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California Energy Commission

STAFF REPORT

Final 2016 Environmental Performance Report of California's Electrical Generation System

Prepared in Support of the *2016 Integrated Energy Policy Report* Proceeding (16-IEPR-03)

California Energy Commission

Edmund G. Brown Jr., Governor

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California Energy Commission

Jim Bartridge
Melissa Jones
Eli Harland
Judy Grau
Primary Authors

Jim Bartridge
Project Manager

Sylvia Bender
Deputy Director
ENERGY ASSESSMENT DIVISION

Michael Lewis
Deputy Director
SITING, TRANSMISSION AND ENVIRONMENTAL PROTECTION

Laurie ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Robert P. Oglesby
Executive Director

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Contributing Authors:

Gerry Bemis

Justin Cochran

Scott Flint

Tom Gates

Jeanine Hinde

Andrea Koch

Suzanne Korosec

Matthew Layton

Paul Marshall

Gabriel Roark

Tim Singer

David Stoms

Marylou Taylor

Lisa Worrall

Sonya Ziaja

Contributing Staff:

Rizaldo Aldas

Al Alvarado

Gina Barkalow

Matt Chalmers

Ann Crisp

Jonathan Fong

Guido Franco

Matt Fung

Chuck Gentry

Mike Gravely

Ashley Gutierrez

Jon Hilliard

David Hungerford

Roger Johnson

Steve Kerr

Ellen LeFevre

Virginia Lew

Ostap Loredo-Contreras

Alana Mathews

Patrick McAuliffe

Jennifer Nelson

Le-Quyen Nguyen

Silvia Palma-Rojas

Jamie Patterson

Fernando Piña

Scott Polaske

Kiel Pratt

Jana Romero

Mike Sokol

Linda Spiegel

Kevin Uy

Carol Watson

Supporting Management:

Aleecia Gutierrez
Energy Generation Research Office Manager

Eric Knight
Environmental Office Manager

Don Kondoleon
Transmission Office Manager

Matthew Layton
Engineering Office Manager

Editing, Formatting, and Publication:

Carol Robinson

ABSTRACT

California's greenhouse gas policies, in conjunction with related energy policies such as the state's Renewables Portfolio Standard, the Emission Performance Standard, the phaseout of electrical generation facilities using once-through cooling, and an increase of smaller and community-based distributed energy resources, have resulted in significant changes to the state's electricity generation system over the last decade. This report builds upon previous *Environmental Performance Reports* by providing an overview of the energy and climate change policy drivers and recommendations from previous EPRs; evaluating changes in the state's energy resource mix and the physical infrastructure for electricity and transmission; analyzing the environmental performance of the system and societal effects; and discussing new climate change policies, as well as transformative technologies and approaches that may have the potential to support the state's long-term greenhouse gas reduction goals. As part of the *2016 Integrated Energy Policy Report Update*, the Energy Commission held a public workshop on the draft *2016 EPR* on August 4, 2016, and this final *2016 EPR* provides an analytical basis for policy discussions and options that may be incorporated into future reports and decisions.

Keywords: *Environmental Performance Report*, environmental impacts, *Integrated Energy Policy Report*, renewable energy, greenhouse gas, renewables portfolio standard, emission performance standard, drought, air quality, public health, environmental justice, once-through cooling, wind turbine, offshore wind, electrolysis, energy storage technologies, solar thermal, photovoltaic, geothermal, biomass, natural gas, nuclear, energy efficiency, distributed energy resources, climate adaptation, climate change, landscape-scale planning, *Desert Renewable Energy Conservation Plan*, Renewable Energy Transmission Initiative, transmission

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EXECUTIVE SUMMARY

Over the last 10 years, California has continued implementing laws and policies to support overall greenhouse gas (GHG) reduction goals, expand renewable energy development, promote energy efficiency investments, encourage distributed generation, modernize the natural gas fleet, and move away from high-GHG emitting generating resources such as coal. The state has also established policies for power plant cooling and water conservation, including restrictions on freshwater use and the elimination of once-through cooling for power plants, as well as policies that protect and conserve natural resources. California's electricity system has achieved GHG reduction, improved air quality, increased water efficiency for power plants, and provided other environmental benefits due to these policies. At the same time, the transformation to a low-GHG emitting electricity system, with a growing share of renewable energy, presents a new set of land use, environmental, and electric system impacts and challenges that the state is addressing.

The *2016 Environmental Performance Report of the California Electricity System* (*2016 Environmental Performance Report*) builds off the *2005 Environmental Performance Report and 2007 Environmental Performance Report* to evaluate changes in the electricity system from climate change and energy policies over the previous decade and report on the associated environmental impacts, including GHG emissions, air quality, public health, water, land use, biological, cultural and visual resources, environmental justice (EJ), and related issues.

The *2016 Environmental Performance Report* also discusses nuclear decommissioning issues associated with the closure of San Onofre Nuclear Generating Station and the proposed closure of Diablo Canyon Power Plant. It discusses transformative technologies and approaches that may support California's long-term GHG reduction goals and reduce environmental impacts from renewable resources. In addition, this report discusses the variety of landscape-scale planning approaches for both renewable energy and transmission development.

California's Energy and Greenhouse Gas Emission Reduction Policies and Context

In 2006, the California Global Warming Solutions Act of 2006 (Núñez, Chapter 488, Statues of 2006) (Assembly Bill 32) and the Emission Performance Standard created a deliberate and comprehensive effort to reduce and limit GHG emissions and shift the state away from fossil fuels to a more secure and sustainable future. Under the initial *AB 32 Scoping Plan* and subsequent revisions, California has accelerated renewable energy, energy efficiency, and related programs to reduce GHG emissions to 1990 levels by 2020. The state has also increasingly moved to organize energy policies and programs around achieving GHG emission reduction goals, in addition to achieving other energy and environmental goals. Governor Edmund G. Brown Jr. and the California

Legislature have since established aggressive goals of reducing GHG emissions by 40 percent below 1990 levels by 2030 and 80 percent below 1990 levels by 2050. Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) (SB 32), put the Governor's goal into law by requiring the state to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030. The companion bill, Assembly Bill 197 (Garcia, Chapter 250, Statutes of 2016) (AB 197), assures that the state's implementation of its climate change policies is transparent and equitable, with the benefits reaching disadvantaged communities

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) codified goals for 50 percent renewable energy and doubling of energy efficiency savings in buildings and retail end uses by 2030, as called for in the Governor's Executive Order B-30-15. SB 350 also requires the California Air Resources Board (ARB) to establish, in coordination with the California Public Utilities Commission (CPUC) and the Energy Commission, emission targets for the electricity sector and load-serving entities that help achieve the statewide 2030 GHG reduction goal. In addition, SB 350 requires retail sellers to develop integrated resource plans to allow for a more cohesive examination of how the different policies and mandates can fit together to achieve the most cost-effective and efficient GHG reductions for the state. SB 350 also requires the Energy Commission to study barriers to and opportunities for low-income and disadvantaged communities to increased access to energy efficiency and renewable energy investments and programs. Electrical corporations must accelerate programs and investments in widespread transportation electrification under SB 350. Finally, SB 350 provides for the voluntary transformation of the California Independent System Operator (California ISO) into a regional organization.

Changes in California's Electricity System

State energy and GHG reduction policies adopted over the past decade including the Renewables Portfolio Standard, the Emission Performance Standard, and the Cap-and-Trade Program have altered California's resource mix, rapidly accelerating renewable resources and putting generation from coal resources on a steep decline. Energy and climate change policy has also affected the customer side of the meter with continued energy efficiency improvements and the emergence of distributed generation, such as rooftop solar photovoltaic (PV) systems, fuel cells, and combined heat and power. In addition, climate change is influencing the demand for electricity as higher temperatures increase air-conditioning loads in summer and decrease heating loads in winter. The following outlines major changes to the electricity system during the last decade.

- The passage and implementation of the state's Renewables Portfolio Standard – starting at 20 percent renewables by 2017 and subsequently accelerated to 33 percent by 2020 and later to 50 percent by 2030 – resulted in an unprecedented deployment of renewable energy facilities in the state. In-state renewable capacity more than doubled, increasing from about 7,500 megawatts (MW) in

2001 to nearly 19,000 MW by 2015. As a result, California is well on its way to meeting the requirement for 33 percent renewables by 2020.

- California implemented a suite of solar programs under Senate Bill 1 (Murray, Chapter 132, Statutes of 2006) that built on California's ratepayer-funded solar incentive programs, as well as net energy metering, to encourage customer adoption of small-scale, distributed renewable generation. The California Solar Initiative goal of installing 3,000 MW of solar system on homes and businesses in California by the end of 2016 was surpassed in 2015. Nearly 560,000 residential and commercial self-generation solar projects totaling more than 4,400 MW have been installed in California.
- Electricity demand growth over the last decade has been relatively flat, tempered by economic and demographic conditions, as well as continued energy efficiency efforts and new distributed generation. Since the 1970s, the state has developed and implemented building and appliance standards and energy efficiency programs to take advantage of cost-effective energy efficiency savings. These energy efficiency efforts have saved California consumers billions of dollars since the 1970s and have held per capita energy use in the state relatively constant, while the rest of the United States has increased per capita energy use by roughly 40 percent
- Future electricity demand is expected to be influenced by climate change, and the potential incremental impacts of these changes are captured in the Energy Commission's adopted demand forecast from the *2015 Integrated Energy Policy Report (2015 IEPR)*. Higher overall temperatures cause increases in peak demand, for example for air conditioning in the summer, as well as decreased heating needs in winter. Drought conditions are also becoming more prevalent, which increase the risk of wildfires and potential damage to the electric grid.
- The retirement and replacement of aging power plants and gas plants using once-through cooling have improved the overall efficiency of the natural gas fleet, with the thermal efficiency of the state's current portfolio of noncogeneration natural gas power plants improving by 29 percent between 2001 and 2014. More efficient and flexible natural gas plants are being deployed that will improve the fleet efficiency while having the ability to help integrate renewable resources into the electricity grid. In the longer run, less carbon intensive technologies – demand response, distributed energy resources, and storage – will be needed to perform this integration function. The state has developed a suite of policies and strategies to implement integration technologies, such as demand response and energy storage.
- The Emission Performance Standard, established under Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006), prevents California utilities from making new long-term financial commitments (five years or more) to high-GHG emitting baseload power plants, such as coal facilities. Because of the Emission

Performance Standard, the investor-owned utilities have already divested themselves of high-GHG emitting power plants, and publicly owned utilities are making significant progress in divesting themselves of long-term ownership of or contractual arrangements with coal facilities. By 2026, virtually all electricity generated by in-state coal- and petroleum-coke-fired facilities or imported from out-of-state facilities is expected to end.

- The development of large amounts of sometimes remote renewable resources, along with reliability challenges associated with the sudden closure of San Onofre Nuclear Generating Station and retirement of natural gas once-through cooling plants, has necessitated significant transmission upgrades. The need to integrate increasing amounts of intermittent wind and solar generation creates operational challenges for the electricity grid that have spurred the use of more regionalized approaches, including the Energy Imbalance Market and the potential transformation of the California Independent System Operator (California ISO) into a regional organization.

The Environmental Performance of the Electricity System

Over the last decade, the state has adopted several policies to support the environmental performance of the electricity system including addressing fresh water shortages and more frequent droughts, eliminating once-through cooling for power plants, protecting and conserving natural resources, and increasing the focus on disadvantaged communities and tribal engagement. The influx in renewable generation has brought with it new and different environmental impacts than the conventional generation resources built in the past. The footprint acreage associated with renewable projects is much larger than for conventional natural gas plants. In addition, remote renewable resources have different impacts than traditional power plants, such as on biological and cultural resources, particularly in desert environments. The following outlines the primary environmental trends from the past 10 years.

In recent years much of the policy regarding climate change has focused on carbon dioxide (CO_2) emissions. This focus is largely because CO_2 is the largest category of GHGs in the state, accounting for 84 percent of total GHGs in 2014. California has made great strides in reducing GHG emissions from the electricity sector. In 2014, carbon dioxide (CO_2) emissions were about 26 percent below 1990 levels. The overall trend shows declining CO_2 emissions, with year-to-year variability as the electricity system compensates for swings in non-emitting hydropower generation from the drought, variations in imports from out-of-state resources, and outages for nuclear refueling and the closure of San Onofre Nuclear Generating Station. According to the U.S. Energy Information Administration, natural gas use was down 20 percent in California in the summer of 2016 compared to the previous year due to better hydroelectric conditions and more renewable energy coming on-line. The overall trend indicated that GHG emissions from the electricity sector are declining relative to the emissions performance of other sectors.

- Air emission trends continued to improve as the state transitioned to a more renewable-intensive electricity system that reduces dependence on fossil fuels. Statewide criteria pollutant emissions have declined over the past 10 years, however, in some regions of the state ambient air quality remains poor, making it difficult to permit even the cleanest generation facilities.
- The *2003 IEPR* policy for power plant water use, which encourages the use recycled water instead of freshwater for power plants and encourages water-efficient technologies such as dry cooling, has allowed the addition of a large number of natural gas fired power plants over the past decade without increasing the consumption of freshwater. In addition, the 2010 once-through cooling policy issued by the State Water Resources Control Board has eliminated ocean water cooling for almost 5,000 MW of fossil and nuclear generation, which reduced biological impacts to California's marine and estuarine ecosystems.
- Water use by utility-scale renewable generators depends highly on both technology and cooling type, but nearly all new renewable capacity in California is from wind power and solar PV technology. These technologies can operate with essentially no water requirements, with the exception of water used during construction and for washing PV panels.
- The general biological impacts of renewable generation include habitat loss, degradation, and alteration due to the large acreage at project sites. In addition, avian mortality presents a concern for wind and solar facilities. In siting cases, the Energy Commission has required a variety of mitigation measures for impacts to habitats and special status species, including avoidance of habitats and securing replacement habitat acreages to compensate for those removed by development.
- The move to large renewable projects in the desert and agricultural areas has increased the number of cultural resources identified on or near project sites. The high level of engagement with tribes in the Energy Commission's siting process – including identifying resources, consultation, expert witness testimony and construction monitoring – has allowed the Energy Commission to prioritize avoiding and minimizing impacts to cultural and archaeological resources, build relationships with tribes, and collaborate in other renewable planning initiatives.
- With continued population growth and diversity, most locations where energy facilities have been and are proposed are likely to include an "environmental justice community," that is, those least able to improve their living conditions and most likely to face barriers to participating in planning or permitting processes. Continued outreach to those communities burdened by air emissions, noise, and other impacts is an important priority in siting energy facilities. Understanding how changes in the environmental performance of the electric system have affected and will continue to affect disadvantaged communities – especially the distribution of environmental impacts across these communities –

could help decision makers understand the degree to which disadvantaged communities might be affected by performance of the electricity system.

Nuclear Decommissioning

Environmental issues related to the decommissioning of California's nuclear power plants have moved to the foreground because of recent developments with the San Onofre Nuclear Generating Station and Diablo Canyon Power Plant. The decommissioning of San Onofre Nuclear Generating Station is underway, and the planning and preparations to shut down Diablo Canyon Power Plant in 2024-2025 will occur over the next several years. The U.S. Nuclear Regulatory Commission is the regulatory agency responsible for the safe dismantling and disposal of the plants radiological components and associated aspects of decommissioning. Beyond the radiological aspects of decommissioning, the environmental remediation of the plant sites must be completed to levels that return the sites to environmentally safe and usable lands. For both plants, public safety and security will continue to be key concerns throughout the decommissioning (and for the remaining operational years of Diablo Canyon Power Plant).

The management of highly radioactive spent nuclear fuel is also a significant issue for the near term and well into the future. Although the long-term storage of spent nuclear fuel at nuclear reactor sites was never envisioned when California's nuclear plants were built, the state must address this reality. Policy makers, local officials, and owners of the plants must plan for the long-term safety and security of independent spent fuel storage installations at the plant sites, taking into account the unique seismic and tsunami hazards of coastal locations, the dense population surrounding the San Onofre Nuclear Generation Station site, and the maintenance and potential replacement issues related to aging storage casks. The safe transport of nuclear waste over California's railways and/or highways must also be planned for and managed for a future date when the federal government begins to accept high-level nuclear waste from decommissioning nuclear plants.

Emerging and Transformative Technologies

Dramatic technological change over the past decade has resulted in renewable energy technologies that are becoming more efficient and less costly. For example, the cost to develop solar PV and wind energy technologies has dropped significantly in the recent years, with utility-scale PV costs declining the most. Bioenergy technologies using forest and other wood waste, agriculture and food processing wastes, organic urban waste from food and yards, waste and emissions from water treatment facilities, and landfill gas, are also improving, and there is growing opportunity to use bioenergy to capture multiple environmental benefits, like using forest biomass as a way to manage the risk of wildfires – expected to increase with climate change – while generating renewable energy.

At the same time, the electricity system is evolving into a more decentralized system that integrates distributed energy resources, including several combinations of small-scale, clean distributed resources such as distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies. Renewable distributed energy resources have less environmental impact per MW than conventional generation and utility-scale renewable energy development. The value of combined distributed energy resource portfolios and the services they may be able to provide are just starting to be quantified or demonstrated. Current and planned research will provide better data and information that can be factored into grid modeling and integrated resource plans.

Energy storage has the potential to play an important role in California's transition to a decarbonized grid by integrating intermittent renewable generation, shifting peak power demand, and reducing the need for additional power plants and transmission and distribution upgrades. Energy storage procurement targets have been established for the investor-owned utilities, and the utilities are in their second round of competitive bids for energy storage systems.

The Energy Commission anticipates further advancement of renewable energy technologies – the use of untapped renewable resources from the ocean, a significant increase in distributed energy resources investment, and deployment of advanced energy storage – for California to meet its ambitious GHG reduction goals. Continuing support of research, development, and deployment of emerging technologies will be needed to transform California's energy system. Multiple technologies will be needed, and remaining technology-neutral will help ensure that all technologies have the opportunity to participate in a competitive market.

Policy Development and Planning Going Forward

While the rapid deployment of renewable energy projects is one of California's great energy success stories, it has also brought with it a different set of environmental challenges. Continuing to advance California's GHG reduction goals will require additional utility-scale generation, new investments in the electric transmission system, and improved planning and coordination. Landscape-level approaches, also known as landscape-scale planning, take into consideration a wide range of potential constraints and conflicts, including environmental sensitivity, conservation and other land uses, tribal cultural resources, and more when considering future renewable energy development. Through previous and current efforts, such as the first and second Renewable Energy Transmission Initiative processes, the joint Renewable Energy Action Team agency work on the Desert Renewable Energy Conservation Plan, and the stakeholder-led San Joaquin Valley Identification of Least-Conflict Lands study, federal and state agencies, local governments, tribes, and stakeholders have gained experience with planning approaches that seek to identify the best areas for renewable energy development. These landscape-level processes and approaches also support Governor

Brown's goal of dramatically reducing the permitting time for transmission projects needed to deliver clean energy to no longer than three years.

California has a unique opportunity to learn from and build upon successful past efforts to permit renewable energy projects and related transmission. These efforts include interagency coordination, permitting best practices, and a variety of landscape-scale planning approaches that can be implemented to help identify broad environmental and land use considerations for different regions with renewable resources.

Adaptation to climate change has grown to be an integral part of all resource sector planning. New laws and policies are empowering planning for climate impacts and adaptation to climate change. Climate adaptation is an issue of increasing importance, and the California Energy Commission should continue working closely with all stakeholders to advance the science and understanding of the issue and strengthen the capacity of local, regional, and state governments to plan for and respond to climate impacts.

Finally, transportation electrification, the use of electricity from external sources of electrical power, including the electrical grid, for all or part of vehicles, vessels, trains, boats, or other equipment that are mobile sources of air pollution and greenhouse gases, is a key element of the state's strategy to reduce GHG emissions, petroleum use, and air emissions in the transportation sector. Achieving Governor Brown's ambitious goal of reducing petroleum use for cars and trucks by up to 50 percent by 2030 will require a transformation of the transportation sector by increasing the use of cleaner vehicles with zero and near-zero technologies in all vehicle categories and other transportation electrification strategies. California's electric utilities are expected to play an integral role in California's efforts to accelerate the transformation of the transportation sector by increasing access to electricity as a primary transportation fuel. In the future, the increasing connection between the electric and transportation sectors could be as significant as the emergence of solar PV, if not more.

CHAPTER 1: Introduction

In 2005, the California Energy Commission produced an extensive *Environmental Performance Report (EPR)*[1] that included a thorough collection of power plant environmental data and an extensive examination of several environmental performance topics, including impacts to air emissions and air quality, impacts from once-through cooling (OTC) technologies, impacts from hydroelectric technologies, and impacts to avian (bird) species from wind turbines.

In 2007, the Energy Commission updated the *2005 EPR,*[2] built off the sources of information and analytic framework from the *2005 EPR,* and assessed five additional environmental topics: cooling water use by California power plants, OTC issues associated with California's coastal power plant fleet, biological resource issues such as impacts to sensitive ecosystems and wildlife species associated with large solar energy facilities in California, an update on guidelines to reduce avian impacts associated with wind farms, and Klamath River Hydroelectric Project energy and economic analyses associated with the Federal Energy Regulatory Commission (FERC) relicensing proceeding.

This *2016 EPR* builds off the previous *EPRs* to evaluate the effects climate change policies and GHG reduction goals have had on the environmental performance of the state's electrical generation system over the last decade. As part of the *2016 Integrated Energy Policy Report (IEPR) Update,* the *2016 EPR* provides an analytical basis for policy discussions and options that may be incorporated into future reports and decisions.

The *Draft 2016 Environmental Performance Report of California's Electrical Generation System* was published in July 2016.[3] The Energy Commission conducted a public workshop on August 4, 2016, where staff presented an overview of the *Draft 2016 EPR*, and the public provided comments on the draft. Five entities provided written comments on the *Draft 2016 EPR* by the August 18, 2016, deadline. The Energy

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1 McKinney, Jim. 2005. *2005 Environmental Performance Report of California's Electrical Generation System.* California Energy Commission, CEC-700-2005-016. http://www.energy.ca.gov/2005publications/CEC-700-2005-016/CEC-700-2005-016.PDF.

2 McKinney, Jim. 2008. *2007 Environmental Performance Report of California's Electrical Generation System.* California Energy Commission. Publication Number: CEC-700-2007-016-SF. http://www.energy.ca.gov/2007publications/CEC-700-2007-016/CEC-700-2007-016-SF.PDF.

3 Bartridge, Jim, Melissa Jones, Eli Harland, Judy Grau. 2016. *Draft 2016 Environmental Performance Report of California's Electrical Generation System.* California Energy Commission. Publication Number: CEC-700-2016-005-SD, available at http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN212338_20160718T142510_Draft_2016_Environmental_Performance_Report_of_California's_Ele.pdf.

Commission staff has considered all oral and written comments received and addressed them herein as appropriate.[4]

Structure of the *2016 Environmental Performance Report*

The report is divided into five main chapters:

Chapter 2 provides an overview of the energy and climate change policy drivers and recommendations from previous *EPRs*.

Chapter 3 evaluates the changes in the state's energy resource mix and the physical infrastructure for electricity and transmission.

Chapter 4 provides an analysis of the environmental performance of the system and societal effects. This chapter evaluates the major changes that have occurred since 2005 and 2007 relating to GHG emissions, air quality, public health, water, land use, biological, cultural resources, visual resources, traffic and transportation, and related issues, including nuclear decommissioning.

Chapter 5 summarizes transformative technologies and approaches that may to support the state's long-term GHG reduction goals.

Chapter 6 describes the policies that will continue to shape California's energy future and the actions that California is taking to improve long-term energy planning for renewable energy resources (both generation and transmission) at the landscape scale. Chapter 6 also describes the steps the state is taking to adapt the energy system to climate change.

Staff findings and conclusions are presented throughout the various chapters and policy recommendations are contained in the *2016 IEPR Update*.

4 The August 4, 2016, workshop transcripts and docketed comments are available at the following website: http://www.energy.ca.gov/2016_energypolicy/documents/index.html#08042016.

CHAPTER 2: Policy Drivers and Context

California has taken a proactive approach to shaping the state's electricity and energy sector through a broad suite of energy and environmental policies. During the energy crisis of the 1970s, California faced the need to ensure energy reliability while protecting natural resources. With electricity demand increasing at a rate of 7 to 9 percent per year, utilities were projecting the need to build new nuclear power plants. At the same time, the nation was experiencing supply shortages in transportation and heating fuel due to the Arab Oil Embargo.

Out of this social context, the Legislature passed the Warren-Alquist Act in 1975, establishing the California Energy Commission to forecast energy demand, develop energy efficiency standards for buildings and appliances, provide for public interest energy research and development, promote renewable energy and alternative fuels, and review and site power plants for the state. In addition, while ensuring a reliable supply of electricity, the Energy Commission was given the broader responsibilities of preserving environmental quality and conserving natural resources such as water and biological and cultural resources.[5] More recently, reporting on the status of the environmental footprint and environmental performance of the electricity system became a specific element of the Energy Commission's mandate.

The focus on GHG emissions began in 1988 with Assembly Bill 4420 (Sher, Chapter 1506, Statutes of 1988), which directed the Energy Commission to prepare an inventory and study of GHG emissions. The act was soon followed with the state's Clean Car Standards, Assembly Bill 1493 (Pavley, Chapter 200, Statutes of 2002) and the state's first Renewables Portfolio Standard (RPS).[6] In 2006, the California Global Warming Solutions Act of 2006 (Núñez, Chapter 488, Statues of 2006) (Assembly Bill 32) and Emission Performance Standard (EPS)[7] created a deliberate and comprehensive effort to reduce and limit GHG emissions and shift the state away from fossil fuels to a more secure and sustainable future.

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5 For more information on the formation of the California Energy Commission and its ongoing and evolving responsibilities, see the YouTube video titled "Energy in California: 40 Years of Leadership," published on January 29, 2015, available at https://www.youtube.com/watch?v=ZLVOk2bvxss.

6 2Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002).

7 Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006).

Evolution of California's Energy and GHG Reduction Policies

Over the last decade, the state has implemented several policies and orders to support the overall GHG reduction goals, address freshwater shortages and more frequent droughts, protect and conserve natural resources, and increase the focus on disadvantaged communities and tribal engagement. Key legislation and policies driving California's strategy to address climate change that affect the electricity system are discussed in the following section.

California Global Warming Solutions Act of 2006 – Assembly Bill 32

In 2006, the Legislature passed AB 32, which required California to reduce its GHG emissions to 1990 levels by 2020. Under this statute, the California Air Resources Board (ARB) was charged with adopting regulations to achieve the maximum technologically feasible and cost-effective GHG emission reductions. The full implementation of AB 32 will help reduce risks associated with climate change, while improving energy efficiency, expanding the use of renewable energy resources, providing cleaner transportation, and reducing waste.[8]

Under AB 32, the ARB, along with the Energy Commission, California Public Utilities Commission (CPUC), and a host of other state agencies and stakeholders, developed an initial scoping plan laying out California's approach to meeting the goal of reducing GHG emissions to 1990 levels by 2020. Through coordinated implementation of this and subsequent iterations of the scoping plan, the state has accelerated energy efficiency, renewable energy, and related programs. It has also moved increasingly to organize energy policies and programs around achieving GHG emission reduction goals, in addition to achieving other energy and environmental goals. This trend is likely to continue as the state moves toward reducing GHG levels to 80 percent below 1990 levels by 2050 and addresses the challenge of climate change adaptation.

The initial *AB 32 Scoping Plan*, adopted in 2008, laid out a range of GHG reduction actions that included direct regulations, alternative compliance mechanisms,[9] monetary and nonmonetary incentives, voluntary actions, and market-based mechanisms. Key recommendations for achieving reductions included expanding and strengthening existing energy efficiency programs, as well as building and appliance standards,

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8 For more information, see the California Air Resources Board website at http://www.arb.ca.gov/cc/ab32/ab32.htm.

9 Per Health and Safety Code Division 25.5 of the California Global Warming Solutions Act of 2006, Part 1 General Provisions, Chapter 3 Definitions an "Alternative compliance mechanism" means an action undertaken by a greenhouse gas emission source that achieves the equivalent reduction of greenhouse gas emissions over the same time period as a direct emission reduction, and that is approved by the state board. "Alternative compliance mechanism" includes, but is not limited to, a flexible compliance schedule, alternative control technology, a process change, or a product substitution.

achieving a statewide renewable energy mix of 33 percent by 2020, developing a cap-and-trade program, and addressing transportation related GHG emissions.

The ARB completed the first update to the *AB 32 Scoping Plan* in May 2014, noting that the set of actions the state is taking to address climate change is driving down GHG emissions and moving California steadily in the direction of a clean energy economy.[10] It notes that as the state's first priority for meeting energy needs, energy efficiency efforts continue to reduce energy use and emissions, make the state's businesses and economy more efficient, and cut energy costs. As renewable energy costs in California have rapidly decreased, making renewables cost-effective for millions of homes and businesses, the state is also making great strides in developing renewable energy. ARB is updating the scoping plan to reflect SB 350 provisions.[11]

Emission Performance Standard – Senate Bill 1368

California's Emission Performance Standard (EPS) has been a driving force behind the state's significant reduction in the use of coal. Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006) created the EPS, which prevents California utilities from making long-term financial commitments (five years or more) to high-GHG-emitting baseload power plants. SB 1368 includes restrictions on capital investments that increase generating capacity or extend the life of projects that exceed the EPS, which is set at 1,100 pounds of carbon dioxide (CO_2) per megawatt-hour (lbs. CO_2/MWh). This restriction is achieving one of the primary goals of SB 1368 to encourage California utilities' divestiture of high-GHG emitting power plants. By divesting from coal power plants early, California utilities forgo the high costs and GHG emissions associated with baseload coal and petroleum coke facilities that will require potentially very large investments to comply with environmental regulations.[12]

Energy Efficiency

By legislative mandate, the Energy Commission is required to reduce the wasteful, uneconomic, inefficient, or unnecessary consumption of energy.[13] To meet this mandate, the Energy Commission has developed building and appliance standards that, along with utility efficiency programs, have saved consumers billions of dollars since the late

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10 California Air Resources Board, *The First Update to the Climate Change Scoping Plan*: *Building on the Framework*, May 2014, http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf .

11 For additional information: http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

12 California Energy Commission, *Tracking Progress – Coal Actual and Expected Energy From Coal for California,* http://www.energy.ca.gov/renewables/tracking_progress/index.html#coal**.** Updated December 15, 2015.

13 Warren-Alquist Act. Public Resources Code, Section 25007, http://www.energy.ca.gov/reports/Warren-Alquist_Act/.

1970s. This wide range of energy efficiency standards and programs has helped keep per capita energy use in California relatively constant, while use in the rest of the United States has increased by roughly 40 percent.[14]

Energy efficiency standards help overcome well-understood barriers in markets for appliances and buildings. Standards eliminate the least efficient products and practices from the marketplace, obtaining large benefits for California's consumers. Building standards, for example, ensure that cost-effective efficiency features are incorporated into each building during construction, the point at which they are least expensive and most cost-effective. Similarly, when a consumer purchases an appliance, he or she frequently does not know the energy cost over the lifetime of the device, which in many cases can surpass the purchase cost. When a consumer has limited knowledge or influence on the energy performance characteristics of a product, the marketplace will not tend to prioritize efficiency, even if it is simple and inexpensive to do so. Appliance standards benefit California consumers by ensuring that the most cost-effective efficiency is incorporated into their purchases. In some cases, California's appliance standards have served as a model for other states. For example, California's television standards were adopted by Oregon, Connecticut, and British Columbia.[15]

California's utilities remain key players in the state's efforts to improve energy conservation and keep per capita energy consumption levels flat by providing energy efficiency programs to their customers since the 1970s. These programs offer some of the lowest-cost energy resource options and play significant roles in meeting California's energy and climate policy objectives. Still, more action is needed to reduce energy consumption in existing buildings as the energy used in them accounts for more than one-quarter of all GHG emissions in California.[16] In 2015, the Energy Commission adopted the *Existing Buildings Energy Efficiency Action Plan*[17] to help meet the Governor's goal to double the efficiency savings of existing buildings by 2030. An update to this 10-year framework to enable substantial energy savings and GHG emissions from California's existing buildings is under development for completion by January 1, 2017, with further updates expected every three years.

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14 As discussed later in this section and in more detail in Chapter 5, Senate Bill 350 (De León, Chapter 547, Statutes of 2015) calls for a doubling of energy efficiency in buildings and other retail end uses by 2030 to help achieve the state's GHG emission reduction goals.

15 California Energy Commission, *2005 Integrated Energy Policy Report*, 2016, p 28, http://www.energy.ca.gov/2015_energypolicy/.

16 California Energy Commission. 2015. *2015 Integrated Energy Policy Report.* Publication Number: CEC-100-2015-001-CMF, p. 10.

17 California Energy Commission. 2015. *Existing Buildings Energy Efficiency Action Plan.* Publication Number: CEC-400-2015-013-F, p. 10, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-05/TN205919_20150828T153953_Existing_Buildings_Energy_Efficiency_Action_Plan.pdf.

Renewables Portfolio Standard

Over the past 30 years, California has built one of the largest and most diverse renewable generation portfolios in the world. California's operating renewable energy capacity is composed of both in-state and out-of-state facilities. California's initial Renewables Portfolio Standard (RPS) was established in 2002 under Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002) with the goal of increasing the percentage of renewable energy in the state's electricity mix to 20 percent by 2017. The *2003 IEPR* recommended accelerating that goal to 20 percent by 2010, and the *2004 IEPR Update* further recommended increasing the target to 33 percent by 2020.

