

DOCKETED

Docket Number:	16-IEPR-01
Project Title:	General/Scope
TN #:	216280
Document Title:	Final 2016 Integrated Energy Policy Report Update- Executive Summary
Description:	N/A
Filer:	Stephanie Bailey
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	2/28/2017 1:15:41 PM
Docketed Date:	2/28/2017

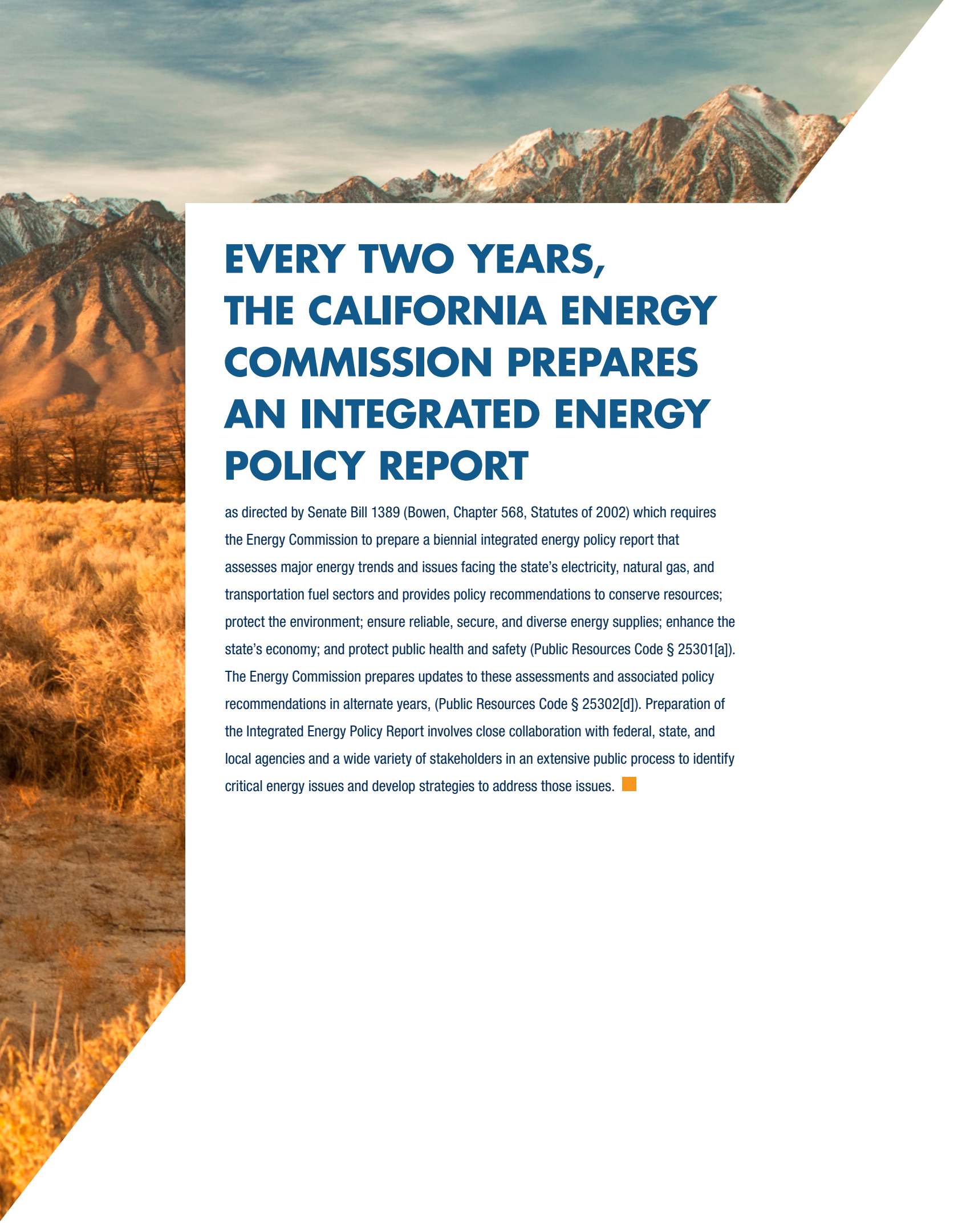


2016 IEPR UPDATE

INTEGRATED ENERGY POLICY REPORT
EXECUTIVE SUMMARY

CALIFORNIA ENERGY COMMISSION
EDMUND G. BROWN JR., GOVERNOR
FEBRUARY 2017 | CEC-100-2016-003-CMF-ES





EVERY TWO YEARS, THE CALIFORNIA ENERGY COMMISSION PREPARES AN INTEGRATED ENERGY POLICY REPORT

as directed by Senate Bill 1389 (Bowen, Chapter 568, Statutes of 2002) which requires the Energy Commission to prepare a biennial integrated energy policy report that assesses major energy trends and issues facing the state's electricity, natural gas, and transportation fuel sectors and provides policy recommendations to conserve resources; protect the environment; ensure reliable, secure, and diverse energy supplies; enhance the state's economy; and protect public health and safety (Public Resources Code § 25301[a]). The Energy Commission prepares updates to these assessments and associated policy recommendations in alternate years, (Public Resources Code § 25302[d]). Preparation of the Integrated Energy Policy Report involves close collaboration with federal, state, and local agencies and a wide variety of stakeholders in an extensive public process to identify critical energy issues and develop strategies to address those issues. ■

ABSTRACT

The *2016 Integrated Energy Policy Report Update* provides the results of the California Energy Commission's assessments of a variety of energy issues facing California. Many of these issues will require action if the state is to meet its climate, energy, air quality, and other environmental goals while maintaining reliability and controlling costs. The *2016 Integrated Energy Policy Report Update* covers a broad range of topics, including the environmental performance of the electricity generation