THE FUTURE OF ENERGY, ENVIRONMENT, AND NATURAL RESOURCES

A CALIFORNIA 100 REPORT ON POLICIES AND FUTURE SCENARIOS

CALIFORNIA 100

VISION & STRATEGY FOR THE NEXT CENTURY

ABOUT CALIFORNIA 100

The California 100 Initiative envisions a future that is innovative, sustainable, and equitable for all. Our mission is to strengthen California's ability to collectively solve problems and shape our long-term future over the next 100 years.

California 100 is organized around 15 policy domains and driven by interrelated stages of work: research, policy innovation and engagement with Californians. California 100's work is guided by an expert and intergenerational Commission. Through various projects and activities, California 100 seeks to move California towards an aspirational vision—changing policies and practices, attitudes and mindsets, to inspire a more vibrant future.

This California 100 Report on Policies and Future Scenarios was produced as part of California 100's research stream of work, in partnership with 20 research institutions across the state. California 100 sponsored grants for data-driven and future-oriented research focused on understanding today and planning for tomorrow. This research, anchored in California 100's 15 core policy domains, forms the foundation for the initiative's subsequent work by considering how California has gotten to where it is and by exploring scenarios and policy alternatives for what California can become over the next 100 years.

The California 100 initiative is incubated through the University of California and Stanford.

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READ MORE ABOUT THE FUTURE OF ENERGY, ENVIRONMENT, AND NATURAL RESOURCES IN CALIFORNIA

For additional background information, read the related Facts-Origins-Trends report at California100.org. The Facts-Origins-Trends report contains all of the references and citations to support the content of this report.

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CALIFORNIA 100 RESEARCH PARTNERS

This Report is one of 15 reports that will be released in 2022 as part of the California 100 Initiative. We are proud to partner with the following research centers and institutes across California on our work:

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Center for Environmental Public Policy

ABOUT THE UC BERKELEY, GOLDMAN SCHOOL, CENTER FOR ENVIRONMENTAL PUBLIC POLICY (CEPP)

The Center was established in 2001 due to growing student interest in environment, energy, and climate policy. The Center's research and publications have addressed a wide variety of challenges associated with climate change, clean energy, environmental justice, and the interactions between pollution control and the economy. CEPP's focus areas in recent years include: air pollution hotspot abatement in minority neighborhoods of Oakland; green public finance; transportation electrification; port and freight pollution; and, electric power sector decarbonization. The Center's staff, consultants, graduate student researchers, and partner organizations work to synthesize scientific, economic, technical, social, financial, and political information to advance policy reform. CEPP collaborates with scientists, community-based organizations, elected and appointed officials, industry representatives, academic leaders and students. The Center is directed by David Wooley, whose experience in government, philanthropy, law and industry help shape the Center's research agenda. Dan Kammen of UC Berkeley's Energy Resource Group serves as Faculty Advisor.

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FOREWORD

"As California Goes, So Goes the Nation, Alas." That was a headline from a *Los Angeles Times* opinion column on April 30, 1989, which noted that, even though "Californians have long considered their state the cutting edge of social and political change… [it] no longer seems the vanguard of political innovation. Other states rarely look to California for policy initiatives."

Fast-forward to 2022, and few would proclaim that California lacks in policy innovation. Quite the contrary. The state has enacted a variety of policies ranging from expansions in immigrant rights and voting rights to health care and higher education, and from large-scale experiments in guaranteed income to ambitious moves towards net-zero emissions in a variety of sectors. And despite the periodic waves of "doom and gloom" reporting about the state, California's economic output over the last 25 years has grown faster than the national average, and on par with GDP growth for the state of Texas.

Even so, much remains to be done. The California Dream has always been marred by a high degree of racial exclusion, and it remains out of reach for millions in the state—whether measured by health outcomes, unaffordable housing, or massive disparities in income and wealth. California also recognizes that future progress depends on recognizing and correcting historical wrongs. Its Truth and Healing Council, for example, will provide recommendations aimed at prevention, restoration, and reparation involving California Native Americans and the State. If California's racial diversity represents America's demographic reality by 2100, our work is essential—not only for the long-term success of the state, but also for our country's innovative and equitable future.

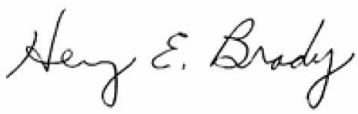
This future-focused work is especially pressing today. The COVID-19 pandemic has scrambled a state and nation already undergoing significant changes in economics, politics, and society. The harmful consequences of climate change are at our doorstep,

with forest fires and droughts that grow in frequency and intensity each year. The weakening of local media and the growth of disinformation threaten both our civic health and our public health. And staggering inequities in income and wealth, home-ownership and health, threaten the state's reputation as a haven for migrants, domestic and international alike.

In addition to immediate threats that affect our long-term future, we also see plenty of opportunity. Record increases in federal and state spending mean that billions of additional dollars are flowing to state, local, and tribal governments in California. Many jurisdictions are looking to invest in infrastructure that meets the long-term needs of their communities. Philanthropic institutions and individual donors are also looking to make transformative investments that have enduring impact. We have an opportunity to inform and enrich all of these plans and conversations.

Most institutions and organizations in California are focused on immediate challenges, and don't have the luxury of time, dedicated talent, and resources to focus on long-term futures. California 100 is grateful for the opportunity to provide added value at this critical time, with actionable research, demonstration projects, and compelling scenarios that help Californians—government agencies, stakeholder groups, and residents alike— to envision, strategize, and act collectively to build a more innovative and equitable future.

Karthick Ramakrishnan, Ph.D.
Executive Director



Henry E. Brady, Ph.D.
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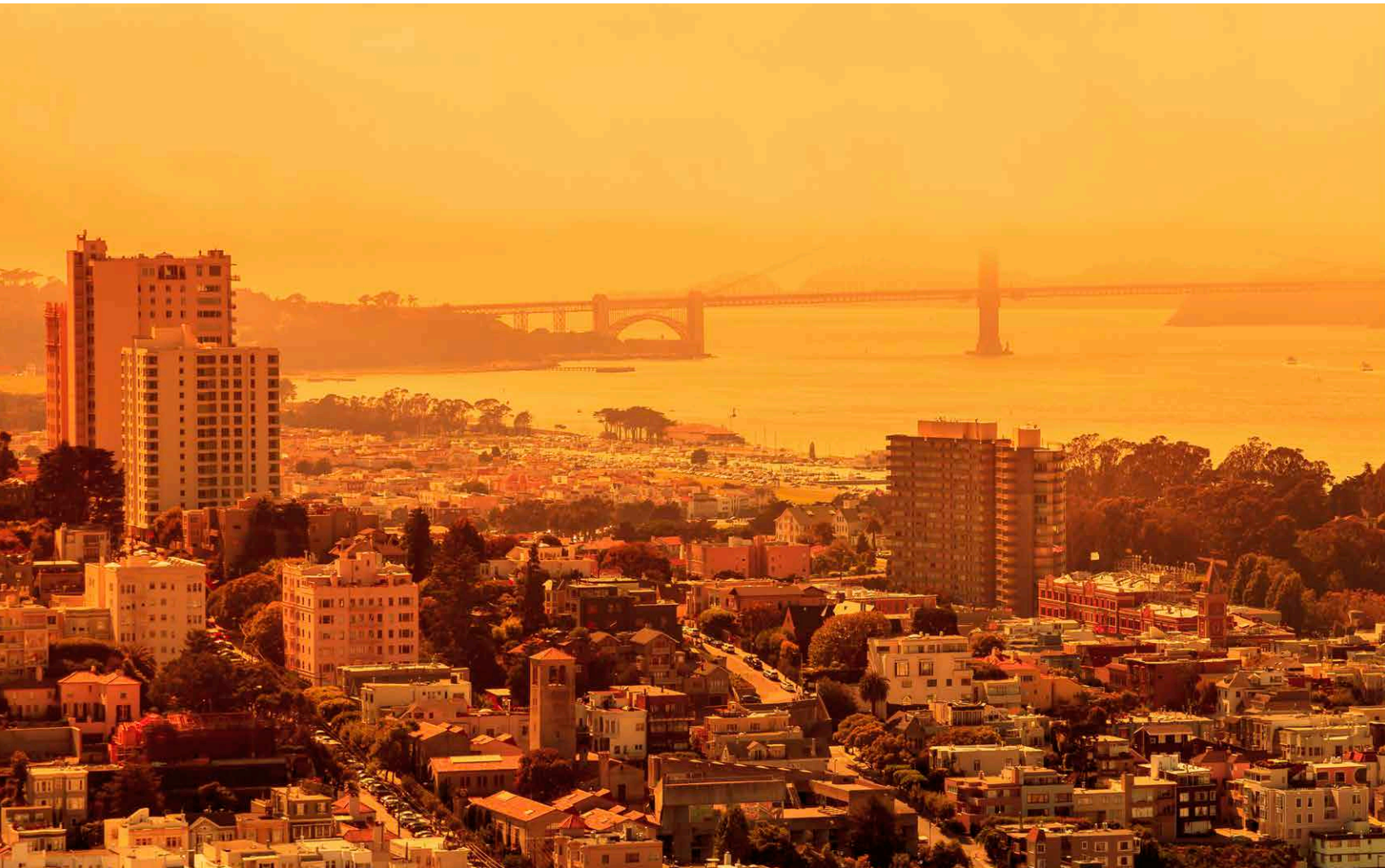
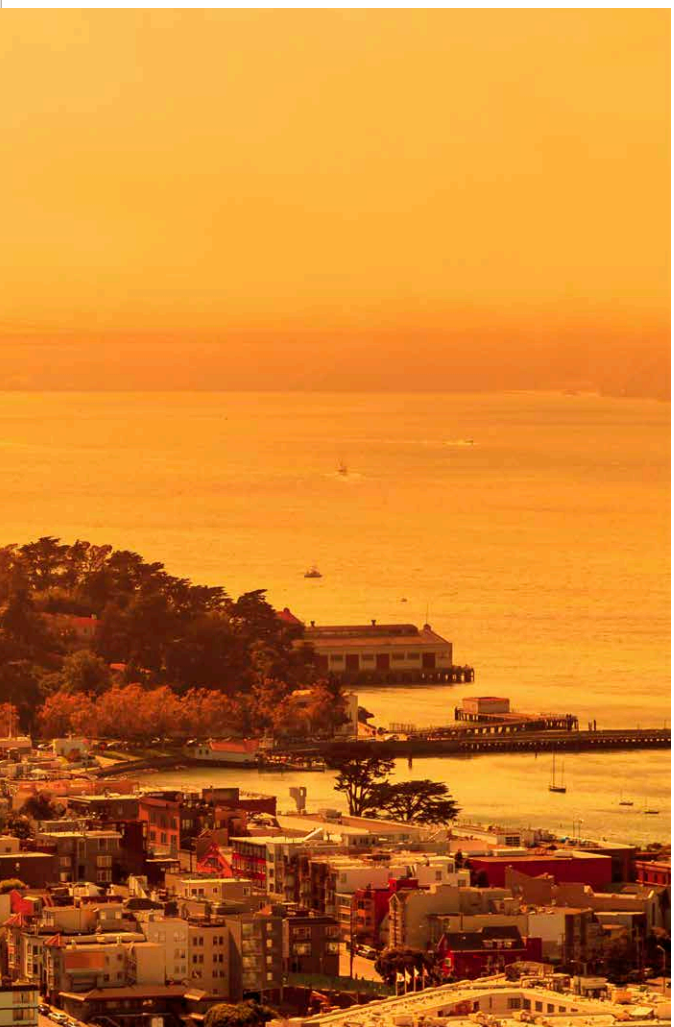
CALIFORNIA'S ENERGY, WATER, AND CLIMATE CHANGE PROBLEMS

A prosperous and livable California depends on a stable climate and sustainable energy and water supplies. Today, California has neither. In the face of accelerating climate change and rising fossil energy costs, the state is working to transition its electricity and transportation sectors, industrial output, building stock, and water systems to zero-carbon technologies. California has established itself as a global leader in reducing global greenhouse gas (GHG) emissions, and with 12 percent of the nation's population and with one of the nation's strongest economies, it produced only 7 percent of the nation's GHG in 2017. California's work on climate protection is far from complete. Transition to zero carbon transportation has just begun. More is needed to reach a low carbon electric sector, and the state has a huge task ahead to address impacts of climate change on water supply.



There are 30 to 50 years of work ahead to succeed. It will not be easy, but solutions are within California's grasp to solve the climate crisis and produce employment and public health benefits.



Moreover, California needs to make progress on climate protection and adaptation in the face of more intense droughts, heat storms, wildfire, flooding, reduced snowfall in the Sierras, and increased evaporation in reservoirs and canals. California's aquifers are being over-pumped and its agricultural industry is threatened. California must face these challenges. There are 30 to 50 years of work ahead to succeed. It will not be easy, but solutions are within California's grasp to solve the climate crisis and to produce very large employment and public health benefits.

Although debate rages around the tactics for fighting climate change, there is a broad scientific consensus that it must be dealt with. Failure is not an option. Research shows that unabated climate change will be catastrophic for present and future generations, here and globally. For California, climate change threatens sustainable water supplies for cities, agriculture, and the environment. Most Californians believe that climate change is real and caused in large part by human activity, that clean energy investment can help, and that the state needs a long-term plan for water supply. [1]

[1] An August 2021 CBS News/YouGov poll found that 79 percent of Californians thought that climate change would affect California a lot (46%) or some (33%).