The RPS was accelerated in 2006 under Senate Bill 107 (Simitian, Chapter 464, Statutes of 2006) by requiring that 20 percent of electricity sales be served by renewable energy resources by 2010. The American Recovery and Reinvestment Act of 2009 (ARRA) also contributed to the unprecedented deployment of renewable energy facilities in California by offering financial incentives to renewable energy projects that met strict development and approval milestones. Between 2010 and 2015 roughly 8,000 megawatts (MW) of large-scale renewable generation was installed in California.[18] For the state and federal permitting agencies, the proposed projects were different from what had been reviewed and permitted in the past – new and different types of renewable energy technologies, locations that tended to be in remote and undeveloped landscapes, large footprints requiring significant ground disturbance, unknown environmental impacts, tribal and cultural concerns, and multiple agency jurisdictions. Evaluating and permitting these projects, and the related transmission planning necessary to integrate different resource profiles, by the ARRA deadlines required a high level of interagency coordination among the state and federal agencies that had permitting roles.

The RPS was subsequently increased to 33 percent by 2030 with the passage of Senate Bill X1-2 (Simitian, Chapter 1, Statutes of 2011) and again to 50 percent by 2030 with the passage of the Clean Energy and Pollution Reduction Act of 2015 (Senate Bill 350, De León, Chapter 547, Statutes of 2015) – and applied to all electricity retailers in the state. The passage and implementation of the state's 33 percent RPS statute resulted in an unprecedented deployment of renewable energy facilities in the state, as is anticipated with the 50 percent RPS mandate.

Distributed Generation Programs

Following the restructuring of the electricity market, the Energy Commission's Renewable Energy Program provided market-based incentives for new and existing facilities powered by small, reliable, renewable energy systems. The Emerging Renewables Program, which ran from 1998 to 2006, offered investor-owned utilities

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18 California Energy Commission, *Tracking Progress: Renewable Energy*, 2016, pp. 3-4, http://www.energy.ca.gov/renewables/tracking_progress/.

(IOUs) customers rebates for grid-connected solar photovoltaic (PV) electricity systems, wind systems, fuel cells (using a renewable fuel), and solar thermal electricity systems.

During the same period, the CPUC oversaw the complementary Self-Generation Incentive Program that funded larger self-generation projects for businesses. It has gone through several iterations, and the current program provides rebates for qualifying distributed energy systems installed on the customer's side of the utility meter that contribute to GHG reduction goals. Qualifying technologies include wind turbines, waste heat to power technologies, pressure-reduction turbines, internal combustion engines, microturbines, gas turbines, steam turbines, fuel cells, biogas, and advanced energy storage systems.

In 2006, Senate Bill 1 (Murray, Chapter 132, Statutes of 2006) established a suite of solar programs that altered these earlier renewables programs. The overall goal of SB 1 is to help build a self-sustaining solar market combined with high levels of energy efficiency in the state's residential and nonresidential buildings. The SB 1 programs build on California's three ratepayer-funded incentive programs for solar energy systems: the Energy Commission's New Solar Homes Partnership, the CPUC's California Solar Initiative (CSI) program, and the collective solar programs offered through the publicly owned utilities (POUs). Combined, these programs encompass new and existing residential, multifamily, and commercial buildings.[19]

The goals of SB 1 are to install 3,000 MW of solar energy systems, establish a self-sufficient solar industry in 10 years so that solar energy systems are seen as a viable mainstream option for residential and nonresidential buildings, and, in 13 years, have solar energy systems on 50 percent of new homes. SB 1 also established minimum requirements for projects participating in the programs: a high-quality installation of a high-performing solar energy system on an energy-efficient building.

California has also used net energy metering (NEM)[20] to further encourage substantial private investment in renewable energy resources and offer incentives for customer adoption of small-scale, renewable generation. The Legislature passed Senate Bill 656 (Alquist, Chapter 369, Statutes of 1995) that established a NEM program for customers with an eligible renewable energy system to receive a bill credit for excess electricity generated from their renewable energy system and sent back to the utility grid.[21] Over the years, various amendments were made to the NEM legislation. Assembly Bill 920 (Huffman, Chapter 376, Statutes of 2009) provided NEM customers with the option of

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19 Solar systems have qualified for various federal tax credits over the years and current tax credits extend 2021.

20 Net energy metering allows customers with an eligible renewable energy system to receive a bill credit for excess electricity generated from their renewable energy system and sent back to the utility grid.

21 Sized to customer's existing electricity needs and no larger than 1 MW.

rolling over excess electricity generation credits indefinitely or receiving financial compensation for the excess electricity generation. Assembly Bill 327 (Perea, Chapter 611, Statutes of 2013) established a NEM program limit that is reached when the combined capacity of NEM systems exceed 5 percent of each utility's combined customer peak demand. Small utilities are no longer required to offer the NEM tariff once the cap is reached.[22] Large utilities are required to offer the NEM tariff until the cap is reached or July 1, 2017, whichever is earlier, after which a successor tariff adopted by the CPUC will take effect.

As of June 2016, the large electric utilities' progress toward meeting these NEM caps are as follows: Pacific Gas and Electric Company (PG&E) at 4.33 percent, Southern California Edison Company (SCE) at 3.61 percent, while San Diego Gas & Electric Company (SDG&E) is at 4.8 percent. NEM has evolved to also include other forms such as virtual NEM, in which customers on the same property, such as an apartment complex with a solar PV system, can offset their energy use by sharing the output of the renewable distributed generation.

California's Cap-and-Trade Program

A central feature of California's climate change strategy is the Cap-and-Trade Program that became effective on January 1, 2013. The Cap-and-Trade Program applies to large power plants, large industrial facilities, and distributors of transportation, natural gas and other fuels. It encompasses around 450 businesses and entities throughout California. The purpose of cap-and-trade is to lower GHG emissions through an economywide cap on cumulative GHG emissions, along with a trading system for compliance instruments, or allowances.

The cap-and-trade system sets a firm limit or cap on GHG emissions that declines roughly 3 percent each year through 2020. Entities covered under the Cap-and-Trade Program must hold enough emission allowances to cover their GHG emissions and are free to buy and sell allowances in the market. For the electricity sector, first sellers or deliverers of electricity into the California market are covered entities.[23] Trading establishes a price on carbon and creates incentives to reduce GHG emissions below allowable levels through investments in clean technologies, spurring technological innovation and investments in clean energy.

Emission allowances under the Cap-and-Trade Program are distributed to businesses by a combination of free allocations and quarterly auctions. Allowances for electric utilities

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22 *Small customers* are defined as having fewer than 100,000 service connections in California, while large electric utilities are those with more than 100,000 in the state.

23 If an out-of-state generator sells energy to a California utility or energy service provider, the generator, not the utility or provider, would be responsible for acquiring sufficient allowances to cover the emissions associated with the generation that was sold, as an example of a covered entity.

(not generators), industrial facilities, and natural gas distributors are free, with the amount of allowances declining over time. Businesses may also buy allowances from other entities that have reduced emissions below the allowances they hold. Market flexibility is provided through provisions for banking, offsets, and a strategic reserve. The Cap-and-Trade Program has three-year compliance periods.

Clean Energy and Pollution Reduction Act of 2015 (Senate Bill 350) and Related Bills

SB 350 was signed into law in October 2015. It sets the path that California will take to meet its aggressive GHG reduction goal of 40 percent below 1990 levels for 2030, as well as to meet the 2050 goal of 80 percent below 1990 levels. It codified goals for 50 percent renewable energy and doubling of energy efficiency in buildings and other retail end uses by 2030 called for in the Governor's Executive Order B-30-15. Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) (SB 32), put the Governor's goal into law by requiring the state to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030. The companion bill, Assembly Bill 197 (Garcia, Chapter 250, Statutes of 2016) (AB 197), assures that the state's implementation of its climate change policies is transparent and equitable, with the benefits reaching disadvantaged communities.

SB 350 also requires the ARB to establish, in coordination with the CPUC and the Energy Commission, emission targets for the electricity sector and load-serving entities that help achieve the statewide 2030 40 percent reduction goal. In addition, it requires load-serving entities, including IOUs, POUs, energy service providers, and community choice aggregators,[24] to develop integrated resource plans to allow for a more cohesive examination of how the different policies and mandates can fit together to achieve the most cost-effective and efficient GHG reductions for the state. SB 350 requires the Energy Commission to study barriers to, and opportunities for, solar photovoltaic energy generation, as well as access to other renewable energy, by low-income customers and disadvantaged communities. SB 350 also requires the CPUC, in consultation with the ARB and Energy Commission, to direct electrical corporations to file for programs and investments to accelerate widespread transportation electrification. In addition, SB 350 directs the state to move toward the voluntary transformation of the California ISO into a regional organization. The provisions of SB 350 are discussed in more detail in Chapters 3 and 6.

Environmental Justice

In February 1994, President Clinton signed Executive Order 12898, which directed federal agencies to make environmental justice a part of their missions by developing a strategy that identifies and addresses disproportionately high and adverse human

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24 *Community choice aggregation* allows local governments and some special districts to pool (or aggregate) their electricity load to purchase and/or develop power on behalf of their residents, businesses, and municipal accounts.

health or environmental effects of federal programs, policies, or activities on minority and low-income populations.

In 1999, California passed its first environmental justice statute: Senate Bill 115 (Solis, Chapter 690, Statutes of 1999). This statute codified the definition of environmental justice as "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations and policies."[25] It also directed the California Environmental Protection Agency (CalEPA) to operate in a manner that ensures environmental justice and designated the Governor's Office of Planning and Research (OPR) as the lead agency for coordinating environmental justice programs.[26] As discussed in Chapter 4, CalEPA uses CalEnviroScreen to identify disadvantaged communities based on geographic, socioeconomic, public health, and environmental hazard criteria.

Building upon this landmark legislation, California instituted other policies to ensure fair treatment, including tribal consultation requirements for planning agencies, State Water Resources Control Board (SWRCB) public meeting notices in both English and Spanish at a minimum, and additional public comment time for oral comments translated into English at state-held public meetings. It also requires that 25 percent of all cap-and-trade auction proceeds be spent on projects that will benefit disadvantaged communities and that at least 10 percent of cap-and-trade auction proceeds are spent on projects located in such communities.[27] [28]

In support of the 2030 GHG reduction goal, the Governor and Legislature put into place a suite of new laws in support of SB 350 to equitably achieve the state's climate goals. Assembly Bill 1613 (Chapter 370, Statutes of 2016) and the companion bill, Senate Bill 859 (Committee on Budget and Fiscal Review, Chapter 386, Statutes of 2016), allocate $900 million from the Greenhouse Gas Reduction Fund (proceeds from California's Cap-and-Trade Program to limit greenhouse gas emissions) to support programs that benefit disadvantaged communities, advance clean transportation, protect the natural environment, and cut short-lived climate pollutant emissions. Assembly Bill 1550 (Gomez, Chapter 369, Statutes of 2016) changes how funding is allocated to benefit disadvantaged communities by assuring a minimum of 25 percent of the funding to projects located within, and benefitting individuals living in, disadvantaged communities and an additional 5 percent to projects that benefit low-income households. Assembly Bill 2722 (Burke, Chapter 510, Statutes of 2016) establishes the

25 Government Code Section 65040.12.

26 http://www.calepa.ca.gov/Publications/Reports/2014/EJUpdateRpt.pdf.

27 SB 18 (Burton, Chapter 905, Statutes of 2004).

28 SB 535 (De León, Chapter 830, Statutes of 2012).

Transformative Climate Communities program to fund programs that advance multiple climate and clean energy efforts in an communitywide approach such as integrating affordable housing near transit, energy efficiency, and clean transportation.

Other Major Policy Drivers

In addition to policies motivated primarily by climate change, environmental policies have influenced the environmental performance of the electricity and transmission systems. These policies are discussed below and include policies to establish priorities for energy resources in the state and to address OTC for power plants, water use and power plant cooling alternatives, drought and water conservation, and air quality.

Loading Order

To meet the growing demand for electricity spurred by an expanding population and a robust economy, California's principal energy agencies established an energy resource loading order in 2003 to guide their energy decisions. The loading order consists of using energy efficiency and demand response as the preferred means to meet growing energy needs, followed by renewable and distributed generation resources, and then clean fossil-fueled sources and infrastructure improvements. The loading order was adopted in the *2003 Energy Action Plan* (*EAP*) prepared by the energy agencies, and the Energy Commission's *2003 IEPR* used the loading order as the foundation for recommended energy policies and decisions.[29] This loading order has guided California's energy agencies in their decision-making over the last decade. The *EAP,* which was subsequently updated and reiterated, recognized the importance of addressing climate change, and as a result, dealing with climate change has been an integral element of California's energy policies even before the passage of AB 32.[30]

Once-Through Cooling Policies

As mentioned in Chapter 1, the *2005 EPR* highlighted the adverse impacts of power plants using OTC systems on marine and estuarine ecosystems. In 2010, the SWRCB adopted a policy for OTC, which establishes clear standards to implement the *Clean Water Act* consistently.[31] The SWRCB must comply with federal *Clean Water Act* Section 316(b), which requires that cooling water intake structures reflect the best technology available to protect aquatic life. The OTC policy was developed to address ongoing

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29 *The Energy Action Plan* was adopted by the Energy Commission and CPUC in 2003. http://www.energy.ca.gov/energy_action_plan/.

30 The *Energy Action Plan II* was adopted in 2005 and updated in 2008.

31 State Water Resources Control Board, *Statewide Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling (Attachment 1)*, 2010, http://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/docs/policy100110.pdf.

marine impacts from the use of coastal and estuarine waters for power plant cooling in the state without disrupting the critical needs of the state's electricity system.

The 19 power plants originally regulated by the OTC policy are collectively able to use billions of gallons of ocean water every day to cool steam for generating electricity. In the process, millions of fish, larvae, eggs, seals, sea lions, turtles, and other creatures are killed each year because they are either trapped against screens or are drawn into the cooling system, where they are exposed to pressure and high heat.[32] The marine life that is killed is primarily at the base of the food chain, which can adversely affect the future of certain species and adversely impact recreational and commercial fishing. As discussed below, several of these facilities have already been retired or repowered.

The SWRCB met regularly during development of the OTC policy with representatives from the agencies and entities that oversee the power plants, including the Energy Commission, CPUC, and the California ISO, to ensure that the OTC policy implementation provisions were realistic. After the OTC policy was adopted, the Statewide Advisory Committee on Cooling Water Intake Structures (SACCWIS) was formally convened to advise the SWRCB on the implementation of the OTC policy. It was charged with ensuring that implementation plans and schedules submitted by the electrical generators are realistic and will not disrupt the state's electrical power supply.

The OTC policy also recognizes that some facilities using OTC technologies are critical for system and local reliability, and provides a specific advisory role to the energy agencies in recommending compliance date changes, if necessary, to avoid reliability issues.[33] In response to the OTC policy, the CPUC decided to identify what share of the capacity ought to be replaced with conventional generation versus various types of preferred resources. Due to the impact of San Onofre Nuclear Generating Station (San Onofre) on reliability in Southern California, the plant closure in 2012 resulted in the development of a preliminary reliability plan that includes close monitoring of retirements and replacements of OTC facilities.[34] Reliability issues related to San Onofre are detailed in Chapter 3.

The OTC policy established specific provisions to address the cooling water withdrawal from the state's nuclear power plants, calling for a special study to "investigate

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32 As noted in written comments filed by PG&E, the statewide entrainment of trillions of fish eggs and larvae is orders of magnitude higher than for turtles and marine mammals. See http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN212861_20160818T164726_Pacific_Gas__Electric_Comments_Pacific_Gas__Electric_Comments_o.pdf.

33 Ibid., Section 1.I.

34 *Preliminary Reliability Plan for LA Basin and San Diego*, August 30, 2013, http://www.energy.ca.gov/2013_energypolicy/documents/2013-09-09_workshop/2013-08-30_prelim_plan.pdf.

alternatives for the plants to meet the policy's requirements."[35] With the closure of San Onofre, a special study was conducted only for the Diablo Canyon Nuclear Power Plant (Diablo Canyon). Diablo Canyon, with a design flow of 2.5 billion gallons per day (BGD), is responsible for the lion's share of the current combined average withdrawals of all OTC power plants in the state.[36] Due to the large, continuous withdrawals of seawater at Diablo Canyon, an estimated 1.5 billion larvae are entrained, and 710 pounds of fish are impinged annually. PG&E recently announced its intent to close Diablo Canyon when its Nuclear Regulatory Commission (NRC) licenses expire in 2024 for Unit 1 and 2025 for Unit 2.[37] The permanent closure of Diablo Canyon would obviate the need for PG&E to develop an alternative to OTC as called for in the OTC policy.

Water Use Policies

Water conservation is of paramount importance to the state. Conserving fresh water and avoiding its wasteful use have long been part of the state's water policy, as reflected in the State Constitution, Article X, Section 2. State water policy regarding power plant water use is also specified in Resolution 75-58 adopted by the SWRCB.[38] With respect to using freshwater, the resolution articulates an underlying policy "to protect beneficial uses of the state's water resources and to keep the consumptive use of freshwater for power plant cooling to that minimally essential for the welfare of the citizens of the State." The policy reflects the state's concerns over discharges from power plant cooling, as well as the conservation of freshwater for cooling.

Specifically, the SWRCB states that it "encourages … power generating utilities and agencies to study the feasibility of using wastewater for power plant cooling" and "encourages the use of wastewater for power plant cooling where it is appropriate." The SWRCB also lists specific "discharge prohibitions" to limit the discharge of blowdown and wastewater from cooling facilities to "maintain existing water quality and aquatic environment of the state's water resources."

The SWRCB further states as a matter of principle: "Where the Water Board has jurisdiction, use of fresh inland waters for power plant cooling will be approved by the

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35 State Water Resources Control Board, 2010, *Statewide Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling (Attachment 1)*, http://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/docs/policy100110.pdf.

36 As noted in PG&E's written comments, at the time the OTC policy was adopted and all OTC plants were operational, Diablo Canyon accounted for 22 percent of total OTC flows and accounted for 8 percent of entrainment.

37 The status of Diablo Canyon is discussed further in Chapters 3 and 4.

38 Department of Water Resources, *Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Power Plant Cooling*, June 19, 1975, mimeo, p. 1.

Board only when it is demonstrated that the use of other water supply sources or other methods of cooling would be environmentally undesirable or economically unsound."

2003 Integrated Energy Policy Report Water Policy

The Warren-Alquist Act reiterates state water policy in terms of conserving water and using alternative sources of water supply: "It is further the policy of the state and the intent of the Legislature to promote all feasible means of energy and water conservation and all feasible uses of alternative energy and water supply sources." In the *2003 IEPR*, the Energy Commission adopted a policy to limit the use of freshwater for power plant cooling to only where alternative water supply sources and alternative cooling technologies are shown to be "environmentally undesirable" or "economically unsound."

Furthermore, as a way to reduce the use of freshwater and to avoid discharges in keeping with the SWRCB's policy, the Energy Commission requires zero-liquid discharge technologies unless such technologies are shown to be "environmentally undesirable" or "economically unsound." The Energy Commission interprets "environmentally undesirable" to mean the same as having a "significant adverse environmental impact" and "economically unsound" to mean the same as "economically or otherwise infeasible." The *2003 IEPR* noted that because power plants have the potential to use substantial amounts of water for evaporative cooling, the Energy Commission has the responsibility to apply state water policy to minimize the use of freshwater, promote alternative cooling technologies, and minimize or avoid degradation of the quality of the state's water resources. Since the *2003 IEPR* was adopted, the Energy Commission has encouraged project owners proposing to build new power plants in California to reduce water consumption with water-efficient technologies such as dry cooling and conserve freshwater by using recycled water. In fact, most solar thermal power plants licensed by the Energy Commission since 2008 are dry-cooled, two of which are operating without using water for cooling. One recently built solar thermal power plant, Abengoa Mojave Solar, is wet-cooled and treats and uses brackish groundwater that is unsuitable for municipal use.[39] In addition to conserving water overall, this direction has also resulted in an electricity system that is more resilient to drought.

Drought Response Water Conservation

The emergence of the drought in California and increasing severity over the past few years have raised questions about the long-term sustainability of water supplies and the allocation thereof to multiple societal demands. On April 24, 2014, Governor Brown proclaimed a continued state of emergency throughout California due to the ongoing drought.

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39 See the Final Energy Commission Decision for the Abengoa Mojave Solar Project, http://www.energy.ca.gov/2010publications/CEC-800-2010-008/CEC-800-2010-008-CMF.PDF

The Sustainable Groundwater Management Act (SGMA) of 2014 required the formation of local groundwater sustainability agencies to evaluate conditions in local groundwater basins and develop management plans for long-term sustainability.[40] The recently enacted SGMA is the most significant new groundwater law in California in a century. SGMA established a new structure for managing California's groundwater resources at a local level by local agencies. SGMA requires the formation of locally controlled groundwater sustainability agencies (GSAs) in the state's groundwater basins and subbasins. A GSA is responsible for developing and implementing a groundwater sustainability plan (GSP) to meet the sustainability goal of the basin to ensure that it is operated within the sustainable yield, without causing undesirable results. It is anticipated that in basins where adjudication has been implemented, this will suffice as a GSP. In areas where there is a groundwater management plan adopted prior to the GSP requirements, it must be reviewed to determine whether it meets the requirement for a GSP and revised, if needed.

After the fifth straight year of drought, and in anticipation of persistent drought conditions, Governor Brown issued Executive Order B-29-15 on April 1, 2015, which mandates statewide water-saving measures and authorizes expedited actions necessary to reduce harm from drought-related impacts. Governor Brown reiterated his ongoing concerns about the drought and the long-term availability of water supplies on May 9, 2016, with Executive Order B-37-16, which transitions interim drought relief measures to longer-term water conservation practices and policies.

Because license amendments have been necessary for several power plant projects due to curtailed water supplies, Executive Order B-29-15 granted the Energy Commission authority to expedite the processing of amendments for power plant certifications for procuring alternative water supplies, if needed. Executive Order B-37-16 leaves the accelerated licensing process in place and requires strengthening of local drought resilience by requiring water agencies to develop water shortage contingency plans. It is unclear how the power plants served by local agencies will be affected by these plans. Other power plants not served by a local agency would be subject to drought impacts on a case-by-case basis.

As the climate continues to change, California must prepare for the possibility that drought conditions may become the norm rather than the exception. The current drought has raised questions about reliability of water supplies for power plant cooling and the impacts water use by power plants may have on other consumptive uses. Water supplies for thermal plants could be vulnerable for several reasons, including curtailed federal and state water project deliveries, water rights seniority issues, potential damage

40 The Sustainable Groundwater Management Act is composed of three bills, Assembly Bill 1739 (Dickinson, Chapter 347, Statutes of 2014), Senate Bill 1319 (Pavley, Chapter 348, Statutes of 2014), and SB 1168 (Pavley, Chapter 346, Statutes of 2014). Senate Bill 13 (Pavley, Chapter 225, Statutes of 2015) made clarifying changes and added additional requirements to the act.

to conveyance systems, reduced recycled water amounts, insufficient carryover or banked water, or depleted groundwater access. Continued or accelerated use of alternative water supplies and technologies will provide a more environmentally sustainable option and make the associated power plants more resilient to climate change and drought.

Air Quality Regulations

Federal Clean Air Act

The federal Clean Air Act requires any new major stationary sources of air pollution, and any major modifications to major stationary sources, to obtain an air pollution permit before commencing construction. This process applies to power plant facilities and is known as the New Source Review (NSR). The requirements of the NSR differ depending on the attainment status of the area where the major facility is to be located. Prevention of Significant Deterioration (PSD) requirements apply in areas that are in attainment of the national ambient air quality standards. The nonattainment NSR requirements apply to areas that have not been able to demonstrate compliance with national ambient air quality standards.[41] The entire program, including both PSD and nonattainment NSR permit reviews, is referred to as the federal NSR program.

Title V of the federal Clean Air Act requires states to implement and administer an operating permit program to ensure that large sources operate in compliance with the requirements included in the Code of Federal Regulations 40, part 70. A Title V permit contains all the requirements specified in different air quality regulations that affect a generating project.

California State Health and Safety Code

The California State Health and Safety Code, Section 41700, requires that "no person shall discharge from any source whatsoever such quantities of air contaminants or other material which causes injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or which endanger the comfort, response, health, or safety of any such person or the public, or which causes, or have a natural tendency to cause, injury or damage to business or property."

The ARB promulgates state-level ambient air quality standards, which are, in general, more stringent than the national ambient air quality standards.

Local Air Districts

41 *Nonattainment area* is an area considered to have air quality worse than the National Ambient Air Quality Standards as defined in the Clean Air Act Amendments of 1970 (P.L. 91-604, Sec. 109).

The U.S. Environmental Protection Agency (U.S. EPA) typically has reviewed and approved the local air quality management district's (AQMD) regulations and has delegated to the AQMD the implementation of the federal PSD, nonattainment NSR, and Title V programs. The AQMD implements these programs, as well as the state's requirements, through its own rules and regulations, which are, at least, as stringent as the federal regulations. Proposed projects are subject to various AQMD rules and regulations. The NSR rule applies to all new and modified stationary sources, which includes power plants. It defines requirements related to best available control technology (BACT), offsets, emission calculation procedures to estimate bankable emission reduction credits (ERCs), and requirements for the federal acid rain program.

Implementation of Air Quality Regulations

Ambient air quality in California continues to improve as local, state, and federal regulators continue implementing the federal and California Clean Air Acts. In-state criteria pollutant emissions inventory data show declines in mass emissions from 2000 to 2012, even if the percentages from the generation sector appear the same or larger.[42] Specific values for electricity production and cogeneration have shown a similar trend. The transition to a high-renewable, low-carbon electricity system is also helping reduce ambient air pollution emissions and emission rates as Californians reduce their dependence on fossil fuel in the generation sector.

As the penetration of renewable resources increases, however, the existing fossil-fueled generation fleet is operating with frequent starts and stops and rapid ramps up and down. These operating fluctuations could cause emission rates to increase, even as overall emissions continue downward as less energy is needed from the fossil-fueled generation fleet. Another concern given the poor air quality in many regions of California is the difficulty in obtaining air permits for even the cleanest facilities.

In addition, meeting air pollution particulate matter requirements is problematic. Particulate matter equal to or less than 10 microns in diameter (PM10) and equal to or less than 2.5 microns in diameter (PM2.5) are small enough to bypass natural defense mechanisms and penetrate deep into human lungs. Unfortunately, particulate emissions result from so many natural and anthropogenic activities, it may be more difficult to reduce ambient particulate matter levels. This also means that it is more difficult to find a large source of particulate matter that can generate emission offsets for a new emission source like a power plant. Particulate matter offsets are scarce in many air districts in California and are particularly difficult to acquire in the South Coast Air Quality Management District (SCAQMD).

42 California Air Resources Board. Almanac Emissions Projection Data. http://www.arb.ca.gov/app/emsinv/2013/emssumcat_query.php?F_YR=2012&F_DIV=-4&F_SEASON=A&SP=2013&F_AREA=CA, accessed April 26, 2016.

While ambient air quality in California is improving, the state's growing population, climate, and geography have made attainment of health-based standards elusive. California has made progress in reducing ambient levels of ozone and the precursor emissions of oxides of nitrogen and reactive organic gases. As these precursors are common by-products of combustion, reducing fuel use and switching to cleaner-burning fuels are responsible for part of the progress. Both state and federal regulators have long recognized that progress on attaining Clean Air Act ambient air quality standards requires no backsliding or easing of emission controls and regulations, even when unforeseen system complications or emergencies occur.[43]

43 The National Highways Traffic Safety Administration's Corporate Average Fuel Economy Standards and ARBs Clean Car Standards (Assembly Bill 1493, Pavley, Chapter 200, Statutes of 2002) have improved the average fuel economy of cars and light trucks that have led to energy savings and emission reductions for the energy sector.

CHAPTER 3: Resulting System and Resource Mix

State energy and GHG reduction policies over the past decade have led to increasing amounts of renewable generation, modernizing the natural gas fleet, and moving away from high-GHG-emitting resources such as coal. Energy and climate change policy has also affected the customer side of the meter with continued energy efficiency improvements and the emergence of distributed generation, such as solar PV systems. In addition, climate change is influencing the demand for electricity as higher temperatures increase air conditioning loads in summer and decrease heating loads in winter, and as drought conditions become more prevalent.

California has seen transmission upgrades brought on-line to deliver growing amounts of renewable resources to load centers and to deal with Southern California reliability issues associated with the early closure of the San Onofre. In addition, there is a move toward a more regionalized grid, including the development of an energy imbalance market and the potential evolution of the California ISO to a regional entity.

This chapter assesses the changes that have occurred in the electricity and transmission systems as California implements energy and GHG reduction policies and programs and transitions to a clean energy economy.

Changes in the Electricity System

California's electricity resource portfolio is composed of both in-state resources and imports from out-of-state power plants. The composition of California's in-state generation capacity (in MW) has undergone several changes between 2001 and 2015, as shown in Figure 1. While natural gas-fired capacity is still a dominant generation resource, in the last few years significant amounts of renewable resources have been brought on-line. In-state renewable capacity more than doubled, increasing from about 7,500 MW in 2001 to nearly 19,000 MW by 2015.[44] The increase in renewable resources is detailed in the next section. In addition, the permanent closure of San Onofre has reduced the amount of nuclear generation capacity in the state. The proposed closure of Diablo Canyon in less than a decade, coupled with plans to use renewable resources to partially replace Diablo Canyon's output, will increase the share of renewable resources in the electricity mix. Several in-state coal facilities have closed, which are relatively

44 California's RPS is measured in percentage of retail sales, not percentage of total generation. As a result, these numbers should not be used to measure progress in achieving the RPS, which is also discussed in this section.

small but still major contributors to GHG emissions.[45] [46] Table 1 provides the total installed in-state electric generation capacity by fuel type for all power plants 1 MW and larger, for each year from 2001 through 2015. Figure 1 shows this information.[47]

Table 1: Installed In-State Electric Generation Capacity (MW) by Fuel Type (2001-2015)

	2001	2002	2003	2004	2005	2006	2007	2008
Fuel Type	Capacity							
Coal	595	595	595	595	595	595	595	571
Biomass	1,143	1,139	1,083	1,075	1,080	1,085	1,093	1,082
Geothermal	2,625	2,623	2,623	2,623	2,623	2,641	2,586	2,598
Nuclear	4,456	4,456	4,456	4,456	4,456	4,456	4,456	4,456
Natural Gas	30,377	32,688	35,063	35,027	38,587	40,238	40,909	41,180
Large Hydro	11,848	11,713	11,713	11,962	11,951	12,042	11,793	12,074
Small Hydro	1,748	1,741	1,737	1,736	1,740	1,738	1,740	1,728
Solar PV	2	2	2	2	2	2	2	6
Solar Thermal	410	378	378	378	378	400	400	400
Wind	1,534	1,544	1,571	2,064	2,089	2,310	2,373	2,462
Oil	590	567	567	567	567	506	575	575
Other	16	16	16	16	16	16	16	16
Grand Total	55,344	57,462	59,805	60,501	64,084	66,030	66,538	67,148

45 Coal plant closures include ACE Cogeneration (108 MW, 10/2014), Buena Vista Biomass (18 MW, 12/2012), East 3rd Street Power Plant (19 MW, 4/2012), Hanford (24 MW, 10/2011), Loveridge Road Power Plant (19 MW, 4/2012), Mt. Poso Cogen (64 MW, 11/2011), Nichols Road Power Plant (19 MW, 4/2012), Port of Stockton (50 MW, 1/2011), Rio Bravo Jasmin (33 MW, 1/2016), Rio Bravo Poso (33 MW, 2/2015), Stockton CoGen (55 MW, 3/2012), TXI Riverside Cement (24 MW, 3/2008), Wilbur East Power Plant (19 MW, 4/2012), and Wilbur West Power Plant (19 MW, 4/2012).

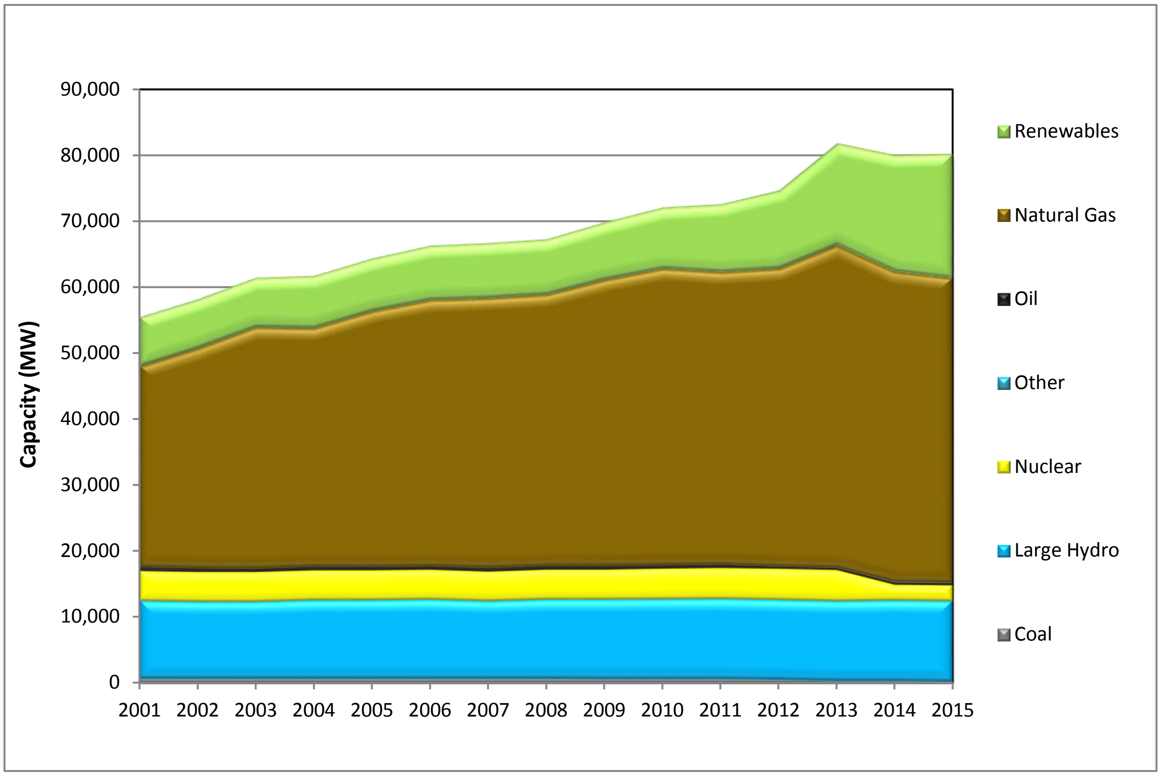
46 For the status of coal and petroleum coke facilities in California see Tracking Progress for Reliance On Coal: http://www.energy.ca.gov/renewables/tracking_progress/#coal (Note: In late 2015 the Rio Bravo Poso cogeneration facility announced that it would close, which isn't reflected in the Tracking Progress report.)