system, landscape-scale planning, the response to the gas leak at the Aliso Canyon natural gas storage facility, transportation fuel supply reliability issues, updates on Southern California electricity reliability, methane leakage, climate adaptation activities for the energy sector, climate and sea level rise scenarios, and the *California Energy Demand Forecast*.

Keywords:

California Energy Commission, electricity demand forecast, Aliso Canyon, natural gas, methane emissions, climate adaptation, climate change, Environmental Performance of the Electricity Generation System, Southern California reliability, nuclear

Please use the following citation for this report:

California Energy Commission Staff. 2016. *2016 Integrated Energy Policy Report Update*.
California Energy Commission. Publication Number: CEC-100-2016-003-CMF-ES.

**“It’s time for courage,
it’s time for creativity,
and it’s time for boldness
to tackle climate change.”**

- Governor Edmund G. Brown Jr.

EXECUTIVE SUMMARY



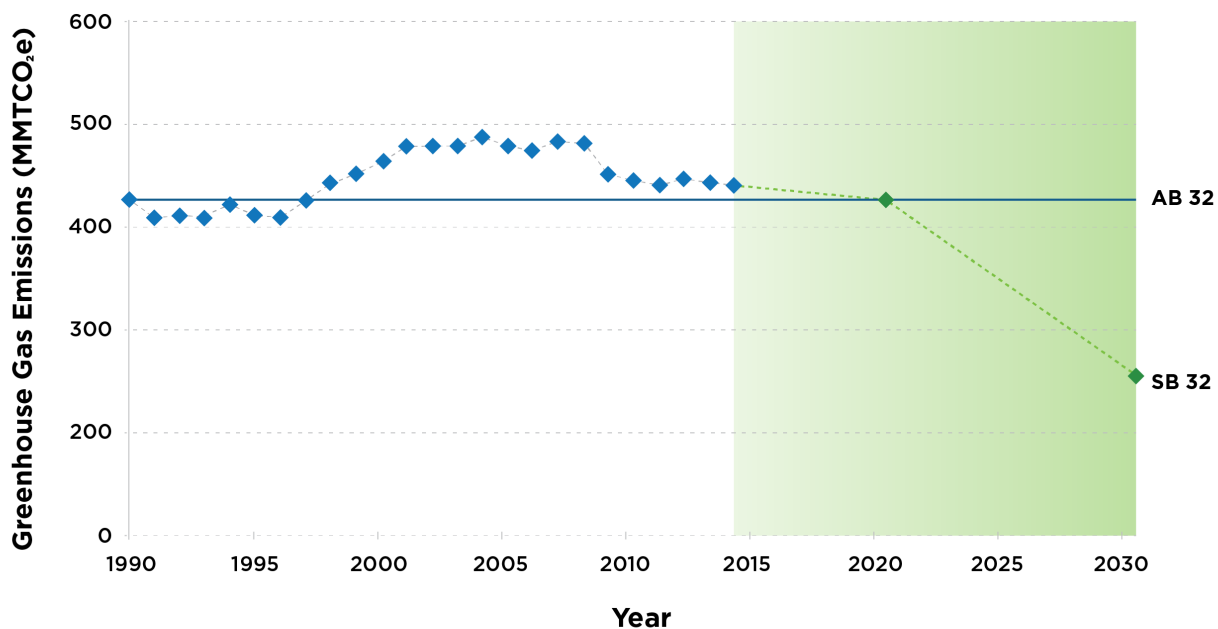
California continues to be a global leader in developing energy and environmental policies to address climate change. As the sixth largest economy in the world, California has demonstrated that it can grow its economy while reducing the environmental footprint of its energy system. Californians rely on their energy system to fuel the cars that get them to work, to power hospitals and schools, to pump water to communities and crops, and to operate machinery—to name only a few examples. Energy fuels the economy, but it is also the biggest source of greenhouse gas emissions that lead to climate change. Despite California's leadership, Californians are experiencing the impacts of climate change including higher temperatures, prolonged drought, and more wildfires. There is an urgent need to reduce greenhouse gas emissions and increase the state's resiliency to climate change. As Governor Edmund G. Brown Jr. said, "It's time for courage, it's time for creativity, and it's time for boldness to tackle climate change."