This report describes water policy as a critical example of what must be done to adapt to climate change. Because California has already taken important actions to decarbonize and because it seems highly unlikely that California will reverse course, the report also highlights California's opportunity to influence other states and national governments through its climate policy innovations. There is a long history of California leadership on pollution control, climate policy, scientific research, and low-carbon product development and market structures. So, it is critical that California gets this right, finds effective ways to export knowledge, and use its culture of innovation to lead climate mitigation and adaptation globally.

Technology plays a critical role in reducing GHG emissions and adapting to climate change. However, it is clear that technology alone will not solve the climate crisis. People and businesses will need to consume less, travel less and differently, conserve water, change diets, and alter other behavior patterns—either out of a sense of public service or because conditions increasingly force changes in the way we live.

Events in recent years remind us of the urgent need to address the racial equity issues and injustices that permeate U.S. society. Equity issues are everywhere, and are particularly evident in climate, energy, and natural resource policy. Air pollution that plagues communities of color is often co-emitted with GHGs. Low-income communities in the U.S. and worldwide are often the first to suffer from climate change and least able to adapt to its effects. Workers displaced from declining

fossil-based industries are often from low- or middle-income communities of color. Well-planned climate mitigation and adaptation can relieve these health and safety burdens and transition oilfield, refinery and auto maintenance workers to new, living wage employment. It is essential to prioritize climate investments to reduce community exposure to fossil fuel emissions, fairly transition fossil industry workers, ensure safe drinking water for all, and help the most vulnerable adapt to heat and flooding effects of climate change.

Given the scope of the climate challenges confronting California, this report narrows the discussion to the best developed options with the most potential to reduce GHG emissions and to adapt energy, transportation, and water systems to climate change. Although the report analyzes the impacts of technologies that are already here and still developing (such as wind and solar power and renewable hydrogen), it does not address all the potential technologies and approaches on the distant horizon, such as clean and low-cost nuclear power, seawater desalination, and direct air capture. But clearly, emerging technologies will be important, and strong research funding from state and federal government and corporations will be important in the short and long term.

CALIFORNIA'S WATER PROBLEM AS AN INDICATOR OF CLIMATE CHANGE

California has the most variable climate of any state in the country, oscillating, sometimes drastically, between dry years and wet years.

Drought is a natural and familiar feature of the state's climate. Regional climate differences within the state are also highly variable: the arid regions of southern California receive only about 5 percent as much rainfall in a typical year compared to some mountainous regions in the north. Through one of the largest water conveyance systems in the world, water is delivered from where there is more of it with relatively less demand, to where there is less of it and greater demand. Herein lies one of the state's fundamental paradoxes—and one of its greatest climate vulnerabilities. For a century, California has largely been able to decouple regional water scarcity and variable precipitation from year-to-year water supply. Barring transformational changes to existing water management practices, climate change seriously threatens that balance.

Climate change is increasing water scarcity and the volatility of California's climate. As average temperatures rise in the state, long-term average annual rainfall is expected to remain fairly stable, but the frequency and distribution of rainfall is expected to change markedly. When storms do occur, they will be more extreme, dropping more rain all at one time, and with less precipitation falling as snow. These changes will make both drought and floods more intense and more harmful to society and the environment. The 2012–2016 drought was the hottest in recorded history and the first two decades of the 21st century may constitute one of the driest periods in the last few thousand years, what some scientists call a "megadrought." California's 2021 water year was the driest in a century.

California has always grappled with challenges related to water supply and management—and climate change makes these problems harder to solve. Water has important equity implications, since one million Californians today lack access to safe and reliable drinking water and water supply is needed to maintain the health of native species and habitats. Increased climate volatility—dryer dry years; and wetter wet years—puts strain on California's water system, limiting the ability to solve existing problems while reducing resilience to future climate impacts. California is experiencing, and must urgently mobilize responses to, the negative, water-related impacts of climate change.

In the face of these problems, California's physical water infrastructure is aging, outdated, and increasingly vulnerable to the impacts of climate change. Many dams and reservoirs in California are old and were not designed for current or future hydrologic conditions. Increased climate volatility will make it more difficult to manage reservoirs to fulfill competing objectives of water storage, flood protection, and environmental flows. Larger storms forecasted under climate change increase the risk of catastrophic dam failure, as witnessed in the 2017 Oroville Dam crisis.

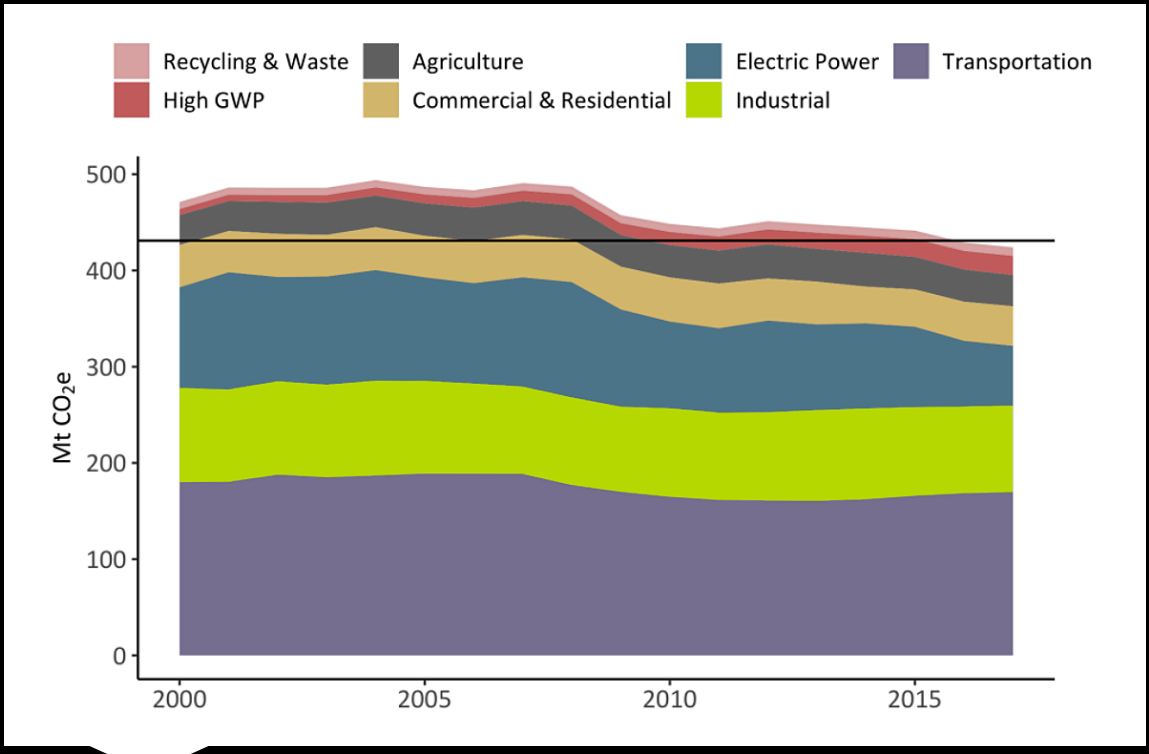
Unsustainable use of groundwater has caused significant land subsidence in many parts of the Central Valley, compromising critical water conveyance infrastructure, such as the Delta-Mendota and Friant-Kern Canals. These impacts reduce the flexibility of our water system, increase operating costs, and require millions, if not billions, in mitigation expenses. Groundwater overdraft has also caused thousands of drinking water wells in the Central Valley to run dry, has reduced water quality in other wells, and has increased operating costs. Thousands more wells could run dry if drought persists, posing a drinking water crisis in some regions. The groundwater problems aggravate related problems regarding surface water supplies for domestic and agricultural uses. Because of its water crisis, California has an enormous stake in reducing global warming, but even under the best of conditions, California has to rethink its water policies to adapt to climate change.

SECTORS THAT PRODUCE GREENHOUSE GASES AND USE WATER IN CALIFORNIA

To combat the impacts of global warming, we must tailor strategies to each sector that uses water and energy in California.

Water use in California is about 50 percent environmental (wetlands, wild rivers, habitat preservation, and water quality maintenance), 40 percent agricultural, and 10 percent urban. Successful water policy must balance the needs of these three sectors, each of which has powerful constituencies with strong perspectives about water use and powerful legal tools available to affect the distribution of water.

Figure 1 **Transportation Produces the Highest Levels of GreenHouse Gases in California**



NOTE: California GHG emissions in million metric tons CO_2 equivalent (Mt CO_2e) per year by sector from 2000 to 2019. California's 2020 GHG emissions target of 431 MtCO_2e, set by AB 32, is indicated by the horizontal black line. **SOURCE:** CARB GHG Emissions Inventory.

Reducing GHG emissions requires understanding the many different ways GHG are produced as Californians go about their daily business. The sector producing the most GHG is transportation, accounting for about 40 percent of the total (see Figure 1 on the previous page). Industry accounts for another 20 percent, and electric power generation almost 15 percent. Other significant sources include commercial and residential buildings (10%), and agriculture (7%). Annual emissions of GWP–gases with high global warming potential (e.g. methane)—are another important factor, which amplifies climate impacts from the state's oil and gas industry.

HOW DID WE GET HERE?

CALIFORNIA'S ENERGY HISTORY

Although California has reduced its GHG emissions, it still produces more GHG than most countries and its economy is heavily dependent upon fossil fuels.

The home of American car culture required a system of freeways and bridges, with increasing demand for concrete and steel, diesel, and petroleum products. As America's bread-basket, California has long relied on high-carbon chemical fertilizers and pesticides, a water system that uses one-third of all electric power consumed in the state, and an agricultural economy powered by diesel equipment. The nation's culture of consumption and California's world class natural harbors fostered industries which handle 40 percent of all the goods imported to the U.S., via ships, ports, and trucks powered by diesel and heavy oil. As a result of these demands and some geologic luck, California has been a leading producer and consumer of crude oil and refined petroleum products for more than a hundred years.

These patterns are now breaking down. It is a time of rapid change for California's relationship to high carbon fuels and production. Although coal was historically a major source of electric power for California, often delivered as electricity via interstate power lines, it is now a very small part of the California electric supply mix. California's oil and gas industry faces a similar fate. Once the largest oil producing state, California's crude oil production is rapidly declining. It still ranks 7th among U.S. states, and California has the third highest oil refining production nationally. However, California now imports 70 percent of its crude oil supply and 90 percent of its fossil pipeline gas. Petroleum, once widely used as a power plant fuel, is now virtually absent from that sector. Electric vehicles are eroding petroleum

demand in transportation. Buildings are no longer just served by remote gas electric power plants and fossil gas production. A growing number of residential, commercial, and industrial buildings produce electric power on-site with solar generators and exchange power in both directions with the electric distribution system. While two-thirds of buildings in California still use gas furnaces and water heaters, electric heat pump technology is challenging the historic dominance of fossil gas in the sector, and will eventually eliminate use of gas in buildings.

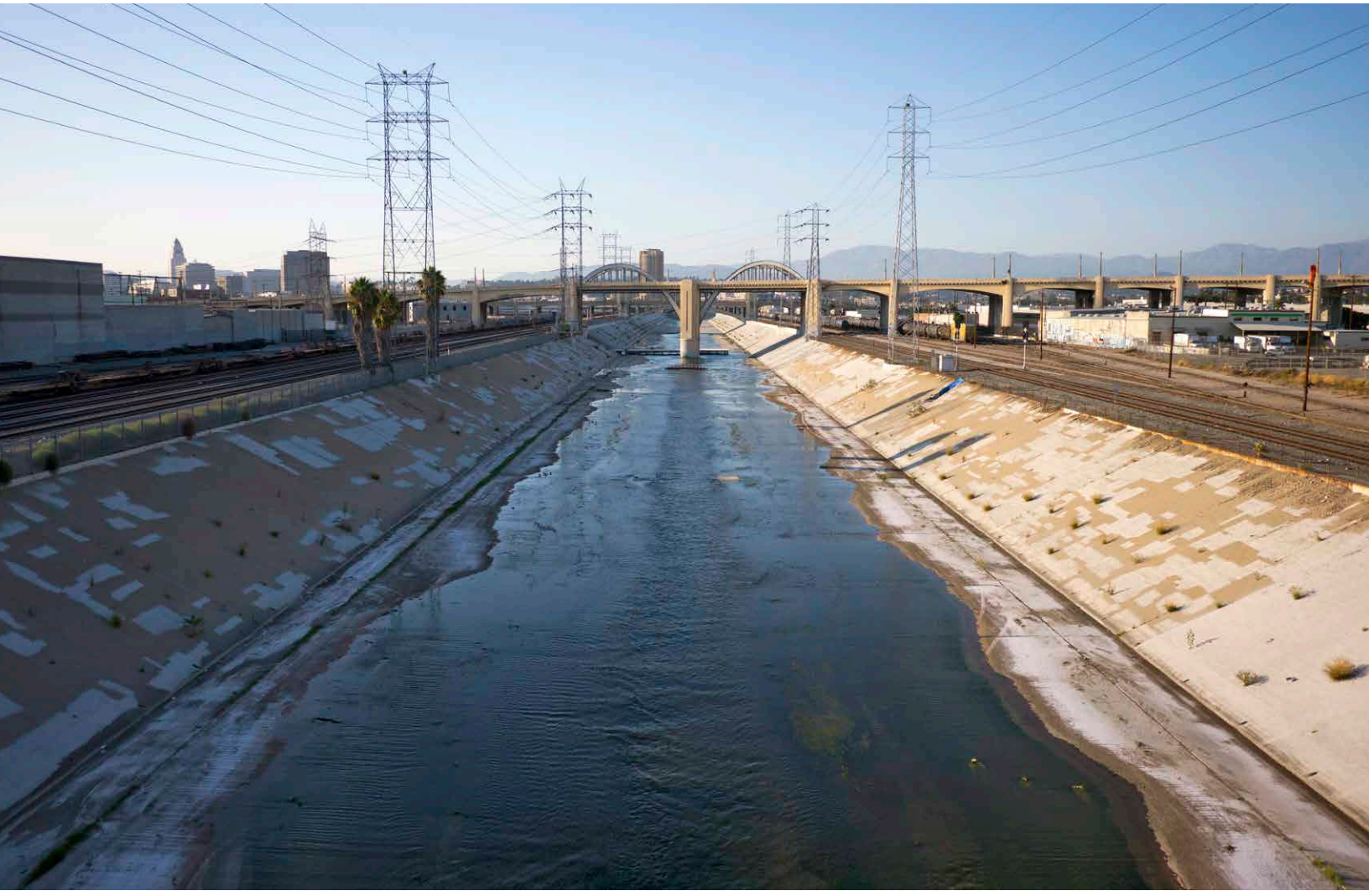
Electrification integrates and optimizes previously separate forms of energy use. Not long ago, energy used for road transport energy use was entirely separate from energy used in the electric power and buildings sectors. These historically siloed, highly polluting, one dimensional energy flows are ending. With the introduction of electric vehicles, today's electricity system sharply overlaps with transportation. Electric vehicles will increasingly interact with building energy systems.