47 The values reported in Table 1 and Figure 1 reflect nameplate capacity, which is the maximum possible output from a generation facility as designated by the manufacturer. See the following website for the latest updates to these values, http://energyalmanac.ca.gov/electricity/electric_generation_capacity.html.

	2009	2010	2011	2012	2013	2014	2015
Fuel Type	Capacity						
Coal	576	581	444	275	275	167	167
Biomass	1,095	1,104	1,153	1,182	1,214	1,296	1,297
Geothermal	2,648	2,648	2,648	2,703	2,703	2,703	2,716
Nuclear	4,456	4,577	4,577	4,577	2,323	2,323	2,323
Natural Gas	43,400	43,980	43,949	44,573	47,135	46,229	45,437
Large Hydro	12,074	12,105	12,145	12,145	12,155	12,244	12,252
Small Hydro	1,735	1,724	1,723	1,735	1,729	1,728	1,720
Solar PV	11	109	214	737	3,031	4,589	5,498
Solar Thermal	408	408	408	408	925	1,300	1,292
Wind	2,728	3,183	3,992	4,967	5,800	5,887	6,288
Oil	552	509	348	350	350	351	351
Other	16	16	16	16	16	16	16
Grand Total	69,699	70,943	71,616	73,668	77,656	78,834	79,359

Source: California Energy Commission, 1304 Power Plant Data Reporting, Energy Assessments Division.

Figure 1: Installed In-State Electric Generation Capacity by Resource Type (2001-2015)

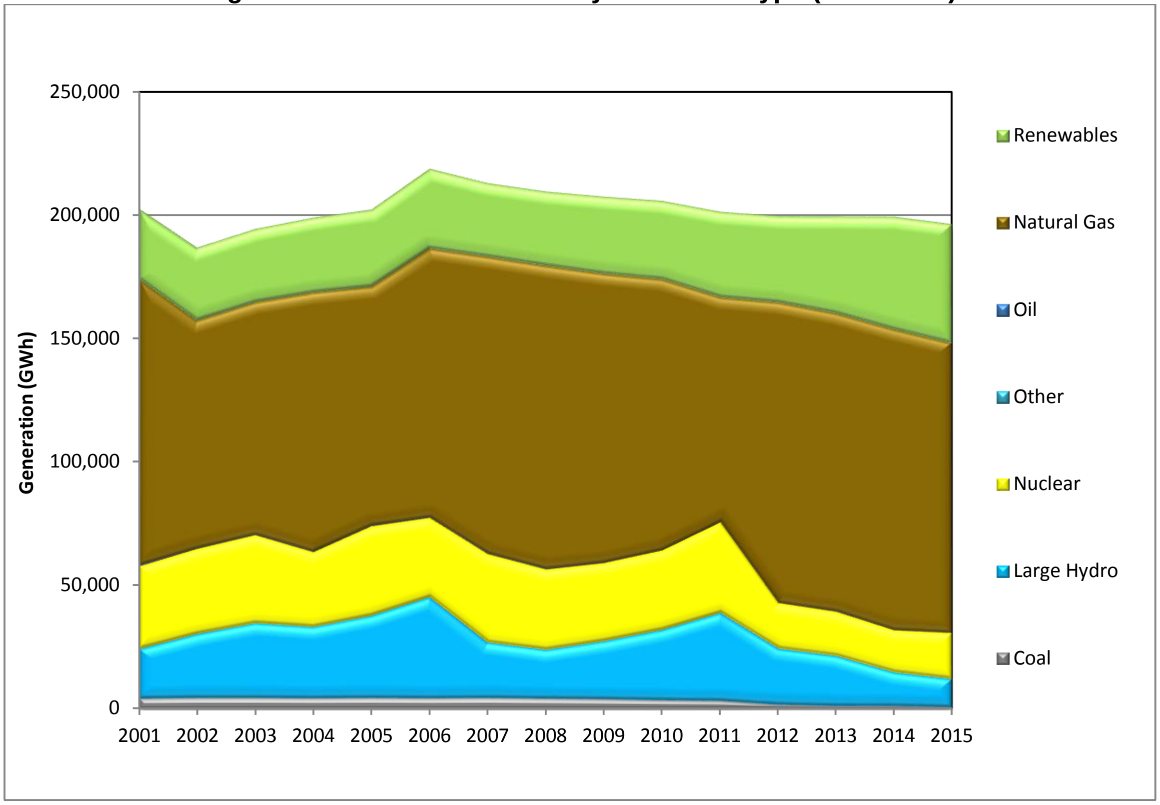


Source: California Energy Commission, 1304 Power Plant Data Reporting, Energy Assessments Division.

Figure 2 shows the total generation (in MWh), from in-state resources, that serves California's electricity loads. Generation over the last 14 years has been relatively flat, increasing only slightly, consistent with slow growth in energy demand. As with capacity, natural gas is still a dominant fuel for electric generation, as shown in Figure 2. However, there has also been substantial growth in renewable generation, with much of it from variable resources. The increase in total generation from renewable resources is not as dramatic as the growth of installed renewable capacity, mostly due to renewable energy with lower capacity factors like wind and solar and recently added renewable capacity that is just beginning to report generation output.[48] Figure 2 also shows the drop in nuclear generation from the closure of San Onofre and the reduction in coal generation from the closure of several small in-state coal facilities.

48 California's RPS is measured in percentage of retail sales, not percentage of total generation. As a result, these numbers should not be used to measure progress in achieving the RPS, which is discussed in a later section.

Figure 2: Electric Generation by Resource Type (2001-2015)



Source: California Energy Commission, 1304 Power Plant Data Reporting, Energy Assessment Division.

Weather and hydroelectric conditions influence year-to-year differences in generation. For example, when hotter summer weather drives up demand for air conditioning, more generation is needed than during a cooler summer. In addition, in good water years when hydroelectric generation resources are abundant, like in 2011, natural gas generation is reduced, as shown in Figure 2. Conversely, during dry hydro conditions, such as the state's current drought, natural gas demand typically increases to make up the difference. With the rise in renewable generation in recent years, also shown in Figure 2, some of the lost hydro due to California's ongoing drought has been made up with renewables resources.

Evolution of the Grid With Renewables

In-state renewable capacity more than doubled, increasing from about 7,500 MW in 2001 to 19,000 MW by 2015, as shown in Figure 3, which is derived from Table 1.[49] The most dramatic change in resource type is the addition of utility-scale solar PV, especially between 2010 and 2015 when installed capacity rose from roughly 100 to 5,500 MW.

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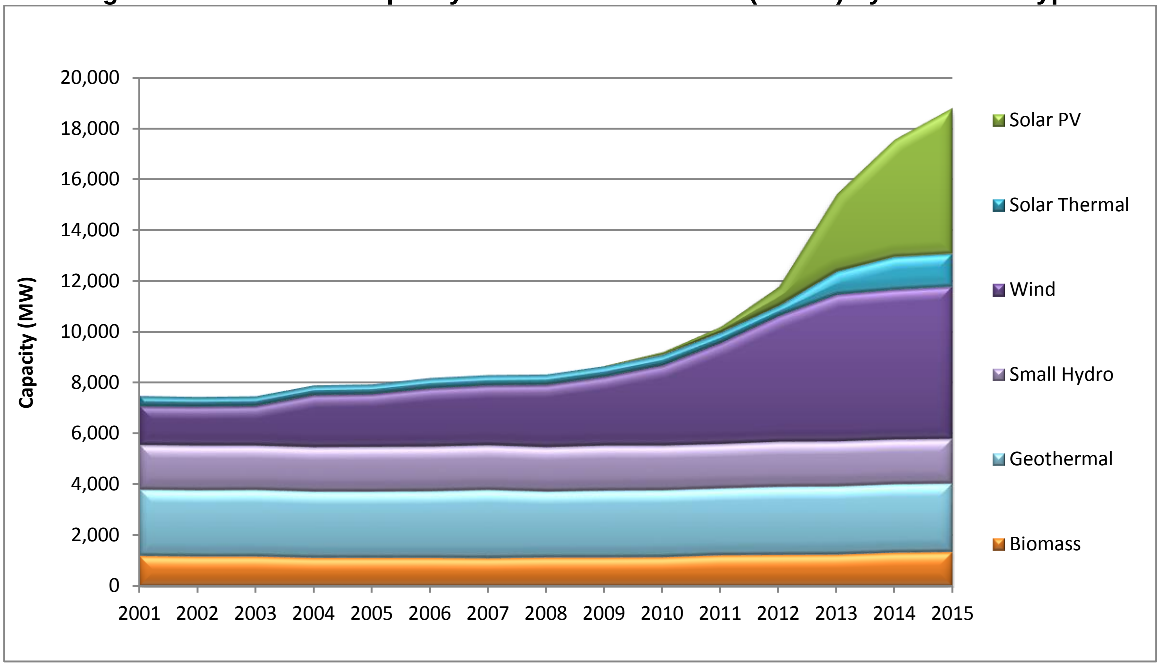
49 *Renewable resources* include the categories of wind, solar PV, solar thermal, small hydro, geothermal, and biomass. These are physical resources and they do not correspond exactly with RPS-eligible renewable resources in the state since they do not reflect contracted capacity and generation requirements measured under the RPS.

This increase includes both new facilities and capacity expansions to existing solar PV plants. Solar thermal technology was the second largest category of growth, increasing from roughly 400 MW in 2012 to 1,300 MW in 2015. Wind generation also increased at a slightly slower pace from around 1,500 MW in 2001 to 4,000 MW in 2011 and then jumped to roughly 6,300 MW by 2015.

Figure 3: Renewable Capacity Installed in California (in MW) by Resource Type



Source: California Energy Commission, 1304 Power Plant Data Reporting, Energy Assessment Division.

During the 1980s, there was a substantial increase in renewable generation in California largely as the result of standard offer contracts that required utilities to buy the output from renewable generators, or *qualifying facilities,* instituted under Governor Brown's first administration.[50] The next major increase in renewable projects came roughly after 2008, when projects procured in response to the RPS began coming on-line.[51] Figure 4 shows the growth in renewable generation serving California by resource type from 1983–2014. The data in Figure 4 are intended to represent RPS-eligible generation, and so they include energy delivered into California from out-of-state facilities that are RPS-eligible. Overlaid on the graph are some of the policies, discussed in the previous chapter, that helped stimulate the market for renewables. The increase in renewable

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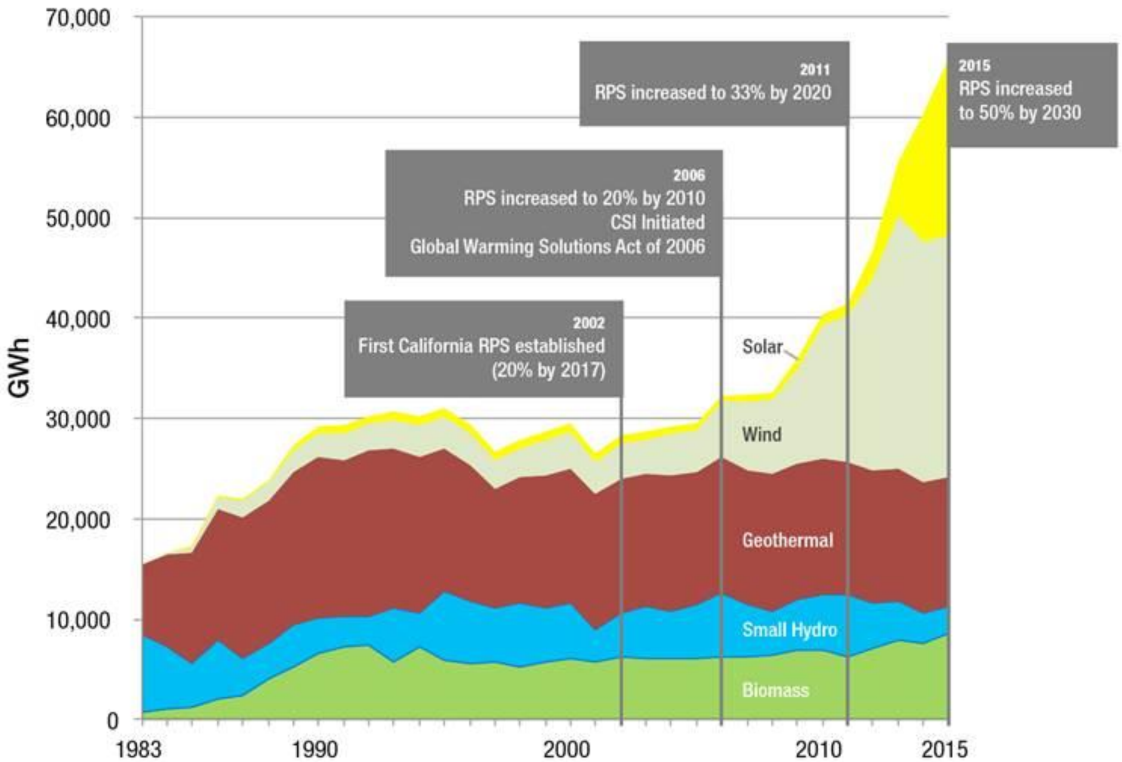
50 The Public Utility Regulatory Policies Act of 1978, which was passed at the federal level in response to the 1973 energy crisis, was designed to encourage energy conservation and promote renewable energy. Qualifying facilities under the act included qualifying small power production facilities and cogeneration plants. A small power production facility is a generating facility of 80 MW or less whose primary energy source is renewable (hydro, wind or solar), biomass, waste, or geothermal resources.

51 The original RPS statute was passed in 2002. See Chapter 2 for discussion on renewable energy policies.

energy generation after 2008 coincides with decreases in GHG emissions in the electricity sector, which are discussed in Chapter 4.

Figure 4: California Renewable Energy Generation From 1983-2014 by Resource Type (In-State and Out-of-State)



Source: California Energy Commission. Tracking Progress Web page. Renewable Energy, updated September 29, 2016.

In 2014, nearly 25 percent of retail electricity sales were served by renewable resources, including wind, solar, geothermal, biomass, and small hydroelectric resources.[52] As a result, California is well on its way to meeting the requirement for 33 percent renewables by 2020.[53] In addition, there are about 11,800 MW of new renewable capacity being proposed that have environmental permits and are in preconstruction or construction.[54] Proposed utility-scale solar PV projects account for nearly all of the new renewable energy capacity expected to come on-line in 2016.[55]

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52 California Energy Commission, Tracking Progress, *Renewable Energy*, http://www.energy.ca.gov/renewables/tracking_progress/index.html, pp. 1-2.

53 Ibid., pp.1-2.

54 Ibid., p. 6

55 Ibid., p. 16.

In a span of 10 years, the state increased the number of large renewable energy facilities, with associated capacity almost tripling from roughly 5,900 MW in 2005 to 15,900 MW in 2015. The rapid deployment of renewable energy facilities over the last decade to help meet the GHG reduction goals has led to a new level of biological, land-use, and cultural impacts that were different from those seen in the review of conventional generation facilities. These new large renewable resources presented challenges due to the larger environmental footprint associated with the different renewable technologies when compared with traditional generation technologies such as natural gas.

As detailed in Chapter 4, the average land use, measured as acreage per megawatt (acres/MW), for renewable projects are 2.5 acres/MW for biomass, 6 acres/MW for geothermal, 7 acres for solar, and 24.8 to 40 acres/MW for wind. This is compared to a natural gas power plant with an average of 0.08 acres/MW. In addition to the scale of these projects, the natural gas plants sited in California had fairly well-understood environmental effects. New renewable projects were being sited in remote locations and desert areas where there were more limited experience and understanding of the associated environmental impacts. To help deploy these facilities, the state has supported and promoted incentives for scientific research and new technologies, such as environmental studies on species habitats and climate change impacts on species, development of improved energy storage systems that could be paired with renewable energy systems, development and deployment of synchrophasors[56] to offer real-time data on the amount of electricity on the grid, research on new mitigation approaches, and coordinated interagency landscape planning.

As California moves toward reducing GHG levels to 40 percent below 1990 levels by 2030 and meeting its climate change adaptation goals,[57] as well as the need to preserve environmental quality and conserve resources, the state will need to continue to advance environmental research, technology development, and coordinated, interagency approaches.

As more variable renewable electricity generating resources, like wind and solar, are added to California's electricity resource mix, it becomes more challenging to integrate

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56 Synchrophasors are a technology that allows precise grid measurements from monitors called *phasor measurement units* (PMUs). PMU measurements are taken at high speed (typically 30 observations per second compared to one every 4 seconds using conventional technology). Each measurement is time-stamped according to a common time reference. Time stamping allows synchrophasors from different utilities to be time-aligned (or "synchronized") and combined, providing a precise and comprehensive view of the entire interconnection. Synchrophasors enable a better indication of grid stress and can be used to trigger corrective actions to maintain reliability. (Source: North American Synchro Phasor Initiative, http://www.nerc.com/page.php?cid=6%7C319.)

57 The 2030 GHG reduction goal is an important step to reducing GHG emissions to 80 percent below 1990 levels by 2050.

them while maintaining grid reliability, safety, and security. Renewable integration issues are detailed later in this chapter.

The California ISO has raised concerns about the large ramps up and down in generation needed to maintain reliability. 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. The grid is already experiencing the large operational fluctuations that grid operators were not expecting until 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.[58] The section below on "Energy Imbalance Market" describes one important tool that is helping balance such fluctuations in supply and demand.

There is a growing need for flexible resources 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 or demand. As California moves toward reducing GHG levels to 40 percent below 1990 levels by 2030, it is important that nonfossil resources are developed to integrate renewables.[59] Potential options are being developed in California, including many varieties of energy storage and demand response. On November 20, 2015, Energy Commission Chair Robert Weisenmiller and CPUC President Michael Picker jointly conducted a workshop to discuss bulk energy storage in California, including the challenges of planning the electric grid and developing future bulk energy storage projects, the potential for bulk energy storage to address grid challenges, and the operations of existing bulk energy storage projects in California.[60] 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. There are also potential regional solutions for integrating renewable resources, including taking advantage of the diversity of renewable resources and related varying generation profiles across the broader western region. (See "Increasing Regionalization" below for more information.")

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58 California ISO Market Performance and Planning Forum presentation, July 21, 2016, p.56, http://www.caiso.com/Documents/Agenda-Presentation-MarketPerformance-PlanningForum-Jul21_2016.pdf.

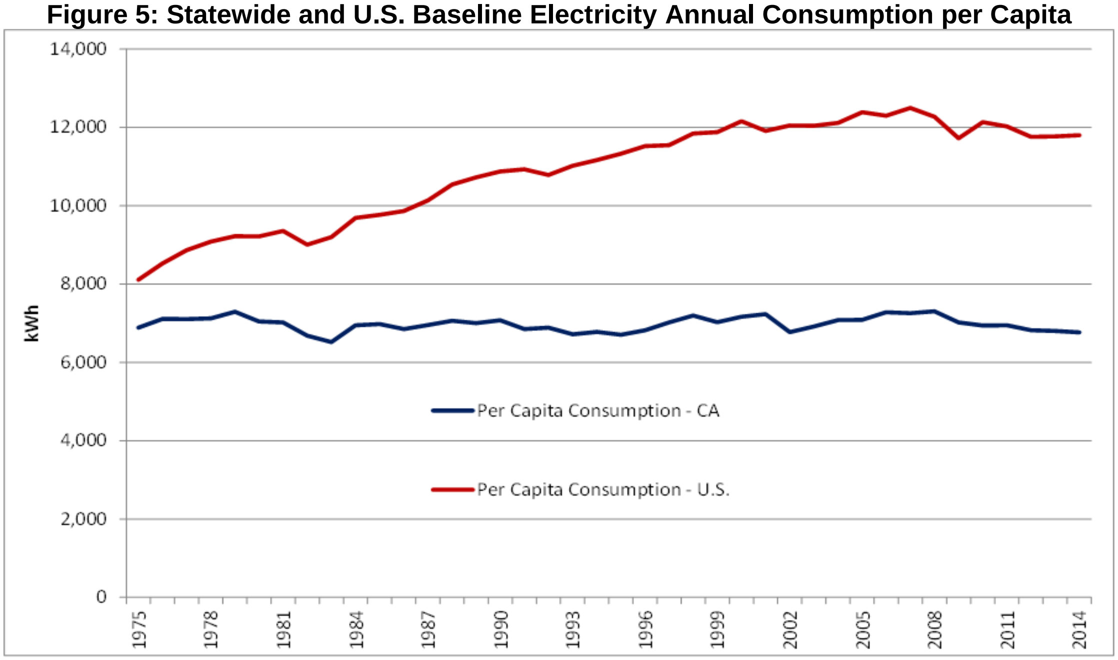
59 The 2030 GHG reduction goal is an important step on the way to reducing GHG emissions to 80 percent below 1990 levels by 2050.

60 Mathias, John, Collin Doughty, and Linda Kelly. 2016. *Bulk Energy Storage in California*. California Energy Commission. Publication Number: CEC-200-2016-006.

Energy Demand, Energy Efficiency, and Distributed Resources

California's per capita electricity consumption has been relatively flat over the last two decades, as shown in Figure 5, but continues to grow in the United States overall.[61] As discussed in Chapter 2, energy efficiency has been a major policy focus since the Energy Commission's inception in the mid-1970s. Californians consume 40 percent less electricity per capita than the rest of the nation due to a number of reasons, including climate, household size, economic growth, industry mix, and aggressive energy efficiency efforts. This is also true for California's per capita GHG emissions, with both energy efficiency and the rapid increase in renewable resources contributing to this decline in consumption, as shown in Figure 6. Also shown in Figure 6, California's economy grew (as demonstrated by growth in gross domestic product or GDP) as its GHG emissions declined over the last 25 years. Figure 7 shows California's GHG emissions per capita and per GDP in comparison with other countries. California has relatively high economic output relative to its GHG emissions and its per capita emissions are similar to Germany and Israel.

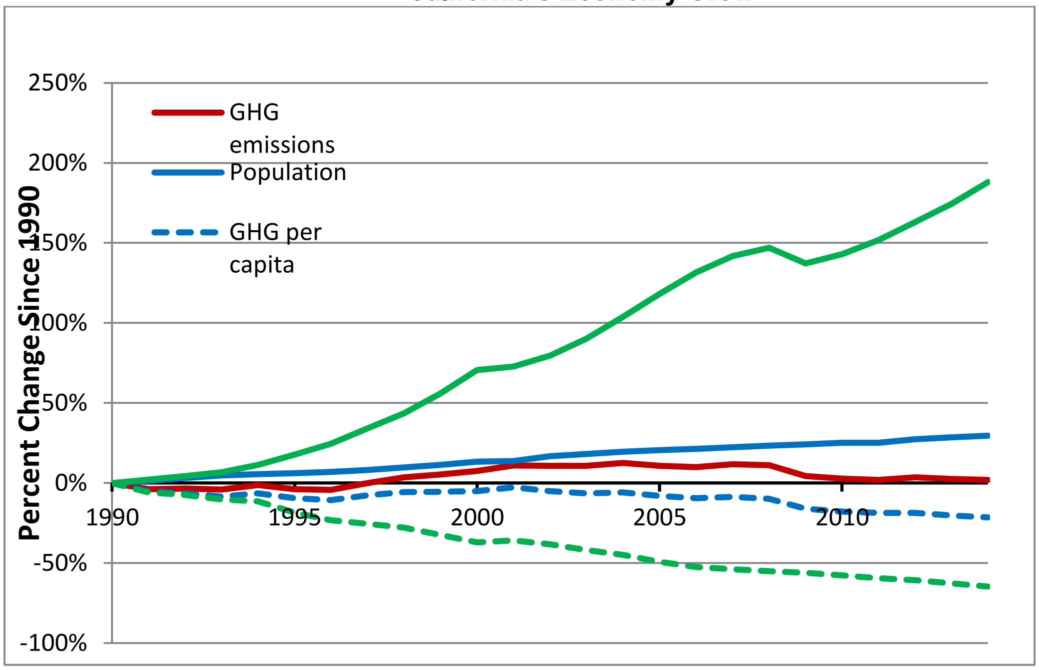
Figure 5: Statewide and U.S. Baseline Electricity Annual Consumption per Capita



Source: California Energy Commission, 2016, *California Energy Demand 2016-2026, Revised Electricity Forecast*. California Energy Commission. Publication Number: CEC-200-2016-001-V1 Adopted 2016

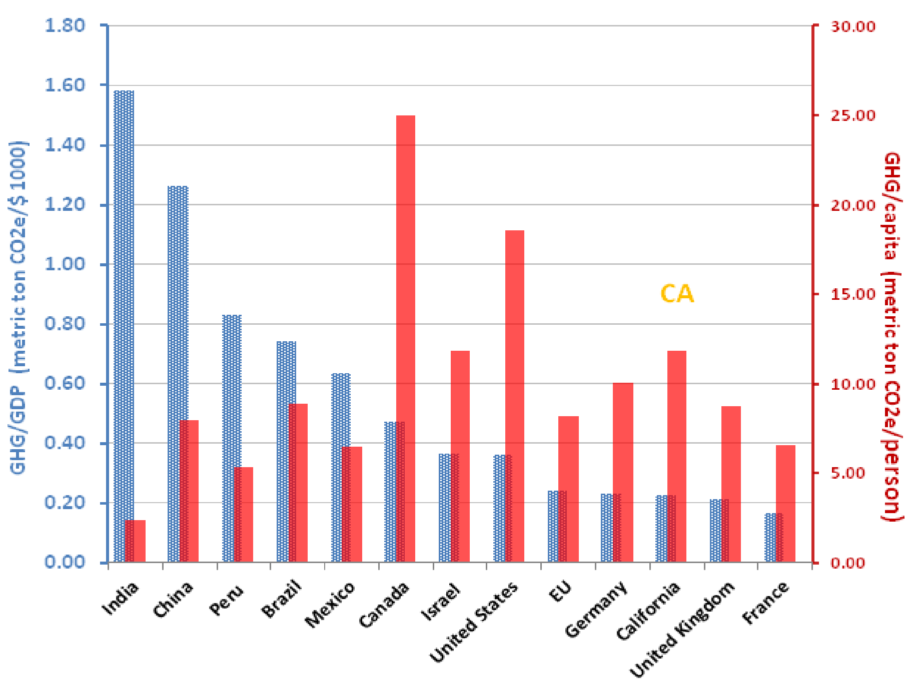
61 The 1999 decrease in consumption is derived from EIA data. However, after further analysis, staff believes this may be an error, to be corrected in the next energy demand forecast report. Some drop in demand was experienced during the 2000-2001 California electricity crisis.

Figure 6: Decline in GHG Emissions per Capita and per GDP Over Last 25 Years While California's Economy Grew



Source: Energy Commission staff

Figure 7: California GHG Emissions per GDP and per Capita in Comparison With Other Countries



Source: Energy Commission staff using data from ARB (GHG Inventory) and the Department of Energy's Carbon Dioxide Information Analysis Center

Combining energy efficiency gains from codes and standards, energy efficiency programs, as well as market and price effects, the cumulative annual efficiency and conservation savings for electricity are estimated at nearly 90,000 gigawatt-hours (GWh) in 2014, as shown in Figure 8.

Energy efficiency reduces electricity infrastructure needs, lowers renewable electricity procurement requirements, and allows greater electric infrastructure flexibility as the state moves toward transportation electrification. The deferral or reduction in infrastructure needs has helped minimize the environmental impacts from the electricity sector. Energy efficiency is also reducing California's energy infrastructure costs by easing the demand that must be met by either fossil fuels or renewable generation. Improvements in energy efficiency also help businesses and homes reduce energy costs and increase building comfort.

Another factor contributing to slow growth in demand is the emergence of behind-the-meter distributed generation or self-generation, primarily solar PV. The CSI had a goal of installing 3,000 MW of solar system on homes and businesses in California by the end of 2016, which was surpassed in 2015.[62] It also calls for 585 million therms of gas-displacing solar water heating by the end of 2017. The Energy Commission's New Solar Home Partnership (NSHP) program provides financial incentives to encourage the installation of eligible solar energy systems on new home construction. The ongoing recovery of the market from the housing crisis (coincident with the start of the NSHP program) has resulted in growing amounts of solar installed on new homes and as of June 27, 2016, about 177 MW was reserved or installed, demonstrating substantial progress toward the program goal of 360 MW. On June 9, 2016, the CPUC approved $111.78 million in additional funding for continuing financial incentives for homeowners, builders, and developers to install solar energy systems on new, energy-efficient homes with the Energy Commission as the NSHP program administrator.[63]

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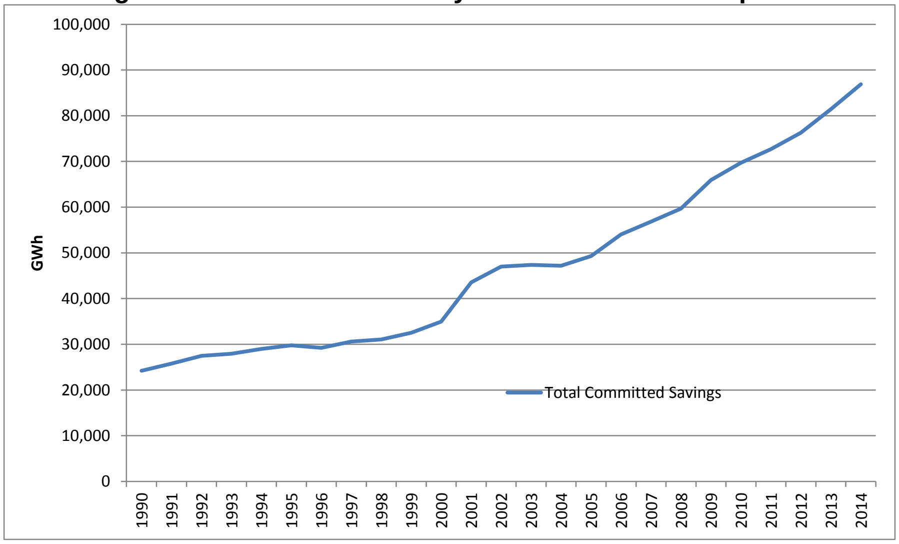
62 California Energy Commission, *2015 Integrated Energy Policy Re*port, 2015, Publication Number: CEC-100-2-15-001-CMF, p. 54, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN210527_20160224T115023_2015_Integrated_Energy_Policy_Report__Small_Size_File.pdf.

63 California Energy Commission, Tracking Progress Web page, Renewable Energy, updated September 29, 2016.

Figure 8: Statewide Efficiency and Conservation Impacts



Source: California Energy Commission, *California Energy Demand 2016-2026*, *Revised Electricity Forecast*, Publication Number: CEC-200-2016-001-V1. Adopted 2016. Figure 20.

As of October 31, 2015, the CPUC's CSI program provided incentives for nearly 1,700 MW of installed capacity and reserved funding for more than 220 MW of pending capacity toward achieving the goal of 1,940 MW for commercial buildings and existing homes in IOU service territories. [64] The POUs have installed nearly 320 MW toward their 700 MW goal as of the end of 2014.[65].

As shown in Table 2, nearly 560,000 self-generation residential and commercial solar projects totaling more than 4,400 MW have been installed in California, about 2,000 MW of which were installed just in 2014 and 2015. This capacity represents more than 40 percent of all solar PV installed in the United States. [66]

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64 Ibid., p. 55.

65 Ibid.. p. 55.

66 Solar Energy Industries Association, Q3 2016 Press Release, September 12, 2016, http://www.seia.org/news/us-solar-market-adds-more-2-gw-q2-2016.

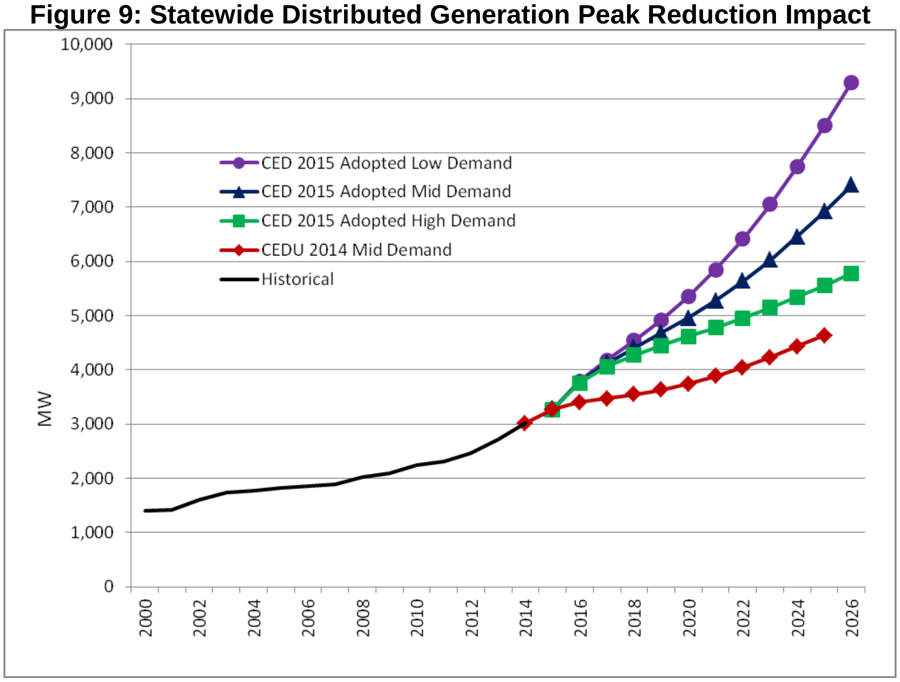
Table 2: Self-Generation Solar installations in California

	Residential		Commercial		Total	
	Installed Systems	MW	Installed Systems	MW	Installed Systems	MW
POU	42,649	229	1,783	169	44,432	398
IOU	500,086	2,586	15,189	1,423	515,275	4,008
Total	**542,735**	**2,815**	**16,972**	**1,592**	**559,707**	**4,407**

Source: (1) Publicly Owned Utilities SB1 Solar Program Status Reports, available at http://www.energy.ca.gov/sb1/pou_reports/ (2) Currently interconnected data set of all solar PV (NEM) systems within PG&E, SCE and SDG&E service territories, available at https://www.californiasolarstatistics.ca.gov/data_downloads/. Commercial also includes educational, industrial, military, nonprofit, other government and school projects.