The world is at a transition point. There is growing international recognition that greenhouse gas emissions are changing the climate with wide-ranging impacts, including higher temperatures that affect everything from human health to energy demand to agricultural output; more extreme weather events such as increasingly

devastating hurricanes, stronger storms, and prolonged heat waves; and rising sea level that is displacing communities and stressing infrastructure. On December 14, 2016, Governor Brown stated, "The time has never been more urgent . . . the world is facing tremendous danger." California's unprecedented drought is resulting in the death of vast swaths of drought-stressed trees that have succumbed to bark beetle infestation—more than 102 million trees have died since 2010. About half of the 20 largest wildfires in California burned in the last decade. Climate change impacts put U.S. military installations at greater risk and could increase international conflict.

For this report, the energy system includes energy extraction, transport, conversion (such as combusting natural gas in power plants to generate electricity or producing gasoline and diesel from crude oil in refineries), and consumption for services (such as electricity for lighting, natural gas use in homes and buildings for space and water heating, and gasoline and diesel to fuel cars and trucks), as well as electricity from out-of-state plants serving California. Using this broad definition, the energy system is the source of 80 percent of the state's greenhouse gas emissions. As is necessary, California must transition its energy system to reduce greenhouse gas emissions. In his 2015 state-of-the-state

Figure ES-1: California's Path to Progress to Meet Climate Goals



Source: California Energy Commission, Tracking Progress Web page, Greenhouse Gas Emission Reductions, updated December 20, 2016.

Note: Not shown is California's 2050 goal to reduce greenhouse gas emissions 80 percent below 1990 levels by 2050 as set in Executive Order B-30-15.

address, Governor Brown laid out his vision for reducing California's greenhouse gas emissions and said that it "means that we continue to transform our electrical grid, our transportation system and even our communities." This report examines how the state is transforming its electricity sector and identifies transformations that are still needed in other sectors of the energy system to achieve the state's energy and climate policy goals.

California's Policy Initiatives to Reduce Greenhouse Gas Emissions

California took a bold new step to reduce greenhouse gas emissions on September 8, 2016. Governor Brown signed Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), putting into law a statewide goal to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030. He also signed a companion bill, Assembly Bill 197 (Garcia, Chapter 250, Statutes of 2016), to assure that the state's implementation of its climate change policies

is transparent and equitable, with the benefits reaching disadvantaged communities.

These bills build on the 40 percent by 2030 greenhouse gas reduction goal set in Governor Brown's Executive Order B-30-15 and come 10 years after enactment of the California Global Warming Solutions Act of 2006 (Assembly Bill 32, Núñez, Chapter 488, Statutes of 2006) (AB 32), the landmark legislation that requires the state to reduce greenhouse gas emissions to 1990 levels by 2020. California is well on its way to meeting the 2020 target, but the new 2030 requirement is much more ambitious and requires renewed focus and creativity to meet it. Figure ES-1 shows California's greenhouse gas reduction goals against historical greenhouse gas emissions.

Another groundbreaking effort to address climate change was Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) (SB 1383), which requires the California Air Resources Board (ARB) to develop and

begin implementing a comprehensive strategy to reduce emissions of short-lived climate pollutants. Short-lived climate pollutants cause more climate change in a shorter time frame than carbon dioxide, the primary greenhouse gas, such that emission reductions can produce faster benefits. By January 1, 2018, the ARB is required to develop a comprehensive strategy to reduce emissions of short-lived climate pollutants to reduce methane emissions by 40 percent, hydrofluorocarbon gases by 40 percent, and anthropogenic black carbon by 50 percent below 2013 levels by 2030. SB 1383 also requires, as part of the *2017 Integrated Energy Policy Report (IEPR)*, the Energy Commission to make recommendations on the development and use of renewable natural gas, including biomethane and biogas.