Similarly, big changes are happening in the water sector. California has taken steps to improve the efficiency of its water supply and wastewater systems. Water supply systems have long consumed a large percentage of the electric power supply in California, powered by centralized, fossil-fueled electricity production and transmission. Today, however, water supply and treatment are increasingly served by distributed and utility-scale wind and solar generation, microgrids—self-sufficient energy systems—and water recycling and efficiency technologies. Wastewater systems have begun to interact with food-waste management and irrigation. Methane recovered from water treatment can (via combustion turbines or fuel cells) power wastewater plants, nearby ports, and industrial plants; or be "steam reformed" into renewable hydrogen for industrial and transportation uses.

CALIFORNIA'S WATER AND NATURAL RESOURCE HISTORY

As California's population exploded following the Gold Rush, regional water supply systems evolved to meet growing demand from domestic and agricultural uses. Massive reclamation and public works projects were initiated in the early 1900s to import water from hundreds of miles away, including the Central Valley Project and the Los Angeles and Colorado River Aqueducts; the State Water Project was added in the 1960s. These sprawling, interconnected systems are the major circuitry of today's "water grid," which includes nearly 1,500 dams, dozens of hydro-power and pumping plants, and thousands of miles of canals.

The massive water infrastructure projects of the 20th century have been very effective at uncoupling year-to-year water supply from the unpredictability of California's climate and lifted the state to become one of the largest agricultural producers and economies in the world. California has been called the most



hydrologically altered land mass in the world. Virtually all of California's rivers are dammed, often many times over.

Meanwhile, California's major water projects have wrought lasting damage to Tribal and environmental resources, damage which California has an obligation to amend. The Central Valley, once a vast system of marshes fed by rivers flowing out of the Sierra Nevada, has been almost entirely converted to agriculture. The Colorado River often does not reach the sea, Owens Lake is gone, the Salton Sea is disappearing, and the San Francisco Bay Estuary has lost one-third of its original size and most of its wetlands to infill. Parts of the San Joaquin River flow in reverse when Delta pumping ramps up and areas of the San Joaquin Valley floor have permanently subsided nearly thirty feet due to extraction of enough groundwater to fill Lake Tahoe. Damming and channelizing rivers was once viewed as a sign of technological progress, but that perspective has shifted with our matured understanding of the services that intact ecosystems provide. This vast alteration and degradation of aquatic ecosystems was frequently justified in the name of economic development, while the impacts to marginalized communities and the environment were discounted, ignored, or overlooked.

Similarly, forest fires were actively suppressed in California since statehood to avoid supposed economic waste (i.e., lost timber extraction). Prescribed and cultural burning were essentially banned. The important role of fire in forest ecology was not well understood by (settler) forest managers until the late 20th century. Widespread fuel accumulation due to fire suppression, along with rising temperatures and declining forest health, have ultimately led to today's catastrophic megafires.

The historic drought from 2012 through 2016 revealed major gaps in the state's preparedness to respond effectively to prolonged, intense lack of rainfall. Research into past state-level responses to drought reveals a pattern of ad-hoc and reactive approaches initiated after drought emergencies have arrived. The state's water data collection and management system are incomplete and poorly organized. For instance, three-quarters of California's watersheds do not have a government-operated streamflow gauge and most agricultural groundwater wells are still not metered, though this is changing. Information about who has a right to water diversions, how much water, and when it can be drawn on is notoriously difficult to ascertain.

Despite huge challenges related to water in a changing climate, there are signs that California is adapting and can continue to do so. California's urban areas are using less water despite a steadily increasing population and are more drought-resilient, the result of concerted conservation and storage efforts over the last few decades. During the 2012–2016 drought, per-capita water use fell in accordance with mandated water cuts but did not rebound to pre-drought levels when the drought broke. Accelerating efforts in water recycling, groundwater management, improved conveyance, and ecosystem-based restoration will increase our resilience to climate volatility.

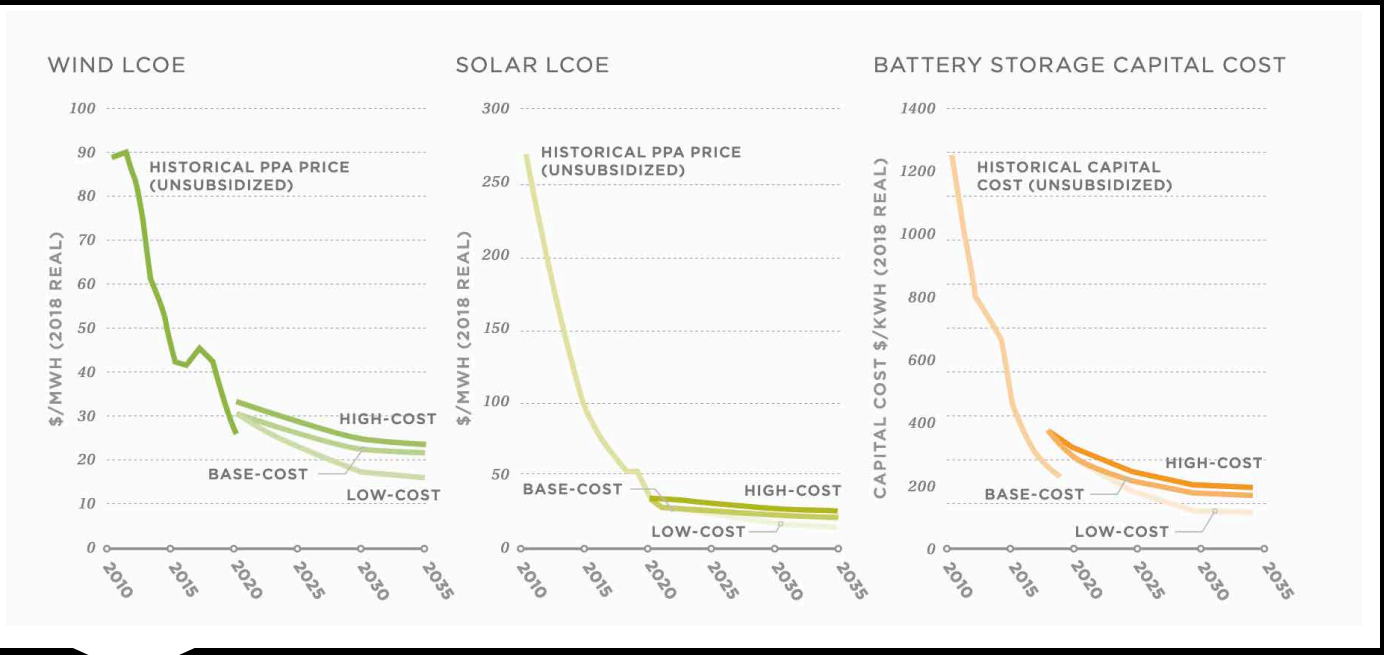
CALIFORNIA'S STEPS TO MITIGATE THE EFFECTS OF CLIMATE CHANGE

Science clearly links carbon emissions to surging wildfire, flooding, drought, heat and storm events, not just in California but across the U.S. and globally. In 2018 California's Fourth Climate Change Assessment determined that a business-as-usual scenario will have significant negative economic repercussions for California's economy. The 2021 Intergovernmental Panel on Climate Change (IPCC) Report reiterates in stark terms that the world has only 10 to 20 years to deeply cut GHG emissions to avoid the worst impacts from climate change. There is also a growing need to adapt coastlines, farmland, water systems, and buildings to withstand increased heat, sea level rise, drought, storm intensity, flooding and other effects of climate change, some of which are now unavoidable.

California began a transition toward a low carbon economy more than 20 years ago. Initially, this was driven by the need to improve air quality and to be more efficient in its use of increasingly costly fossil fuels. Beginning in 2005, California established increasingly aggressive climate change policies, recently reflected in the 2018 law requiring California to procure 60 percent of all electricity from renewable sources by 2030 and 100 percent from carbon-free sources by 2040. The state recently adopted policies to completely *decarbonize* transportation. Nevertheless, California has only recently begun to see the downward curve of emissions. There is a long way to go, but identified solutions can scale rapidly now that zero-carbon alternatives cost less than fossil-based transport and electric power.

Efforts to address climate change will be costly. In the energy sector alone, cost estimates for the U.S. are between $4.5 trillion and $5.7 trillion in 2030, or about one-quarter of the U.S. debt. The cost to transition the transportation, power, and buildings sectors, however,

Figure 2 **Shrinking Costs for Renewable Energy Can Help Mitigate the Impacts of Climate Change**



SOURCE: Phadke, Amol and Nikit Abhyankar. 2021. "Plummeting Costs and Dramatic Improvements In Batteries Can Accelerate Our Clean Transportation Future". April 2021.

can be covered by savings in fossil fuel costs. Figure 2 shows that the costs of wind-power, solar-power, and battery storage have plummeted over the past decade, and they are projected to fall even further. Wind and solar generation are now cheaper than electricity from fossil fueled power plants, even after accounting for the cost of electricity storage needed when wind or sun are not available. The costs to adopt these new sources will also be offset by avoided disaster recovery, insurance costs, and productivity losses that otherwise will occur if climate change is not abated. Other benefits include improved public health from reduced exposure to air pollution emissions; opportunities to improve local resilience and reliability amidst a changing climate; reduced climate risk for vulnerable populations; and high-quality jobs and careers in the clean energy industry.

CAN CALIFORNIA ACHIEVE A NET-ZERO CARBON ECONOMY?

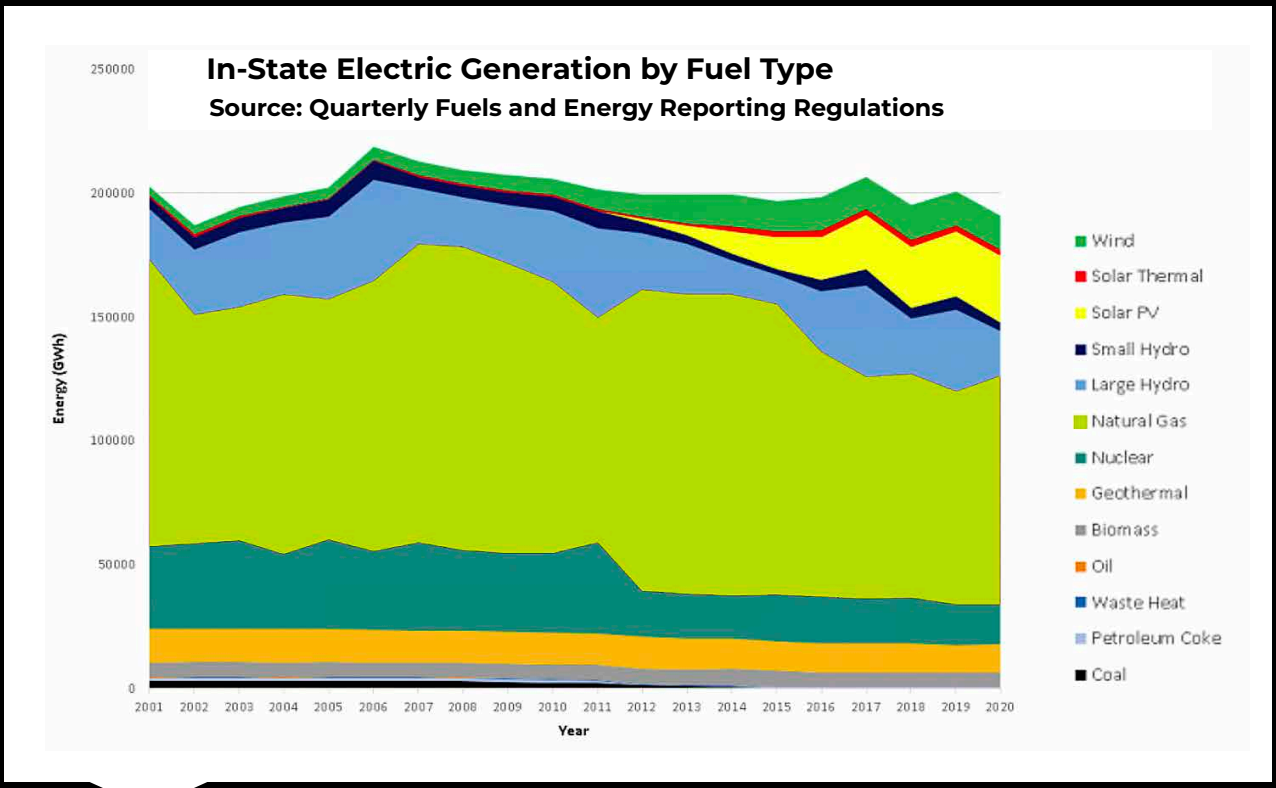
Electric Power as a Case Study

California has already achieved strong momentum toward a zero-carbon energy sector. There have been double digit percentage reductions in the use of fossil energy in the electric sector since 2006. This progress in the

electric sector is partly a result of earlier clean energy policies, principally energy efficiency, building standards, appliance and equipment standards, research and development (R&D), and early renewable energy subsidies, going back almost 30 years. These policies halted growth in electric and gas demand and served as the foundation for later policies that support systems to generate electricity from zero-carbon renewable energy and storage.