Figure 9 shows the growth in distributed generation since 2000 and the impact of projected distributed generation installation on peak demand.

Figure 9: Statewide Distributed Generation Peak Reduction Impact



Source: California Energy Commission, *California Energy Demand 2016-2026, Revised Electricity Forecast*, Publication Number: CEC-200-2016-001-V1. Adopted 2016

Future electricity demand is expected to be influenced by climate change.[67] Statewide average temperatures in California have increased by 1.7 degrees Fahrenheit from 1895 to 2011, with warming the greatest in the Sierra Nevada. Rising temperatures can cause more severe wildfires, sea level rise, increased energy demand, decreased hydroelectric availability, and several other impacts on California's population and natural

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67 California Energy Commission, *California Energy Demand 2016-2026, Revised Electricity Forecast*, 2016, Publication Number: CEC-200-2016-001-V1, pp. 36-38, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf.

resources.[68] The adopted *California Energy Demand (CED) 2015 Revised (CED 2015 Revised)* incorporates the potential incremental impacts of climate change on both electricity consumption and peak demand using temperature simulations developed by the Scripps Institution of Oceanography.[69] Consumption effects are estimated through projected changes in the number of annual heating and cooling degree days, while peak demand impacts are estimated through increases in annual maximum daily average temperatures.[70]

Electricity consumption is affected by both heating and cooling degree days, so the effect of increases in the average annual number of cooling degree days as a result of climate change is tempered by a decreasing average number of heating degree days (since both minimum and maximum temperatures increase). Higher overall temperatures cause increases in peak demand, more air conditioning in the summer for example, as well as decreased heating needs in winter. In addition to consumption effects, electricity demand will also be affected by increasing transportation electrification in response to climate change goals, which is also captured in the Energy Commission's demand forecast.[71]

Figure 10 shows projected statewide impacts of climate change on peak demand in the mid and high demand cases.[72] In the mid demand case, peak demand increases by around 700 MW by the end of the forecast period and by around 800 MW over the high demand case. Over the 10-year period, annual maximum temperatures increase in each planning area by an average of around ½ degree Fahrenheit in the mid demand case and ¾ degree in the high demand case.

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68 California Energy Commission, *Our Changing Climate 2012: Vulnerability & Adaptation to the Increasing Risks From Climate Change in California, 2012*, www.energy.ca.gov/2012publications/.../CEC-500-2012-007.pdf.

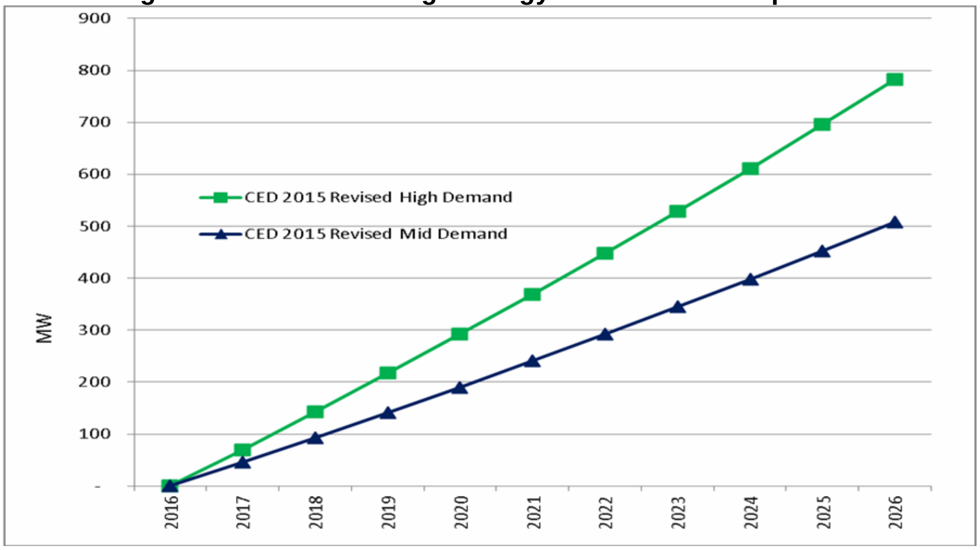
69 These impacts should be considered incremental to the extent that climate change has already affected temperatures and, therefore, consumption and peak demand in California.

70 Heating and cooling degree days are determined by the difference between the daily average temperature and a reference temperature (for example, 65 degrees). The number of days is summed for a given year. An average temperature below the reference temperature adds to heating degree days, and an average above the reference temperature adds to cooling degree days.

71 California Energy Commission, *California Energy Demand 2016-2026, Revised Electricity Forecast*, 2016, Publication Number: CEC-200-2016-001-V1, pp. 39-41, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf.

72 The Energy Commission's demand forecast includes three cases designed to capture a reasonable range of demand outcomes over the next 10 years. The high demand case incorporates relatively high economic/demographic growth and climate change impacts. The low demand case includes lower economic/demographic growth and no climate change impact. The mid demand case uses input assumptions between the high and the low case. Climate change impacts are presented only for the high and mid cases because there was no observed change in the low case.

Figure 10: Climate Change Energy Peak Demand Impacts



Source: California Energy Commission, *California Energy Demand 2016-2026, Revised Electricity Forecast*, Publication Number: CEC-200-2016-001-V1. Adopted 2016

Modernizing the Natural Gas Fleet

Beginning with the *2003 IEPR*, the Energy Commission raised concerns about reliance on aging natural gas-fired power plants due to the lower efficiency and higher emissions of these facilities when compared to modern combined-cycle plants. Several factors contribute to changes to the natural gas fleet, including modernizing aging plants, the state's OTC policy, changing demands on the gas fleet for integrating renewable resources, and customers adopting distributed generation, lessening dependence on the gas fleet.

The thermal efficiency of the state's current portfolio of noncogeneration natural gas power plants has improved by 29 percent compared to 14 years ago.[73] Reduced dependence on aging gas-fired power plants is another factor responsible for the improvement in California's systemwide heat rate.[74] In the *2005 IEPR*, the Energy Commission recommended that the state's utilities procure sufficient resources to allow for the orderly retirement, repowering, or replacement of aging power plants, recognizing that some aging plants played an important role in providing local and system reliability. A large number of gas-fired power plants using OTC have been or will be retired or replaced. In addition, as other gas-fired plants that do not use OTC reach

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73 California Energy Commission, *Thermal Efficiency of Gas-Fired Generation in California: 2015 Update*, 2016 Publication Number: CEC 200-2016-002, p. 12, http://www.energy.ca.gov/2016publications/CEC-200-2016-002/CEC-200-2016-002.pdf.

74 Because the aging plants run for fewer hours during the year than in previous years and more efficient units run more of the time, the overall thermal efficiency of the natural gas power plant fleet has improved.

the end of useful life, additional retirements are expected. This will continue to drive improvements in the efficiency of the natural gas fleet.

Aging power plants, generally those plants built before 1980, are being phased out or repowered with more efficient technologies due to air quality and environmental concerns. California's aging plants are predominately older steam turbines or steam boilers. Aging plants along the California coast using OTC technology as part of the design must comply with the OTC policy by about 2020, with some extending to about 2029. A more detailed discussion of the OTC policy is presented in Chapter 2, and the disposition of OTC power plants is addressed in Chapter 4.

As boiler facilities have aged, they are being replaced by new, more flexible combined-cycle and simple-cycle combustion turbine facilities. In 2001, there were 27 aging power plants with an operational nameplate capacity of almost 20,000 MW.[75] By 2014 there were 18 operational aging power plants with a combined nameplate capacity of roughly 13,300 MW, a drop of nearly 7,000 MW.[76] Figure 11 shows how the total nameplate capacity of the natural gas fleet has changed over time.[77]

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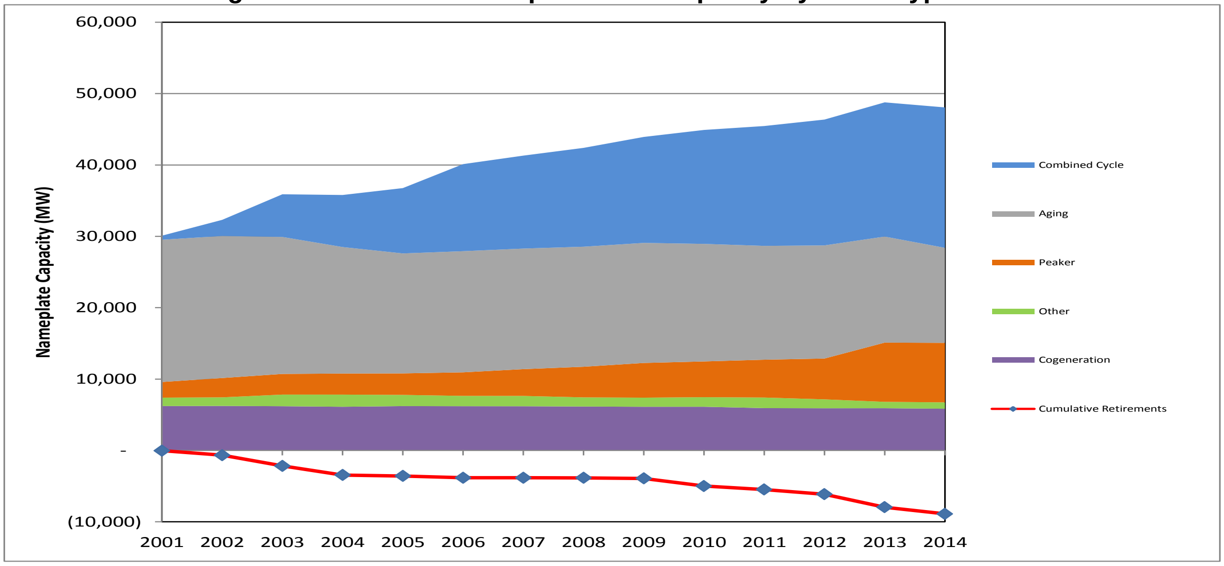
75 California Energy Commission, *Thermal Efficiency of Gas-Fired Generation in California: 2015 Update*, 2016, Publication Number: CEC 200-2016-002, pp. 5-6, http://www.energy.ca.gov/2016publications/CEC-200-2016-002/CEC-200-2016-002.pdf.

76 Ibid., p. 5-6. Power plant retirements included Contra Costa (680 MW), Humboldt Bay just south of Eureka (107 MW), Hunters Point in San Francisco (222 MW), Long Beach (585 MW), Magnolia in Burbank (108 MW), Morro Bay in San Luis Obispo County (912 MW), and Potrero in San Francisco (207 MW). Two aging steam units totaling 686 MW were retired at the Haynes Generating Station in Long Beach in June 2013.

77 The retirements shown in Figure 9 include retirements of all categories of natural gas-fired power plants, not just aging power plants. Of the 10,000 MW of retirement, roughly 7,000 are aging power plants.

Figure 11: Total Annual Operational Capacity by Plant Type



Source: California Energy Commission, Supply Analysis Office

Natural gas-fired combined-cycle power plants are increasingly operated to integrate growing levels of renewable resources, such as wind and solar, rather than being used as baseload or peaking resources. Since aging boilers are generally at least 40 years old and not flexible enough to back up renewable resources, most are being replaced by new, flexible, fast-ramping combustion turbine facilities that help integrate the variable output of intermittent renewable supplies.

Newer natural gas-fired power plants are being used to follow load up and down throughout the day, to meet peak demand on hot days, to provide backup generation during low hydroelectric or drought conditions, to provide reserves for unplanned contingencies like forced outages due to fire or equipment failure, and to provide ancillary services such as frequency regulation to support the electricity and transmission grid. As California moves to meet higher GHG reduction goals, it will be increasingly important to deploy nonfossil approaches to meeting these needs. As noted in the section on renewable resources, the state is pursuing several options, such as electricity storage, demand response programs, and new technologies that can help with many of the services identified above.

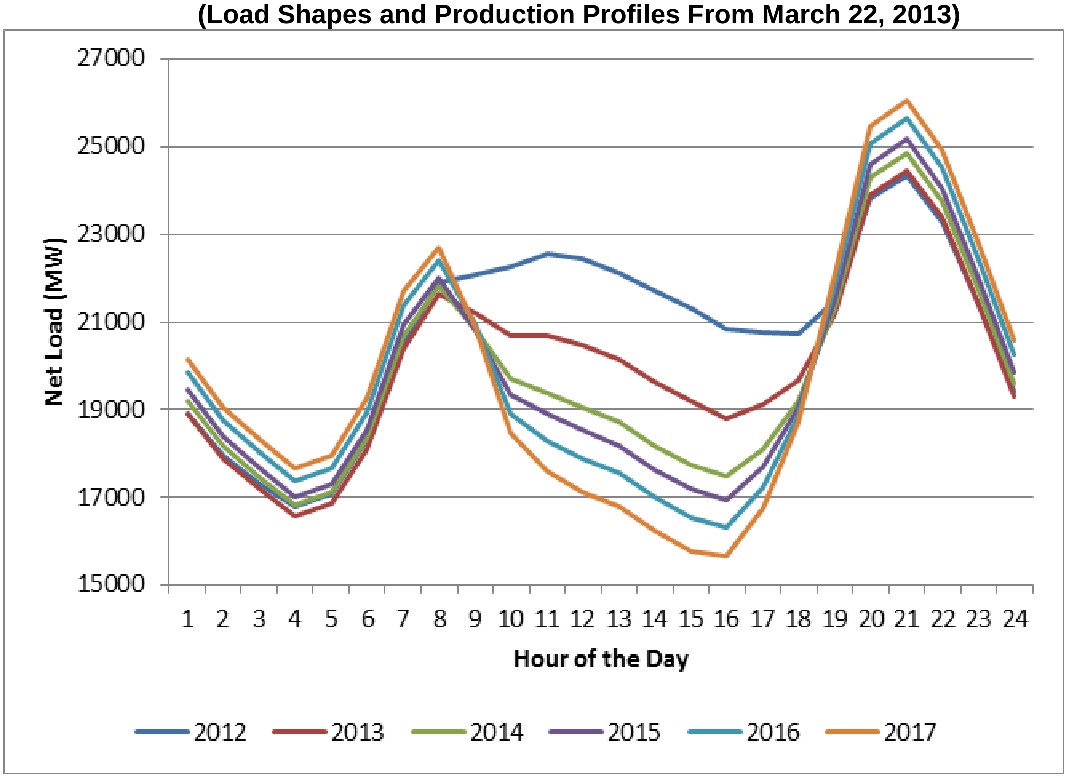
Integrating Renewable Resources

In California's complex system of electricity resources, generation must match demand instantaneously and continuously. Balancing electricity generation with load, while maintaining the voltage and frequency within operational tolerances, is achieved through resource commitment and dispatch. Fitting any particular generating unit into that process, whether conventional or renewable, is referred to as *integration*. As California moves toward a system relying on increasing amounts of variable renewable resources, it is necessary to have resources that can back up or firm output to ensure reliability and deliverability of electricity supplies.

Electricity system operators routinely plan for outages of significant energy resources, such as nuclear plants or transmission lines, and are able to bring grid frequency back into balance within minutes. Wind and solar output can rise or drop from moment to moment, across hours, and over days or months. Knowing how much variability to plan for is essential for grid operators. Accurate forecasting of variable energy needs in the day-ahead and real-time operational time frame is important because resources must be procured ahead of time to balance supply and demand.

The flexible natural gas-fired power plants used to integrate renewables must be able to sit idle or at very low levels of output while renewable resources are on-line, then quickly start and rapidly ramp up as renewable resources come off the grid, such as when the sun sets or the wind dies down. In addition, backup supplies must be able to quickly ramp up by as much as 11,000 MW to 13,000 MW as the solar intensity declines, a significant change in just a few hours, as shown in Figure 12 (also referred to as the *duck curve*).

Figure 12: Illustrative Change in Net Load Curves
(Load Shapes and Production Profiles From March 22, 2013)



Source: California Energy Commission, Energy Assessments Division

Wind and solar are the two primary renewable resources that have variable output and need reliable backup sources. Wind turbines tend to produce power at maximum output during late afternoon and evenings. However, as the wind begins to wane around 8 to

9 p.m., nonrenewable supplies are used to provide electricity supplies as demand slacks off. The net effect is represented by the *head and beak* portion of the duck curve.

On the other hand, solar supplies tend to produce power at maximum output during midday when the sun is directly overhead. As additional solar supplies come on-line over time, the duck curve shows a *belly* region, with the belly growing deeper as more solar capacity is added to the system. Peak solar production occurs during a narrow band of time when maximum solar intensity occurs, which is about one half-hour for California.[78] [79]

California relies on natural gas power plants and portions of its hydroelectric resources to integrate renewable resources. Some of the natural gas plants being used to integrate renewables are capable of being shut down during the midday hours when solar output is at maximum output. Other gas generators must remain on-line at a minimum load point if they are to be available for dispatch later in the day. Many aging plants cannot quickly start or stop. Hydroelectric generation, while non-GHG-emitting, is not always available year-round and can be significantly curtailed late in the summer or during droughts. Coal, nuclear, or cogeneration plants generally do not vary output or must remain on-line during midday, even when maximum solar output is available. Therefore, combustion turbine facilities are the flexible, dispatchable, fast-ramping generation relied on to integrate renewables.

Several potential options to integrate renewables are being developed in California, including energy storage and demand response. There are also potential regional solutions for integrating renewable resources, including taking advantage of the diversity of renewable resources and related varying generation profiles across the broader western region. The different options for integrating renewables are discussed in Chapter 5.

Out-of-State Coal Ownership and Contracts Are Being Retired

As discussed in Chapter 2, the purpose of SB 1368 is to discourage new long-term investments by the state's utilities in high-carbon baseload resources. The Energy Commission has regulations in place for POUs that establish an EPS of 1,100 lbs CO_2 per megawatt-hour, which power plants under new or renewed long-term investments must meet. In addition, the POUs are required to post notices of public deliberations on these

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78 The state is oriented more or less in a north-south direction; therefore, this solar variability occurs east-to-west but not north-to-south. Since the surface of the Earth at the equator rotates about 1,000 miles during any one-hour period, California, as a state roughly 500 miles from west to easternmost point, rotates quickly through peak solar insolation.

79 Chair Robert B. Weisenmiller, California Energy Commission, Panel on Preparations for Los Angeles Basin Gas-Electric Reliability and Market Impacts (AD16-21-000), May 19, 2016, slides 9-10, http://www.energy.ca.gov/commissioners/weisenmiller_docs/index.html.

long-term investments to promote public awareness of utility investments in non-EPS-compliant facilities.

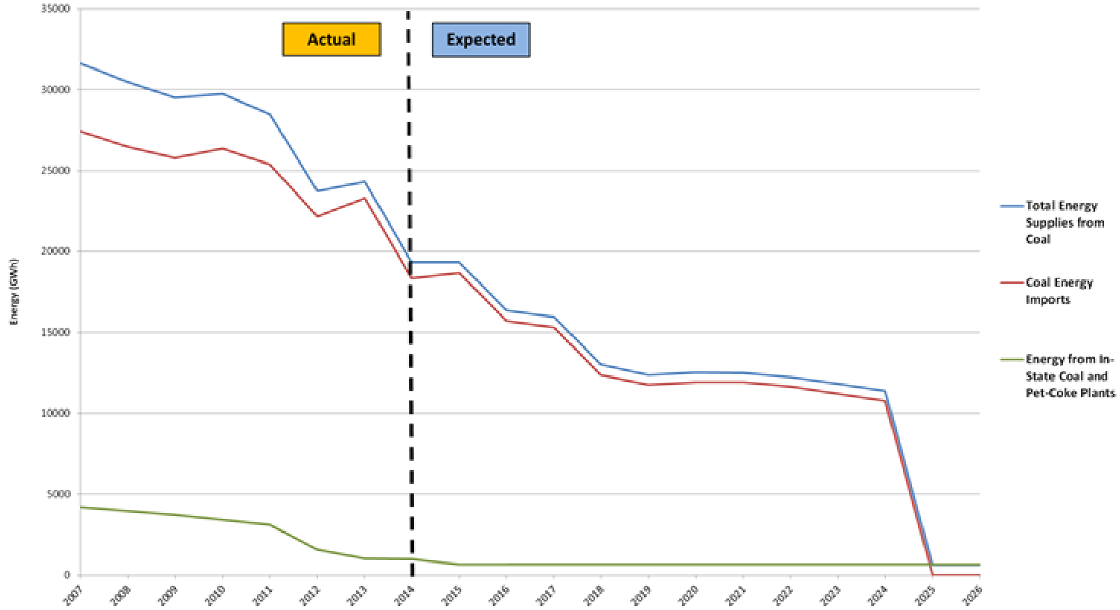
The state's IOUs under the CPUC's jurisdiction have already divested themselves of high-GHG-emitting power plants. POUs under the Energy Commission's jurisdiction have made significant progress in divesting themselves of ownership or contractual arrangements for baseload power plants that do not comply with the EPS under SB 1368.

Los Angeles Department of Water and Power (LADWP) is taking actions that resulted in divestiture of its out-of-state coal-fired Navajo Generating Station (on the Navajo Indian Reservation in Page, Arizona) in 2015 and will allow divestiture of the Intermountain Power Project (IPP, in western Utah) by 2025. LADWP, along with the other participants in IPP, are taking actions necessary to transition IPP from coal to natural gas, which would potentially make it an SB 1368-compliant facility.

Five members of the Southern California Public Power Authority (SCPPA), as well as the City of Anaheim and the M-S-R Public Power Authority, are exiting the San Juan Generating Station in northwestern New Mexico. Under a final agreement with the U.S. EPA, two of four units of the plant will be retrofitted with emission reduction technology, and the remaining two units will be retired by the end of 2017.

Figure 13 shows the decline in the amount of coal-fired electricity serving California from 2007 and over the next decade. In 2014, electricity supplies from existing coal and petroleum-coke plants represented less than 5 percent of total energy requirements to serve California demand, and nearly all of it (93 percent) was from power plants outside California. By 2026, virtually all electricity generated by known coal- and petroleum-coke-fired generation serving California loads is expected to end.

Figure 13: Annual and Expected Energy From Coal Used to Serve California (1996-2026)*



Source: California Energy Commission, CPUC, and ARB presentation at the October 1, 2015, kickoff public workshop on Scoping Plan Update to Reflect 2030 Target, http://www.arb.ca.gov/cc/scopingplan/meetings/10_1_15slides/2015slides.pdf
*Includes identified coal imports, but does not include possible imports of coal that are reported by utilities under SB 1305 Power Source Disclosure as unspecified.

Status of California's Nuclear Plants

Before the permanent closure of San Onofre in June 2013, California's two in-state nuclear power plants, San Onofre and Diablo Canyon, provided roughly 11 percent of the in-state electric generation.[80][81] The permanent closure of San Onofre followed the shutdown of both units in January 2012, due to damaged steam generator tubes.[82] Despite the loss of zero GHG-emitting generation from San Onofre and reduced hydroelectric generation due to the drought, GHG emissions from the electricity sector continue to decline due to an increase in renewable generation and a decrease in reliance on coal.[83]

Diablo Canyon is operating under NRC licenses that expire in 2024 for Unit 1 and 2025 for Unit 2. Although Pacific Gas and Electric Company (PG&E) had applied to renew the licenses in 2009, it suspended activities in April 2011 to complete seismic studies. On

80 California Energy Commission, Quarterly Fuels and Energy Report, Energy Assessments Division.

81 Imports from out-state nuclear from the Palo Verde Nuclear Generating Station in Arizona adds about another 7 percent to the proportion of nuclear generation in California's generation portfolio.

82 California Energy Commission, *2013 IEPR*, 2014, p.196, http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF-small.pdf.

83 California Air Resources Board, *California GHG Emission Inventory, 2016 Edition.* http://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2014/ghg_inventory_trends_00-14_20160617.pdf.

June 21, 2016, PG&E announced a joint proposal with labor and leading environmental organizations that calls for the retirement of Diablo Canyon at the end of the current operating licenses. PG&E pledges to increase investment in energy efficiency, renewable energy, and energy storage beyond current state mandates to replace the nuclear output without increasing GHG emissions.[84] Several actions will need to be taken to fulfill this proposal, including seeking approval from the CPUC and other agencies. Because the proposal calls for replacing Diablo Canyon's electrical output with renewable and other zero-carbon resources, the loss of this zero GHG-emitting nuclear facility is not expected to lead to an increase in GHG emissions.

Chapter 4 details decommissioning issues for San Onofre and potentially for Diablo Canyon, as well as seismic issues related to Diablo Canyon. In addition, the *2015 IEPR* contains a more detailed discussion of related nuclear issues including storage of spent fuel, decommissioning of San Onofre, Diablo Canyon seismic and safety concerns and other issues related to the state's nuclear facilities.

Transmission Systems

Transmission system additions have historically been driven by reliability needs, customer load growth, and opportunities to access lower-cost power. While energy efficiency and other measures have led to reductions in demand, the phase-out of fossil-fired OTC units and the retirement of the San Onofre pose challenges on the supply side. Furthermore, many transmission additions are driven by the renewable energy and decarbonization policy mandates and goals described in Chapter 2.

The need to interconnect intermittent and sometimes remote wind and solar generation not only affects the planning, siting, and permitting of California's transmission system additions, but creates increasing challenges for the operation of the entire interconnected Western grid system. California continues to pursue regional opportunities that provide benefits to both California and Western states. For example, the California ISO's energy imbalance market has already demonstrated significant economic and environmental benefits, which should be enhanced as more entities join. Another opportunity on the horizon is the possible transformation of the California ISO into a regional organization, as envisioned by SB 350.

Transmission Additions/Upgrades for Renewable Resources

Early in the RPS program, the lack of adequate transmission to deliver some of the most promising renewable resources in the state to load centers was identified as a major

84 PG&E News Release, "In Step with California's Evolving Energy Policy, PG&E, Labor and Environmental Groups Announce Proposal to Increase Energy Efficiency, Renewables and Storage While Phasing Out Nuclear Power Over the Next Decade." June 21, 2016. Retrieved from http://www.pge.com/en/about/newsroom/newsdetails/index.page?title=20160621_in_step_with_californias_evolving_energy_policy_pge_labor_and_environmental_groups_announce_proposal_to_increase_energy_efficiency_renewables_and_storage_while_phasing_out_nuclear_power_over_the_next_decade.

barrier.[85] Once the RPS was accelerated from 20 percent in 2010 to 33 percent in 2020, the availability of new transmission was again identified by utilities as a major source of uncertainty in their ability to meet the 33 percent RPS goal.[86] In some cases, RPS contracts were being signed by utilities contingent on new transmission that was not yet underway.[87] In 2007, the Energy Commission noted that key transmission projects to access renewable resources in the Tehachapi area and in Imperial County were facing delays that threatened the state's ability to meet its renewable goals.[88] In the ensuing years, through concerted efforts by the Energy Commission, CPUC, California ISO, and the state's utilities, substantial progress has been achieved in removing transmission barriers to renewable development.

In 2009, due to California's adoption of new environmental policies and goals, particularly increasing renewable energy resources, the California ISO initiated a stakeholder process to design needed changes in its transmission planning. The FERC approved the revised transmission planning process tariff amendment in December 2010. The California ISO's *2010-2011 Transmission Plan* was the first plan produced under the revised transmission planning process and the first to include transmission upgrades needed to meet California's public policy mandates. In particular, the plan placed a high priority on the interconnection and deliverability of electricity from renewable generation projects funded by the American Recovery and Reinvestment Act of 2009.

As noted in the *2013 IEPR*, the California ISO, the IID, and the LADWP identified and approved 17 transmission projects for the integration of renewable resources to enable California to meet the 33 percent RPS by 2020 requirement.[89] According to the California ISO's *2015-2016 Transmission Plan*, the transmission needed to access renewable generation development to achieve the state's 33 percent RPS by 2020 has largely been identified, and those projects are moving forward.[90] As a result, the California ISO did not identify the need for any new transmission projects to support the 33 percent RPS.

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85 California Energy Commission, *2004 IEPR Update*, 2004, p.35, http://www.energy.ca.gov/2004_policy_update/.

86 California Energy Commission, *2007 IEPR*, 2007, pp. 119-122. http://www.energy.ca.gov/2007_energypolicy/.

87 For example, RPS contracts had been signed for more than 800 MW of solar in Imperial County that would require new transmission.

88 Ibid., pp 110-111.

89 California Energy Commission, *2013 IEPR*, 2007, pp. 160-167. http://www.energy.ca.gov/2013_energypolicy/.

90 California ISO. 2016. *2015-2016 Transmission Plan.* Available at http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=D5EE02E2-0E3A-46DF-BDA9-52EDBD09AC8E.

The California ISO has indicated that future annual planning cycles will focus on moving beyond the 33 percent framework (in response to SB 350) when renewable generation portfolios become available through the process established with the California Public Utilities Commission and Energy Commission.[91] [92]

San Onofre Closure – Reliability Upgrades

As noted in the *2015 IEPR*, with the impending retirement of several fossil-fired power plants using OTC, as well as the closure of the San Onofre in June 2013 in Southern California, ensuring the region's electricity system reliability has been a major focus since 2011. Shortly after the announced closure of the San Onofre plant, Governor Brown asked for a multiagency plan to address the replacement of the power and energy that the plant had provided. This effort resulted in the *Preliminary Reliability Plan for LA Basin and San Diego*, prepared jointly by technical staff of energy agencies, air districts, the ARB, and utilities.[93]

The preliminary plan called for a rough replacement target of 50 percent preferred resources (energy efficiency, demand response, fuel cells, renewable distributed generation, combined heat and power, and others) and 50 percent conventional generation. The plan also raised the need to authorize transmission upgrades to reduce local capacity requirements, as well as to assess transmission alternatives as mitigation. Finally, the plan called for establishing contingency plans in the event these resources fail to materialize.

On March 13, 2014, the CPUC authorized SCE and SDG&E to procure up to 700 and 800 MW, respectively, of additional capacity to meet local needs. Of that capacity, SCE and SDG&E were required to procure 400 and 200 MW, respectively, of preferred resources or energy storage. These authorizations were made in addition to previous authorizations, bringing the total minimum authorizations for SCE to 2,115 MW (1,900 MW in Los Angeles Basin and 215 MW in Big Creek/Ventura), and 800 MW for SDG&E.[94] The CPUC has since approved contracts for a total of 1,813 MW of capacity in SCE

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91 For more information on transmission upgrades, see the document titled *Transmission Expansion Projects for Renewables* on the Energy Commission's Tracking Progress Web page, available at http://www.energy.ca.gov/renewables/tracking_progress/#renewable.

92 For details on project schedules, completion dates, and permitting issues associated with investor-owned utility transmission projects under the CPUC's jurisdiction, see http://www.cpuc.ca.gov/uploadedfiles/cpuc_website/content/utilities_and_industries/energy/reports_and_white_papers/final12302015section913_6report.pdf.

93 *Preliminary Reliability Plan for LA Basin and San Diego*, August 30, 2013, http://www.energy.ca.gov/2013_energypolicy/documents/2013-09-09_workshop/2013-08-30_prelim_plan.pdf.

94 CPUC Decision (D.13-02-015), available online at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M050/K374/50374520.PDF, and CPUC Decision (D.) 14-03-004, available online at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M089/K008/89008104.PDF.

territory: 1,382 MW of gas-fired generation and 431 MW of preferred resources and energy storage. An additional 274 MW of resources at Moorpark and 2 MW of behind-the-meter PV submitted through SCE's Preferred Resources Pilot are under review. For SDG&E, the Commission approved a 500 MW repower of the Encina Power Station[95] and directed SDG&E to allocate an additional 100 MW to preferred resources and energy storage.[96]

In response to the preliminary plan, the California ISO identified several transmission projects that could alleviate the transfer limitations and reliability problems caused by the shutdown of San Onofre in its *2013-2014 Transmission Plan*. At the request of the California ISO, the Energy Commission funded a consultant report that provides a high-level assessment of the environmental feasibility of several electric transmission alternatives under consideration by the California ISO to address reliability and other system challenges resulting from the San Onofre closure.[97] The alternatives were ranked on a qualitative four-step scale that ranges from possible, possible but challenging, challenging, to very challenging. As noted in the *2014 IEPR Update*, "One or more of the alternatives may be considered by Energy Commission staff in the state's electric transmission corridor designation process."[98] The Energy Commission continues to evaluate this option as appropriate based on Southern California reliability needs.

An interagency team has continued to meet regularly to advance the preliminary plan. The team tracks the status of preferred resource projects, conventional generation projects, and transmission projects needed to ensure that local capacity requirements[99] are met in Southern California. Maintaining reliability requires close coordination of the fossil-fired OTC unit retirements and resource development in the right locations to satisfy local capacity requirements. Contingency planning to date has focused on mitigation measures, such as possible deferral of OTC compliance dates and developing

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95 SDG&E Application (A.14-07-009) available online at
http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=98406519.