Through Assembly Bill 1613 (Committee on Budget, Chapter 370, Statutes of 2016), Senate Bill 859 (Committee on Budget and Fiscal Review, Chapter 368, Statutes of 2016), Assembly Bill 1550 (Gomez, Chapter 369, Statutes of 2016), and Assembly Bill 2722 (Burke, Chapter 510, Statutes of 2016) the Governor and Legislature allocated \$900 million from the Greenhouse Gas Reduction Fund to help equitably achieve the state's 2030 greenhouse gas reduction goal. The funding distributes proceeds from California's Cap-and-Trade Program to limit greenhouse gas emissions by supporting programs that benefit disadvantaged communities, advance clean transportation, protect the natural environment, and cut short-lived climate pollutant emissions.

While California is taking bold steps to reduce its greenhouse gas emissions, the state generates only 1 percent of global emissions—reducing California's emissions will not be enough to solve climate change. Speaking in Beijing, China, in 2013, Governor Brown called for unified action to combat climate change. "We're in one world. We've got one big problem, and we all have to work on it. And what's beautiful and exciting about climate change is no one group can solve the problem— not the United States, not California, not Japan, not

China—we all have to do it. This is a great unifier. This is an imperative where human beings could collaborate."

To advance global action, the Governor is spearheading the Under2Coalition, a commitment by cities, states, and countries to take action to help limit the rise in global average temperature to below 2 degrees Celsius. Signatories agree to reduce greenhouse gas emissions 80 to 95 percent below 1990 levels by 2050 or achieve a per capita annual emissions target of less than 2 metric tons by 2050; such emission reductions are considered sufficient to avoid catastrophic climate change. Collectively, 167 jurisdictions representing 33 countries, 1.09 billion people, and 35 percent of the global economy have signed or endorsed the *Subnational Global Climate Leadership Memorandum of Understanding*. (See <http://under2mou.org/> for the latest statistics on the "Under 2 MOU.") Governor Brown was also a leader at the 2015 United Nations Climate Change Conference in Paris and has signed accords with leaders from Mexico, China, Canada, Japan, Israel, and Peru to reduce greenhouse gas emissions. In December 2016, Governor Brown joined the governors from Oregon and Washington, as well as leaders from Chile and France, to launch a new partnership of jurisdictions worldwide to protect coastal communities and economies from rising ocean acidity—the International Alliance to Combat Ocean Acidification.

California is also working with its partners to address climate change through regional efforts. Governor Brown joined Alaska, British Columbia, Oregon, and Washington to form the Pacific Coast Collaborative, a forum for leadership and information sharing on issues of concern to the Pacific North America. The Clean Energy and Pollution Reduction Act (De León, Chapter 547, Statutes of 2015) (Senate Bill 350) paves the way for a regional electricity grid that will provide benefits in terms of lower energy costs, lower greenhouse gas emissions, and better reliability.

In his 2015 inaugural speech, the Governor set the following goals for 2030: double efficiency of existing buildings and make heating fuels cleaner, increase from one-third to 50 percent electricity derived from renewable

sources, and reduce today's petroleum use in cars and trucks by up to 50 percent. The Governor also called for the state to "reduce the relentless release of methane, black carbon, and other potent pollutants across industries. And we must manage farm and rangelands, forests, and wetlands so they can store carbon." The Governor's energy efficiency and renewable energy goals were codified in SB 350, which also requires investor-owned utilities to increase the access to electricity as a transportation fuel to support widespread transportation electrification.

Transformation of California's Electricity System Over the Last Decade

California has realized tremendous progress in the environmental performance of its electricity system over the last decade, primarily as a result of its energy and environmental policies. While AB 32 sets an economywide, rather than sector-specific, requirement to attain 1990 levels by 2020, greenhouse gas emissions from the electricity sector are already 20 percent *below* 1990 levels. With transportation accounting for about 37 percent of California's greenhouse gas emissions in 2014, transforming California's transportation system away from gasoline to zero-emission and near-zero-emission vehicles is a fundamental part of the state's efforts to meet its climate goals.

Reduced greenhouse gas emissions from the electricity sector is attributable largely to increases in renewable energy and decreases in coal-fired generation. Installed capacity of renewable energy in California has more than tripled from 6,800 megawatts (MW) in 2001 to 26,300 MW (including small, self-generation such as rooftop solar) as of October 31, 2016. Meanwhile, coal-fired electricity served about 11 percent of California's electricity demand in 2000 but has steadily declined to serve less than 6 percent by the end of 2015, and is expected to decline to zero by the middle of the next decade. Criteria pollutant emissions from the electricity sector (emissions that cause smog and harm human health) are modest, contributing

just 2 percent of total emissions in 2000, and were cut by more than half by 2015.

