundwater levels and expand flexible, high-efficiency groundwater pumps;
- Provide financial incentives and regulatory pathways for water suppliers to invest in less energy- and GHG-intensive water systems, including through existing financial incentives and programs for energy efficiency and GHG reduction;
- Expand and standardize water data reporting and energy usage tracking; and
- Formalize coordination between water and energy regulatory agencies about forecasted energy demand changes.