96 The Commission decision has since been contested and is under review of California First Court of Appeal. If the court finds that the Commission acted lawfully in approving the Encina contract, the Commission decision will stand. The stated commercial on-line date (COD) for the Encina plant is November 1, 2017. If Encina/Carlsbad is delayed much past November 2017, some of the capacity may have to stay on-line. The California ISO would need to start studying this by late summer or early fall 2016 to have time to request SWRCB compliance deferral for some units.

97 The Aspen Environmental Group report titled *Transmission Options and Potential Corridor Designations in Southern California in Response to Closure of San Onofre Nuclear Generating Stations (SONGS): Environmental Feasibility Analysis*, as well as its two addenda, is available at
http://www.energy.ca.gov/2014publications/CEC-700-2014-002/.

98 California Energy Commission. 2015. *2014 Integrated Energy Policy Report Update*. Publication Number: CEC-100-2014-001-CMF. http://www.energy.ca.gov/2014publications/CEC-100-2014-001/CEC-100-2014-001-CMF-small.pdf, p. 153.

99 Local capacity requirements (LCR) describe the amount of generating capacity that must be available within the local area.

generation projects already permitted, but not constructed for lack of power purchase agreements.[100] The *2016 IEPR Update* proceeding has included an assessment of Southern California electricity infrastructure reliability.[101]

The California ISO Energy Imbalance Market

An important tool to help integrate renewables into the grid is the California ISO's real-time *energy imbalance market* (EIM). The EIM is a voluntary market for trading imbalance energy to balance supply and demand deviations in real time from 15-minute energy schedules and dispatching least-cost resources every 5 minutes in the combined network of the California ISO and EIM entities. The many benefits of the EIM include reduced costs for utility customers and California ISO market participants, reduced carbon emissions, more efficient use and integration of renewable energy, and enhanced reliability through broader system visibility.

Figure 14 shows the existing and future EIM entities. The California ISO and PacifiCorp launched the EIM on November 1, 2014. NV Energy began participating as an EIM entity December 1, 2015,[102] while Puget Sound Energy and Arizona Public Service began as EIM entities on October 1, 2016. On November 23, 2015, Portland General Electric and the California ISO filed an implementation agreement with FERC, which paves the way for Portland General Electric to join the EIM in October 2017. On September 24, 2015, Idaho Power Company announced its plan to pursue participation in the California ISO's EIM in April 2018. On October 18, 2016, the California ISO and El Centro Nacional de Control de Energía announced that the Mexican electric system operator has agreed to explore participation of its Baja California Norte grid in the EIM. The LADWP is taking steps to participate in the EIM, and Seattle City Light is exploring the possibility as well.

Figure 15 shows the EIM transfer capability among the EIM entities as of July 2016 (California ISO, PacifiCorp-West, PacifiCorp-East, and NV Energy.) The economic and environmental performance of the EIM has continued to improve, especially with the addition of NV Energy in December 2015. Table 3 shows the monthly EIM transfers into the California ISO by supporting fuel type, from January 2015 through June 2016. As shown in Table 3, coal-fired generation supplied only a small fraction of EIM transfers into the California ISO, even before NV Energy joined in December 2015. Since January

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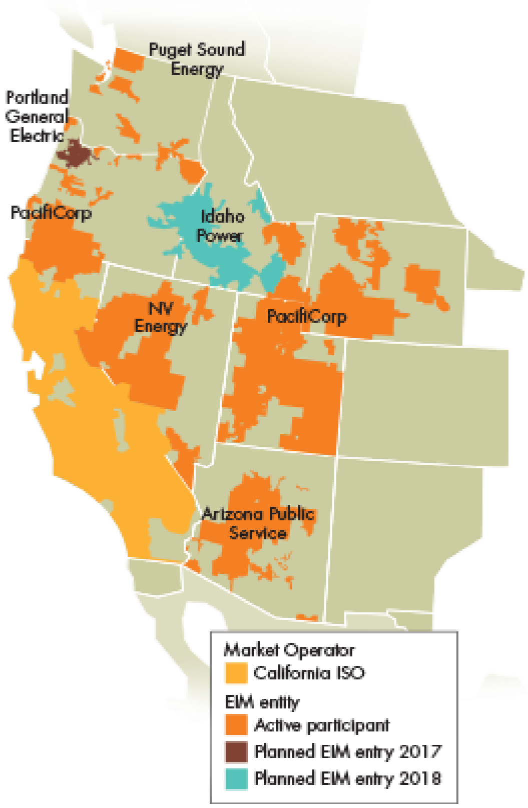
100 Jaske, Michael R. and Lana Wong, 2016. *Mitigation Options for Contingencies Threatening Southern California Electric Reliability*. California Energy Commission. Publication Number CEC-200-2016-010. August 2016. http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-06/TN212836_20160818T131005_Staff_Report_Mitigation_Options_for_Contingencies_Threatening_S.pdf.

101 See Docket 16-IEPR-06, *Southern California Electricity Infrastructure Reliability*, available at http://www.energy.ca.gov/2016_energypolicy/index.html.

102 PacifiCorp operates within two balancing authorities: Pacific Power in Oregon, Washington, and California; and Rocky Mountain Power in Utah, Wyoming, and Idaho.

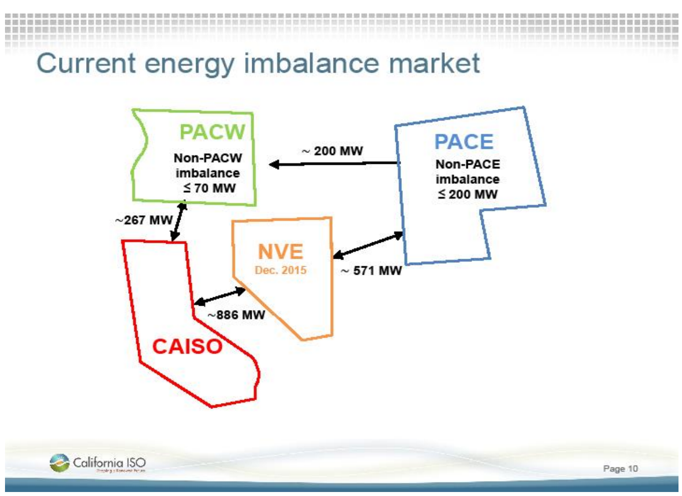
2015, roughly half of EIM transfers into the California ISO are from non-emitting generation resources.

Figure 14: Existing and Future EIM Entities



Source: California ISO, http://www.caiso.com/informed/Pages/CleanGrid/EIMOverview.aspx, accessed October 3, 2016.

Figure 15: Energy Imbalance Market Transfer Capability (as of July 2016)



Source: Eric Hildebrandt, California ISO, *EIM Market Monitoring and Market Issues/Performance*, slide 10, April 6, 2016, available at http://www.caiso.com/Documents/EIMMarketMonitoringMarketIssuesPerformance.pdf.

Table 3: Energy Imbalance Market Transfers Into California ISO by Supporting Fuel Resource Type (January 2015 to June 2016)

Month	Coal (MWh)	Coal (%)	Gas (MWh)	Gas (%)	Non-Emitting (MWh)	Non-Emitting (%)	Total (MWh)	Total (%)
Jan-15	53	0.07%	4,664	6.22%	70,273	93.71%	74,990	100.00%
Feb-15	159	0.33%	42,906	87.72%	5,848	11.96%	48,913	100.00%
Mar-15	273	0.48%	55,918	97.94%	903	1.58%	57,094	100.00%
Apr-15	61	0.12%	33,557	64.56%	18,361	35.32%	51,978	100.00%
May-15	1	0.00%	75,030	83.82%	14,484	16.18%	89,515	100.00%
Jun-15	0	0.00%	87,223	72.88%	32,454	27.12%	119,676	100.00%
Jul-15	0	0.00%	83,155	65.41%	43,972	34.59%	127,127	100.00%
Aug-15	14	0.02%	74,328	86.51%	11,581	13.48%	85,923	100.00%
Sep-15	0	0.00%	56,262	92.21%	4,754	7.79%	61,016	100.00%
Oct-15	44	0.10%	42,758	99.89%	0	0.00%	42,803	100.00%
Nov-15	0	0.00%	20,654	25.25%	61,156	74.75%	81,811	100.00%
Dec-15	0	0.00%	23,958	15.79%	127,793	84.21%	151,751	100.00%
Jan-16	0	0.00%	36,615	28.96%	89,823	71.04%	126,438	100.00%
Feb-16	0	0.00%	35,915	22.21%	125,791	77.79%	161,706	100.00%
Mar-16	0	0.00%	18,287	12.72%	125,499	87.28%	143,786	100.00%
Apr-16	0	0.00%	60,947	46.26%	70,810	53.74%	131,756	100.00%
May-16	0	0.00%	45,608	51.63%	42,721	48.37%	88,329	100.00%
Jun-16	0	0.00%	65,497	67.89%	30,973	32.11%	96,471	100.00%
Cumulative	605	0.03%	863,282	49.58%	877,196	50.38%	1,741,083	100.00%

Source: Based on California ISO's August 22, 2016, Excel spreadsheet titled "Monthly EIM Transfer ISO Imbalances (MWh)," prepared in response to California Air Resources Board June 24, 2016, Workshop, available at http://www.caiso.com/informed/Pages/EIMOverview/Default.aspx.

As noted in the California ISO's Second Quarter *2016 Energy Imbalance Market Gross Benefits Report*:

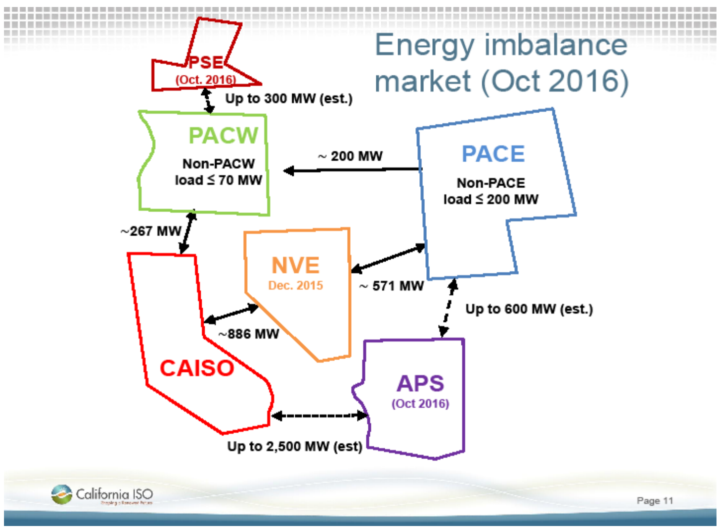
> "The EIM helps avoid renewable curtailments within the ISO, which has both economic and environmental benefits. The EIM benefit calculation includes the economic benefits that can be attributed to avoided renewable curtailment within the ISO. If not for energy transfers facilitated by the EIM, some renewable generation located within the ISO would have been curtailed via either economic or exceptional dispatch. The total avoided renewable curtailment volume in MWh for Q2 2016 was calculated to be 67,373 MWh (April) + 49,296 MWh (May) + 42,136 MWh (June) = 158,806 MWh total. The energy being exported by the ISO included a significant level of renewable generation.
>
> The environmental benefits of avoided renewable curtailment are significant. Under the assumption that avoided renewable curtailments displace production from other resources at a default emission rate of 0.428 metric tons CO_2/MWh, avoided curtailments displaced an estimated 67,969 metric tons of CO_2 for Q2 2016. Avoided renewable curtailments may also have reduced the volume of

renewable credits that would have been retracted. However, this report does not quantify the additional value in dollars associated with this benefit."[103]

The benefits of avoided renewables curtailment are significant according to California ISO studies, with an estimated 272,000 MWh exported instead of curtailed, which displaced an estimated 116,000 metric tons of CO_2 in the first and second quarters of 2016.[104]

Going forward, the addition of Arizona Public Service and Puget Sound Energy on October 1, 2016 will enhance the robustness of the EIM. The estimated transfer capabilities with these two recent additions are shown in Figure 16.

Figure 16: Expected Energy Imbalance Market Transfer Capability (Beginning October 1, 2016)



Source: Eric Hildebrandt, California ISO, *EIM Market Monitoring and Market Issues/Performance*, slide 11, April 6, 2016, available at http://www.caiso.com/Documents/EIMMarketMonitoringMarketIssuesPerformance.pdf.

Increasing Regionalization

Interest in multistate transmission projects and regional markets continues to increase in light of the 50 percent RPS by 2030 and GHG emission reduction requirements (discussed in Chapter 2), the success of California ISO's EIM covering eight states in the

103 California ISO, Second Quarter 2016 Benefits for Participating in EIM, July 28, 2016, available at http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=5180B3C9-2B88-4678-B6AD-2A6B55CE8DEB.

104 http://www.caiso.com/Documents/ISO-EIMBenefitsReportQ2_2016.pdf and http://www.caiso.com/Documents/ISO_EIM_BenefitsReportQ1_2016.pdf.

West (discussed above), the potential addition of PacifiCorp to the California ISO's balancing authority area (discussed below), and compliance with FERC's interregional Order No. 1000. The U.S. EPA's Clean Power Plan implementation of Section 111(d) of the 1990 Clean Air Act has also sparked interest in regional cooperation to comply with state GHG reduction targets for existing power plants. The ARB recently released the *Proposed California Compliance Plan for the Federal Clean Power Plan*, prepared in collaboration with the Energy Commission and CPUC, for public comment.[105] California is the first state to show how CPP compliance can work and to do so in ways that demonstrate the federal mandates can support state programs, and vice versa. Planned generation associated with several multistate transmission projects could provide seasonal and geographical diversity that could complement California's renewable generation.

On April 13, 2015, the California ISO and PacifiCorp signed a memorandum of understanding to explore the feasibility, costs, and benefits of PacifiCorp's full participation in the California ISO as a participating transmission owner. As noted above, PacifiCorp participates in the California ISO's 15-minute and 5-minute markets through the EIM. Joining the California ISO would extend PacifiCorp's participation to the day-ahead energy market and allow full coordination of the western region's two largest high-voltage transmission grids, thereby giving customers served by both entities access to a broader array of electric generation resources at lower costs. An expansion of the regional market offers several potential advantages, including:

- More efficient day-ahead unit commitment and dispatch of resources, beyond what can be achieved through the California ISO's EIM, resulting in reduced costs for customers across the footprint.
- Reduced reserve requirements, both for peak demand and operating requirements, due to the regional diversity of loads across a broader footprint.
- Smoother integration of increasing renewable resources due to a more diverse supply, both technologically and geographically, reducing otherwise expected curtailments of renewable generation.
- More efficient and cost-effective transmission system planning across a broader geographic footprint.

The California Legislature recognized these potential benefits in its SB 350 provisions regarding the voluntary transformation of the California ISO into a regional organization. SB 350 also recognized that modification of the California ISO governance structure, through changes to its bylaws or other corporate governance documents, would be needed to allow this transformation. As a point of reference, the California ISO

105 http://www.arb.ca.gov/cc/powerplants/powerplants.htm.

Board of Governors appointed 11 members to the EIM Transitional Committee in May 2014. That committee was composed of regional stakeholders whose primary role was to advise the board on a long-term independent governance design for the EIM. That work concluded with the June 2016 board appointment of five members to the western EIM Governing Body.

As directed by SB 350, the voluntary transformation of the California ISO shall occur through additional transmission owners joining the ISO with approval from their own state or local regulatory authorities, as applicable. In addition, the Energy Commission, CPUC, and ARB are required to hold at least one public workshop where the California ISO presents the proposed governance modifications. In support of that requirement, the Energy Commission and Governor's Office hosted three regional governance development meetings (including one out of state) in May and June 2016. The CPUC, Energy Commission, and ARB hosted a joint public workshop on July 26, 2016, in Sacramento on topics related to regionalization of the ISO, including the development of a governance structure and studies on the environmental and economic impacts of a regional grid operator.

For more information on the benefit and other studies being conducted in response to SB 350, see Chapter 5.

Conclusion

Over the past decade, the electricity and transmission systems have undergone major changes that have led to changes in the environmental footprint. Renewable resources have increased dramatically in the state because of the RPS and distributed generation programs. The natural gas fleet has needed to respond to changing conditions, such as the elimination of OTC, the need to modernize aging facilities, and, most importantly, the emergence of renewable resources. The integration of variable utility-scale renewable resources is requiring changes in the way the natural gas fleet is operated.

The influx in renewable generation in the state has reduced the GHG emissions from the electricity system. But it has also brought with it new and different environmental impacts than the conventional generation resources sited in the state in the past. The amount of acreage associated with renewable resources is much larger than for conventional natural gas plants. In addition, remote renewable resources have different impacts, such as on biological and cultural resources, particularly in desert environments. The extent and nature of the environmental impacts from renewable are detailed in Chapter 4.

At the same time changes on the customer side of the meter with the emergence of distributed generation, primarily solar PV, along with the temperature impacts of climate change, are changing the demand profile, which the electricity system must accommodate. In response to the EPS, the state's utilities have already, or are in the process of, eliminating out-of-state coal imports from long-term contracts. This elimination does not directly affect GHG emissions in the state but should help reduce GHG emissions in the larger western region. Finally, the role of nuclear facilities in the electricity system has diminished with the closure of San Onofre, and PG&E's planned closure of Diablo Canyon would eliminate in-state nuclear generation.

CHAPTER 4: The Environmental Performance of the Electricity System

As discussed in Chapter 3, the state's electricity system has changed significantly over the last 10 years, driven in large part by the state's climate, environmental and energy policies discussed in Chapter 2. Some of these changes, as discussed earlier and repeated here, include the modernization of the natural gas fleet, OTC plant replacements, divestment from coal resources, and the dramatic expansion and integration of renewable energy and the move toward a regional grid. The state has also seen an increased focus on energy efficiency, demand response, distributed generation, energy storage, and various grid-side technologies, as well as unforeseen changes such as the shutdown of the San Onofre.

A major success story of the past decade is the expansion of renewable energy, which has also altered the environmental footprint of the state's electricity system, both by helping achieve GHG reductions and other benefits described in the chapter and raising a new set of land-use and environmental challenges that have been addressed both in project permitting and in a series of landscape planning initiatives for renewable energy.

This chapter describes the environmental performance of the electricity system in the issue areas that have been most changed since the *2005* and *2007 EPRs*.

Greenhouse Gases

Climate change poses an ever-growing threat to the well-being, public health, natural resources, economy, and the environment of California.[106] The increase in GHGs[107] is of particular importance because it is proceeding at a rate unprecedented in the last 1,300 years.[108] GHGs, in trace amounts in the atmosphere, surround the Earth and act as a thermal blanket for the planet.

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106 Governor Edmund G. Brown Jr., Executive Order B-30-15, April 29, 2015, available at https://www.gov.ca.gov/news.php?id=18938.

107 Anthropogenic GHGs, or those from human activity include carbon dioxide, nitrous oxide, methane, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6), together known as F-gases or High-GWP (global warming potential). Black carbon from fossil fuel combustion and forest fires is a particulate, not a gas that contributes to global warming. Water vapor is an important GHG but not attributable to human activity.

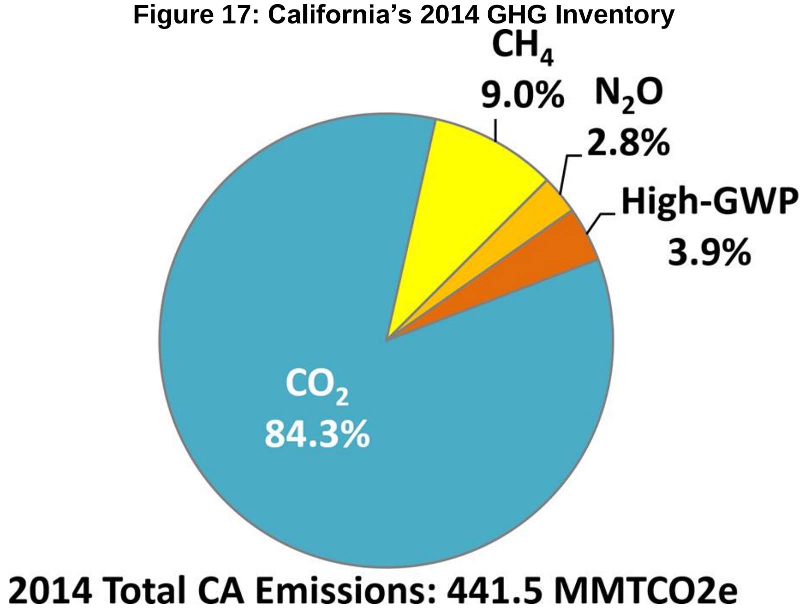
108 NASA, Global Climate Change: Vital Signs of the Planet, http://climate.nasa.gov/causes/.

However, human activities such as the burning of fossil fuels have increased the concentration of GHG since the preindustrial era.[109] Scientists have high confidence that global temperatures will continue to rise for decades to come. The Intergovernmental Panel on Climate Change (IPCC) finds that limiting global warming to 2 degrees Celsius by 2050 is necessary to avoid catastrophic global climate change impacts. Some of the impacts of global climate change include drought, heat waves, more severe smog, and harm to natural and working lands. For these reasons, California has positioned itself as a world leader in taking actions to reduce GHGs.

Carbon Dioxide (CO_2) Emissions

In recent years, much of the policy regarding climate change has focused on CO_2 emissions. This is largely because CO_2 is the largest category of GHGs in the state, accounting for 84 percent of total GHGs in 2014, as shown in Figure 17. As mentioned, the California Global Warming Solutions Act of 2006 (Assembly Bill 32, Núñez, Chapter 488, Statutes of 2006) established a goal of reducing GHG emissions in the state to 1990 levels by 2020. As discussed in Chapter 2, CO_2 reduction goals have now been set in California for 2030 and 2050.

Figure 17: California's 2014 GHG Inventory



Source: ARB California GHG Emission Inventory, 2016 Edition: http://www.arb.ca.gov/cc/inventory/data/data.htm. "GWP" is global warming potential.

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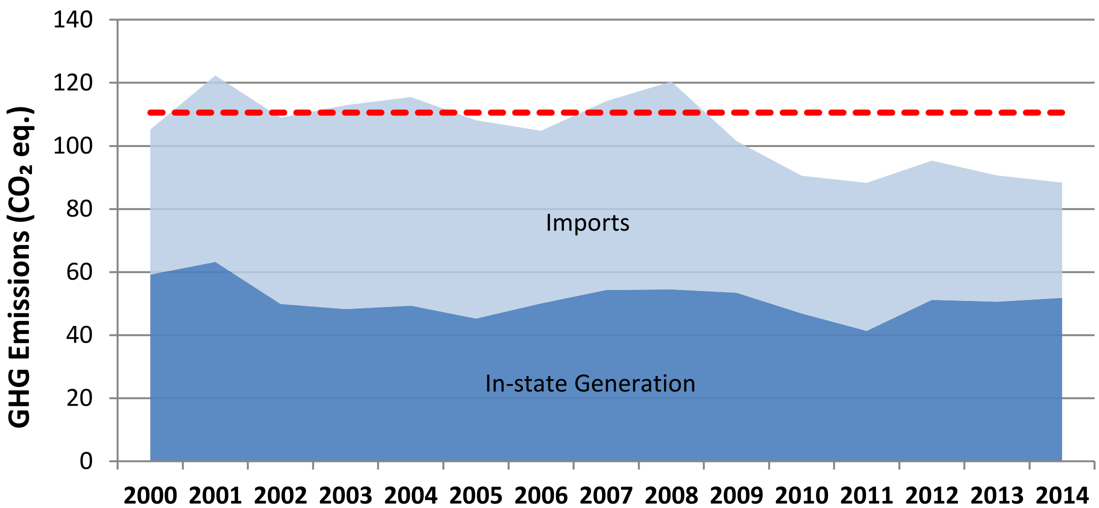
109 The Intergovernmental Panel on Climate Change, *Climate Change 2014: Synthesis Report, Summary for Policymakers* (*Fifth Assessment Report)*, 2014, available at https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf.

The electricity sector has made great strides to advance the state's GHG reduction goals, with emissions in 2014 at about 26 percent below 1990 levels.[110] Figure 18 shows California CO_2 emissions from the electricity sector from 2000 – 2014, which have declined roughly from 105 million tonnes (metric tons) of CO_2-equivalent[111] contributions to 88 million tonnes.[112] As discussed in Chapter 2, the Scoping Plan acknowledges that close coordination of the state's climate change and energy policies is necessary to achieve future GHG reduction goals.

Figure 18: Historical CO_2 Emissions (in Million Tonnes CO_2e) From the Electricity Sector



Source: California Energy Commission staff using data from the ARB's 2016 edition of its GHG inventory.

As shown in Figures 18 and 19 there is a general trend showing a decrease in GHGs from the electric power sector, with significant year-to-year variability as the system compensates for swings in generation due to variation in hydro, such as the drought California is experiencing, imports from out-of-state resources, or outages for refueling of nuclear power plants, as well as the shutdown of San Onofre. However, the overall trend indicates that GHG emissions from the electricity sector continue to decline relative to the emission performance of other sectors. Figure 19 shows the total California GHG emissions and associated percentage by sector, which indicates that in-state and imported electricity is responsible for about 20 percent of GHG emissions. As discussed in Chapter 3, the decline in GHG emissions in the electricity sector is due to

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110 *ARB California GHG Emission Inventory, 2016 Edition*: http://www.arb.ca.gov/cc/inventory/data/data.htm.

111 CO_2 equivalent is calculated by converting each GHG into an equivalent metric tons or tonnes of CO_2, based on the global warming potentials relative to CO_2.

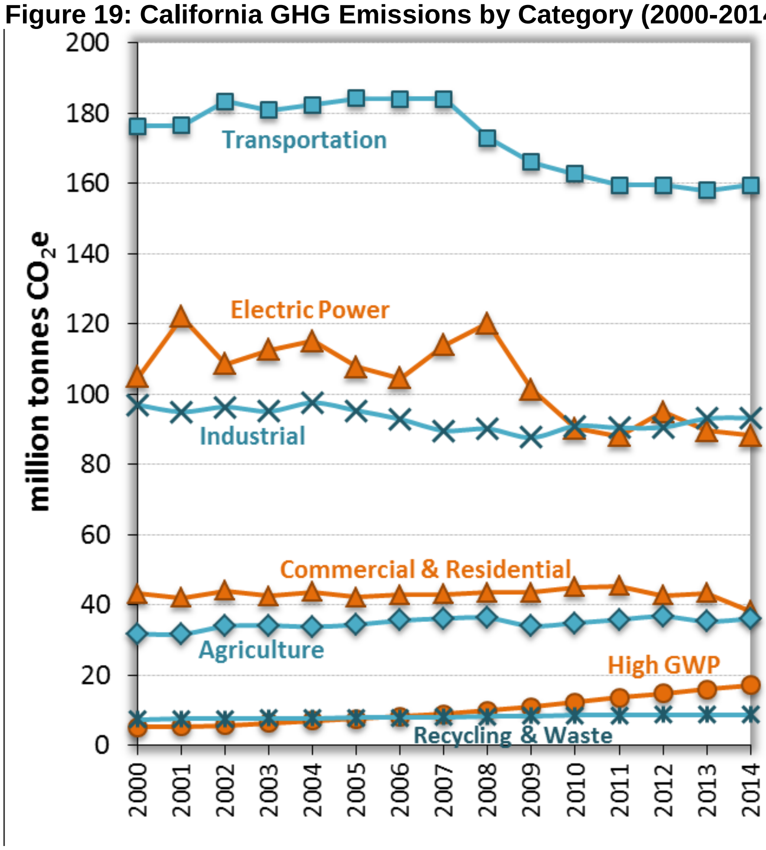
112 California Air Resources Board, April 2015, *California Greenhouse Gas Inventory for 2000-2013 – by Category as Defined in the 2008 Scoping Plan*, available at: http://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_2000-13_20150831.pdf.

many factors, including the increase in renewable generation, increased energy efficiency and distributed resources, modernization of the natural gas fleet, the decline in out-of-state coal-fired generation purchases, as well as transmission additions and changes to electricity markets.

As shown in Figure 19, GHG emissions from the two largest categories—transportation and electric power—declined much more from 2007 to 2014 than other categories. However, Figure 19 also demonstrates that GHG emissions from transportation are much higher than other categories. In fact, GHG emissions from transportation are close to twice as much as from the electric power sector. Given that in-state electric power contributed about half of the total GHG emissions from electric power, or about 50 million metric tons, transportation GHG emissions are nearly four times greater than GHG emissions from in-state electric power generation.

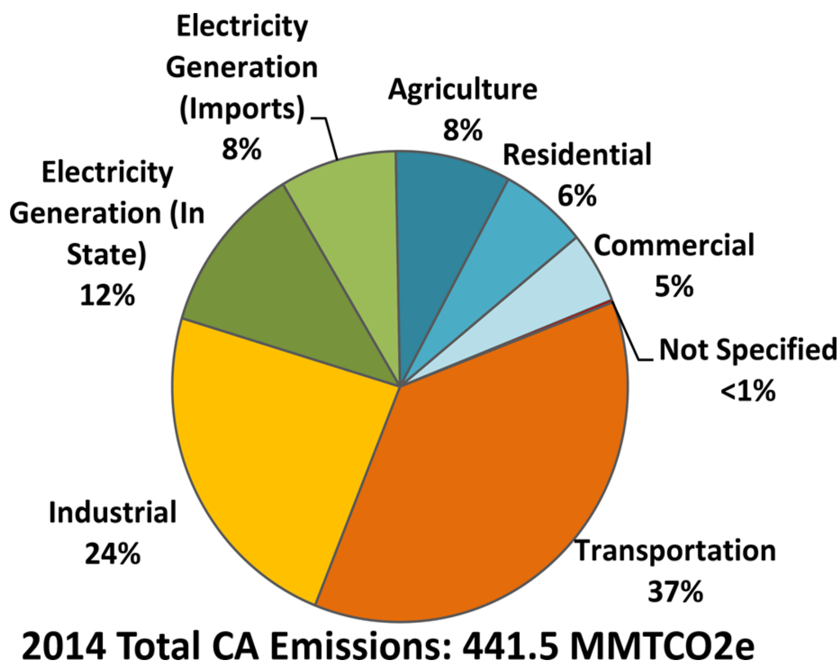
However, in the future the increasing connection between the electricity and transportation sectors could mean significant changes in the proportion of GHG emissions contributed by each category. The transformation could be as significant as the emergence of distributed generation, if not more. Increasing electrification of transportation is expected to bring tremendous air quality and GHG benefits to the state.

Figure 19: California GHG Emissions by Category (2000-2014)



Source: *ARB California GHG Emission Inventory, 2016 Edition*: http://www.arb.ca.gov/cc/inventory/data/data.htm.

Figure 20: 2014 GHG Emissions by Sector



Source: *ARB California GHG Emission Inventory, 2016 Edition*: http://www.arb.ca.gov/cc/inventory/data/data.htm.

Methane Emissions

Methane is a highly potent, short-lived, climate pollutant. Although the lifetime of methane in the atmosphere is much shorter than CO_2, methane is more efficient at trapping radiation than CO_2. Atmospheric methane breaks down over time, so the global warming potential is highest when first emitted, and then it declines.[113] As a result, 1 ton of methane is equal to 72 tons of CO_2 over a 20-year time frame and 25 tons over a 100-year time frame.[114] The ARB estimates that methane makes up about 17 percent of GHG emissions in the state on a 20-year basis, using the IPCC assessment of global warming potential.[115]

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113 LaCount, R., *Methane Emissions in the Natural Gas Life Cycle*, April 2015, page 3. http://westernenergyboard.org/2015/05/final-report-released-by-mj-bradley/.

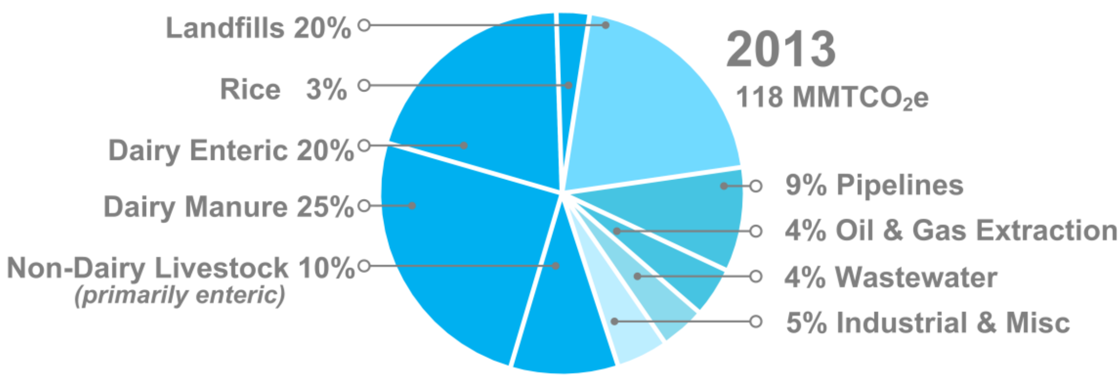
114 Forster, P., et.al. "Changes in Atmospheric Constituents and in Radiative Forcing." *In Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* 2007, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Page 212. http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html.

115 ARB estimates that methane makes up about 8 percent of GHG emissions in the state on a 100-year basis, using the Intergovernmental Panel on Climate Change assessment on global warming potential.