Most of the growth in renewable energy resources has come from wind and solar. Solar in particular has realized tremendous growth in California, increasing from a little more than 400 MW in 2001 to more than 7,000 MW in 2015. The most dramatic change is the addition of utility-scale, solar photovoltaic power plants, especially between 2010 and 2015 when installed capacity rose from roughly 40 MW to 5,700 MW. Residential solar installations have also grown dramatically, with California accounting for more than 40 percent of the installed capacity nationwide. Enacted in 2006, Senate Bill 1 (Murray, Chapter 132, Statutes of 2006) set the goal to install 3,000 MW of solar energy systems on new and existing residential and commercial sites by 2017. The state has already exceeded that goal with the installation of 4,400 MW, almost 2,000 MW of which were installed just in 2014 and 2015.

California rightly treasures its natural landscapes. Its beauty is an enduring draw to visitors, and it is home to diverse wildlife and vegetation. The land and waterways are also sacred to many California Native Americans. As part of an effort to protect its natural resources while planning for needed development, California has made tremendous strides in its land-use planning for electricity generation and transmission projects. The increased development of large-scale renewable energy projects, particularly in sensitive desert landscapes, prompted federal, state, and local agencies to conduct landscape-scale planning to both protect the region's cultural resources and foster development of needed renewable generation. The *Desert Renewable Energy Conservation Plan* is a comprehensive effort to identify the most appropriate areas for large-scale renewable energy development within 22 million acres of public and private desert landscape while protecting and conserving desert ecosystems. After eight years of extensive stakeholder engagement and multiagency collaboration, on September 14, 2016, the U.S. Secretary

of the Interior Sally Jewell approved Phase I of the *Desert Renewable Energy Conservation Plan* covering 10.8 million acres of public lands managed by the Bureau of Land Management in the California desert.

Building on such planning efforts, the Energy Commission, California Public Utilities Commission (CPUC), California Independent System Operator (California ISO), the California Natural Resources Agency, and the U.S. Bureau of Land Management launched the Renewable Energy Transmission Initiative (RETI 2.0) to identify the constraints and opportunities for new transmission needed to access additional renewable energy resources.

As water is an increasingly precious resource in California, the state has worked to reduce water consumption associated with electricity generation and the impacts on aquatic environments. Over the past decade, the fossil-fueled power plant fleet in California has become more water-efficient, resulting in a relatively modern fleet of thermal power plants that consume little water. Energy production uses less than 1 percent of all consumptive water use in California, but the use can impact the water supply of local communities. The total amount of freshwater used for cooling has not increased in the last decade, despite the addition of numerous thermal power plants. The increased use of dry-cooling technologies and the use of recycled water have significantly increased the water efficiency of power plants in California. Even greater improvements can be achieved, however, by updating the 2003 *IEPR* water policy to require the use of recycled water and alternative technologies for all power plant operations. Based upon the last four to five years of drought, it is time to make California's energy system resilient to drought.

More Work Is Needed to Decarbonize California's Overall Energy System

The advancements in California's electricity system demonstrate that California is capable of transforming its energy system in a relatively short time frame; however,

much more work is needed to reduce greenhouse gases to 40 percent below 1990 levels by 2030. California must dramatically reduce emissions even as its population is expected to grow from about 38 million today to more than 44 million by 2030.

The rapid growth in California's renewable resources has brought new challenges for grid operators trying to maintain reliability while managing swings in wind and solar generation. In 2013, the California ISO projected that net energy demand after subtracting behind-the-meter generation (net load) could be as low as 12,000 MW by 2020 and that meeting peak demand may require ramping up 13,000 MW in three hours. Two days in 2016 illustrate that the grid is already experiencing unprecedented operational fluctuations that grid operators were bracing for in 2020. On May 15, 2016, the net load reached a minimum of 11,663 MW, and on February 1, 2016, the three-hour ramp was 10,892 MW, with the peak shifting to later hours in the day. Helping address such challenges, the California ISO, PacifiCorp, NV Energy, Arizona Public Service, and Puget Sound Energy participate in an Energy Imbalance Market (EIM) to balance supply and demand deviations in real time and dispatch least-cost resources every five minutes. With the EIM, excess energy in the California ISO balancing area can be transferred to other areas in real time. If not for energy transfers through the EIM, the California ISO would have curtailed 328,000 MWh of renewable energy in 2016, equivalent to 140,000 metric tons of carbon emissions.