Specifically, Figure 3 shows the dramatic increases in the use of wind and solar generation over the past decade, reaching 23 percent of total electric power production in 2020. Including small hydro, geothermal, and biomass, California's in-state electric generation is now about one-third renewable. California's remaining two-thirds of energy generation rely mostly on natural gas, at 48 percent of its total production, with large hydro and nuclear power contributing another 9 percent each. In addition to this in-state generation of power, California imports about 15 percent of its electric power from other states. The renewable energy percentage of these imports is about the same as in-state generation.

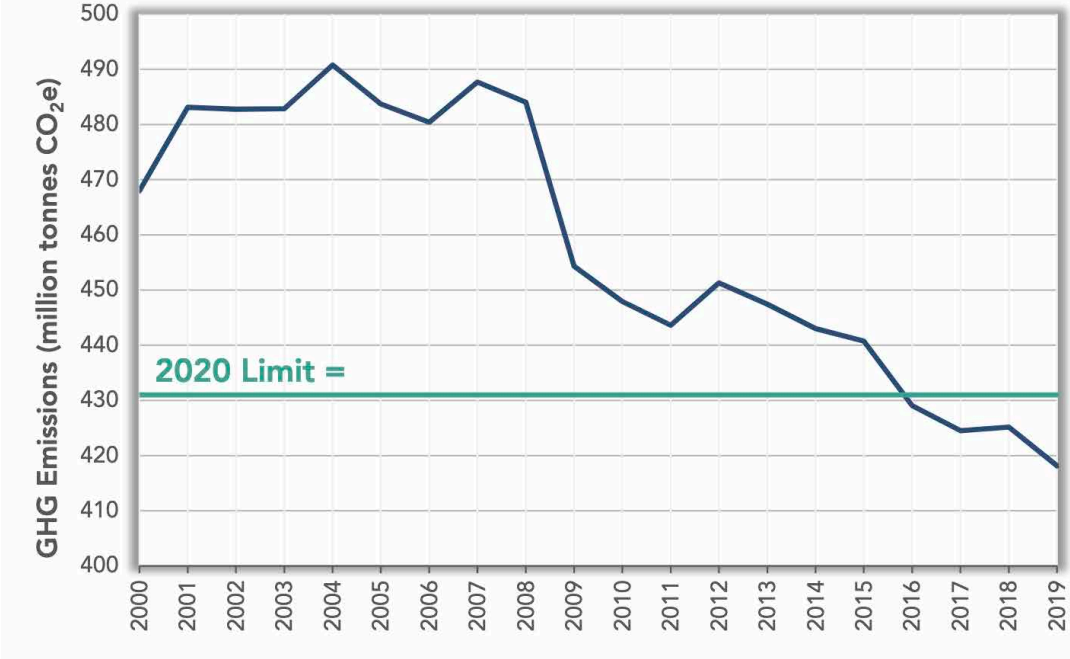
Figure 3 **California Has Made Dramatic Increases in Its Generation of Electric Power by Wind and Solar in the Last 20 Years**



SOURCE: "Electric Generation Capacity and Energy". California Energy Commission. 2019.

Transitioning our electric power supply to zero carbon, however, will only solve part of the problem. Oil and gas are still heavily used in other parts of the economy such as transportation, buildings, and manufacturing. On an economy-wide basis, the effect of the state's climate and clean energy policies on GHG emission is, admittedly, very disappointing. California has only reduced total GHG emissions by about 8 to 9 percent after trying hard to do so for 15 years, as Figure 4 shows. Nevertheless, there are several reasons why California is poised to accelerate decarbonization of the economy. The state's current objective is to eliminate net GHG emissions economy-wide by 2050, with deep reductions by 2030 and 2040, while maintaining prosperity and conserving natural resources.

Figure 4 **California Has Made Substantial Reductions in GHG Emissions Since 2000 But It is Not Enough**



NOTE: This graph shows California's annual GHG emissions from 2000 to 2019 in relation to the 2020 GHG Limit required by the California Global Warming Solutions Act (Assembly Bill 32). In 2016, California's GHG emissions dropped below the 2020 GHG Limit and have remained below the 2020 GHG Limit since that time.

SOURCE: "California Greenhouse Gas Emissions for 2000 to 2019". California Air Resources Board. July, 2021

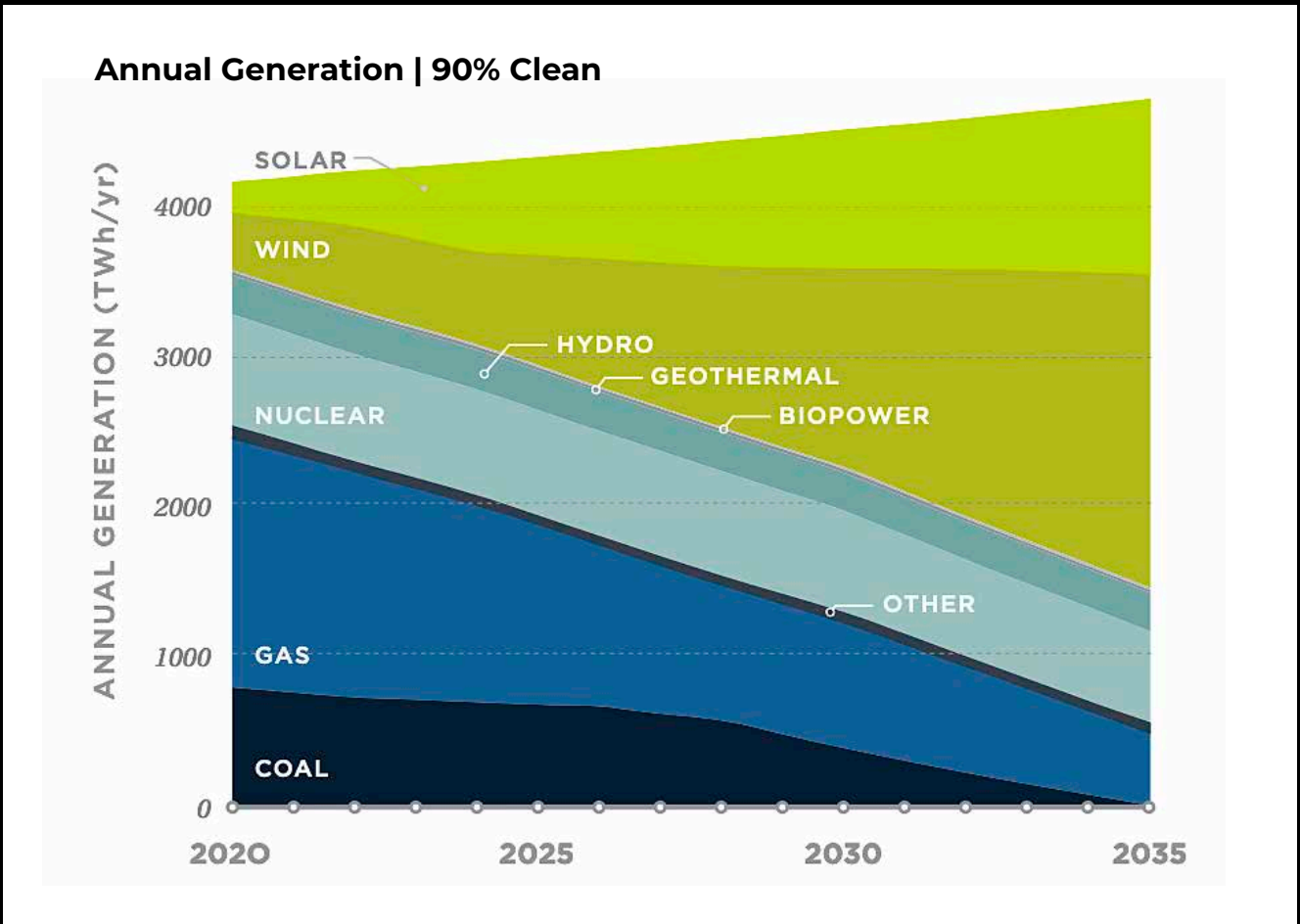
CALIFORNIA'S MOVE AWAY FROM FOSSIL FUELS:

Eliminating Net GHG Emissions by 2050

Is all of this change possible? A nationwide study of electric power generation (see Figure 5) showed how the U.S. could reduce the fossil-fuel share of electric power generation to about 10 percent by 2035. With proper policy support, renewables, battery storage, and other forms of clean generation technologies will reduce coal's share to zero and gas's share of national electricity generation to about one-third of what it is today by 2035. In 15 to 25 years, the remaining gas in the electric sector could be phased out in favor of higher levels of renewable generation coupled with new forms of short- and long-duration storage and demand response. With its head start, it seems eminently possible for California to decarbonize the electric sector even faster. This transition will help relieve the state's dependence on imported fossil gas. About 90 percent of fossil gas consumed in California today is imported from other states. To meet state climate goals, the use of fossil fuels including fossil gas will need to decrease by 80 percent or more by 2050. This would mean fewer consumer dollars going on a one-way trip down a gas or oil well somewhere else. There is an economic and environmental imperative to get rid of it in favor of zero-carbon replacements.

As discussed above, electric cars and trucks are, or shortly will be, much cheaper to operate than gas and diesel-fired internal combustion engines. Oil is about to lose its main market, and climate change policies will hurry its exit, particularly in California.

Figure 5 **California Has the Opportunity to Focus on Wind and Solar Energy in the Coming Decades**



SOURCE: Phadke, E Amol; Umed Paliwal, Nikit Abhyankar, Taylor McNair, Ben Paulos, David Wooley, Ric O'Connell. "2035 Report: Plummeting Solar, Wind, And Battery Costs Can Accelerate Our Clean Electricity Future". Goldman School for Public Policy. June 2020.

The biggest problem with oil is not how to stop using it, but how to clean up the residual pollution from 120 years of drilling, spilling, and refining, and how to put tens of thousands of workers from oil fields, refineries, and gas/diesel distribution to work doing something else. There are 20 years of employment for oil field workers to plug all the wells, clean up drilling sites, toxic waste dumps, and contaminated groundwater. Some refinery workers will keep jobs making carbon free liquid fuels. For the remainder, replacement jobs must be found, and they must pay a living wage. The job losses in the oil industry will be gradual and so

there is time to plan a fair transition for these workers, but planning is needed today to avoid adverse impacts, particularly in Central Valley communities. It is essential to prioritize vulnerable communities for both a just transition and immediate relief from health impacts resulting from proximity to fossil fuel emission sources.

Demand Response refers to services and incentives that shift customers' electric power demand to match output of low-cost renewables, and away from peak demand periods, when fossil gas generation tends to operate.

Fossil gas can and should follow oil's decline. California is the second largest consumer of fossil gas in the country and imports around 90 percent of the gas it consumes. The building sector is one of the largest sources of GHG emissions in California and it leads the nation in new building gas service hook-ups. Therefore, reducing fossil gas use in California's electric grid presents a large and ultimately cost-effective means to reduce carbon emissions and improve housing stock. Fossil gas use in buildings will likely decline more gradually than the use of petroleum in transportation, but electric heat pump technology is already less expensive than gas for new buildings. Existing buildings will gradually shift over to the use of electric heat pump technology as well.

The big problem for gas is what to do about all the pipeline infrastructure throughout the state and how we will equitably cover transition costs. Maintenance of gas lines under streets is expensive, but essential to prevent methane leaks and explosions. Ultimately California should shrink this infrastructure by retiring strategic pipeline sections, such as those needing expensive repairs. But, as consumers gradually abandon gas systems, some pipeline maintenance costs will not go down. This could cause the remaining customers–many of whom will be low-income–to bear rate increases. Hence, it is important to carefully plan gas distribution infrastructure shrinkage and address the stranded costs in a way that does not overburden low-income consumers.

There are important synergies among these decarbonization strategies. Decarbonizing electric power helps lower emissions from industry and building energy uses. Electrification of the transportation, building, and industrial sectors helps cost-effectively decarbonize the power sector by lowering daily and seasonal variations in demand.

CALIFORNIA MUST ADAPT TO CLIMATE CHANGE AND NOT RELY ONLY ON MITIGATION EFFORTS

Until recently, California has mostly attempted to address climate change through *mitigation*, or interventions meant to reduce or capture GHG emissions.