Natural gas, which is about 90 percent methane, has the potential to reduce CO_2 emissions by shifting away from higher CO_2-emitting fuels like coal in power plants and gasoline or diesel in vehicles, and allowing a shift to more efficient generation technologies. To the extent that natural gas leaks from anywhere along the natural gas supply chain contribute to the GHG impact of using natural gas, actual GHG impacts of natural gas can be higher compared to just the CO_2 emission impacts from combustion. Methane emissions come from intentional and unintentional releases of natural gas. Unintentional releases of methane, or *fugitive emissions*, can come from multiple sources and phases of the natural gas system, such as from leaking pipelines, abandoned wells, or inefficient combustion. Intentional releases are purposeful and known emissions that occur in the normal operations of the natural gas system. For example, safety dictates the venting of natural gas when pressures reach levels where there could be a safety risk.

Natural gas pipelines emit nearly 9 percent of the methane released to the atmosphere, and process losses from oil and gas extraction account for an additional 4 percent, as shown in Figure 21. According to the ARB, methane comprised about 9 percent of California's GHG emissions in 2013. Therefore, methane emissions associated with the natural gas system contribute up to 13 percent of California's methane emissions but just more than 1 percent of the total GHG emissions in California.

Figure 21: California 2013 Methane Emission Sources



Source: ARB, *Proposed Short-Lived Climate Pollutant Reduction Strategy: April 2016*. See http://www.arb.ca.gov/cc/shortlived/meetings/04112016/proposedstrategy.pdf.

A fundamental question regarding climate emissions from the natural gas generation fleet is how much methane is escaping from the natural gas system. Estimates of methane emissions to date are highly variable and uncertain.[116] The recent methane leak from Southern California Gas Company's (SoCal Gas) natural gas storage facility, Aliso

116 California Energy Commission, *AB 1257 Natural Gas Act Report: Strategies to Maximize the Benefit Obtained From Natural Gas as an Energy Source,* 2015, Publication Number CEC-2000-2015-006, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-04/TN206470_20151030T160233_STAFF.pdf.

Canyon, highlights the importance of addressing and understanding methane emissions.[117] Some studies estimate methane emission levels that are high enough to offset the benefits of burning natural gas in place of more carbon-intensive fuels. For this reason, it is critical that California policy makers have a clear understanding, as well as an accurate and comprehensive assessment, of the GHG emissions associated with the natural gas system to develop effective GHG reduction strategies.

ARB is developing a strategy to further reduce short-lived climate pollutants, including methane in accordance with Senate Bill 605 (Lara, Chapter 523, Statutes of 2014). Research is underway to better understand emissions from the natural gas system and identify actions to immediately reduce methane emissions. For example, the Environmental Defense Fund (EDF) is coordinating a program that is the most comprehensive set of studies trying to improve the characterization of methane emissions from the natural gas system.[118] In addition, the ARB has already developed regulations for methane from municipal solid waste landfills and is developing regulations to reduce methane from oil and gas production, processing, and storage operations.

The *2015 IEPR* recommended several areas where additional research could help reduce the uncertainty in the current estimates of methane emissions.

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117 SoCal Gas has committed to mitigate methane emissions from Aliso Canyon, including signing letters of intent with several dairies, which are the highest source of GHG-emitting sectors.

118 There are 16 studies covering all parts of the of the natural gas system such as natural gas production sites, gathering and processing facilities, transmission and storage in interstate pipelines, and utility distribution systems. See EDF, *Methane Research: The 16 Studies Series, An Unprecedented Look at Methane From the Natural Gas System.* https://www.edf.org/sites/default/files/methane_studies_fact_sheet.pdf.

Methane Emissions From Aliso Canyon

On October 23, 2015, a significant natural gas leak was detected at the Aliso Canyon storage facility operated by the Southern California Gas Company (SoCal Gas). After several unsuccessful attempts to plug the leak near the wellhead, SoCal Gas began drilling a deep relief well in December, and the California Department of Conservation, Division of Oil, Gas and Geothermal Resources issued an order prohibiting the further injection of gas into the facility.[a]

On January 6, 2016, Governor Brown issued an emergency proclamation mobilizing seven state agencies to coordinate on regulatory and oversight actions to protect public health, oversee SoCal Gas's actions to stop the leak, track methane emissions, ensure worker safety, and safeguard energy reliability. The order also directs further action to protect public health and safety, ensure accountability, and strengthen oversight of gas storage facilities.[b]

The Energy Commission, the CPUC, and other state agencies including the Department of Conservation's Division of Oil, Gas and Geothermal Resources, and the Governor's Office of Emergency Services, as well as the California ISO, worked with LADWP and SoCal Gas to assess potential impacts to natural gas and electricity reliability, recognizing that the storage field could be out of service or available only at reduced capacity for some period.[c]

The leak was permanently sealed in February 2016, and there is a moratorium prohibiting injection of gas into the Aliso Canyon storage field until a comprehensive safety review is completed. As of early April 2016, only about one-fifth of the capacity of the facility (15 billion cubic feet of natural gas) remains for use to maintain electrical and gas service in the region, if it is needed. Gas supply from Aliso Canyon has never before been constrained at current levels, which introduces uncertainty and concerns regarding energy reliability in the Greater Los Angeles area.[d]

A preliminary estimate by the ARB shows that leakage from Aliso Canyon from October 23, 2015, to January 12, 2016, added about 2 million metric tons of carbon dioxide equivalent) ($MMTCO_2e$), which is equivalent to about 21.6 percent of the methane emissions from all sources in California for the same period (82 days).[e] SoCalGas is exploring methane emissions mitigation from multiple sources, including dairies and landfills, and have already signed letters of intent with several California dairies. They are finalizing a mitigation plan in the coming months to be reviewed by the appropriate regulators including the ARB and CPUC.

This recent natural gas leak at Aliso Canyon not only reinforces the need to focus on the safety and reliability of the natural gas system, but also to further understand the sources and impacts of methane emissions associated with the electrical generation system.

a - http://www.conservation.ca.gov/dog/Pages/AlisoCanyon.aspx

b - Office of Governor Brown, *Governor Brown Issues Order on Aliso Canyon Gas Leak*, January 6, 2016, available at https://www.gov.ca.gov/news.php?id=19264.b

c - Findings from the *Aliso Canyon Action Plan to Preserve Gas and Electric Reliability for the Los Angeles Basi*n show that Aliso Canyon plays an essential role in greater L.A. natural gas and electric reliability – it serves 11 million customers and 17 power plants -- and the moratorium creates the possibility of up to 14 days this summer during which gas curtailments could cause electricity service interruptions. The report recommends measures including prudent use of remaining stored gas, completion of safety review as quick as possible, deployment of efficiency, conservation, demand response programs, flex alerts for consumers, prioritization of solar thermal programs for low-income customers, acceleration of storage projects, and protection of ratepayers from any possible market manipulations attempts, to help mitigate the impact of the situation.

d - For further information related to Aliso Canyon, see IEPR docket 16-IEPR-02. The *Aliso Canyon Action Plan to Preserve Gas and Electric Reliability for the Los Angeles Basi*n was released on April 5, 2016, a workshop was held on April 8, 2016, and the next workshop is anticipated in late summer/early fall 2016.

e - http://www.arb.ca.gov/research/aliso_canyon/aliso_canyon_natural_gas_leak_updates-sa_flights_thru_jan_12_2016.pdf.

Air Quality and Public Health

Air quality entails the science and regulations that define safe levels of certain air emissions. State and federal regulators have developed ambient air quality standards (AAQS),[119] or *safe concentrations*, for *criteria air pollutants*,[120] that are protective to humans, crops, forests, and buildings. Moreover, industrial processes such as generating renewable and fossil-fueled electricity can emit trace amounts of toxic air contaminants that have cancerous and noncancerous effects on public health but are not covered by AAQS. The regulations limit emissions and emission rates based on fuel and equipment types, to limit direct impacts from sources, and eventually bring cumulative ambient levels below the AAQS and reduce impacts to public health.

Past findings from the *2005* and *2007 EPRs* have been clear and consistent regarding the footprint of the California generation sector in terms of air quality and public health:

- Air emission trends continue to improve.
- Power plant emissions are not the principal driver of California's ambient air quality.
- Environmental performance is not a factor in the economic dispatch of power plants.
- Generation rates vary across technologies and plant types.

Similarly, for public health past findings included the following:

- Toxic air contaminants from normal operation of California electric generators are not a major contributor to local or regional public health.
- No health clusters are being seen at or near power plants.

The air quality and public health findings above still hold true for the California electricity system, particularly in the performance of the natural gas-fueled generation components.

Statewide criteria pollutant emissions inventory data show declines from 2000 to 2012, which was predicted in the *2005 EPR*. Specific values for electricity production and for cogeneration have shown a similar trend. These data represent emissions from the facility only and do not include fuel production or delivery emissions. Only in-state generation and emissions are included in the table.

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119 Ambient air quality standards (AAQS) define clean air, and are established to protect even the most sensitive individuals in communities. For more information, see http://www.arb.ca.gov/research/aaqs/caaqs/caaqs.htm.

120 Criteria air pollutant emissions are those pollutants that have ambient air quality standards. Criteria air pollutants common to the power sector include nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), respirable particulate matter (PM10), and fine particulate matter (PM2.5). In addition, volatile organic compound (VOC) emissions are analyzed because they are precursors to both O_3 and particulate matter. Ammonia is not considered a criteria air pollutant.

The electricity and cogeneration facilities contribute a small percentage of California's overall criteria pollutant emissions, as shown in Tables 4 and 5, with values ranging from 0.3 to 5.6 percent of statewide emissions in 2013 and 0.3 to 2.5 percent of statewide emissions in 2000. Sulfur dioxide emissions from electricity and cogeneration facilities represent a larger percentage of statewide emissions in 2013, shown in Table 2, because other sectors[121] were able to reduce sulfur dioxide emissions to a greater extent than electricity and cogeneration facilities, and because these two types of facilities already relied on very low sulfur-containing natural gas in 2000.

The turnover of the OTC fleet to modern, more flexible generation and the continued deployment of zero- to low-emitting renewables resources have contributed to the criteria emission reductions. Furthermore, evolving air and energy policies resulted in direct and indirect air quality improvements. The state expects the electricity generation system to continue to contribute to improving air quality. However, while ambient air quality in California is improving, its growing population, climate, and geography have made attainment of the health-based ambient air quality standards elusive.

Table 4: Statewide Emissions From California Electricity and Cogeneration in 2013 (Tons per Day, Except Percentage of Total Emissions)

Source Category	ROG	CO	NOx	SOx[122]	PM10	PM2.5
Electricity Production	2.5	36.3	21.1	4.8	5.5	5.0
Cogeneration	1.9	35.7	15.6	1.1	2.4	2.3
Electricity Total	**4.4**	**72**	**36.8**	**5.9**	**7.9**	**7.3**
Other Stationary Sources	989	1,158	321	52	1,328	325
Mobile Sources	746	6,142	1,747	47	124	85
Total Emissions	**1,739**	**7,372**	**2,106**	**105**	**1,460**	**418**
Electricity & Cogeneration Percent of Total Emissions	**0.3%**	**1.0%**	**1.7%**	**5.6%**	**0.5%**	**0.7%**

Source: California Air Resources Board. Almanac Emissions Projection Data. http://www.arb.ca.gov/app/emsinv/2013/emssumcat_query.php?F_YR=2012&F_DIV=-4&F_SEASON=A&SP=2013&F_AREA=CA, accessed April 26, 2016.

121 Ultra-low-sulfur diesel (ULSD – 15 ppm sulfur) has been required in California since 2006. Nationally, highway diesel fuel has been ULSD since 2010. Railroad locomotive and marine diesel fuel moved to 500 ppm sulfur in 2007 and to ULSD in 2012. The inventories reflect the phasing out of sulfur in diesel, both for on-road use and for off-road and stationary equipment uses.

122 As total sulfur oxide (SOx) emissions dropped from 2000 to 2013, the power plant sector's SOx mass emissions (which also decreased) became a larger portion of the now much small total mass of SOx emissions. Sulfur emissions have been reduced from both the transportation fuels (for example, diesel sulfur limits were changed from 5000 ppm to 15 ppm) and from power sections emissions as the last few liquid-fueled power plants are retired, and coal or petroleum coke is used only at two small in-state power plants. Lastly, any sulfur emission from geothermal, biomass, and gas, liquid or solid fossil-fuel use in the power or industrial sectors are small and contribute to state and local SOx levels that are well below ambient air quality standards.

Table 5: Statewide Emissions From California Electricity and Cogeneration in 2000 (Tons per Day, Except Percentage of Total Emissions)

Source Category	ROG	CO	NOx	SOx	PM10	PM2.5
Electricity Production	4.7	69.2	60.6	5.4	7.2	6.9
Cogeneration	3.0	48.1	28.7	1.8	3.5	3.7
Electricity Total	**7.7**	**117.3**	**89.3**	**7.2**	**10.7**	**10.6**
Other Stationary Sources	**1,339**	**1,545**	**590**	**134**	**1,457**	**400**
Mobile Sources	**1,555**	**12,908**	**3,103**	**148**	**161**	**123**
Total Emissions	**2,902**	**14,570**	**3,782**	**289**	**1,629**	**534**
Electricity/Cogeneration Percent of Total Emissions	**0.3%**	**0.8%**	**2.4%**	**2.5%**	**0.7%**	**2.0%**

Source: California Air Resources Board. Almanac Emissions Projection Data. http://www.arb.ca.gov/app/emsinv/2013/emssumcat_query.php?F_YR=2000&F_DIV=-4&F_SEASON=A&SP=2013&F_AREA=CA, accessed April 26, 2016.

Air Quality Permitting Issues and Reliability

Past EPRs have raised concerns about system reliability given potential barriers to obtaining air permits for new and replacement generation facilities in some air basins. This issue is heightened where multiple or overlapping system stressors occur in an area, resulting in potentially thin reserve margins and shortened planning horizons. For example, the unexpected retirement of more than 2,200 MW at San Onofre and the likely retirement of more than 5,000 MW of OTC plants in 2017 to 2020 are challenging Southern California reliability planning.

On top of this, the moratorium on natural gas injections at the Aliso Canyon storage facility is stressing reliability in parts of Greater Los Angeles. As discussed earlier in this report, with 11 million customers affected and in-basin generating capacity being reduced by retirements, maintaining reliable electrical service while balancing natural gas supplies, including developing tools and measures to reduce curtailments, is a concern for the state for winter 2016-2017.

Local air districts have recognized that their permitting processes could compound local reliability issues, whether due to uncertain permitting time frames[123] or scarce emission offsets. In particular, the South Coast Air Quality Management District (SCAQMD) crafted rules that both address air quality improvements and permitting of power plants. Like the OTC plants, the proposed in-basin replacements are natural gas-fired. But the improvement in efficiency and dispatchability should limit operations to only when needed, providing reliability while reducing gas use. SCAQMD Rule 1304(a)(2) allows exiting boiler units such as the OTC plants an exemption from offsets on a MW-per-MW basis, ensuring that generation could be built within the basin. SCAQMD is

123 For example, new rules that lower emission thresholds for PM2.5 may increase costs, while evolving federal, state, and local rules on GHGs have required additional time to complete air permits.

developing two additional 1304 exemption rules that will open up some emission offsets to greenfield[124] power plant projects.

Over the next decade, the state expects to see the following trends and changes to its electricity system.

More Efficient Fleet of Natural Gas Generation Facilities

Over the past decade, California's natural gas facilities have become more efficient with a thermal efficiency improvement of 29 percent compared to 14 years ago.[125] This efficiency is primarily due to the retirement of aging power plants and the development of new more efficient combustion turbine plants.

A large number of gas-fired power plants using OTC have been or will be retired or replaced. As other gas-fired plants that do not use OTC reach the end of the useful life, additional retirements are expected. As described in Chapter 3, they are being replaced by new, more flexible combined-cycle and simple-cycle combustion turbine facilities that can start-up and respond in 10 to 20 minutes as opposed to 10 to 15 hours. These retirements and replacements will continue to drive improvements in the efficiency of the natural gas fleet.

Increasing Reliance on Renewable Energy Facilities That Typically Do Not Have Combustion Emissions Has Changed the Operating Profile of the Natural Gas Fleet

The market is also moving toward more flexible natural gas-fired power plants that are able to integrate growing levels of renewable resources, such as wind and solar. While this new operational profile may emit more CO_2 and criteria air pollutant emissions during the ramping periods, the reduced operation of the facilities over the longer term is showing reduced air pollutant emissions and GHG emissions overall.

Air Quality Impacts Are a Concern From Dust Movement During Construction

Coccidioidomycosis, or "valley fever," is a fungal infection encountered primarily in southwestern states, particularly in Arizona and Southern California. Since it is spread through spores in airborne fugitive emissions and not though person-to-person contact, exposure to the fungus occurs during construction, natural disasters, wind events, or sweeping a patio. According to the California Department of Public Health, even young and healthy people can get valley fever, but those who live, work, or travel in areas with high rates of valley fever may be a higher risk of infection, especially if they work in

124 Greenfields are lands not previously developed or polluted.

125 California Energy Commission, *Thermal Efficiency of Gas-Fired Generation in California: 2015 Update,* 2016 Publication Number: CEC 200-2016-002, p. 12, http://www.energy.ca.gov/2016publications/CEC-200-2016-002/CEC-200-2016-002.pdf.

jobs where dirt and soil are disturbed.[126] Trenching, excavation, farm, and construction workers are often the most exposed population. In California, 28 employees working on the construction of solar facilities on ranch lands in San Luis Obispo County have been reported as contracting valley fever. Farmed lands generally have fewer valley fever spores, probably the result of the mechanical tilling and the application of nitrogen-based fertilizers. As such, the development of solar projects on farmed land in the San Joaquin Valley may have reduced potential for exposure to valley fever.

Environmental Justice

California law defines *environmental justice* as "the fair treatment of people of all races, cultures and income with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies."[127] This section discusses the findings from previous *EPRs* related to environmental justice (EJ) and provides updates for the 2005-2015 period.

Findings From 2005 and 2007 Environmental Performance Reports

The *2005 EPR* included the following findings related to EJ:

- The Energy Commission and California Department of Transportation were the first agencies to include EJ concerns and demographic information in their environmental impact analyses.
- The Energy Commission's approach to EJ emphasizes local mitigation and seeks to reduce environmental impacts that could affect local populations to less-than-significant levels.
- As of Census 2000, minorities (several ethnic groups who are other than non-Hispanic white) comprise the majority of the population in the state, so EJ will likely be a consideration in most future power plant siting cases.
- Power plants proposed in densely populated urban areas are often sited where residential land uses encroach on older industrial areas.
- Community involvement related to EJ during siting cases has occurred primarily in the large urban areas of Greater Los Angeles and the San Francisco Bay Area.
- The Energy Commission and the electricity generating industry should work together to develop criteria for identifying power plant sites to avoid disproportionately impacting low-income and minority communities.

The *2007 EPR* did not discuss EJ.

Environmental Justice Trends Over the Last 10 Years

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126 See https://www.cdph.ca.gov/HealthInfo/discond/Documents/VFGeneral.pdf.

127 Government Code Section 65040.12; Public Resources Code, Sections 71000-71400.

The Energy Commission includes EJ concerns and demographic information in its environmental impact analysis of proposed power plants by evaluating the demographics of the population around the power plant site and how the project might affect a minority and/or low-income population. Mitigation to reduce environmental impacts, particularly as they affect EJ populations, is recommended to be targeted to the affected or impacted EJ communities. The most recent US Census data[128] (2014) show there is 61.7 percent minority population in California, compared with 53.3 percent minority population in 2000.[129]

As part of its analysis of applications for certification to construct and operate thermal power plants, Energy Commission staff uses U.S. Census data to identify minority populations and the most recent U.S. Census data from the American Community Survey to identify below-poverty-level populations typically living within the area surrounding a proposed project.[130] The demographic screening is based on *Environmental Justice: Guidance under the National Environmental Policy Act*[131] and *Guidance for Incorporating Environmental Justice Concerns in EPA's Compliance Analyses*,[132] which also provides staff with information on outreach and public involvement.

Energy Commission staff will identify an EJ population where one or more census blocks in the area surrounding the power plant has a minority population greater than or equal to 50 percent, or where the percentage of persons living below the federal poverty level is greater than the below-poverty-level population living in other appropriate reference geographies, such as census county divisions, the county, or the state. Maps are prepared to show the location of the EJ population based on race and ethnicity. Staff then uses these maps in appropriate technical disciplines[133] to evaluate

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128 U.S. Census Bureau. 2000. DP-1: Profile of General Demographic Characteristics: 2000. Available at http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

129 U.S. Census Bureau. 2014. DP05: ACS Demographic and Housing Estimates, 2014 1-Year American Community Survey Estimates. Available at http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

130 For gas-fired thermal power plants, staff uses a six-mile radius around the proposed site based on the parameters for dispersion modeling used in staff's air quality analysis to obtain data for a better understanding of the demographic makeup of the communities potentially impacted by the project. For some renewable projects, such as solar power towers, that have the potential to be visible for great distances, the area used in the demographic screening would likely be much larger than a six-mile radius.

131 https://ceq.doe.gov/nepa/ccenepa/exec.pdf

132 https://www.epa.gov/communityhealth/guidance-incorporating-environmental-justice-concerns-epas-national-environmental

133 These technical disciplines include air quality, hazardous materials management, land use, noise and vibration, public health, socioeconomics, soil and water resources, traffic and transportation, transmission line safety and nuisance, visual resources, and waste management.

projects effects on these minority and below-poverty-level populations and propose feasible mitigation to reduce any significant direct, indirect, or cumulative impacts, as required by the California Environmental Quality Act (CEQA). Energy Commission siting staff is aware of the California Environmental Protection Agency's CalEnviroScreen tool (described below) but has not determined how or if CalEnviroScreen would be used in power plant siting. If staff uses this tool, it would be one of a variety of other tools and would not substitute for an environmental review process under CEQA, which is listed among the list of limitations for the tool. If deemed beneficial to staff's analysis, the use of the tool would be in addition to the environmental analysis staff performs as part of the siting process. Staff is aware of the limitations and would be mindful of how data are used.

CalEnviroScreen

The California Environmental Protection Agency (CalEPA) uses CalEnviroScreen[134] to identify communities that are disproportionately burdened by multiple sources of pollution and to designate communities as disadvantaged under Senate Bill 535 (De León, Chapter 830, Statutes of 2012). SB 535 requires CalEPA to identify disadvantaged communities based on geographic, socioeconomic, public health, and environmental hazard criteria. It also requires that the investment plan developed and submitted to the Legislature following Assembly Bill 1532 (Pérez, Chapter 807, Statutes of 2012) allocate no less than 25 percent of available proceeds from the carbon auctions held under California's Global Warming Solutions Act of 2006 to projects that will benefit these disadvantaged communities. The development of the tool was a major step in implementing CalEPA's *2004 Environmental Justice Program Update*,[135] which called for developing guidance to analyze the impacts of multiple pollution sources in California communities. CalEnviroScreen assesses communities at the census tract level in California to identify communities most burdened by pollution from multiple sources and most vulnerable to the effects, taking into account socioeconomic characteristics and underlying health status. The California Communities Environmental Health Screening Tool Report lists the following uses and limitations of CalEnviroScreen[136]:

CalEnviroScreen Is Used To:

- Administer Environmental Justice Small Grant Program and guide other grant programs.

134 California Environmental Protection Agency. 2014. California Communities Environmental Health Screening Tool, Version. 2.0 (CalEnviroScreen 2.0), Guidance and Screening Tool. October 2014. Available at http://oehha.ca.gov/ej/ces2.html.

135 California Environmental Protection Agency. 2004. *2004 Environmental Justice Program Report.* Available at http://www.calepa.ca.gov/EnvJustice/ActionPlan/PhaseI/March2005/EJrptSept2004.pdf.

136 California Communities Environmental Health Screening Tool Report (CalEnviroScreen 2.0, updated October 2014), available at http://oehha.ca.gov/media/CES20FinalReportUpdateOct2014.pdf.

- Promote compliance with environmental law.
- Prioritize site cleanup activities.
- Budget scarce resources for cleanup and abatement projects.
- Plan community engagement and outreach
- Identify and plan for sustainable development opportunities in heavily impacted neighborhoods

Limitations of CalEnviroScreen

- No new programs, regulatory requirements, or legal obligations. There is no mandate to use the tool.
- Not an expression of health risk.
- Not a health or ecological risk assessment for specific sites/projects.
- Does not provide quantitative information on increase of cumulative impacts for specific sites/projects.
- Does not provide basis for determining when the difference between scores are significant in relation to public health or environment.
- Cannot be used in lieu of performing analysis of the potentially significant impacts of specific project.
- Scoring results are not directly applicable to cumulative impacts analysis required under CEQA.
- Cannot be used as a substitution for analyzing a specific project's cumulative impacts required in a CEQA environmental review.
- May provide a baseline for CEQA references.

The Office of Environmental Health Hazard Assessment (OEHHA) intends to update CalEnviroScreen[137] in 2016 to ensure that the most current information available is incorporated in the tool. Other improvements are also expected to be part of this update. The proposed changes will be released in a draft version of the tool, including a revised draft report and maps of the draft results. OEHHA will host regional public meetings to share the proposed updates to the tool, answer questions, and take public comment. For more information, see the following website: http://oehha.ca.gov/calenviroscreen/general-info/calenviroscreen-update.

Conventional Generation

The potential effects of natural gas power plants and concerns of EJ populations have not changed over the past 10 years. Energy generation from conventional sources such as natural gas is generally proposed in industrial areas, where transmission, fuel, and water infrastructure is either onsite or typically nearby. Potential continuation or an

137 Office of Environmental Health Hazard Assessment (OEHHA). 2016. CalEnviroScreen Update. June 2, 2016. Available at http://oehha.ca.gov/calenviroscreen/general-info/calenviroscreen-update.

increase of pollution burden from the power plant and associated effects top the concerns from EJ populations. For more information, see Environmental Justice in the *2005 EPR*.

Overall, the electricity system improvements discussed in Chapter 3 of this report – including that natural gas or other fossil fuel facilities are running less frequently, are cleaner and more efficient, or have been retired over the past decade – have resulted in some improvements of the environmental performance of the electricity system. However, a significant number of new facilities have been built during this period. While these newer power plants are more efficient and often tend to run less than older natural gas plants, they still can raise significant community concerns, including EJ concerns. This EPR did not perform a facility-by-facility comparison of power plant additions, retirements, and changes in operating profile between 2005 and 2015; thus, staff does not reach overall conclusions about how the environmental performance of the electricity system has changed with regard to environmental justice.

Large-Scale Renewables

Large-scale renewable projects are generally proposed in rural or remote locations such as the San Joaquin Valley and southern desert region of California. While projects proposed in the southern desert region may not have an EJ population living within the affected area, various tribal uses may occur in the project area. For more information, see the Cultural Resources section below.

Staff has found that identifying low-income populations living in a rural or remote area is difficult. Poverty data are provided through the U.S. Census Bureau's American Community Survey (ACS), and because the data in the ACS are sample data, the sample size (indicative of the population size) needs to be large enough to yield reliable estimates. When projects are proposed in rural or remote locations, to obtain reliable poverty estimates, data are used for a much larger geographic area than the potentially affected area around the project site. Consequently, the data may not accurately reflect local conditions around the project site.[138] In these cases, staff must rely on alternative data sources such as the California Department of Education to determine the presence of below-poverty-level populations living near the project site.[139]

Implementing Environmental Justice Policies

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138 The proposed Hidden Hills Solar Energy Generating System (11-AFC-02) was near a low-income community, Charleston View. Because Inyo County was the smallest geographic area to yield reliable poverty estimates, the population living in Inyo County did not rank as a low-income population and did not reflect the local community near the project site.

139 Staff uses California Department of Education data showing the percentage of children enrolled in a free or reduced-price meal program by school district.

All departments, boards, commissions, conservancies, and special programs of the California Natural Resources Agency (CNRA) must consider EJ in making decisions if their actions impact the environment, environmental laws, or policies. Such actions that require EJ consideration may include adopting regulations, enforcing environmental laws or regulations, making discretionary decisions or taking actions that affect the environment, funding activities that affect the environment, and interacting with the public on environmental issues.

As stated in the CNRA's EJ Policy, environmental justice communities are commonly identified as those where residents are predominantly minorities or live below the poverty level; where residents have been excluded from the environmental policy-setting or decision-making process; where they are subject to a disproportionate impact from one or more environmental hazards; and where residents experience disparate implementation of environmental regulations, requirements, practices, and activities in their communities. EJ efforts attempt to address the inequities of environmental protection in these communities.

The Energy Commission has been integrating EJ issues into its CEQA analysis of thermal power plants since 1995. The cornerstone of the Energy Commission approach is based on wide-reaching public outreach efforts to notify, inform, and involve community members, including non-English-speaking people. Moreover, the Energy Commission translates public meeting notices and key project information and provides interpretation services at public meetings, when appropriate.

In addition to the outreach efforts of the Commission's Siting Division, Hearing Office, and Media and Public Communications Office, the Commission has a Public Adviser whose sole purpose is to ensure that all interested groups and the public are able to participate fully and adequately in Energy Commission proceedings. Services provided by the Public Adviser include translating key documents and providing interpretive services when appropriate, targeting outreach, and offering assistance and information to members of the public. Furthermore, the Public Adviser seeks feedback from stakeholders and the public on how the Energy Commission may better serve EJ communities. Also, as described in Chapter 6, SB 350 directs the Energy Commission to identify barriers and opportunities for low-income and disadvantaged communities to increase access to energy efficiency and renewable energy investments and programs.

Environmental Justice Outlook

With continued population growth and diversity, most locations where energy facilities are proposed are likely to include an EJ population. Attention to protecting those least able to improve their living conditions and most likely to face barriers to participating in planning or permitting processes is important. Continued outreach to those communities most vulnerable to potential increased burdens from effects such as air emissions and noise is critical to ensure their concerns are heard and addressed.

Disadvantaged, vulnerable, and EJ communities will likely bear a disproportionate burden of climate change impacts. As climate impacts become more pronounced across the state, climate adaptation efforts focused on communities most vulnerable to potential increased burdens from the effects of climate change, such as air emissions and extreme heat days, will be increasingly important. On a global scale, Pope Francis noted in a Papal Encyclical that climate change disproportionately affects the poor who have limited "financial activities or resources which can enable them to adapt to climate change or to face natural disasters, and their access to social services and protection is very limited."[140] For more information on adaptation to climate change, see Chapter 6.

Decision makers could benefit from considering how changes in the environmental performance of the electric system have affected and will continue to affect communities, especially disadvantaged communities. Understanding how the environmental impacts have been distributed across these communities could help decision makers understand the degree of disproportionate impacts on disadvantaged communities.

The Energy Commission is interested in receiving input on ways to assist EJ communities in participating more effectively in the Commission's planning and permitting activities, including access, outreach, and translation services.

Water Resources

Typical water consumption at power plants can vary due to technology, cooling method, age, efficiency, fuel type, location, water quality, and wastewater disposal requirements/limitations. Thermal power plants generate heat that must be removed to keep the plant running efficiently. Generally, the largest use of water among thermal power plants is for evaporative or wet-cooling towers, which reject heat from the steam condensers and allows boiler water to be reused in the steam cycle for a steam turbine generator. Steam turbine generators are found in the steam portion of combined-cycle plants and in stand-alone thermal steam plants (fueled by either natural gas, solar, or geothermal energy).

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140 *Encyclical Letter Laudato Si' of the Holy Father Francis On Care for Our Common Home*, May 24, 2015. Excerpt: "Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods. It represents one of the principal challenges facing humanity in our day. Its worst impact will probably be felt by developing countries in coming decades. Many of the poor live in areas particularly affected by phenomena related to warming, and their means of subsistence are largely dependent on natural reserves and ecosystemic services such as agriculture, fishing and forestry. They have no other financial activities or resources which can enable them to adapt to climate change or to face natural disasters, and their access to social services and protection is very limited. For example, changes in climate, to which animals and plants cannot adapt, lead them to migrate; this in turn affects the livelihood of the poor, who are then forced to leave their homes, with great uncertainty for their future and that of their children." http://w2.vatican.va/content/francesco/en/encyclicals/ documents/papa-francesco_20150524_enciclica-laudato-si.html.

Simple-cycle combustion turbine plants typically require much less water compared to combined-cycle plants because they do not have a steam cycle, and they typically run only to meet high electricity demand is, to provide ancillary services to maintain the grid, or to integrate renewables. Some simple-cycle plants, however, have relatively high water-use intensity, as shown in Table 6. Other water uses that can apply to both combined-cycle and simple-cycle plants include water for power augmentation, evaporative inlet air cooling, compressor intercooling, spray compression, emission controls, and auxiliary systems cooling. Table 6 shows the range and average rates of water consumption per MWh for various technologies. The table does not include technologies that use OTC such as nuclear facilities because the water is not consumed in the process. Water use for OTC is discussed in a later section.

Table 6: Water Consumption Rates for Thermal Power Plants

Technology	Typical Water Consumption Ranges Gallons per MWh		
	Minimum	Maximum	Average Use
Wet-cooled combined-cycle	200	300	250
Dry-cooled combined-cycle	5	20	13
Simple-cycle peaker – aero-derivative (1-100 MW)	12	345	180
Simple-cycle peaker – frame machine (>200 MW)	39	51	45
Geothermal – wet cooled	2,000	5,700	3,850
Solar thermal – dry cooled	24	52	38
Solar Thermal – wet cooled	500	1,500	1,000

Source: California Energy Commission Staff and Quarterly Fuel and Energy Report

The *2003 IEPR* acknowledged the increasing number of new power plants sited in areas with limited freshwater supplies. In response to concerns about power plants contributing to significant impacts on local water supplies, the Energy Commission adopted the *2003 IEPR* water policy, which calls for the use of alternative technologies and water sources. The *2005 EPR* reported a trend away from the use of freshwater for power plant cooling compared to previous years, as well as increased use of recycled water, more efficient cooling technologies, dry cooling, and recycling of process wastewater through zero-liquid-discharge (ZLD) systems. It concluded that water use by the electricity sector could be reduced if Energy Commission policies could increase the amount of power produced with the same amount of water use.