Development of a regional, westwide electricity market is critical to help integrate renewable energy resources, maximize the use of these resources, and achieve benefits beyond those gained with the EIM. The California ISO's study found that a regional grid would save California ratepayers up to \$1.5 billion per year; create between 9,900 and 19,300 additional jobs in the state, primarily due to the reduced cost of electricity; and reduce greenhouse gas emissions by more than 7 million metric tons by 2030.

As California moves away from fossil fuels to reduce greenhouse gas emissions, it will need more resources that can be depended on to quickly and cost-effectively ramp up or down to help maintain the reliability of the electricity system. Flexibility is necessary to compensate for hourly changes in variable renewable generation and energy demand, as well as outages for power plant maintenance and seasonal variations in hydropower generation. Natural gas-fired power plants offer the most flexibility for quickly, reliably, and cost-effectively ramping up or down to balance supply and demand. California relies on the ramping capabilities of natural gas even as it is moving away from using it. In the summer of 2016 natural gas use was down 20 percent in California compared to the previous year due to better hydroelectric conditions and more renewable energy coming on-line. The state will need to transition to other options, however, to meet its flexibility needs, including reliably and quickly ramping energy load up or down (demand response) and deploying cost-effective storage to manage excess generation and then inject it into the system when needed. Assembly Bill 33 (Quirk, Chapter 680, Statutes of 2016) requires the CPUC to analyze the potential for long-duration bulk energy storage to help integrate renewable resources. Even as the state works to increase demand response and storage capacity by orders of magnitude, it will likely depend on some natural gas-fired generation to meet its needs for flexibility.

Another change in California's energy system is the decision by hundreds of thousands of homeowners to install solar on their rooftops. However, the electricity distribution system was designed on a different model, one that was based on the use of large-scale, conventional power plants and in which electricity would flow to the end user. The growing use of small, distributed generation requires upgrades to the distribution system that will better enable California to meet its greenhouse gas reduction goals and maintain a safe and reliable system. As California electrifies its transportation system, this need will only grow.

Similarly, developing more utility-scale renewable generation to meet the state's 2030 greenhouse gas reduction goals and Renewables Portfolio Standard requirements will require new investments in the state's electric transmission system. (The Renewables Portfolio Standard was established in 2002 to require 20 percent of electricity retail sales be served with eligible renewable energy by 2017 and became increasingly more aggressive to require 50 percent by 2030 [set in 2015].) In his Clean Energy Jobs Plan, Governor Brown set a goal to dramatically reduce the permitting time for transmission projects needed to tap new renewable resources to no longer than three years. The permitting process, however, continues to lag, taking six to eight years. It is past time for the Energy Commission, CPUC, and California ISO to implement the Governor's vision for transmission permitting, and the agencies should do so within the next two years through a determined effort of regulatory process reform.

Energy efficiency and demand response are also key components of the state's strategy to reduce greenhouse gas emissions. Consistent deployment of efficiency through building codes, appliance standards, and ratepayer-funded programs has had a tremendous positive impact. At sufficient scale, energy efficiency reduces the need for new generation and transmission resources. The Energy Commission is implementing the *Existing Buildings Energy Efficiency Action Plan* to help meet the Governor's goal. But the state will need to do even more.

Transforming California's transportation sector away from gasoline to zero-emission and near-zero-emission vehicles—powered predominantly with renewable electricity—is fundamental to California's strategy for meeting its greenhouse gas reduction goals. While sales are growing and infrastructure deployment is advancing, much more growth is needed to meet the Governor's goal of 1.5 million zero-emission vehicles on California roadways by 2025.

All Californians need to have access to, and realize the benefits from, efforts to advance energy efficiency

and weatherization, renewable energy, and zero-emission and near-zero-emission vehicles. In accord with SB 350, state agencies are evaluating the barriers for low-income customers, including those living in disadvantaged communities, to access these clean energy technologies and are providing recommendations for how to address these barriers. The Energy Commission reported on energy efficiency and renewable energy, while the ARB is reporting on clean transportation, in consultation with other state agencies, by early 2017. To ensure the full economic and societal benefits of California's clean energy transition are realized, the Energy Commission is also evaluating the barriers to contracting opportunities for local small businesses in disadvantaged communities, along with potential solutions.

Finally, innovative ideas and technologies will help spur advancements and technology breakthroughs needed in the years ahead. California leads the nation in the development of innovative technologies and must continue to support the research, development, and deployment of emerging technologies that will be critical to ultimately transform its energy system.