However, even aggressive emission reductions will not be significant enough to avoid all impacts from climate change. The plight of California's water supplies indicates the need to focus on climate adaptation. In California, climate *adaptation* means actions to preserve food and water supply, protect people from extreme heat, prepare coastlines for sea level rise, and reinforce critical infrastructure. Society must match climate change mitigation with adaptation measures.

Climate adaptation:
Actions to preserve food and water supply, protect people from extreme heat, prepare coastlines for sea level rise, and reinforce critical infrastructure

Climate mitigation:
Interventions meant to reduce or capture and sequester greenhouse gas emissions

California is one of the biggest and most diverse states in the country making it uniquely vulnerable to climate change. Adaptation to climate change is increasingly unavoidable as the U.S. and California face an uptick in climate change-fueled natural disasters, such as floods, droughts, sea level rise, heatwaves, and wildfires. Studies from California's Fourth Climate Assessment estimate that costs from direct climate impacts are likely to be in the tens of billions of dollars stemming from human deaths, damage to coastal properties, droughts and mega-floods. In 2021 alone, California experienced two billion-dollar disasters from flooding, a severe drought and accompanying summer heatwave, as well as a billion-dollar disaster from wildfires.

CLIMATE ADAPTATION FOR CALIFORNIA'S WATER SYSTEMS

California faces a growing issue of water scarcity that is projected to intensify. The state experienced the worst drought on record in the last ten years, and 45 percent of California is currently facing an "Exceptional Drought" as defined by the National Oceanic and Atmospheric Administration (NOAA). Governor Newsom declared a regional drought emergency in 50 counties during 2021. The drought has led to severe water shortages in the Klamath Valley of Northern California. In Southern California, the U.S. Bureau of Recla-

mation declared the first ever water shortage on the Colorado River in 2021, and the Lake Oroville reservoir had to take their hydroelectric generators offline for the first time. These two sources supply about half of the water to the Metropolitan Water District of Southern California. The Fourth Climate Assessment projects that, by 2100, the state could lose up to 65 percent of its snowpack as well as face a growing agrarian demand for water as soil moisture decreases.

Adapting to increased climate risk will require transformational changes to existing water management practices to simultaneously manage intensifying droughts and floods, to restore depleted groundwater aquifers, and to ensure safe and affordable water supply for all Californians. Solutions require better management of groundwater sources in the Central Valley of California, surface water resources that come from the Sierra Nevada mountains, and water flow from the Colorado River system that originates in the Rocky Mountains. Tradeoffs will have to be made between environmental, agricultural, and urban uses of water.

The policy reforms needed in the water sector are many. California has only recently begun serious efforts to protect groundwater resources and that effort needs strong follow through from state and local governments. California will also need to redesign the current hydrological system of California to deal with changed weather conditions–improving conveyance and storage systems to reduce leakage, reduce evaporative losses and increase underground storage. The state needs to clarify water rights,

improve methods for the legal transfer of water from one user to another, provide information about the availability and ownership of water, and develop new markets for allocatinge water supply. Finally, agriculture is particularly vulnerable to climate impacts, and it will have to implement water saving practices and adopt production systems that are resilient to unpredictable water supply.

To aid a swift and just transition to a climate-resilient water system, the state also needs to comprehensively overhaul California's water data collection and management systems, increase coordination between water and energy systems, and sustain investment in nature-based climate solutions and public health protections. Just as the state's climate policies have driven innovation in the energy sector, California's water policies are spurring innovation in water technology and agriculture. Water reuse is one of the most promising new supplies of clean water.

As total water demand increases with projected population increases, California will need to increase urban water conservation and efficiency measures which reduce both GHG emissions and help preserve water supply. Good water policy is good energy and climate policy: strong water conservation and efficiency measures can simultaneously increase resilience to intensifying drought *and* reduce the GHG footprint of our water system.

Emblematic of the systemic problems faced by California, the Colorado River Basin–spanning seven western states–supplies water for nearly 40 million people in two countries (the Unit-

ed States and Mexico), 29 tribal nations, and multiple National Wildlife Refuges and National Parks. Colorado River water supplies about one-third of total use in Southern California cities, as well as some of the fastest-growing metropolitan areas in the country, like Phoenix and Las Vegas. The River also supports important agricultural markets, including the Imperial Valley in California, which contributes roughly 90 percent of U.S.-grown winter vegetables. In addition, hydroelectric power stations on the River generate more than 4,000 megawatts of energy for Western states.

However, legally-apportioned water use exceeds the total supply that the River can provide. This excess demand for water, combined with severe and chronic drought across the American West, led water storage in Lake Powell and Lake Mead to all-time lows in 2021. Climate models predict that River supplies could dwindle by as much as 55 percent by the end of the century. Environmental and public health conditions at the Salton Sea in the Coachella Valley, originally created by overflows from the Colorado River in 1905, are worsening. The lake has historically been maintained by irrigation runoff from farms in the Imperial Valley, but agricultural water conservation measures and increased drought and heat are causing the lake to shrink. Reduced supplies from the Colorado River may also increase demand for supplies from the Sacramento-San Joaquin Delta, frustrating restoration goals. Further demand reduction and conservation efforts will present difficult tradeoffs.

Perhaps the biggest problem facing water policy-making is the fragmented water governance structure in California, which involves governmental units in Mexico, adjoining states, and hundreds of water districts, counties, and cities in California. Our water governance system was designed for the needs of gold prospectors, not for tackling 21st century management issues. It needs a fundamental overhaul. The wide array of powerful interests lobbying for the environment, agriculture, and cities, makes it hard to see who can lead efforts to reconcile conflicting interests. On top of this fragmented set of actors, is a long history of disagreements over water between north-south and coast-versus-mountains regions, a conflict that reflects differences in climate as well as ideology. But as the water crisis deepens, the motivation for change across these interests may increase to the point that innovative solutions are possible. Meanwhile, progress can be made to improve data collection and transparency that is critical to agreements for action.

One potential way to bridge this divide concerns a potential new revenue source for agriculture. The opportunity to sequester carbon in soils is huge, and would have additional benefits of improved agricultural productivity, water retention, rehabilitation of degraded farmlands, and increased or stabilized agricultural employment. Although agriculture causes 7 percent of California's GHG emissions, there are many ways to reduce these emissions. Changes in irrigation, cover crops, and tilling practices can reduce GHG emissions and sequester carbon in soils. Electrification of tractors, trucks, and processing equipment can lower operating costs and reduce risks fossil fuel price volatility. New market and regulatory structures are needed to support the transition to a low carbon agriculture economy.

CALIFORNIA MUST ALSO ADAPT TO CLIMATE CHANGE INDUCED SEA LEVEL RISE, EXTREME HEAT, AND WILDFIRE

The state of California has approximately 1,100 miles of coastline. Coastal counties account for 22 percent of California's land area, 68 percent of the population, and 80 percent of the state's GDP. California's coasts already experience the impacts of climate change. The Fourth Climate Assessment modeled many potential impacts from sea level rise. By 2100, without policy changes, between 31 and 67 percent of Southern California beaches may completely erode. Statewide, sea level rise damages could reach nearly $17.9 billion by 2050 from 20 inches of sea-level rise (95th percentile). A Union of Concerned Scientists model estimated in 2017 that over 20,000 homes are at risk of becoming chronically inundated by 2045.

There can be deadly consequences if societies fail to prepare for sea level rise. In September 2021, 43 people were killed across the East Coast from flooding related to Hurricane Ida. Many of these were low-income people living in basement apartments. Investing in resilience measures to mitigate flood damage from sea level rise is less costly than the impacts associated with failing to adequately adapt.

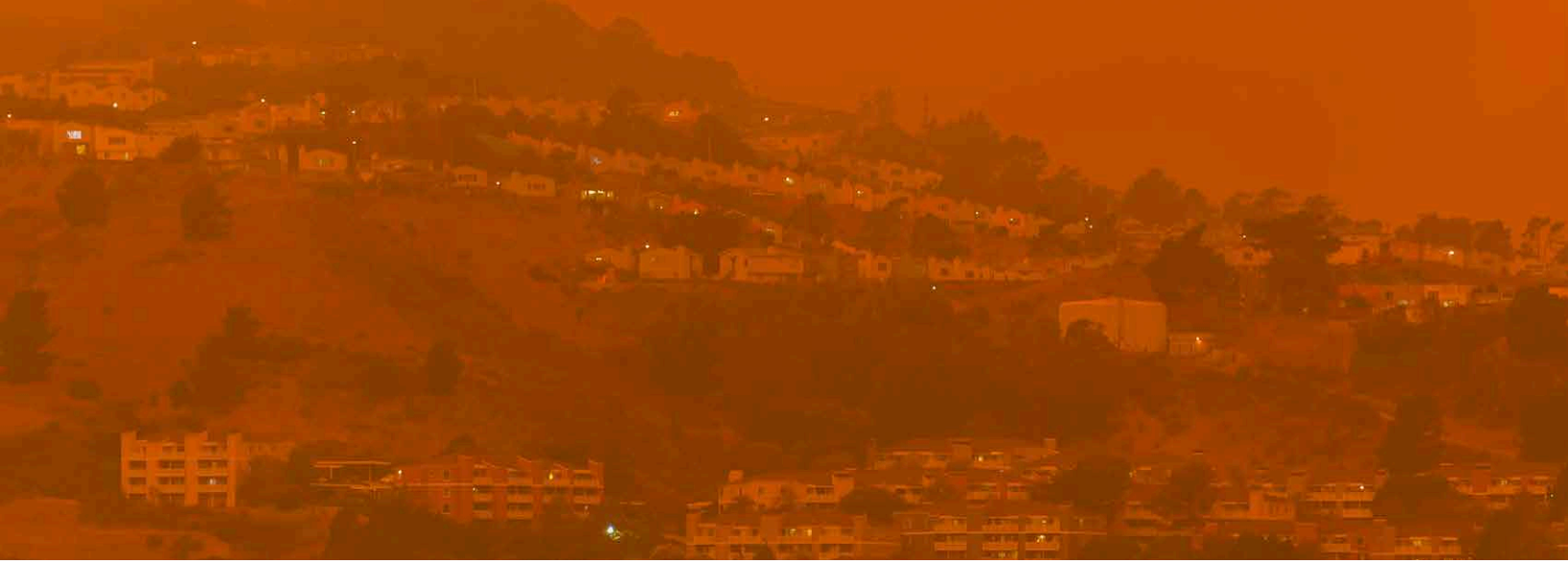
Extreme heat will also be a problem for California. The heat wave across the west during the summer of 2021 killed at least 138 people. Additionally, from 1999 to 2009, there were 19

heat-related events with significant impacts on human health including about 11,000 hospitalizations. According to the Fourth Climate Assessment, Heat-Health Events will continue to worsen throughout California by 2050: we can expect these events to occur four to ten times more often in the Northern Sierra region and for two weeks longer on average in the Central Valley.

Increased drought and rising temperatures also contribute to wildfires. Eight of the ten largest fires in California's history have occurred in the last five years, but California has still not taken appropriate steps to plan for and invest to mitigate rising wildfire risks. For example, poorly designed and maintained electric transmission infrastructure regularly causes wildfire during dry season storms. One study in the Fourth Climate Assessment found that if greenhouse gases continue to rise, the occurrence of extreme wildfires that burn more than 25,000 acres would increase by nearly 50 percent, and the average area burned statewide would increase by 77 percent by 2100. The areas with the highest fire risk would see costs for wildfire insurance rise by 18 percent by 2055 and leave many property owners without access to fire insurance.

DISPARATE IMPACTS OF CLIMATE CHANGE ON LOW-INCOME COMMUNITIES AND COMMUNITIES OF COLOR

Recent events remind us of the urgent need to address the racial inequities that permeate U.S. society. Historic and persisting inequities are particularly evident in climate, energy, and natural resource policy. Air pollution that plagues communities of color is often co-emitted with GHGs. Low-income communities are often the first to suffer from climate



change and least able to adapt to its effects. Workers displaced from fossil-based industries are often from low- or middle-income communities of color. As California experiences more extreme heat waves and wildfires, low-income communities and communities of color will be disproportionately affected because they are least likely to have air-conditioning and air purification systems or, for rural poor, resources to mitigate wildfire risk. Low-income workers may not be able to afford to take days off during days with bad air quality or extreme heat, or may have language barriers that prevent them from gaining knowledge about protective gear or legal rights. Well-planned climate mitigation and adaptation strategies can relieve these health and safety burdens, such as transitioning oil field and refinery workers to new, living wage employment, and provide emergency response and cooling centers equipped with air filters on hot or smoky days. It is essential to prioritize initial climate investments to reduce minority community exposure to fossil fuel emissions and the effects of climate change.

As we have learned from the drinking water tragedy in Flint, Michigan, people of color and low-income communities are often disproportionately affected by environmental problems. Droughts in California, particularly in the Central Valley, have caused shallow wells to run dry or become contaminated, especially in areas with low-income populations and communities of color (see Figure 6 on the next page). Many aquifers in California are laced with a cocktail of natural and manmade chemicals, some of which will never break down ("forever" chemicals). Less than 10 percent of the chemicals used in commerce today have been studied for human health effects and millions of new chemicals are created annually, all of which could eventually end up contaminating surface and groundwater. Since environmental racism affects communities of color and low-income communities disproportionately, California should acknowledge that these chemicals will likely negatively impact those communities first, and it should take steps to test wells and supply clean drinking water.