Increased Use of Alternative Water Sources and Cooling Technologies

The downward trend in water use continued as a growing number of applications for new thermal power plants proposed water conservation features upfront. The *2007 EPR* reported that applications submitted from 2004 through 2007 included plants totaling 2,732 MW capacity proposing to use air cooling and plants totaling 3,861 MW capacity proposing to use recycled water. These proposals amounted to 71 percent of the total proposed capacity during this period designed for alternative cooling, compared to the

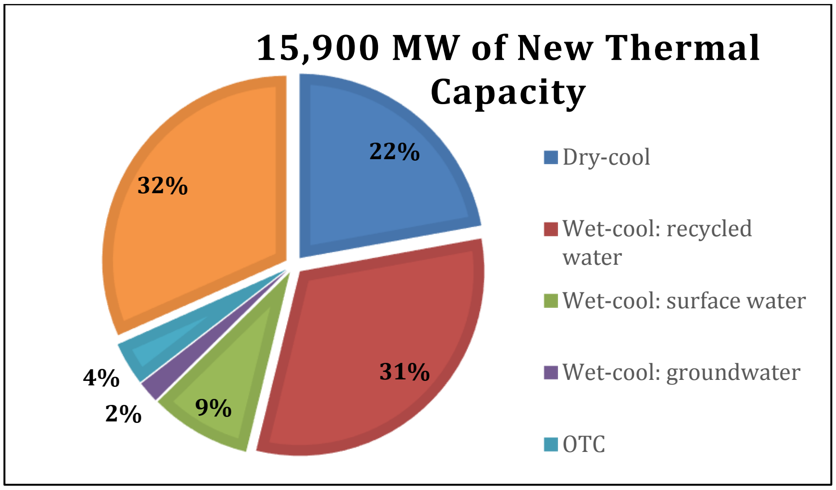
37 percent of the capacity proposed between 1996 and 2003. The trend toward ZLD systems also increased on a capacity basis, with 48 percent of the proposed capacity from 2004 through 2007 designed with ZLD compared to 33 percent for the preceding period.

Even before adoption of the *2003 IEPR* water policy, a good portion of California's steam cycle facilities (combined-cycle, steam boiler, and geothermal) used recycled water for cooling. Of the 13,400 MW of installed capacity using a steam cycle in 2003, 30 percent used recycled water, 63 percent used freshwater, and 7 percent used dry cooling. Of the roughly 22,500 MW of total capacity installed[141] after the *2003 IEPR* water policy took effect, nearly 15,900 MW were from thermal power plants. As shown in Figure 22, about 30 percent (or about 5,000 MW) is composed of facilities that do not use steam to generate power, such as simple-cycle combustion turbine plants.

Although the remaining facilities use steam and therefore require steam condensing, roughly 80 percent of this operating capacity uses either recycled water or dry cooling. The total capacity of steam-cycle facilities has increased from about 13,400 MW in 2003 to about 23,800 MW in 2014. Of the 13,400 MW of installed capacity using a steam cycle in 2003, 30 percent used recycled water, 63 percent used freshwater, and 7 percent used dry cooling. Of the 23,800 MW in 2014, 47 percent used recycled water, 35 percent used freshwater, and about 18 percent used dry cooling. Over the same period, freshwater used for cooling remained roughly the same, as shown in Figure 23. This trend of improved water efficiency has significantly reduced overall potential demand of freshwater for power generation in California.

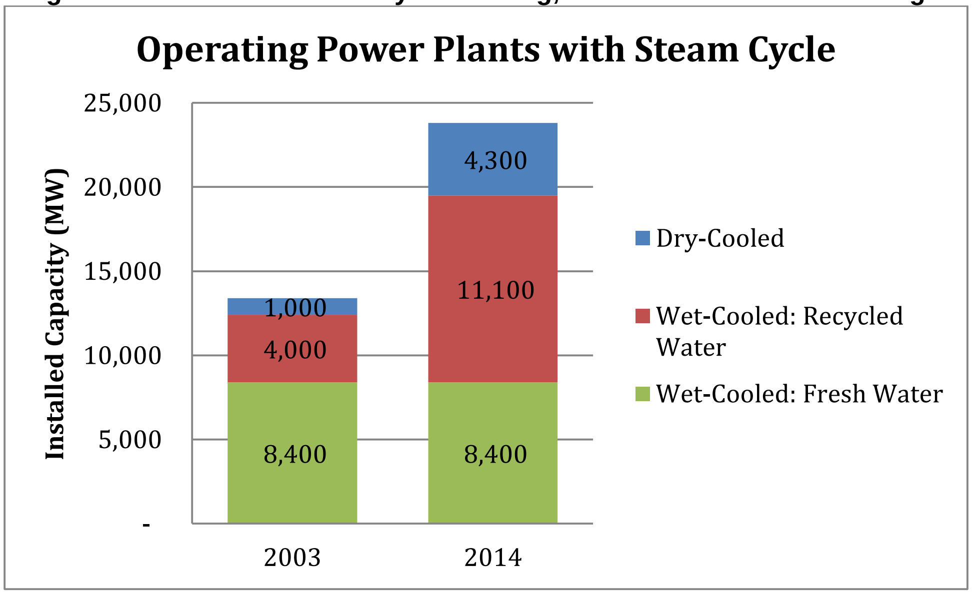
141 The 22,500 MW of total capacity installed includes all power plants larger than 75 MW, including nuclear, natural gas, geothermal, solar thermal, wind, and PV.

Figure 22: California Power Plants 75 MW or Larger, On-Line From 2005 Through 2015



Source: California Energy Commission staff and Quarterly Fuel and Energy Report

Figure 23: California Steam Cycle Cooling, Power Plants 75 MW or Larger



Source: California Energy Commission staff and Quarterly Fuel and Energy Report

Improved Water Efficiency of Power Generating Sector

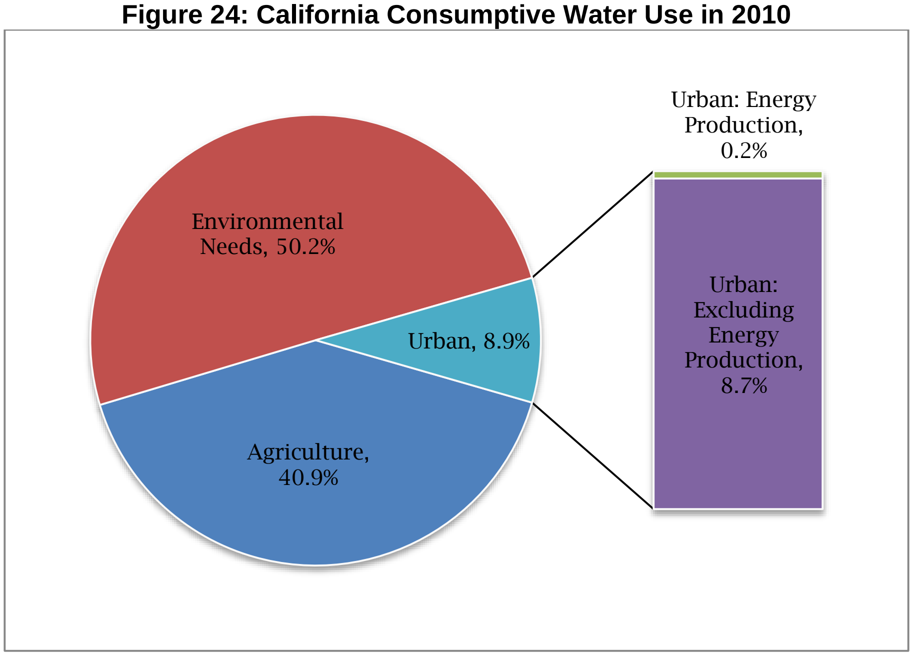
Over the past decade, the California fossil-fueled power plant fleet has become more water-efficient, resulting in a relatively modern fleet of thermal power plants that consume little water. Energy production uses less than 1 percent of all consumptive water use in California, as shown in Table 7 and Figure 24. While water used at power plants is a relatively small portion of total water consumption, it can be a significant local use and is frequently a contentious issue during siting discussions. The combined effects of a growing population with expanding agricultural, commercial, and industrial activity have led to growing demands for both water and electric power. The drought has raised questions about the reliability of water supplies for power plants and the impacts that water use by power plants may have on other consumptive uses.

Table 7: Estimated Volumes of California Consumptive Water Use in 2010

Water Use	Million Acre-Feet	Percent
Environmental Needs	29.2	50.2
Agriculture	23.8	40.9
Urban [142]	5.2	8.9

Source: Department of Water Resources, *California Water Plan, Update 2013*

Figure 24: California Consumptive Water Use in 2010



Source: Department of Water Resources, *California Water Plan, Update 2013*

Table 7 above shows the typical water consumption for thermal power plants by technology type and cooling method. Coastal power plants using ocean water for cooling do not consume freshwater and, therefore, have small impact on freshwater supplies and are not included in Table 7. As they are subject to the SWRCB's OTC policy, nearly all of them will be replaced or shut down to avoid the cost of redesigning the ocean water intake infrastructure.

142 The Department of Water Resources defines this as the use of water for urban purposes, including residential, commercial, industrial, recreation, energy production, military, and institutional classes. The term is applied in the sense that it is a kind of use rather than a place of use.

Compared to other states, California is among the most efficient users of freshwater for power plant cooling, as shown in Table 8. As OTC power plants are replaced or shut down over the next 10 years, in California and nationwide, the practice of recirculation cooling (wet or dry) is expected to increase.[143]

Table 8: States With Largest Water Consumption Rates for Wet-Cooled Thermal Power Plants Compared to States With Lowest Percentage of Freshwater

Rank	State	2010 Average Water Use (MGD)	Wet-Cooled Rate (gal/MWh)	Percent Freshwater	Freshwater Rate (gal/MWh)	2010 OTC Ratio
1	Minnesota	946	25,393	100	25,393	2.12
2	North Carolina	1,360	12,864	100	12,864	1.86
3	South Carolina	1,090	6,615	100	6,615	0.64
4	Pennsylvania	2,360	4,967	100	4,967	0.16
5	Louisiana	370	3,844	100	3,844	0.81
44	California	114	920	56.6%	521	0.89
47	Florida	195	706	43.4%	306	0.97
49	New Hampshire	4	318	43.7%	139	2.96
50	Maine	5	225	60.4%	136	0.04
51	Hawaii	4	871	7.7%	67	2.93

Source: U.S. Geological Survey, Circular 1405
Notes: MGD – million gallons per day
Gal/MWh – gallons per megawatt-hour
OTC Ratio – the ratio of power generated with once-through cooling to power generated with wet cooling (both freshwater and saline sources)

Modern Generation Technologies Are Less Dependent on Water

As power plants are retired or replaced in California, new and more efficient generating technologies have emerged. From 2005 to 2015, California gained about 80 new generating facilities (75 MW or larger) representing more than 22,000 MW of installed capacity. About 25 percent of this new capacity consists of wind power and solar PV, at 15 percent and 10 percent, respectively, both of which operate with essentially no water

143 Not all OTC power plants in other states may choose to continue using OTC by redesigning the cooling water intake structures, so the practice of recirculation cooling (wet or dry) is expected to increase nationwide. States with a high OTC ratio generated more electricity using power plants with OTC than with wet-cooled power plants. States with water sources that are not vulnerable are likely to replace OTC with wet-cooled plants. California encourages replacement of OTC with dry-cooled plants to minimize impacts to freshwater supplies.

requirements. Thermal power plants make up the remaining balance, with natural gas-fueled facilities at 70 percent and solar thermal facilities at 5 percent.[144]

Seeking Options for Water Conservation

Some power plants contribute funds into local community water conservation to offset freshwater use when the use of dry cooling or recycled water is not feasible. Examples of this approach from Energy Commission siting decisions include:

- A water conservation plan to advance the local water district's leak detection and repair program for the survey and potential repair of more than 300 miles of water mains
- A water conservation program that required the installation of irrigation controllers in a desert
- The conversion of a golf course to the use of recycled water through construction of an interconnection from the wastewater treatment plant
- Fallowing agricultural land.

Some water conservation approaches, particularly fallowing of land, present unique challenges from a measurement and management perspective and in terms of potential environmental and economic impacts.

Renewables Water Use

Over the last 10 years, the trend in decreased water use through alternative water supplies and technologies has continued. This is due in part to continued implementation of the *2003 IEPR* water policy and, in part, to the increased use of renewables and resulting changes in the energy market. Some fossil-fueled power plants that use water are no longer needed because renewable energy sources displace them. In turn, the increased emphasis on renewable energy in California energy policies has created market conditions that favor relatively low-water-use peakers or fast-start hybrid plants that run only during down periods when renewable production is limited. The water-use intensity of these plants can be high, but these plants run less often and have significantly less overall water use compared to the traditional fossil-fueled power plants.

Another consequence of the increased use of renewables is the reduction of opportunities for ZLD Systems. Onsite reuse of process wastewater typically involves routing wastewater from one system for use in another system. For example, high-quality water that is no longer useful for the steam cycle could potentially help cool an onsite auxiliary system. Another example of onsite reuse is through operation of a

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144 California Energy Commission Energy Almanac, Electric Generation Capacity & Energy, available at http://energyalmanac.ca.gov/electricity/electric_generation_capacity.html.

wastewater treatment or purification system that removes specific contaminants and restores water quality. Increasing the tower cycles of concentration (the number of times water recirculates in the cooling tower) with this type of reuse can extend the service of source water. However, peaker plants typically operate intermittently, and the wastewater volume is significantly less than that of a combined-cycle plant, making the use of a ZLD system for a peaker infeasible.

Water Use for Wind and Solar PV

Nearly all the new capacity from large sources of renewable energy in California is from wind power (50 percent) and solar PV technology (40 percent). Both technologies can operate with essentially no water requirements, though PV facilities typically use some water for panel washing. However, because they are large, all utility-scale renewable energy facilities can require large amounts of water during construction for dust control and soil grading. With sandy, dry, and windy conditions typical of the desert where many projects are located, the amount of water used for construction can be considerable, especially in light of limited water supplies available in many parts of the desert.

Solar Thermal and Geothermal Water Use

Because both solar thermal and geothermal technologies use heat to produce power, the impacts of these technologies to water resources are similar to fossil fuel thermal power plants.[145] In fact, the California power plants with the largest water consumption rates are solar thermal and geothermal facilities. The water use rates for Imperial County's Second Imperial (80 MW) and Inyo County's Coso (302 MW) geothermal plants from 2010 through 2013 averaged 5,080 and 1,880 gallons/MWh, respectively. The rates of solar thermal plants known as Solar Electric Generating System VIII/IX (127 MW) and Solar Electric Generating System III-VII (171 MW) averaged about 1,120 and 1,010 gallons/MWh, respectively. They are all wet-cooled using freshwater, either surface or groundwater, and 90 percent of the total MW was constructed before 1990.

As with conventional generation, geothermal and solar thermal facilities can be designed and built to incorporate water conservation and water efficiency. For example, almost 1,500 MW of geothermal capacity now uses recycled water, and nearly 30 MW of geothermal units are successfully dry-cooled. Since adoption of the *2003 IEPR* water policy, dry-cooled solar thermal generation contributes 642 MW of capacity, using more than 90 percent less water per MWh than wet-cooled counterparts.

Utility-scale solar thermal facilities require very large parcels of land, similar to solar PV. These facilities not only require use of water during operation, as shown in Table 4, but

145 As noted, nuclear power plants such as San Onofre and Diablo Canyon withdraw large amounts of OTC, but because the water is returned to the ocean or estuary, albeit at temperatures higher than when withdrawn, the water use is not considered consumptive for the purposes of Table 6.

can require large amounts of water during construction for dust control and soil grading. Geothermal power plants can have impacts on water quality in addition to consumption. Hot water pumped from underground reservoirs often contains high levels of sulfur, salt, and other minerals. Most geothermal facilities have closed-loop water systems, in which extracted water is pumped directly back into the geothermal reservoir after it has been used to prevent contamination and land subsidence. In most cases, however, not all water removed from the reservoir is reinjected because some is lost as steam. To maintain a constant volume of water in the reservoir, outside water must be used.

Sustainable Groundwater Management Act

As described in Chapter 2, it is uncertain whether the SGMA will result in additional adjudicated water basins, where the use of groundwater will be monitored and controlled by GSAs. It also remains to be seen how power plants may be affected by this law. It is anticipated that where a power plant already exists and relies on groundwater as a supply, the needs for the power plant will be considered in the water supply planning and accommodated as part of the current basin balance. However, depending on the requirements developed through the locally controlled planning process, especially where overdraft remedies require aggressive reductions in water use, power plant supplies could be affected. Where a new power plant is proposed in a groundwater basin where a GSP is implemented, the applicant would have to evaluate whether the water supply would be available in accordance with the requirements of that plan. Where basins are in critical overdraft, some idea of how water supply might change could be available as soon as 2020 when the first GSPs are due for implementation. There may also be a question for the Energy Commission about whether it should play a role in local planning because of the effect its decisions may have on water supply and power plant reliability.

Water Conservation Efforts

As discussed in Chapter 2, Governor Brown issued Executive Order B-29-15, which mandates statewide water-saving measures and authorizes expedited actions necessary to reduce harm from drought-related impacts. Governor Brown cited specific concerns for decreased water levels in California's reservoirs, reduced flow in rivers, and shrinking supplies in underground water basins.

As described in Chapter 2, the Energy Commission is authorized to create and implement an alternative process to consider such petitions. Executive Order B-29-15 states that this alternative process may delegate amendment approval authority, as appropriate, to the Energy Commission's Executive Director. Thus far, Executive Order B-29-15 has provided the Energy Commission with an interim tool to accelerate postcertification proceedings in two distinct limited circumstances. Under Executive Order B-29-15, statutory and regulatory provisions of the CEQA were suspended for actions taken to secure alternative water supplies necessary for continued operation of power plants.

The utility of Executive Order B-29-15 was reconfirmed by the issuance of Executive Order B-37-16 on May 9, 2016. Executive Order B-37-16 transitions interim drought relief measures to longer-term water conservation practices and policies throughout the state. As emphasized by Executive Order B-37-16, the state's sustained dedication to improving water conservation programs and policies to address persistent drought conditions reaffirms the need for a unified, but flexible, water use policy for power plant operations.

Form CEC-1304 Reporting Requirements

Developing adequate data for measuring progress remains a key priority. In 2007, the Energy Commission adopted new regulations requiring submission of data on water use from power plant owners.[146] These data allow for a more refined analysis of water use, evaluation of trends in water use and technology, identification of what components of a power plant use water and how much, and wastewater disposal methods and reuse efficiencies. The data have become essential in understanding the water use and supply footprint of California's power plants in general and most recently to understanding the drought resilience of California's electricity system.

Using information available for 2010 to 2013, staff assembled for the first time statewide data on power plant water supplies, water use, capacity factors, and locations in an online map of the state's largest 100 thermal power plants. The map and data show that, within this group, those using surface water are spread across 17 water districts, with no water district having more than 8 percent of the total operating capacity displayed on the map. The 20 plants using groundwater as a primary supply are spread across 13 groundwater basins, limiting the impact to any groundwater basin. Only two plants are in basins with significant overdraft and subsidence related to groundwater pumping. These plants represent about 2 percent of the operating capacity shown on the map.[147] These findings are a positive indicator of the resilience of California's relatively water-efficient electricity generation system.

Drought and Power Plant Cooling Water

Drought is perhaps the most critical factor for the energy sector because supply interruptions can render even a modern plant inoperable. Deliverability interruptions and supply curtailments can be electricity system reliability concerns.

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146 California Code of Regulations, Title 20, Division 2, Chapter 3, Article 1. This reporting requirement for annual environmental information is part of the regulations under Quarterly Fuel and Energy Report (QFER).

147 The map can be found here: http://energy.ca.gov/siting/documents/2015-06-25_water_supplies_map.pdf.

Surface water supplies are the most uncertain supply sources. Federal and state regulators have significantly curtailed some surface water deliveries, and these curtailments have the potential to reduce deliveries to power plants. So far, affected plants have been able to identify and access alternative water supplies, sometimes requiring license amendment approvals by the Energy Commission.[148] Over the past two years, four projects have required and obtained licensing amendments for water supply. In addition, four power plants in west and south Kern County that rely on significant supplies from the State Water Project could eventually be affected. They have backup supplies in place, but it is possible these could be affected with prolonged drought, climate change, and the SWRCB proposed changes in flow criteria for the Delta.

Power plants that rely on groundwater from on-site wells generally are concerned about the depth of groundwater and the adequacy of these wells to produce the necessary supply. In some areas of California, groundwater levels have dropped, and modification of well equipment has been required to maintain the necessary supply. Although adequate supply from groundwater for the near term appears to be available, (sometimes requiring well modification where needed), this use does not address long-term effects, such as overdraft and subsidence of the groundwater basin.

Power plants that use secondary- or tertiary-treated recycled water as the primary supply are considered to have the most drought-resistant supply. Many power plants in California are priority customers for the recycled water suppliers. These power plants generally are customers that use recycled water year-round, which is desirable for recycled water suppliers. In several cases, the supplier has specifically agreed to supply multiple power plants first and provide other users only a portion of the supply, if there is excess available. Although production of recycled water has increased overall in the state, the capital costs to construct a treatment facility and dedicated infrastructure are significant. As a result, availability in some municipalities is limited or development timelines postponed. In some cases, power plants able to use recycled water could have problems meeting wastewater discharge requirements for acceptance at a wastewater treatment plant.

There is some concern about the effects of local requirements for water conservation to the recycled water supply of an area. If significant water conservation is achieved, as directed by the recently adopted SWRCB regulations, the flows to wastewater treatment plants that produce recycled water could be reduced. Recycled water could also become more valuable to sell on the market. Experience thus far is that there has been little

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148 Over the past two years, the four projects requiring licensing amendments for water supply include Tracy Combined Cycle Power Plant, Mariposa Energy Project, Colusa Generating Station, and High Desert Power Plant. Four power plants in west and south Kern County that rely on significant supplies from the State Water Project could also eventually be affected.

effect on recycled water supplies, and there does not appear to be significant concern on the part of the suppliers.

Staff believes the effects of urban water conservation on recycled water will be case-specific and depend on the source(s) of flow the treatment plant receives. In some cases, there are significant volumes of wastewater treated at a plant to both secondary and tertiary levels. In these cases, secondary-treated effluent is discharged where there is little to no further human use. Any reduction in flow could be made up by treating more of the secondary-treated effluent to tertiary standards. In other areas of California, wastewater is treated to tertiary standards, yet there are limited customers to use it, and excess is discharged with no further human use. In these cases, even if there were reductions in wastewater flow, there would be adequate flow to make up for the need at a power plant or other customers. In general, municipalities that supply recycled water specifically for reuse will plan and build only the infrastructure necessary to serve known and proposed customers that have indicated they are willing or required to use recycled water for operation. In those cases, supply of wastewater may not be a limitation, but the ability to expand infrastructure to meet demand may be.

Conclusions: Outlook of Energy System Effects on Water Resources

- California generation is water-efficient, and this will continue to improve as the fleet modernizes, alternative water sources are used preferentially, and renewables are deployed.
- California is addressing OTC regulatory compliance with retirements and replacement of aging/OTC plants.
- Reliable water is a key contributor to a reliable generation sector.

Potential Gains From Revisiting the *2003 IEPR* Water Policy

The Energy Commission has achieved significant gains with the *2003 IEPR* water policy. Many of the factors that contributed to this success, including the modernization of the generation fleet and higher penetrations of renewable energy, are likely to continue. Nevertheless, there may be opportunities to update the *2003 IEPR* water policy to better reflect current conditions related to some or all of the following topics:

- **Adapt the water policy to reflect drought conditions and support climate adaptation policy objectives.**

  Current policy allows for consideration of assessment of water supply diversity in California, changes in technology, and other conditions unique to a case. The current water policy could be considered in the context of ongoing drought conditions and in light of potential long-term impacts of climate change to increase the resiliency of the system.

- **Eliminate the distinction between cooling and noncooling uses of water made in the *2003 IEPR*.**

"Power plant cooling" for power plants typically refers to removing heat from a steam cycle, allowing for condensation to a liquid so it can be returned to the boiler or steam generator for reuse. Steam cycles appear as stand-alone boilers with steam turbine generators or one of the cycles in a combined cycle. Water use for steam condensing also is common in geothermal plants.

Although natural gas combustion turbines do not use a steam cycle, various types and levels of equipment and system cooling are required to operate, or to operate efficiently. Most modern combustion turbines can use water in evaporative inlet air cooling, compressor intercooling, spray compression, combustor emissions controls, and power augmentation. Additionally water is often used in auxiliary cooling systems like lube oil cooling. The policy does not specifically address these water uses, as they do not involve condensing steam. Although these water uses are generally an order of magnitude less than a wet-cooled combined-cycle or steam boiler plant, they are the remaining area where a "waterless" system could be used to achieve additional savings.

- **Consider whether the water policy should be updated in light of the Sustainable Groundwater Management Act.**

As discussed above, the recently enacted SGMA established a new structure for managing California's groundwater resources at a local level by local agencies, which are responsible for developing and implementing a GSP to ensure that groundwater basins are operated within the sustainable yield.

Existing power plants that rely on groundwater as a supply may be affected by this new law. Where a new power plant is proposed in a groundwater basin where a GSP is implemented, the applicant would have to evaluate whether the water supply would be available in accordance with the requirements of that plan.

Once-Through Cooling

As discussed in the *2005 EPR* and the *2005 IEPR*, California had 21 power plants that were designed and constructed to use nearly 17 BGD (52,000 acre-feet per day) of coastal or estuarine water in a single-pass, OTC system for cooling.[149] [150] Current OTC volumes are less, due to the lower capacity factors of most of the plants. The totals in

149 When the OTC Policy was adopted in 2010, there were 19 power plants with the ability to use up to 15 billion gallons of seawater per day.

150 For perspective, if San Francisco Bay had no water flowing into it, and this volume of water was removed from it every day, the bay would be drained dry in roughly 100 days.

2010 and 2015 were 6.6 BGD and 5.1 BGD, respectively, with California's nuclear plants alone using 4.4 BGD and 2.4 BGD, respectively.[151]

This sheer volume of coastal or estuarine water required by OTC is directly linked to significant impacts on the coastal or estuarine ecosystem, including effects from the discharge of heated water and the death of a multitude of species through impingement and entrainment.[152] Impacts to coastal or estuarine ecosystems due to OTC were identified as a major source of concern in the *2005 EPR,*[153] supporting assertions of both public agencies and private organizations that this impact to coastal or estuarine resources was not sustainable.

The SWRCB notes that California's generating facilities using OTC, many of which have operated for 30 years or more, present a considerable and chronic stressor to the state's coastal aquatic ecosystems. Over a year, billions of fish eggs and larvae are removed from coastal waters, or entrained, as they are drawn through the cooling systems of power plants. In addition, millions of adult fish are lost due to impingement when they are trapped against screens meant to exclude larger objects from entering the cooling system. The accepted premise among industry and regulatory agencies is that the number of organisms entrained is more or less proportional to the water volume withdrawn through the intake structure.[154] [155] Reduced intake flow is also assumed to reduce the impingement rates.[156] Furthermore, not only do the OTC systems impact important fisheries, they contribute to the overall degradation of the state's marine and estuarine environments.[157] As the environmental document for this OTC policy states, "The consensus among regulatory agencies both at the state and federal levels is that

151 Appendix A, *Report of the Statewide Advisory Committee on Cooling Water Intake Structures,* April 2016.

152"Impingement" is the entrapment and death of large marine organisms on cooling system intake screens, and "entrapment" is the death of small plants and animals that pass through the intake into the plant.

153 For an in-depth discussion of the impacts associated with OTC, please refer to Chapter 3 of the *2007 Environmental Performance Report.*

154 *Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling: Final Substitute Environmental Document*, State Water Resources Control Board, May 4, 2010, p. 60. http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/docs/cwa316may2010/sed_final.pdf.

155 The reduction in OTC water usage does not necessarily result in a one-for-one reduction in marine and estuarine impacts. Multiple factors, including seasonality, play a role, and the relationship is site–specific, as facility entrainment rates vary substantially.

156 Ibid. p. 60.

157 Ibid. p. 1.

OTC systems contribute to the degradation of aquatic life in their respective ecosystems."[158]

The final rule issued by the SWRCB directs power plants using OTC to reduce their intake flow rate to the level attained by a closed-cycle, wet-cooling system or reduce impacts to aquatic life by other means and became effective on October 1, 2010.[159] [160] In addition, SWRCB established a joint-agency working group to oversee implementation and to offer any recommendations or modifications to the SWRCB. Table 9 shows the latest compliance schedule for the power plants affected by the OTC policy, including California's two nuclear plants that were operational when the OTC policy was implemented.

Table 9: OTC Implementation Schedules

Facility and Units[161]	**NQC**[162]	**SWRCB Compliance Date**	**Owner Proposed Compliance Method/Date**
Humboldt Bay 1, 2	135	Dec. 31, 2010	Retired Sept. 30, 2010
Potrero 3	206	Oct. 1, 2011	Retired Feb. 28, 2011
South Bay	296	Dec. 31, 2011	Retired Dec. 31, 2010
Haynes 5,6	535	Dec. 31, 2013	Repowered as air cooled June 1, 2013
El Segundo 3	335	Dec. 31, 2015	Repowered as air cooled July 27, 2013
El Segundo 4	335	Dec. 31, 2015	Retired Dec 31, 2015
Morro Bay 3, 4	650	Dec. 31, 2015	Retired Feb. 5, 2014
Scattergood 3	450	Dec. 31, 2015	Repowering as air cooled in progress
Encina 1,2,3,4,5	946	Dec. 31, 2017	Plans to comply by Dec. 31, 2017
Contra Costa 6, 7	674	Dec. 31, 2017	Retired April 30, 2013[163]

158 Ibid p. 29,

159 California Code of Regulations, Title 23, section 2922.

160 Due to the closure of San Onofre, the study was carried out for Diablo Canyon Nuclear Power Plant only.

161 Some power plants have multiple units of differing age and configuration that have different compliance dates.

162 NQC is *net qualifying capacity.*

163 Although NRG retired Contra Costa 6-7, the Marsh Landing facility was constructed beside it.

Facility and Units[161]	NQC[162]	SWRCB Compliance Date	Owner Proposed Compliance Method/Date
Pittsburg 5,6,7	1,307	Dec. 31, 2017	Plans to comply by Dec. 31, 2017[164]
Moss Landing 1,2	1,020	Dec. 31, 2017	Settlement defers compliance to 12/31/2020[165]
Moss Landing 6,7	1,510	Dec. 31, 2017	Settlement defers compliance to 12/31/2020[166]
Huntington Beach 1,2	452	Dec. 31, 2020	Plans to retire HB 1 on 10/31/2019 and HB 2 on 12/31/2020[167]
Huntington Beach 3,4	452	Dec. 31, 2020	Retired Nov. 1, 2012
Redondo 5	178	Dec. 31, 2020	Plans to retire by Aug. 31, 2019, to allow Alamitos to be repowered[168]
Redondo 6,7, 8	989	Dec. 31, 2020	Plans to retire by Dec. 31, 2020
Alamitos 1,2	350	Dec. 31, 2020	Plans to retire on Dec. 31, 2020[169]
Alamitos 3,4	668	Dec. 31, 2020	Plan to retire on Dec. 31, 2020
Alamitos 5,6	993	Dec. 31, 2020	Plans to retire AL 5 on Nov. 30, 2019, and AL 6 on July 31, 2019, to allow Alamitos to be repowered
Mandalay 1,2	430	Dec. 31, 2020	Plans to comply on Dec.31, 2020
Ormond Beach 1,2	1,516	Dec. 31, 2020	Plans to comply on Dec. 31, 2020

164 Unit 7 (682 MW) cannot operate independently of Units 5-6.

165 Dynegy/SWRCB Settlement Agreement, http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/docs/energy_comp/settlement_dynegy_2014.pdf.

166 Dynegy/SWRCB Settlement Agreement, http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/docs/energy_comp/settlement_dynegy_2014.pdf.

167 AES Huntington Beach, letter to SWRCB, April 23, 2015.

168 AES Redondo Beach, letter to SWRB, April 23, 2015.

169 AES Alamitos, letter to SWRB, April 23, 2015.

Facility and Units[161]	NQC[162]	SWRCB Compliance Date	Owner Proposed Compliance Method/Date
San Onofre 2,3	2,246	Dec. 31, 2022	Retired June 7, 2013 [170]
Scattergood 1,2	367	Dec. 31, 2024	Plans to repower by Dec. 31, 2020
Diablo Canyon 1,2	2,240	Dec. 31, 2024	Plans to comply on Dec. 31, 2024[171]
Haynes 1,2	444	Dec. 31, 2026	Plans to repower by Dec. 31, 2023[172]
Harbor 1, 2, 5	229	Dec. 31, 2029	Plans to repower by Dec. 31, 2026[173]
Haynes 8 – 10	575	Dec. 31, 2029	Plans to repower by Dec. 31, 2029

Source: California Energy Commission, Supply Analysis Office

As of the end of 2015, 4,994 MW of OTC gas-fired and nuclear plants in California had been retired or replaced. It is anticipated that by 2020, 10,987 MW of capacity will be retired and/or replaced. By 2029, another 3,488 MW of capacity are expected to be retired, repowered or replaced, including Diablo Canyon. Figure 25 shows the annual reduction in the use of ocean water for cooling over the period from 2010 to 2030.[174] A large share of the OTC withdrawals have historically been made by San Onofre and Diablo Canyon nuclear facilities, which each has design flows of close to 2.5 billion gallons per day. Because these nuclear facilities have tended to run at very high capacity factors, along with ongoing cooling requirements related to the safety of the facilities, withdrawals have historically been close to the design flows continuously. Other OTC power plants have historically used much less of the design flows since they operate at lower capacity factors compared to the nuclear plants, and when they are operating less,

170 Although both San Onofre units ceased generation by January 31, 2012, they draw limited amounts of ocean water to cool nuclear fuel rods and other "hot" equipment. According to an SCE report to the SWRCB dated November 27, 2013, the combination of Units 2 and 3 is now drawing water at approximately 4 percent of normal power flow rates. The report says that San Onofre will continue to draw ocean water throughout the decommissioning, but not above Track 1 compliance levels. San Onofre has reduced water intake below 93 percent of normal power flow rates and therefore, complies with Track 1 of the OTC policy. http://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/powerplants/san_onofre/docs/sce_112713.pdf.