California Needs to Manage the Legacy of Its Aging Infrastructure

While California must take swift action to address climate change, it is also grappling with the legacy of an aging energy infrastructure. In the past few years, the state has suffered two major disruptions in its energy infrastructure that require vigilance and have tested the state's abilities to provide reliable energy services to Southern California. Californians expect a reliable energy supply; energy supply disruptions can put public health and safety at risk and have consequences to local businesses and the economy as a whole.

The most recent disruption stems from the massive leak at the Aliso Canyon natural gas storage facility in late 2015 that severely disrupted the local community and continues to put the energy reliability of the area at risk. The ARB estimates that the leak added about 20 percent

to statewide methane emissions over the duration.¹

The Energy Commission, CPUC, California ISO, and the Los Angeles Department of Water and Power worked together to assess the risks to local energy reliability and develop action plans to reduce the risk. The action plans identify measures to reduce reliance on the Aliso Canyon natural gas storage facility. The *Aliso Canyon Action Plan to Preserve Gas and Electric Reliability for the Los Angeles Basin* focused on reducing natural gas used to produce electricity and better matching gas deliveries with demand on a daily basis. In the summer, electricity demand is high as air conditioners run more in hot weather. In the winter, the demand for natural gas used in homes and business for heating goes up, and the demand for electricity goes down. Thus, the *Aliso Canyon Gas and Electric Reliability Winter Action Plan* focuses on reducing natural gas use for heating.

In response to the leak at Aliso Canyon, the Legislature passed a suite of bills addressing the storage of natural gas. Senate Bill 380 (Pavley, Chapter 14, Statutes of 2016) continues the moratorium on injection of natural gas at the Aliso Canyon gas storage facility until specified standards are met. Senate Bill 826 (Leno, Chapter 23, Statutes of 2016) appropriates \$2.5 million to the California Council on Science and Technology to study the long-term viability of natural gas storage facilities in California in accordance with the Governor's Aliso Canyon State of Emergency Proclamation. Senate Bill 887 (Pavley, Chapter 673, Statutes of 2016) establishes a framework for reforming natural gas storage well oversight and regulation. Senate Bill 888 (Allen, Chapter 536, Statutes of 2016) assigns the Office of Emergency Services as the lead agency for large natural gas leak emergency responses and directs the CPUC to level financial penalties for gas leaks and use the funds to reduce the impacts.

1 The Southern California Gas Company has committed to address methane emissions from Aliso Canyon, including signing letters of intent with several dairies, which are the largest source of methane emissions in California.

Apart from the major leak at Aliso Canyon, there are concerns about ongoing leaks that occur throughout the natural gas system, including extraction, transmission, distribution, and end use. Natural gas is composed of methane primarily, a more potent greenhouse gas than the carbon dioxide created when it or other fossil fuels are burned for energy use. Ongoing research is aimed at identifying and reducing such leaks, and Assembly Bill 1496 (Thurmond, Chapter 604, Statutes of 2016) requires the ARB to monitor methane emissions and conduct a life-cycle analysis of natural gas.

The second ongoing risk to energy reliability in Southern California stems in part from the unexpected shutdown of the San Onofre Nuclear Generating Station (San Onofre) in 2012 and the permanent closure of the plant in 2013. This was compounded by the planned closure of several natural gas-fired power plants along the Southern California coast as a result of the phaseout of once-through cooling technologies. Once-through cooling was commonly used when power plants were developed in the 1950s through the 1970s, and the related phaseout is an important improvement in the environmental footprint of California's energy system. Implementation of the policy, however, must be made with careful consideration to the impacts on local electricity reliability. A multiyear, joint agency effort has been closely tracking the development of resources needed to assure reliability in the area, including preferred resources (such as energy efficiency, demand response, distributed renewable energy generation, and storage), transmission additions, and conventional generation. One of the conventional generation projects that the interagency team is tracking, the Carlsbad Energy Center, was planned to replace the Encina plant but is facing delays from legal challenges. Although the joint agency efforts have worked diligently to maintain reliability while meeting the once-through cooling phaseout schedule, the joint agencies may need to request that the State Water Resources Control Board delay the schedule for the Encina power plant.