Climate adaptation is also an environmental justice issue. The impacts of climate change will not be felt uniformly across the state and California has an obligation to help prevent adverse climate impacts on low-income communities and communities of color.

Figure 6 **Regions Throughout California Experience Unsafe Drinking Water and Water Shortages**

SOURCES: Systems with unsafe water (as of June 2019) and systems needing emergency drought funding: State Water Board; household water shortages: Department of Water Resources.

SOURCE: PPIC. "Priorities for California's Water." 2019.

California's Fourth Climate Change Assessment in 2018 was the first to include Climate Justice and Tribal and Indigenous Communities reports. Moreover, the reports in the fourth assessment show how climate adaptation can reduce climate impacts to disadvantaged communities. Consideration of environmental justice in state climate policy making is so new that many communities affected by climate change have no effective protection or support. Environmental justice should be a priority as California works to mitigate and adapt to the effects of climate change.

CALIFORNIA'S ADAPTATION EFFORTS AND NEXT STEPS

In March 2018, former Governor Jerry Brown and legislative leaders announced a coordinated effort to develop solutions to make California more resilient to natural disasters and climate change. This announcement included a commitment to ensure that future utility and public infrastructure is designed, constructed, and operated to maximize resilience to extreme weather events and natural disasters. The announcement also included updates to liability rules and regulations for

utility services considering the changing climate and the increased severity and frequency of extreme weather events. These actions and the Fourth Climate Assessment ultimately created California's *Climate-Safe Infrastructure Working Group*.

In 2021 the California legislature enacted a new law to create the state's first comprehensive sea level rise program, which will in turn help local governments mitigate the harmful effects of rising sea levels. The bill allocates $100 million per year towards mitigating negative environmental, social, and economic effects of sea level rise and expands an existing environmental justice grant program by $500,000 specifically for organizations working to manage sea level rise in disadvantaged coastal communities. These funding opportunities will play a critical role in prioritizing equity and actively implementing adaptation measures in California's most vulnerable communities.

While California has made considerable headway toward improved climate change adaptation, many of California's communities are still at high risk of climate disaster and many adaptation measures are underfunded and incomplete. It is imperative that California continues to be a leader on climate adaptation. Currently, there is very little national coordination of climate adaptation and California has a chance to lead these efforts for the country.

TRENDS UNDERLYING CALIFORNIA'S FUTURE ENERGY, ENVIRONMENT, AND NATURAL RESOURCES

GALLOPING TECHNOLOGY AND COLLAPSING COST OF ALTERNATIVES

A sense of optimism is warranted regarding our ability to dramatically reduce greenhouse gases and transition to a zero-carbon economy. Optimism is driven by many studies that confirm the economic and public health benefits of zero-emission technologies such as solar and wind generation, electric vehicles and heat-pumps. These were once thought too expensive to be practical. Now, these technologies often cost less than fossil-dependent engines, appliances and power plants. These changes will also bring important equity benefits. For example, electrification of trucking, port and freight operations, and reduced oil production/refining will largely eliminate air pollution hot spots in many minority communities. Similarly for building systems, LED lights, heat pumps for heating and cooling, on-site renewables, and battery storage all

improve building performance, reduce emissions, and lower costs.

Other sectors of the economy, once thought "hard to decarbonize," have near- and mid-term options:

- Low- or zero-carbon liquid and gaseous fuels are emerging for aviation;
- Ships and locomotives have battery, hydrogen, and other alternatives to fossil fuels;
- Prominent manufacturing industries can both reduce carbon emissions and sequester CO2 in products, (e.g. cement) geology, and soil.

California is on the edge of climate-driven reindustrialization. New markets and industries, built on the state's research capacity and culture of technical innovation, are here already—in vehicle and battery manufacturing, low carbon fuels, water and energy efficiency, and renewable energy. In the case of climate change, a crisis is certainly an opportunity. Today, climate research, consumer sentiment, corporate responsibility, and youth activism animate a proactive and hopeful attitude about climate stabilization, and drive changes in investment, procurement, behavior, and government policy. Economic and political conditions, however, will affect pace of change and resources available to scale low-carbon technologies throughout the State.

ENVIRONMENTAL IMPULSE BECOMES CLIMATE IMPERATIVE

Policymakers and the public are paying attention to climate change. This is due to a 30-year trend of increased public concern for environmental quality. Today, Californians believe that climate change is caused in large part by human activity, and they support investment in clean energy. This trend is not unique to California. Polling in June 2020 by the Pew Center found that two-thirds of Americans think the government should do more to protect climate. Concern about climate change has been steadily rising among Americans for the past decade. In a 2019 poll from The Washington Post-Kaiser Family Foundation, 63 percent of people who said their area had been affected by severe storms, droughts, or extremely hot days identified climate change as a "major factor."

Public opinion is driving national and state policy changes. In November 2021, the U.S. Congress, with bipartisan support, passed an infrastructure bill that contains new funding for climate mitigation and adaptation. Federal agencies are pursuing a wide range of climate policy reforms and budget reallocations. These pursuits include rules on climate risk disclosure for financial investment and GHG emission standards for methane sources, power plants, vehicles, and manufacturing. Corporations worldwide, including ones that once staunchly resisted action on climate, have set goals and invested to reduce their impact on climate and adapt to climate risks. In California, massive wildfires and extreme drought drive new investment and policy changes to phase in zero-emission cars and trucks, microgrids, water conservation, and fossil-energy free buildings.

DISASTER & RISK – NEED AS THE MOTHER OF INVENTION

The world is in the midst of a period of unprecedented global attention to risks associated with climate change. In August 2021, the IPCC issued its latest report, describing climate change as an urgent crisis and urging rapid action to reduce emissions. Record setting floods (Germany, China, Tennessee), heat events (Pacific Northwest of the U.S.), drought (Southwest U.S.), extreme cold (Texas), and wildfires (Western U.S., Siberia, Southern Europe) now beset virtually every region of the world. Society already feels the impacts of climate change, and failure to urgently reduce emissions will affect human well-being for centuries into the future. An important round of international negotiations on climate occurred in November 2021 and spurred a wave of private and public commitments to reduce emission and invest in low carbon technology.

Nothing drives change quite so dramatically as the prospect of running out of water, or being washed away in a flood. Almost one-third of Americans live in counties declared a disaster in 2021 by the Federal Emergency Management Authority (FEMA) from wildfire, flooding, heat-events, and hurricanes. Corporate perception of climate risk is increasing fast and today affects investment patterns globally. This perception of risk is also changing consumer behavior.

The transition to a zero-carbon economy requires a wide range of supportive policies on vehicle charging infrastructure, building decarbonization, finance, electric power markets, carbon sequestration, industrial innovation, fuel production and adaptation. Some of this policy infrastructure is already in place, but it will have to evolve and deepen to achieve climate and sustainability goals.

ECONOMIC CRISIS AND OPPORTUNITY

Although California and the Biden Administration are committed to dealing with climate change, it is not clear that governments in Washington will always be committed in the future. The Trump administration pulled out of the Kyoto protocol and worked assiduously to reverse previous policies to decarbonize, and sought to take away California's powers to adopt stricter auto pollution regulations.

Changes in Washington might put California in a difficult position with respect to the national government. Moreover, the internal politics of California might diminish support for decarbonization if it is seen as too costly and difficult, especially if there is an economic downturn, the rest of the world is not seen as doing its part, and climate policy is viewed as creating inequalities across population groups and geographic areas. Californians might, for example, decide that it is more important to invest in critical infrastructure to ensure adequate water supplies rather than investing in the reduction of greenhouse gases.

The challenge for California will be to show that it can create new technologies and new manufacturing jobs based in part on climate change solutions. Today's trade and shipping disruptions intersect with rising labor rates in China to make this an opportune time to re-

industrialize California. The term "reindustrialize" is not optimal, since California already has a robust manufacturing sector. But in popular culture, it is common to hear of all the industry that has left California (and the U.S.) since the 1980s. Indeed, some manufacturing has left, driven out in part by federal policies that encouraged offshoring, and a failure of state and federal governments to compete against economic development policies and subsidies for nascent industries in Asian countries.

Clean energy and transportation policies play to California's strengths in scientific innovation and skilled workforces. Skilled workers and companies are naturally attracted to places with improving air quality, water quality, and climate resilience. Global disruption of shipping is likely to persist and animates on-shoring of manufacturing due to rising cost and time delays of trans-pacific shipping. Labor is a declining element of manufactured goods, as industry embraces high-tech manufacturing processes. California industry is uniquely positioned to benefit from these circumstances due to the state's robust transportation links to many parts of the U.S. There are indications that manufacturing has begun to return to California.

OTHER ECONOMIC OPPORTUNITIES ARISE FROM A ZERO-CARBON ECONOMY

- Renewable energy and electrification are, or will shortly, outcompete fossil fuels in the electric power and transportation sectors. Both sectors require or tend to prefer workforces and production in proximity to markets. This is evident in the rise of electric vehicle manufacturing in California.
- Rising fossil gas prices and technical advances are rapidly narrowing the cost gap between renewable-hydrogen and fossil-based inputs to refining, metals, cement, fertilizer and other industries. Renewable hydrogen production, like construction and renewable generation, is a hard to export supply chain because it is expensive to transport long distances.
- Local battery production and recycling has cost advantages over foreign and domestic competition, as does production of low carbon fertilizer and biomass feedstocks for aviation fuel.

Climate mitigation and adaptation policies will also help preserve other economic engines in California. Investments to increase climate resilience and environmental safety are critical to retention of tourism and ensuring a high quality of life. Successful adaptation policies can stabilize or even lower insurance rates. Growing investor demand for climate friendly investment can, with policy changes, preserve access to capital, and potentially lower cost of capital for California enterprises and government bond issuers. Policies to increase urban density can revitalize cities and stem the fire and flooding risks associated with sprawl. Policies to ensure stable, long-term sources of water for California will support growth in construction, fishery, and agriculture industries. These are just a few examples of why a zero-carbon economy in California is not just an environmental imperative, but a jobs-and-economy one as well.

THE FUTURE OF ENERGY, ENVIRONMENT, AND NATURAL RESOURCES IN CALIFORNIA

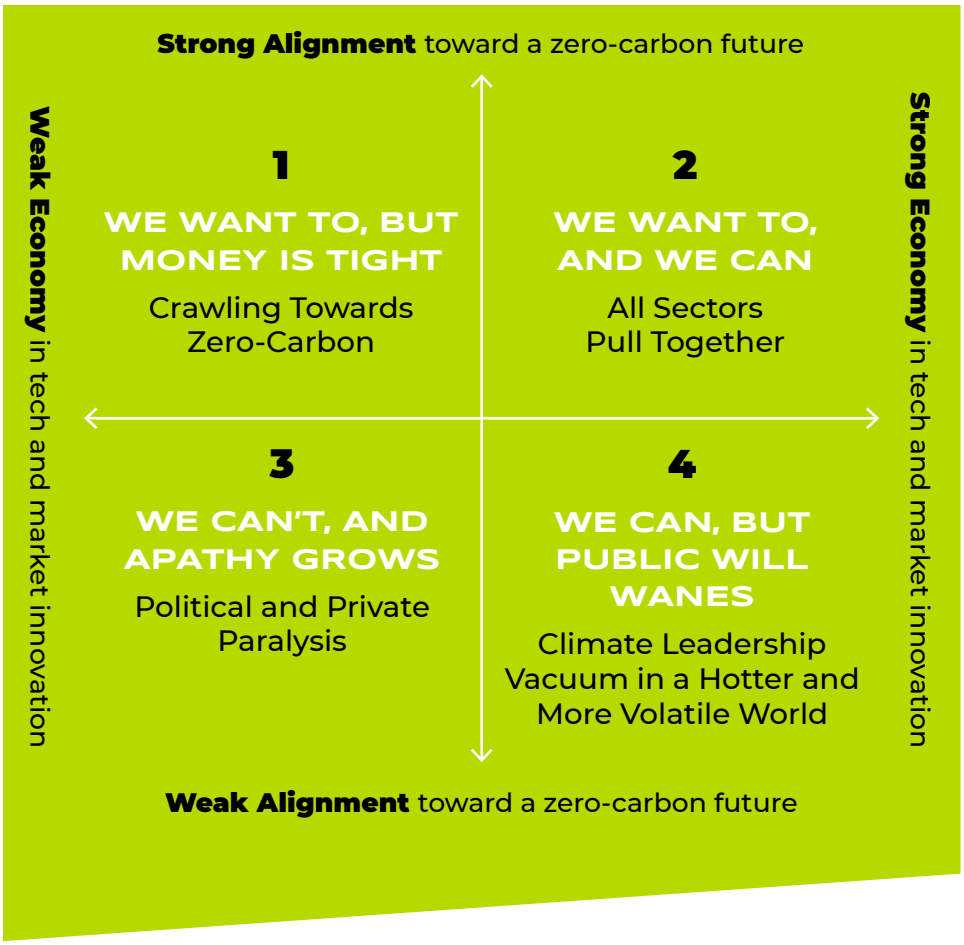
FOUR ALTERNATIVE SCENARIOS

SCENARIOS FROM THE FUTURE

ENERGY, ENVIRONMENT, AND NATURAL RESOURCES

Foresight practitioners use scenarios to help make future possibilities more vivid and tangible, immersing the reader in the particular details of a future world so that they can mentally situate themselves in what it would feel like to live there. Without scenarios, the signals, trends, and other research that underlie strategic foresight work can feel distant and abstract. Scenarios can be used to center a group conversation in a positive and concrete picture of a future state so that stakeholders can pursue a shared vision for how to respond to that possibility, or mobilize action to avoid an undesirable outcome.

The future of energy and water in California will play a fundamental role in how the state adapts to the rising threats of climate change. As such, the following scenarios were produced with the assumption that the state should aspire to a zero-carbon economy within the next 25 to 30 years, with improved environmental quality, economic prosperity, and equity. To imagine future scenarios for energy and water in California, we have selected two critical uncertainties based on the origins and trends identified: whether the state can realize unified public/private leadership towards a zero-carbon future, and whether the state's economy is strong or weak during this decisive period, as reflected in technology and market innovation.



WE WANT TO, BUT MONEY IS TIGHT

Crawling Towards Zero-Carbon

There is strong political and private will to advance a net-zero economy and to solve California's water problems, but continued economic downturns and instability have made it challenging to invest. Investing in zero-carbon technologies or participating in voluntary markets is constrained. As a result, zero-carbon technologies are emerging but have been slow to commercialize or reach hard-to-decarbonize sectors (e.g., steel, cement, agriculture, aviation).

The electric sector is still on a path to decarbonizing, with 2040 as a soft target. Nearly 50 percent of light and heavy-duty vehicle sales are electric. Agriculture and manufacturing have reduced energy and water use, but have yet to receive subsidies for sequestering carbon in the soil or fully electrifying their equipment and processes. Heat pumps dominate sales of new gas furnaces, but homeowners and businesses are slow to invest in fully electrified buildings. The gas distribution system has shrunk marginally. Local and state governments are beginning to invest in climate adaptation, but private industry resists aligning around a shared vision. Californians have developed innovative plans for the storage, use, reuse, and distribution of water, but the plans are behind schedule because of lack of money.

HISTORICAL PRECEDENTS

The economy is impacted by the COVID-19 pandemic and financial industry crises (2020, 2009-11).

In most regions of the U.S., public opinion and private investment in clean environment and energy remain high during economically-troubled times.

Environmental protection and clean energy policies tend to be resilient in the face of economic downturns.

FUTURE DRIVERS

Rising fossil fuel prices could empower electrification and renewable hydrogen tech.

Inflation and rising interest rates may constrain governmental and private clean energy investments.

Increases in frequency and severity of drought could affect jobs and agricultural production.

Asian and EU nations may move more quickly than the U.S. or California to control markets for clean energy technologies and critical raw material supplies.

SIGNALS

Clean energy investors wary

WHAT: Inflation reaches near-record levels in January 2022, causing tighter monetary policy and a market correction.

SO WHAT: Clear shifts toward climate protection by investors in recent years may stall or reverse.

Source: wsj.com; journalofeconomic structures.springeropen.com; sciencedirect.com

States focus on climate adaptation, ignoring emissions

WHAT: Officials plan to address sea-level rise from climate change but resist efforts to reduce GHG emissions.

SO WHAT: Others could follow this lead if the world economy suffers a downturn, and impacts of climate change could gradually overwhelm efforts to adapt.

Source: wsj.com

State leaders reject high-speed rail

WHAT: High-speed rail would reduce GHG emissions by reducing airline and vehicle travel.

SO WHAT: CA would be unable to follow other countries' lead in reducing GHG emissions through expansion of electrified rail operations.

Source: latimes.com

WE WANT TO, AND WE CAN

All Sectors Pull Together

Progress and momentum exist in all policies and markets for zero-carbon technology. That includes equitable tech access for low-income people and just transitions for fossil fuel workforces. A reasonably healthy economy drives availability and cost-effectiveness of zero-carbon products. There is strong financial and political support for R&D, supportive regulatory regimes, and market innovations. These forces trend toward the collective will to reduce carbon emissions and to adapt to climate change by developing better ways to manage water in California.

The electric power sector has almost fully decarbonized. All new sales of light-duty and most new heavy-duty vehicles are electric. The agricultural and manufacturing sectors have reduced energy consumption and water use significantly, and receive compensation for the carbon they sequester into the soil. New gas appliance sales are banned by late 2020s. Local and state governments are actively facilitating climate adaptation, including regulation of coastline and flood-plains development, wildfire preparation, and innovative plans for the storage, use, reuse, and distribution of water.

HISTORICAL PRECEDENTS

Rapid shift from landlines to cell phones.

Rapid acceptance of hybrid vehicle technology in CA.

Strong polling & political support for climate/environmental protection.

Corporate commitments to reduce carbon footprints.

Recent federal and state financial commitments to zero carbon transition.

1990 Clean Air Act Amendments (bipartisan, resilient, and popular).

FUTURE DRIVERS

Cost savings for vehicle owners, building owners/operators.

Youth enthusiasm for climate protection.

Emerging market structures, such as financing models to support transition of small and large trucking fleets to zero-carbon vehicles.

A 2022 agreement to establish a transpacific green shipping corridor.

Costs continue to decline for zero-carbon technology.

Technological advances such as electric vehicles and heat pumps.

Critical shortages of water drive policy reforms.

SIGNALS

Massive shift in budget priorities toward climate

WHAT: California's state budget for 2021 included $15B for climate-related expenditures, with an additional $137.5B contained in recent federal infrastructure bill.

SO WHAT: CA could establish new industries to mitigate effects of climate change.

Source: kqed.org

Shell's oil production peaks, and EU-based oil industry begin shift toward renewables

WHAT: As oil peaks, the ability of the oil industry to influence federal and state governments declines.

SO WHAT: Oil and gas industries are no longer major barriers to electrification.

Source: nytimes.com

Surge of corporate climate commitments

WHAT: A large wave of corporate restructuring to meet climate targets.

SO WHAT: Government and individual action on climate are multiplied by business investment, procurement, and political engagement.

Source: reutersevents.com

WE CAN'T, AND APATHY GROWS

Political and Private Paralysis

The will for shared visions can scarcely be found as stakeholders are forced to continuously respond to economic downturns and rising instability. Gridlocked governments turn their back on climate issues, allocating their limited resources to partisan priorities and triage efforts.

Regulatory and policy regimes focused on decarbonization have loosened or been revoked entirely. As a result, zero-carbon technologies and development have stagnated. Fracking grows and gas prices remain low. Regional, national, and global economies suffer grievous damage from extreme weather events, causing trade disruptions and increased flows of climate migration (and the transnational conflicts that come with it). Global progress on clean energy investment and penetration dwindles as California backs down from the effort. Customers continue to invest in some energy efficiency in buildings and higher-mileage electric vehicles, but both efforts remain a small fraction of the market. California focuses on its critical problems of managing water and wildfires, and political leaders argue that "it's time for California to solve its problems, not everyone else's."

HISTORICAL PRECEDENTS

2016 Federal election.

The Dust Bowl of the 1920-30s.

Economic impacts of COVID-19 pandemic and financial industry crises (2020, 2009-11).

Trade disruptions or global conflicts impair availability of key components of zero-carbon technologies (e.g., computer chips, batteries, battery raw materials).

FUTURE DRIVERS

Oil industry continues to promote false narratives on climate crisis.

Fossil fuel price volatility sends mixed signals to consumers and investors.

Job losses in oil fields and fossil distribution systems create backlash to climate and environmental protection policy innovation.

Campaign finance and election reforms fail or succeed.

SIGNALS

Donald Trump is considered viable presidential candidate for 2024

WHAT: Nation remains sharply divided between status quo in fossil energy use and those who would seek decarbonization.

SO WHAT: Political headwinds could dry up federal budget expenditures for climate protection and suppress state climate policy initiatives.

Source: thehill.com/

U.S. Supreme Court likely to constrain ability of federal government to act on climate under federal Clean Air Act

WHAT: Federal Judiciary has grown increasingly conservative in relation to governmental power to address pollution and climate change.

SO WHAT: Transition to a low carbon economy slows.

Source: www.newyorker.com

In 2021 the Texas electric grid and gas supply collapses during a climate-driven deep freeze

WHAT: Failure to plan for climate-driven storm intensity kills dozens of people, and imposes billions of dollars of recovery costs.

SO WHAT: Texas is a harbinger of impacts from hurricanes, drought, heat storms, and polar vortex events nationwide

Source: forbes.com

WE CAN, BUT PUBLIC WILL WANES

Climate Leadership Vacuum in a Hotter and More Volatile World

The economy is strong, but changes in political leadership (state and federal) have resulted in weak levels of regulation and public funding for the transition to a zero-carbon economy in California. Other issues demand public attention and reduce voters' interest in proactive climate policies. Some clean energy technologies are commercializing, and piecemeal actions by individual cities slowly advance zero-carbon technologies and climate resilience investment. The state focuses on the water problem as a critical necessity, but neglects its responsibility to lead efforts to reduce greenhouse gas emissions.

On the ground in 2030, the energy sector has been slow to decarbonize. Natural gas remains a prominent generation source. Agriculture and manufacturing have reduced energy usage based on general price signals, but do not embrace renewable alternatives. Wealthy households invest in electric heat pumps for heating and cooling, but middle- and low-income households remain dependent on gas despite volatile fossil gas prices. Local and state governments incentivize some energy and water efficiency measures, but there are very few comprehensive programs. The state prioritizes near-term resilience investment and emergency response, especially with regard to water supply and wildfires. Sales of light-duty electric vehicles have increased incrementally, but little progress has been made on heavy-duty vehicle electrification. The U.S. fails to invest in raw material supplies and recycling for batteries, which drives up costs and increases supply chain interruptions that slowly strangle the domestic production of electric vehicles.

HISTORICAL PRECEDENTS

The George W. Bush Presidency.

Corporate investment in low carbon technology increased partly in response to Trump Administration rhetoric.

FUTURE DRIVERS

Well-funded lobbying efforts create longstanding resistance.

Accelerating concentration of wealth.

Declining faith in institutions.

Decisions to prioritize solutions to California's water supply problem consume resources previously devoted to greenhouse gas emission reductions.

Volatile or rising prices for fossil gas and electricity.

SIGNALS

Build Back Better bill fails in Congress

WHAT: The largest climate spending proposal in history failed in a divided Senate in 2021.

SO WHAT: Policy failure creates momentum for climate deniers to block federal government action on climate.

Source: nbcnews.com

California PUC staff proposes rule that would destroy market for residential solar

WHAT: Some California officials would financially penalize people who invest in renewable generation on their own property.

SO WHAT: Puts renewables out of reach for low and middle income households and retards building and vehicle electrification.

Source: latimes.com

EU and China outpace American investment, reaping the gains

WHAT: China is outspending the USA in climate investment by 2 to 1.

SO WHAT: As other global powers outpace American investment, America is left with less leverage and opportunity in emerging sectors.

Source: cnbc.com

FUTURE ENERGY, ENVIRONMENT, AND NATURAL RESOURCES POLICIES IN CALIFORNIA

Choices among governmental policies depend partly upon which future scenarios seem most attractive to us, but they also depend upon our perspectives on the proper role of government, on the resources available to government, and on the likelihood that government will succeed in its endeavors. Doing nothing is sometimes the best policy option, but doing nothing often uncritically accepts the current mix of policies and the future they entail without considering the alternatives. Over the past seventy-five years in California, that meant accepting discriminatory racial housing covenants, restrictive zoning laws, few restrictions on air or water pollution, "separate but equal" schooling, the dismantling of transit systems, and many more things that are now thought to have been wrong or misguided. We have also seen aggressive policy measures in California that have had unintended consequences, from the impacts of Proposition 13 on local government budgets to the way the California Environmental Quality Act has affected housing supply and manufacturing.

Because we are thinking about the future and we do not want to be hemmed in by the status quo or a lack of imagination, we put forth an array of alternative policies, and we tie them to different scenarios. Readers can decide which ones (or combinations of them) they prefer, but, as a team and in interviews with stakeholders, most prefer the "We Want To, and We Can" future. Many of our policy suggestions will favor this scenario, and look critically at approaches that do not include both united leadership and climate innovations. Readers should consider which scenario best captures the California they want to live in, and evaluate which policy recommendations they believe will get us there.

In the case of climate change, there is currently strong political and public support in California for policies to reduce GHG emissions and to solve the state's water problems. It would take an encyclopedia-sized publication to list and discuss all the existing policies used in California to reduce emissions, move toward a zero-carbon economy, preserve natural resources, and increase resilience to climate change. The policy recommendations described below focus on a few of the most pivotal policy changes needed in California in the energy (electric power and road transport), buildings, water and adaptation sectors.

THESE POLICY RECOMMENDATIONS FALL WITHIN SEVERAL GENERAL CATEGORIES OF GOVERNMENT POLICIES AVAILABLE TO REDUCE GREENHOUSE GAS EMISSIONS AND CO-EMITTED AIR POLLUTANTS AND TO SECURE ADEQUATE SUPPLIES OF WATER INCLUDE:

- **Direct regulation of emissions (e.g., emission controls for vehicles, power plants, factories and oil/gas wells) or use of water;**
- **Market-based mechanisms that directly or indirectly place a price on carbon (e.g., cap and trade systems, low carbon fuel standards) or on water;**
- **Incentives to consumers, corporations and government agencies to adopt consumption and procurement practices that reduce emissions and save water;**
- **Land use changes and government infrastructure investment to reduce road transport, conserve water, improve resilience of infrastructure;**
- **Building codes and equipment standards that progressively increase energy and water efficiency and installation of zero emission equipment (heating and cooling systems, rooftop solar energy);**
- **Taxes on carbon or water intensive activity, operations and consumption.** [2]

[2] Carbon emission taxes are not discussed in the recommended policies for California because the existing cap-and-trade system and low carbon fuel standards effectively place a price on carbon in transportation and electric power. The effect of these policies is similar to a tax, but operates more efficiently and more progressively than a tax on carbon emissions or fossil fuel sales.