The last operational nuclear power plant in California, Diablo Canyon, will close by 2025 as part of an agreement among Pacific Gas and Electric Company, labor, and environmental organizations. The decommissioning of San Onofre is now underway, and the planning and preparations to shut down Diablo Canyon in 2024–2025 will occur over the next several years. For both plants, public safety, security, environmental remediation, and the management of radioactive materials will continue to be key concerns throughout the decommissioning (and for the remaining operational years of Diablo Canyon). Policy makers, local officials, and the owners of the plants must plan for the long-term management of spent nuclear fuel onsite, taking into account the unique seismic and tsunami hazards of coastal locations, the dense population surrounding San Onofre, and the maintenance and potential replacement issues related to aging systems. Citizen groups, local government, and state agencies continue to express concern over long-term onsite storage, while engaging federal agencies and congressional representatives for expedited development of both interim and permanent storage options for nuclear materials. Furthermore, the safe transport of nuclear waste over California's railways and highways must also be planned and managed for a future date when the federal government begins to accept high-level nuclear waste from decommissioning nuclear plants.

Planning for the Future

Over the last decade, regulators focused primarily on developing program-specific targets to advance California's energy system (such as separate targets for renewable energy, energy efficiency, demand response, storage, and other attributes), but the state is shifting to a more comprehensive approach aimed at improving the performance of the system and achieving the 2030 greenhouse gas reduction goals. SB 350 requires investor-owned utilities, other electricity retail sellers, and larger publicly owned utilities to develop integrated resource plans that incorporate both supply- and demand-side resources

to meet greenhouse gas emission reduction goals, maintain reliability, and control costs. The integrated resource plans will be the primary tool for implementing greenhouse gas reduction measures in the electricity sector.

In planning for new transmission and generation infrastructure, the state needs to continue refining and implementing proactive strategies, like landscape-scale planning, to reduce energy infrastructure impacts. Such efforts integrate environmental information into statewide energy planning and decision making and can be used for local planning efforts. Further, the state needs to accelerate efforts to incorporate climate science and adaptation into landscape-level and infrastructure planning. The Energy Commission, in coordination with other state and federal agencies, should update and provide guidance documents to advance best management practices in permitting renewable energy power plants.

Charting a new course to meet the 2030 greenhouse gas reduction goals will also require expanded and improved analytical capabilities. The energy demand forecast informs infrastructure planning decisions, such as the need for additional energy resources or transmission that can have long-term implications for the state's greenhouse gas emissions. To reflect changes in the evolving energy system, forecasters need access to more granular data, particularly more locational data, to track supply and demand fluctuations associated with, for example, increases in distributed energy resources, energy efficiency, and zero-emission vehicle charging. Further analysis is also needed to better understand how the peak demand is shifting to later in the day with the increased use of rooftop solar. It will also be important to understand the potential effects of new residential time-of-use rates that encourage consumers to change when they use electricity. Efforts to begin addressing these issues in this *IEPR* lay the groundwork for revisions to the Energy Commission's forecast in the *2017 IEPR* and beyond.

California will need to redouble its efforts to reduce greenhouse gases from the transportation sector. Ongoing

efforts to transform California's transportation system requires among other things, advancing both zero-emission and near-zero-emission vehicle infrastructure and vehicle deployment. The Energy Commission and other California state agencies will continue to implement the actions set forth in the *Zero-Emission Vehicle Action Plan* to meet the Governor's goals for zero-emission vehicles.

Despite efforts to reduce greenhouse gas emissions, California's climate is changing, requiring action to protect lives, livelihoods, and ecosystems. Governor Brown's Executive Order B-30-15 mandates expansion of state adaptation efforts, with the goal of making the anticipation and consideration of climate change a routine part of planning. Also in 2015 and 2016, four bills became law in California that will collectively enhance the state's capacity to anticipate and remain resilient in the face of climate change at local and regional levels, across a variety of economic sectors, and in a manner that protects people, places, and resources. The bills are Senate Bill 379 (Jackson, Chapter 608, Statutes of 2015), Senate Bill 246 (Wieckowski, Chapter 606, Statutes of 2015), Assembly Bill 1482 (Gordon, Chapter 603, Statutes of 2015), and Assembly Bill 2800 (Quirk, Chapter 580, Statutes of 2016).

More research is needed to continue monitoring and to better understand how the energy system impacts the environment and how the changing climate will affect the environmental performance of the energy system. Continued climate research for the energy sector is also needed to better inform climate adaptation and mitigation strategies; for example, energy planners should use a common set of climate scenarios as selected by the Climate Action Team Research Working Group and implement updated guidance from the Ocean Protection Council.

The state needs to build on and expand the successes realized in the electricity sector over the last decade. Meeting the 2030 greenhouse gas reduction goal in the energy sector will be a considerable challenge, but California has the talent, tenacity, and resources to make the necessary transformation. ■

CALIFORNIA ENERGY COMMISSION

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ACKNOWLEDGEMENTS

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