SCENARIO

WE WANT TO, WE CAN, AND ALL SECTORS PULL TOGETHER:

Public Support is Strong and the Economy is Strong

With strong public support and a strong economy, California has the will and the wherewithal to adopt decarbonization policies across all sectors.

Electric Power and Road Transportation—Regulatory and Legislative Actions to Stem GHG Emissions

Legislation is enacted to end the sale of fossil fueled vehicles, and regulations are promulgated to implement Governor Newsom's executive order (N-79-20) requiring 100 percent zero-emission-vehicles (ZEV) sales by 2035, with phase-in beginning in 2025. Legislation enacts a production cap on new and existing oil and gas wells that goes down over time and controls on methane emissions that get stricter over time, focused initially on extraction from fields with relatively high extraction costs and carbon emissions and wells near sensitive sites such as schools or residential areas. Legislation is enacted to accelerate the timeline to achieve a net zero electric power sector in California. Legislation and regulations are adopted to ramp down the refining of fossil fuels or to otherwise reduce carbon emissions from the refining industry. This ramp down should be designed to track declines in California's consumption of transportation fuels.

Electric Power and Road Transportation—Regulatory and Legislative Actions to Facilitate New Power Sources and Carbon Sequestration

Regulations facilitate the development of distributed energy resource (DER) deployment along with micro-grids and long-duration storage facilities. Regulations also fully open existing wholesale markets to competition from distributed renewable generation. Legislation accelerates the permitting and construction of 4000MW of offshore wind. Regulations or legislation make community solar viable in California and preserve net metering for solar on buildings. The state funds and facilitates public private partnerships to establish three to five hubs focused on green hydrogen production, carbon capture (in products) and CO2 sequestration. These hubs produce, store, and use green hydrogen and captured CO2 for a variety of industrial processes, transportation fuel, and long-term power sector storage uses. This effort would coordinate with and complement recent federal funding to support four hydrogen hubs with one likely to be in California.

Industry, Manufacturing, and Agriculture – Reform of California's compliance carbon offset markets, Targets for Large GHG Emitters, and Incentives for New Technologies and Sequestration

Changes to California's cap-and-trade system ensure that offsets produce real climate benefits, and expand offset eligibility to manufacturing processes capable of CO2 capture in products (such as cement manufacturing) in California. Agriculture is given a stake in a zero-carbon economy through incentives for innovative technologies and markets for carbon sequestration in soils, NO2 emission reductions, electrification of farm equipment, support for carbon free fertilizer production, and data collection on water and fertilizer use.

Industry, Manufacturing, and Agriculture – Job Training and New Industries

Job training and economic development are focused on replacing fossil industry jobs with high-road replacement employment (particularly in Central Valley and other regions with high oil and gas production and refining employment). Funding and incentives are provided for supply chain decarbonization and on-shoring of low carbon product manufacturing, especially those kinds of manufacturing that would resolve supply chain issues for critical raw materials and goods and reduce fossil fuel use. This should be designed to take advantage of CA's unique transportation network (currently used predominantly to move goods imported from Asia) to supply raw material and finished products produced in California throughout North America. California sets mandatory targets combined with tax or other incentives and international cooperative agreements to decarbonize freight and air-transport industries (aviation and shipping).

Buildings – Decommission Gas Infrastructure and Develop Better Ventilation and Air Quality Standards for Buildings

The California Public Utilities Commission leads an effort to implement affordable, equitable, reliable, and safe approaches to decommissioning existing gas infrastructure and electrifying the built environment. Working with local Air Quality Management Districts, state agencies develop new ventilation and air quality standards to reduce health and environmental costs of gas combustion in homes and businesses. Efforts are made to ensure that electrification technologies are deployed at low or no cost in low-income and disadvantaged communities, including multi-family housing and rental units. Goals are set for the gradual reduction in gas use in buildings and decommissioning of gas distribution segments - focused on the oldest gas infrastructure.

Water – Develop new Water Management Infrastructure

Using state and federal funds, dams that are reaching the end of their service life and whose costs to the environment and taxpayers outweigh benefits are retired. Remaining reservoirs are "re-operated" to meet multiple management goals, including climate resilience, groundwater replenishment, and minimum stream flows needed to protect fisheries and wildlife and provide high water quality. Reservoir re-operation (changing the schedules and rates by which water is stored and released from dams) is currently being studied by the state in order to meet multiple management objectives. The state shifts away from its reactive approach toward a proactive drought adaptation planning approach. The state strongly enforces the Sustainable Groundwater Management Act (SGMA) to mitigate groundwater overdraft statewide. To help meet the sustainability requirements of the SGMA and support water use efficiency, State agencies develop and support effective, transparent, and responsible local and regional, surface and groundwater markets. The Water Board sets ecosystem water budgets--administered by a trustee, and guided by a watershed plan and improved water accounting--access to which can be traded just like a priority water rights. In partnership with the U.S. Forest Service, the state successfully scales up prescribed and cultural fires from an estimated 125,000 acres per year today to 1 million per year by 2025, and it doubles the rate of forest thinning by 2025. The state uses and expands the existing Clean Water State Revolving Fund (SB 200) to support recycling and reuse projects for wastewater. Local and regional agencies recycle or reuse at least 2.5 million acre-feet of water a year in the next decade, and then ramp-up significantly from there. Los Angeles sets an example by recycling 100 percent of its wastewater by 2035. Proposals for expensive, inflexible large, new reservoirs are rejected in favor of more flexible reuse, conservation, and nature-based solutions.

SCENARIO

WE WANT TO, BUT MONEY IS TIGHT

Public Support is Strong but the Economy is Weak

In an economic downturn (reduced revenues, rising interest rates, and inflation), the capacity of government, businesses, and individuals to invest in zero-carbon technology and services is constrained. In this period, fossil gas and oil prices rise, which increases pressure on low-income consumers, but also makes zero carbon alternatives more cost-effective (e.g., electrification of transport and buildings, renewable hydrogen and zero-carbon liquid fuels for aviation and shipping). Relative to the federal government, California has very limited ability to engage in deficit spending and economic stimulus. Hence, it needs to find ways to decarbonize the economy that depends less on government spending.

Among the risks and challenges in this scenario is that low-income and environmental justice communities get left behind, as economic conditions limit available budgets for incentives and transition support for these communities. There is also the risk that an unjust economic transition occurs that alienates communities and workers in fossil fuel industries who see no alternative to pumping oil and refining. This could result in weakening confidence in government and political support for decarbonization.

Regulatory Actions and Low-Cost Options

The focus should be on regulatory initiatives, including market-based regulation, that accelerate transition to zero-carbon energy and transport and produce monetary surplus in the economy to support industry transitions. For example, as markets mature, electric vehicle and building systems will save money for consumers and shippers relative to fossil-based systems, and reduce drag on the economy from crude oil and fossil gas imports. Government can also fund

low-cost options including public education and facilitation to help businesses and individuals contribute to carbon emission reduction and climate resilience. Government should:

1. Prioritize procurement, building and lands management practices/ investment that are paid for by avoided energy and water costs;
2. Promote public/private partnerships where costs of climate mitigation and adaptation are shared with private sector partners;
3. Reduce costs of climate transition for local government (e.g., services that help local government to secure low-cost financing for climate mitigation and resilience); and
4. Share costs of recycling, wildfire preparedness, and other municipal services with the private sector.

SCENARIO

WE CAN, BUT POLITICAL AND PRIVATE WILL WANE

Public Will is Weak, but the Economy is Strong

While the economy is still reasonably healthy and both technology and market innovations are strong, the public and business communities have grown weary of the push to decarbonize. It is taking too long and there are too many uncertainties. In addition, increasing severity of climate disasters, including wildfires, have diverted interest towards near-term climate resilience and adaptation measures instead of efforts to stabilize climate in the long-term. In a period of reduced public and private support for climate policy, state and local governments need to pay more attention to low-risk investments in climate adaptation and resilience, workforce and economic development, and policies that produce short term economic and health benefits.

Risks and challenges in this scenario are that the state invests in climate adaptation tactics without a long-term strategy to curb emissions. As a result, higher-income households and large corporations continue to invest in adaptation and new decarbonization technologies, while low- and middle-income households and individuals are left few options to respond to climate emergencies or rising energy and water costs.

Electric Power and Road Transportation

The state should deploy Distributed Energy Resources where they are most cost-effective and can provide health, resilience, and economic benefits. To remain globally competitive on EV and battery storage deployment and manufacturing, the state should invest in new technology deployment, workforce training, and economic development grants to attract new manufacturing.

Industry and Manufacturing

State Economic Development Agencies should refocus job training and economic development investment to create alternatives to fossil fuel industry jobs in Central Valley and coastal refinery towns. State agencies should coordinate a managed decline in oil and gas production and refining with reduced demand for fossil transportation fuels, and work with the private sector to create new low-carbon industries that preserve employment from existing California oil/gas fields (e.g., geothermal power production and critical mineral recovery, oil field remediation that reuse oil and gas infrastructure and utilize workforce skill sets).

Buildings

The state legislature and agencies should focus on workforce training keyed to low carbon construction and maintenance practices for buildings. Support for heat pump water heaters, central HVAC heating and cooling, and residential and commercial energy storage should be deployed, in part, to support microgrid capabilities and emergency response for climate-related disasters.

Water

The state should incentivize agriculture to shift land use to crops that require less water, or to non-agricultural uses. It should focus staff on creating public-private partnerships to undertake adaptation planning and drought-preparedness. The state legislature and agencies should double down on incentives for conservation of groundwater resources and invest in water use efficiency, data collection, and R&D.

Adaptation

Policies should aim to double down on preparedness, response, and recovery to climate impacts. Investments in critical infrastructure systems should be advanced as public safety and employment measures. The state should invest in data and mapping tools to identify disaster prone priority areas and support resiliency measures such as updating power grids and water infrastructure. Regulatory policies should be implemented to avoid overburdening ratepayers or shifting costs to low- and moderate-income communities.

SCENARIO

WE CAN'T, AND APATHY GROWS

Public Will is Weak and the Economy is Weak

The authors view this as the least likely future scenario, but one that cannot be discounted completely given the recently volatile nature of national politics, the state of the global economy, and external stresses (e.g., COVID-19). The nightmare scenario for California is a

a period of economic and policy stagnation in the face of mounting climate impacts. The storyline below includes references to existing policy flaws and recent events that illustrate how this scenario could become reality.

This scenario could occur for a combination of reasons. Corporations such as oil companies and electric and gas utilities block changes that affect them. People retreat to their automobiles and shun mass transit after COVID-19. Funding for electric vehicle infrastructure runs out and there are no means by which to reduce consumer range anxiety, which breeds an aversion to electric vehicles. The state experiences major infrastructure and climate-related failures – dams fail, fires ravage California forests, storms and sea level rise destroy large amounts of property along the California coast. Fire and flood insurance become unavailable or unaffordable for large portions of Californians. Rural areas of California are gradually depopulated by wildfire, flooding, heat and drought; there is increased homelessness in urban areas, where displaced rural people mix with climate refugees from Central American regions made unlivable due to heat, drought and hurricanes. California loses its agricultural product export markets to drought, labor scarcity and extreme heat. The state and local governments lose access to low-cost financing for infrastructure due to heightened physical risks and a continuing failure to disclose climate risk and mitigation information to investors. Air pollution hotspots and groundwater contamination persist in most communities of color. As school districts run out of funding for clean water and air filters, graduation rates drop while childhood asthma rates and health care costs rise.

The federal government falls under the control of climate deniers who block California mobile source controls on smog and GHG emissions and collapse federal spending on climate adaptation and GHG emission reduction. Consumers and the agriculture industry ignore pleas to reduce water use; depletion of ground water resources continues due to weak implementation of state groundwater protection laws. California's tourism industry wilts in extreme heat, wildfire smoke, snow-melt, and homelessness. The State's tax base and credit ratings erode as wealthy people flee California climate risk.

Factors unrelated to climate magnify stresses on business, governments and populations:

- A major earthquake in northern California;
- Southern California logistics and transport industry lays off 50,000 workers due to military or political conflicts that disrupt trade with Asia.
- A new epidemic spreads along the Pacific rim.

Under these circumstances policy options to address climate narrow sharply. With a bad economy (rising energy prices, interest rates, inflation and unemployment), the government turns its resources toward emergency response, and short-term adaptation investments. Reducing Greenhouse Gases is seen as a fruitless effort since, without U.S. and California leadership, hopes for an effective global climate response fade. Mounting climate change damages and declining public support for climate mitigation foster an insular “California-First’’ mentality.

This would be a period to focus available resources on hardening the state’s water and electric power infrastructure, coastlines and floodplains against climate impacts. Adaptation becomes more important than mitigation measures to protect future generations, wildlife and distant human populations. Infrastructure hardening expenditures help drive some economic recovery and employment, but can’t keep up with climate impacts.

Among risks and challenges in this scenario are increasingly severe impacts of the fossil fueled economy on minority and low-income communities with the state providing only limited relief and investment for low-income and environmental justice communities. These communities will continue to bear the disproportionate impacts of pollution and climate change.