171 The OTC requirements for Diablo Canyon may be affected by a study of mitigation options overseen by the SWRCB's Review Committee for Nuclear Fueled Power Plants.

172 LADWP's proposed compliance dates are based on its *2014 Power Integrated Resource Plan.*

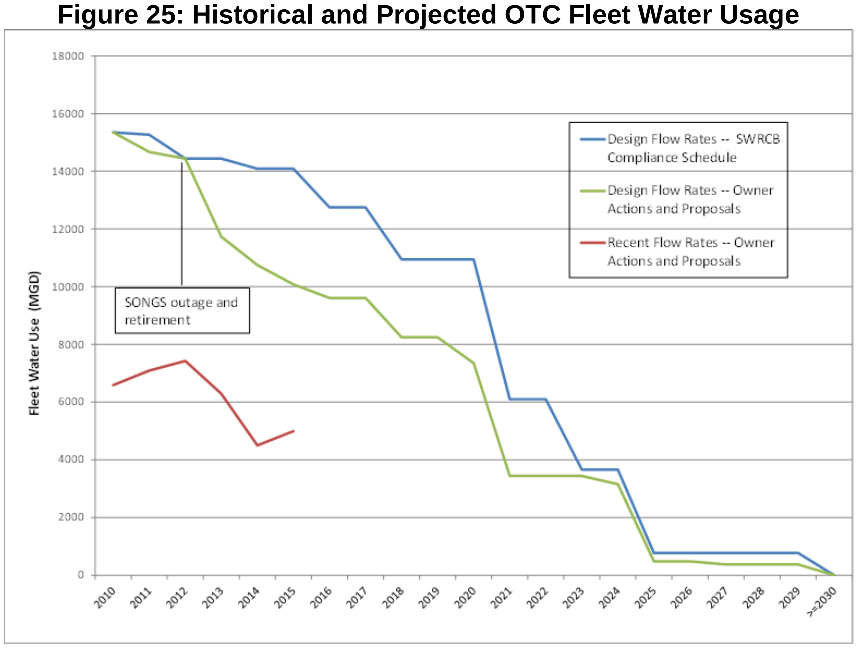
173 Harbor 1-2, 5, and Haynes 8-10 are combined-cycle units. Although only the heat recovery steam generator uses OTC technology, it is unclear whether LADWP will repower just that portion or replace the combustion turbines.

174 For more information, see the following website: http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/.

withdrawals are reduced.[175] Consequently, the closure of San Onofre, along with the proposed closure of Diablo Canyon, will eliminate a significant portion of the total OTC fleet water usage.[176]

However, assuming that OTC units continue to repower or retire as expected in Table 9, the withdrawal of water for cooling of power plants would be almost eliminated by 2030, removing the source of a significant negative impact to California's marine ecosystem. This policy will also most likely lead to the eventual shift to technologies that use little or no water for cooling or to the retirement of almost all California power plants that are using OTC.

Figure 25: Historical and Projected OTC Fleet Water Usage



Source: California Energy Commission, *Tracking Progress: Once-Through Cooling Phase-Out*, available at http://www.energy.ca.gov/renewables/tracking_progress/documents/once_through_cooling.pdf

Environmental Impact of OTC Policy

The goal of the OTC policy was to reduce the impacts of ocean water cooling on the marine environment. This goal is being achieved, and in the process, numerous aging power plants have been retired or replaced by newer, more efficient dry-cooled natural gas power plants. This has contributed to several important advances in the environmental performance of the electricity system as discussed elsewhere in this

175 State Water Resources Control Board, Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling, Final Substitute Environmental Document, May 4, 2010, p. 33, http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/docs/cwa316may2010/sed_final.pdf.

176 The reduction in OTC water usage does not necessarily result in a one-for-one reduction in marine and estuarine impacts. Multiple factors, including seasonality, play a role, and the relationship is site-specific, as facility entrainment rates vary substantially.

report, including reduced GHG and criteria pollutant emissions, greater efficiency, and more ability to provide flexible ramping.

California places particular importance on the integrity of its coastline, including its natural beauty and social and economic benefits. The visual incongruity of large power plants near the coast has become more apparent as adjacent residential, recreational, and tourist-oriented uses have encroached on and sometimes replaced historical energy generation and resource extraction areas. Retiring or replacing natural gas facilities constructed in the 1950s and 1960s offers an opportunity to improve the visual aesthetic of the coastline. However, repowering or replacement of natural gas-fired generation projects in visually sensitive coastal areas will continue to generate controversy. Working with project stakeholders on effective measures to restore and enhance the coastal environment, including specific measures intended to visually screen power plant structures and sites, may provide opportunities to create visual mitigation strategies that are acceptable to local communities.

As mentioned in the earlier water use discussion, as power plants using OTC are replaced or shut down over the next 10 years, both in California and nationwide, the practice of recirculation cooling (wet or dry) is expected to increase, and the use of water for cooling will increase.

Thermal Plumes

The potential for natural gas-fired power plants and cooling towers to generate thermal plumes that could affect aviation is being recognized and considered. While impacts to air traffic from natural-gas fired generation have remained unchanged over the last 10 years, these were not discussed in the previous *EPRs*.

Power plants emit thermal plumes through exhaust stacks, dry-cooling towers, and wet-cooling towers. The thermal buoyancy and the volumes of air and exhaust used in the processes create a vertical thermal plume. Exhaust stacks tend to generate higher velocity plumes than those generated by cooling towers. Aircraft flying over high-velocity plumes at low altitudes could experience loss of stability and control. Plume-related hazards to aircraft can be reduced by notifying pilots to avoid overflight at low altitudes and by siting projects away from airport areas, including approach and departure corridors.

The Federal Aviation Administration (FAA) has regulations advising when facility, or facility feature, height requires a review and hazard determination by FAA,[177] has acknowledged that thermal plumes can pose hazards, and provides guidance to pilots for avoiding them in flight. In its December 2015 *Aeronautical Information Manual*, the FAA states that plumes can be hazardous to aircraft, especially during low-altitude

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177 Code of Federal Regulations Title 14 Aeronautics and Space, Part 77 - Objects Affecting Navigable Airspace.

flight in calm and cold air, and in and around approach and departure corridors or airport traffic areas. The FAA advises that pilots should avoid exhaust plumes whenever possible by flying upwind of smokestacks or cooling towers.

The FAA has recently provided tools for local agencies to evaluate potential hazards from thermal plumes, even though the FAA does not perform these evaluations or regulate plumes. In an FAA memorandum dated September 24, 2015, the FAA states that land-use planning and permitting agencies around airports are encouraged to evaluate and take into account potential flight impacts from existing or planned development that produces plumes.

Nuclear

The ongoing decommissioning of San Onofre by Southern California Edison (SCE) and operations at the Diablo Canyon plant, as well as the future decommissioning of Diablo Canyon by Pacific Gas and Electric (PG&E), present a number of emerging environmental and public safety issues that will require close attention over the next decade and beyond.

San Onofre

Three years after SCE permanently ceased operations at the San Onofre nuclear plant, decommissioning is well underway. The transition from an operating nuclear plant to one that is being decommissioned has focused attention on certain near- and long-term environmental and public safety issues. From a public safety perspective, emergency preparedness is both a near-term and a long-term issue. The restoration and remediation of the power plant site are the most immediate environmental focus. In the years and decades ahead, the safety and security of spent nuclear fuel stored at the plant will need attention and oversight.

Decommissioning a nuclear generating facility involves transferring spent fuel from reactors into safe storage, followed by the removal and disposal of radioactive components and materials from the plant site. The Nuclear Regulatory Commission (NRC) allows up to 60 years to complete this process; however, SCE has stated it intends to complete the full NRC-mandated decommissioning process for San Onofre Units 2 and 3 within 20 years.[178] Per SCE's decommissioning plan, a dry cask storage facility will remain at the plant site at least until 2051, at which time the site restoration will be complete.[179]

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178 California Energy Commission, *2015 IEPR*, 2016, p 171, http://www.energy.ca.gov/2015_energypolicy/index.html.

179 The target date of 2051 is predicated on the assumption that the federal government will accept the stored spent nuclear fuel in the dry cask storage facility for final disposal in a federal nuclear waste facility in the period leading up to 2051.

As of June 2016, SCE had achieved the necessary site modifications for placing the plant in a “cold and dark” state, which means the San Onofre plant is de-energized and in safe, non-operating conditions. SCE has also begun constructing spent fuel pool “islanding” equipment. Islanding the spent fuel pools involves replacing the normal systems that support the spent fuel pools with stand-alone cooling and filtration systems. SCE’s goal was to complete the full islanding system by the third quarter of 2016 and indicated in the September 2016 Decommissioning Update that the cooling island is in service.[180] As the decommissioning of the plant and its various systems progresses, the environmental risks related to radiation will lessen.

As part of decommissioning, SCE must meet certain environmental restoration and remediation requirements under the terms of its lease agreement with the U.S. Navy. (SCE leases the land on which the San Onofre facility sits from the United States Navy.) California also requires the plant site to be restored to the original condition. To meet the restoration and remediation requirements for both the Navy and California, SCE will need to undertake additional clean up beyond that required by the NRC. SCE and the Navy (plus the minority owner of San Onofre, SDG&E) must negotiate the terms for the restoration and/or remediation of the San Onofre site before the land is returned to the Navy at a future date, a contributing reason that costs are $2 billion higher than Diablo Canyon’s estimated decommissioning costs. The Navy has expressed its position to SCE that the land must be restored to a standard that ensures future unrestricted use of the land.[181]

Aside from the restoration and remediation of the San Onofre plant site, the chief concerns related to decommissioning the San Onofre plant are associated with the near- and long-term handling and storage of the spent nuclear fuel. The near-term concern is the safe handling of highly radioactive waste as it is transferred first from the shut reactors and placed in spent fuel pools for cooling and then from the pools into storage casks. SCE has safely transferred all of the fuel rods from the reactors of Units 2 and 3 to the spent fuel pools for cooling and expects to complete the transfer of fuel rods from the pool to dry storage by 2019.[182] The Energy Commission has advocated that spent fuel be moved expeditiously to dry cask storage once the spent fuel has

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180 Palmisano, Tom, Decommissioning Update, September 15, 2016, https://www.songscommunity.com/docs/091516_DecommissioningUpdate.pdf

181 https://www.documentcloud.org/documents/2658565-Navy-Letters-San-Onofre-August-2015.html. Document accessed June 1, 2016.

182 The high level of radioactivity of spent nuclear fuel requires that fuel be initially cooled in the spent fuel pools, a system that is not within the containment vessel and requires constant monitoring and oversight. The NRC has authorized the transfer of spent fuel from cooling pools into dry casks with as little as three years of cooling time; the actual cooling period is defined by the terms of the NRC license for the specific dry cask technology. The industry norm is roughly 10 years.

sufficiently cooled in the pools.[183] This policy, supported by the CPUC and the Union of Concerned Scientists, was recommended because leaving spent fuel rods in pools for longer periods would pose an unnecessary safety risk, particularly in a seismic hazard area.[184]

In the medium and long term, the safe and secure storage of nuclear waste is a paramount concern for California. When California's nuclear power plants, including San Onofre, were constructed, the long-term storage of spent nuclear fuel at the plant sites was never envisioned. The federal government is responsible for the final disposal of high-level nuclear waste. For decades the U.S. Department of Energy (U.S. DOE) has worked to resolve issues associated with the safe transport and permanent disposal of nuclear waste at a geological repository. The history of long delays and inability to establish such a disposal facility means that high-level nuclear waste will remain at decommissioned plant sites in California, including San Onofre, for decades to come.

SCE, like other nuclear plant owners, has responded to this situation by building independent spent fuel storage installations (ISFSIs) and employing dry cask storage technology. SCE already has a dry cask storage facility at San Onofre to store spent fuel from the retired Unit 1 reactor and the Units 2 and 3 reactors. Instead of adding the remaining spent fuel from Units 2 and 3 to the existing, above-ground dry cask storage facility, SCE plans to build a separate ISFSI with a significant portion of the facility underground.

Current NRC regulations do not specify a *maximum* time for the storage of spent fuel in dry casks.[185] In 2014 the NRC published a rule, the Continued Storage rule, which confirms that spent fuel may be stored in dry storage facilities safely for an indefinite period, meaning that in the absence of a federal facility, nuclear waste will be stored in dry casks and will remain at San Onofre (and other decommissioned nuclear power plants in California).[186] The NRC states that spent fuel can be stored safely in either pools or casks for at least 60 years beyond the licensed life of any reactor without significant environmental effects. This policy poses concerns about the presence of nuclear waste in any heavily populated region, as well as concerns about the impacts of aging on dry casks used for storage.

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183 Ibid., p. 173.

184 Ibid., p. 173.

185 "Spent Fuel Storage in Pools and Dry Casks Key Points and Questions & Answers", U.S. Nuclear Regulatory Commission Spent Fuel Storage FAQ. Retrieved from http://www.nrc.gov/waste/spent-fuel-storage/faqs.html.

186 The final "Continued Storage" rule, U.S. NRC, Commission Voting Record, Decision Item SECY-14-0144, Request by Southern California Edison for Exemptions from Certain Emergency Planning Requirements, March 2, 2015. http://pbadupws.nrc.gov/docs/ML1506/ML15062A141.pdf.

Long-term or indefinite storage in dry casks is likely to require maintenance, repairs, and possibly replacement as the casks age. In addition, it requires on-site radiation monitoring. Donna Gilmore, an advocate for nuclear safety issues at San Onofre, has argued that the specific ISFSI system that SCE plans to use – the Holtec HI-STORM UMAX system – has been licensed by the NRC for only a 20-year period (with possible license extensions for an additional 40 years). Under SCE's plans, spent fuel will be transferred no later than 2019 into the Holtec canisters. Given the NRC license period of 20 years, SCE will need to seek a license extension on or before 2039 for the Holtec canisters or transfer the spent fuel into new canisters to cover the 10-year gap between the license termination date of the canisters (2039) and the currently expected completion date for when all waste will have been transferred to DOE (2049). Ms. Gilmore has also argued that the HI-STORM UMAX system may suffer stress corrosion cracking or other forms of degradation due to the proximity to the ocean and marine air. The likelihood exists that the San Onofre dry-storage canisters may need repairs or may need to be replaced in the decades ahead.

Adequate emergency preparedness at the San Onofre site and surrounding area is another concern. As part of the decommissioning of San Onofre, SCE sought and was granted approval for certain exemptions from the NRC's emergency planning requirements, including the requirement to maintain formal offsite radiological emergency plans and a reduced scope for onsite emergency plans.[187] In the *2015 IEPR* and in comments filed with the NRC, the Energy Commission noted that approval of this request would diminish the safeguards put in place to protect public health and safety.[188] The Energy Commission pointed out that the unique seismicity and tsunami risks to San Onofre necessitated a high level of emergency preparedness until all spent fuel has been moved to dry storage.[189] SCE's justification for the request was that San Onofre had ceased operations, and the types of possible accidents had diminished. The NRC's decision allowed SCE to use an emergency plan based on a permanently defueled plant, with spent fuel remaining in the spent fuel pools until 2019.

The San Onofre Community Engagement Panel has provided a forum for the local community to engage in the decommissioning of the San Onofre Nuclear Generating Station. At a March 2016 meeting, all five of the state representatives that presented recommendations on the new decommission rulemaking identified the need for some form of community engagement panel. One of the recommendations in the comment letter submitted by the Energy Commission on the decommissioning rulemaking was the

187 The NRC approved the SONGS Permanently Defueled Emergency Plan in June 2015.

188 California Energy Commission, *2015 IEPR*, 2016, p. 174, http://www.energy.ca.gov/2015_energypolicy/index.html.

189 May 14, 2015, letter from Chair Weisenmiller to Ms. Vietti-Cook of the Nuclear Regulatory Commission concerning SCE license amendment request, http://pbadupws.nrc.gov/docs/ML1513/ML15135A304.pdf.

formation of an expanded, independent community engagement panel that would engage with both the operator and the NRC during the decommissioning.[190] During the March 15, 2016, meeting, the NRC staff referenced the San Onofre panel and strongly encouraged licensees to establish a local community advisory panel.

Diablo Canyon

PG&E recently announced plans to shut down Diablo Canyon at the end of its current licenses in 2024-2025 in accordance with an agreement among PG&E, labor, and leading environmental organizations.[191] [192] As part of the proposal, PG&E will provide generous retention and retraining programs for employees, estimated at $350 million, and financial support for the community, estimated at $49.5 million.[193] The agreement sets in motion several regulatory and policy planning actions that will need to occur within the next few years to ensure an orderly transition in PG&E's electricity supply portfolio and the regional power market. The period until the retirement of the plant also provides ample opportunity to plan for the decommissioning of Diablo Canyon. Even as PG&E, other stakeholders, and policy makers look to a post-Diablo Canyon future, the issues and concerns of having an operating nuclear power plant located in a seismic area remain and must not be pushed aside.

Under a joint proposal agreed to by PG&E, labor, and environmental organizations, PG&E will not pursue relicensing of Diablo Canyon's Units 1 and 2. Instead, the Diablo Canyon plant will be retired at the end of the current operating licenses in 2024 and 2025. PG&E will invest in renewable energy, energy efficiency, and energy storage to replace the electricity produced by Diablo Canyon and to ensure that the retirement of the plant does not result in an increase in GHG emissions. PG&E pledged to have 55 percent renewable energy in its electricity mix by 2031 and to procure 2,000 GWh of new energy efficiency projects and programs from 2018-2024. PG&E will also strive to add more flexible generation resources to its supply portfolio to improve the integration of renewable resources in the overall supply mix. The overall intent of the joint proposal and the objective of the various parties to the joint proposal are to ensure an orderly

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190 March 17, 2016, letter from Chair Weisenmiller to Ms. Vietti-Cook of the Nuclear Regulatory Commission concerning Draft Regulatory Basis: Regulatory Improvements for Power Reactors Transitioning to Decommissioning (Docket ID: NRC-2015-0070), http://www.nrc.gov/docs/ML1609/ML16092A238.pdf.

191 PG&E subsequently filed a formal application with the CPUC (A.16-08-006) seeking approval of the retirement of Diablo Canyon under the joint proposal.

192 Parties to the joint proposal are PG&E, International Brotherhood of Electrical Workers Local 1245, Coalition of California Utility Employees, Friends of the Earth, Natural Resources Defense Council, Environment California and Alliance for Nuclear Responsibility.

193 Specific details can be found in the proposal posted online at http://www.pge.com/includes/docs/pdfs/safety/dcpp/JointProposal.pdf.

replacement of the carbon-free power produced by Diablo Canyon with carbon-free resources.

PG&E highlighted a number of factors underlying its decision to retire Diablo Canyon at the end of the current operating licenses. PG&E cited the uncertain future demand for electricity provided by PG&E as a result of an increased role for community choice aggregation programs. PG&E also forecast a decline in the need for electricity from conventional generation resources such as Diablo Canyon as renewable resources are added to the grid. There is also the challenge of operating an inflexible resource in a market with an increasing amount of renewable resources in the overall portfolio mix. Finally, the future costs to operate Diablo Canyon were highly uncertain, with potential major investments needed to comply with the state's cooling water regulations, other state and federal regulations, and maintenance and repairs of an aging plant.

The first step in implementing the joint proposal was to secure an extension of a State Lands Commission (SLC) lease to allow the continued use of tidal lands for water intake structures, breakwaters, cooling water discharge channel, and other structures associated with Diablo Canyon. The newly extended lease, approved unanimously in June 2016 by the SLC, will expire concurrent with the existing NRC operating licenses.[194] The SLC voted not to require an environmental impact report before extending the lease, following the SLC staff recommendations that a report was not needed since the license covers existing structures. The commission's lease extension is a critical first step toward realizing the joint agreement announced by PG&E.

The SLC staff's recommendation regarding the need for an environmental impact assessment was that Diablo Canyon is an existing facility, and as such, it meets the categorical exemption from CEQA review.[195] An exception to the categorical exemption, however, applies where there is a "reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances."[196] The Alliance for Nuclear Responsibility (A4NR) urged the SLC to consider that unusual circumstances, including the potential for earthquakes, exist at Diablo Canyon. A4NR argued that SLC staff ignored the "unusual circumstance" presented by Diablo Canyon as the "state's only operating nuclear plant; the sole source of additional high-level nuclear waste;

194 At a December 18, 2015, meeting the SLC deferred action on the lease applications directing SLC staff to analyze the level of review required under CEQA and as trustee pursuant to the common law Public Trust Doctrine. The SLC received additional information at its February 9, 2016, and April 5, 2016, meetings.

195 SLC Calendar Item 96: Consider Termination of Lease Nos., PRC 4307.1 and 4449.1, A General Lease – Right-of-way Use and a General Lease, Revised 6-24-2016, pp. 4-9, http://www.slc.ca.gov/Meetings/06-28-16/Agenda.htm.

196 Ibid.

California's largest marine predator…"[197] A4NR recommended a full environmental impact assessment before granting the lease extension, a recommendation the SLC did not adopt.[198] Under the terms of the joint proposal, A4NR had waived its rights to appeal an SLC decision in connection with approval of the short-term lease.

On August 3, 2016, the World Business Academy, a nonprofit think tank, filed a lawsuit with the County of Los Angeles Superior Court against the SLC. The World Business Academy asked that the state review potential significant dangers to the environment and human health that could result from continued operation of the Diablo Canyon Nuclear Power Plant.[199]

There have always been concerns about seismic hazards at Diablo Canyon. The disaster at the Fukushima Daiichi nuclear power plant in Japan in 2011 following a major earthquake, as well as the discovery only a few years ago of the Shoreline fault near Diablo Canyon, has underscored these concerns. PG&E has maintained the Long-Term Seismic Program at Diablo Canyon since the 1980s to research and study seismic conditions at the plant site. The program has contributed substantially to understanding the geological and seismic conditions at Diablo Canyon. Nevertheless, PG&E's scientists, outside seismic experts, and the NRC continue to debate whether the probability for earthquake ground motions is above the seismic design basis of the plant. Improving the knowledge base of the seismic hazards present at the Diablo Canyon site will continue to be an important goal even with the planned shutdown in 2024-2025, both for the remaining operational years and for the postshutdown period when spent fuel will be stored on site.

Although the planned shutdown of Diablo Canyon in 2024-2025 means that certain risks associated with aging nuclear power plants are now bounded by a set period, some operating risks remain as long as the plant operates. Unit 1 of Diablo Canyon began commercial operation in 1985, followed by Unit 2 in 1987, and the units are in or nearing their fourth decade of operation. As nuclear plants age, the systems, structures, and components are all subject to age-related degradation, which, if unchecked, could lead to a loss of function and impaired safety.[200] In addition, as nuclear plants age, they are at greater risk of outages, which across the nation have become more frequent,

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197 Letter to the Honorable Betty T. Yee, State Controller and Chair of California State Lands Commission, June, 27, 2016, filed by Alliance for Nuclear Responsibility.

198 Ibid.

199 Verified Petition for Writ of Administrative Mandamus CCP 1094.5 and CEQA case California Public Resources Code 21167, 21168, 21168.5. Retrieved from http://www.newtimesslo.com/files/08-04-16-WBA_diablo_lawsuit.pdf.

200 California Energy Commission, *An Assessment of California's Nuclear Power Plants: AB 1632 Report*, 2008, p. 16, http://www.energy.ca.gov/2008publications/CEC-100-2008-009/CEC-100-2008-009-CMF.PDF.

longer lasting, and increasingly more expensive.[201] PG&E maintains maintenance and monitoring programs that have been approved by the NRC to address the risks associated with aging plant systems. The reactor vessel heads and the steam generators at Diablo Canyon were replaced; Unit 2 was replaced in 2008, and Unit 1 was replaced in 2009.

The early retirement of a number of nuclear plants in the United States including San Onofre, some for purely economic reasons and others based on excessive costs of repair, have caused concern regarding the continued operation of aging nuclear plants. Aging nuclear plants face increasing nonfuel-operating and maintenance costs, including for capital additions, related to degradation from wear and tear.[202] Repairing and retrofitting aging reactors are costly.[203]

The joint proposal also addressed the future decommissioning of Diablo Canyon. First, PG&E agreed to prepare a site-specific decommissioning plan no later than the date when PG&E must file the 2018 Nuclear Decommissioning Cost Triennial Proceeding with the CPUC. Second, PG&E pledged to expedite the transfer of spent nuclear fuel from the cooling pool to dry storage upon the retirement of the plant in 2025. PG&E will develop "technically feasible" transfer schedules that are based on SCE's spent nuclear fuel transfer schedule as providing a benchmark for Diablo Canyon. PG&E will also provide the plan to the Energy Commission and collaborate with the Energy Commission on the postshutdown transfer of spent nuclear fuel to dry cask storage.[204]

NRC's Decommissioning Rulemaking

In November 2015, the NRC published an Advance Notice of Proposed Rulemaking (ANPR) providing public notice of the NRC's intent to develop new regulations for decommissioning nuclear power plants. The NRC has stated that the need for a new decommissioning regulatory framework is not based on any identified safety or public health risks of the current framework; rather, the NRC is seeking to make the decommissioning process more efficient and predictable.[205] The existing regulatory approval process for decommissioning focuses on identifying what aspects of a nuclear

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201 California Energy Commission, *An Assessment of California's Nuclear Power Plants: AB 1632 Report*, 2008, p. 16-18, http://www.energy.ca.gov/2008publications/CEC-100-2008-009/CEC-100-2008-009-CMF.PDF.

202 Cooper, Mark. July 18, 2013, *Renaissance in Reverse: Competition Pushes Aging U.S. Nuclear Reactors to the Brink of Economic Abandonment*, Mark Cooper, Institute for Energy and the Environment, Vermont Law School, p.4-12. See https://will.illinois.edu/nfs/RenaissanceinReverse7.18.2013.pdf.

203 For example, the CPUC authorized roughly $700 million - $800 million for steam generator replacements at Diablo Canyon, which were done in 2008/2009. See http://www.energy.ca.gov/2006publications/CEC-150-2006-001/CEC-150-2006-001-F.PDF.

204 PG&E Application 16-08-006, filed on August 11, 2016. Attachment A, Joint Proposal, page 13.

205 NRC Docket NRC-2015-0070, Regulatory Improvements for Decommissioning Power Reactors, page 15.

plant operating license are no longer warranted when a plant is shut down and removing these license conditions for the owner/operator.[206] This approach does not permit a comprehensive consideration of how the decommissioning of a plant should proceed, nor does it grant much consideration to the concerns of local communities or state agencies. The NRC has set a goal of developing new decommissioning regulations by 2019.

The NRC sought public comment on the ANPR and received a large number of comments from state and local stakeholders who urged the NRC to give greater consideration to the interests and concerns of host communities. State and local stakeholders pointed out that although the risk of a nuclear reactor accident is reduced with the defueling of a reactor, other radiological risks remain or may actually increase. As noted in the *2015 IEPR,* the exemption for certain emergency preparedness measures granted to SCE by the NRC illustrates the low priority placed by the NRC on state and local concerns with the decommissioning process.[207] At a March 2016 meeting held before the NRC commissioners, a combination of state, community, and industry representatives expressed the need for the NRC to make the decommissioning regulatory framework more responsive to state and local concerns.[208]

For example, states and host communities will need to deal with a range of issues arising out of a nuclear plant site for decades and longer after a nuclear plant is decommissioned. As a result, state and community representatives urged the NRC not to adopt any changes to decommissioning regulations that would effectively reduce safety, security, or emergency preparedness requirements as long as any radiological risk remains.

Proposals for Nuclear Waste Storage Over the Long Term

In the *2015 IEPR*, the Energy Commission highlighted the issues and proposed solutions for dealing with the nation's nuclear waste. The failure of the federal government to license a geologic repository for nuclear waste at Yucca Mountain has led to proposals for an alternative approach for an interim storage site.

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206 For example, under the decommissioning process in place, plant owners may ask the NRC to approve exemptions and/or amendments to the operating licenses as the decommissioning moves forward. Nuclear plant owners may seek license exemptions and/or amendments based on reduced safety and security hazards. For example, once a reactor is permanently defueled, a plant owner (licensee) may seek a license amendment or exemption in operations areas such as staffing and training, security, and emergency preparedness to reflect the new defueled status of the reactor. Licensees can adjust these operational areas only with the NRC's approval for a licensing amendment.

207 California Energy Commission, *2015 IEPR*, 2016, p. 174, http://www.energy.ca.gov/2015_energypolicy/index.html.

208 U.S. Nuclear Regulatory Commission Briefing on Power Reactor Decommissioning Rulemaking, March 15, 2016. Resources available at http://www.nrc.gov/reading-rm/doc-collections/commission/tr/2016/.

The DOE developed its proposed approach for consent-based siting[209] based on the findings and recommendations of the Blue Ribbon Commission on America's Nuclear Future. As the *2015 IEPR* noted, the DOE's proposal is to initially develop a pilot interim storage facility followed by the siting and licensing of a larger interim storage facility. The final step would be to site and license a permanent geologic repository. In April 2016 the DOE hosted a public meeting in Sacramento, one in a series of public meetings held throughout the United States, to solicit public input on the important issues for the DOE to consider as it moves forward with the consent-based siting proposal. The DOE also asked for written comments from the public, which the Energy Commission provided in a June 2016 letter.[210] The Energy Commission supported transparency in the site selection process; early and consistent engagement with local, regional, and state stakeholders and regulators; and attention to transportation logistics and routes as an equally important part of the overall site planning process.

Federal legislators, including California's Senator Dianne Feinstein, also have attempted to address the issue of spent nuclear fuel with new legislation. In 2015 Senator Feinstein cosponsored the Nuclear Waste Act of 2015, which essentially codified the DOE's proposal for consent-based siting. The bill was introduced in the United States Senate in March 2015; however, no further action was taken on the bill. In 2016 House Representatives introduced the Interim Consolidated Storage Act of 2016. U.S. Rep. Darrell Issa has pushed for Congressional action on proposed legislation.

Land-Use Changes From Renewable Energy Expansion

This section reviews the increase in renewable energy generation across the state from a land use perspective. While the estimated average efficiency of each technology in regard to land use varies, renewable technologies tend to require more land per megawatt than natural gas and nuclear power plants, as shown in Table 10. As a result, the amount of land needed for electricity generation has increased with the expansion of large-scale renewable energy technologies. The average acres per MW shown in Table 10 are planning assumptions that were used for planning in the *Desert Renewable Energy Conservation Plan (DRECP)* and are based on averages for each technology type. These values are used in this *EPR* to better understand the scale of the number of acres developed for renewable energy. The acreage assumptions in Table 10 are direct land use disturbances. These acreage effects do not account for other disturbances such as those associated with extraction of natural gas, nuclear, and biomass.

Table 10: Average Land Use per MW by Fuel Type

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209 For more information on DOE's consent-based siting initiative, see http://www.energy.gov/ne/consent-based-siting.

210 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN213746_20160921T094108_072916_Weisenmiller_Responce_to_DOE_IPC.pdf.

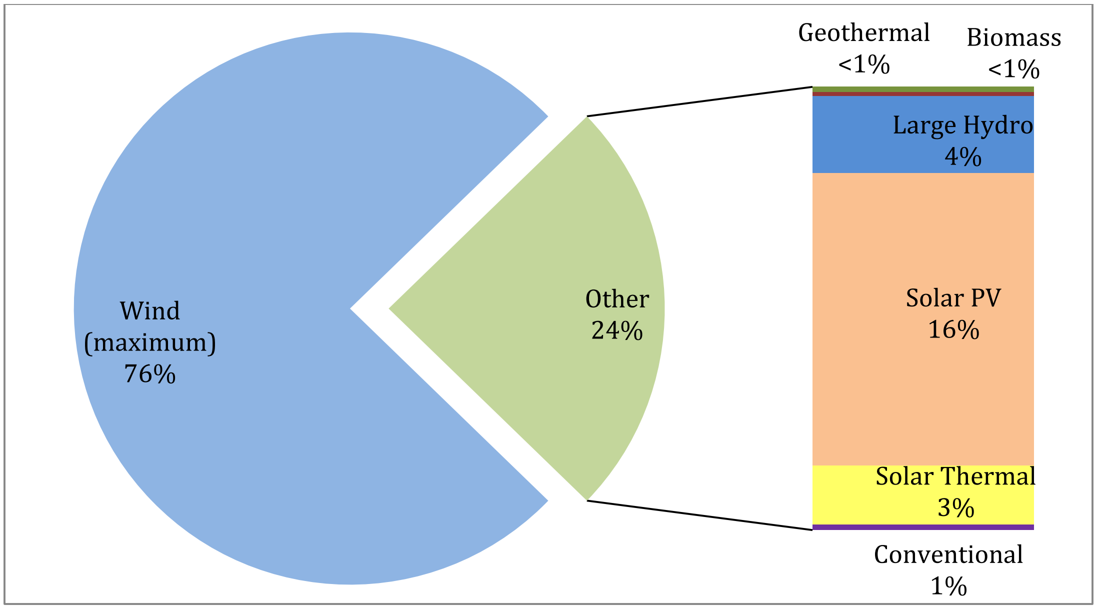
Fuel Type	Average Land Use per Megawatt
Natural Gas	0.08 acres/MW
Nuclear	0.832 acres/MW
Biomass	2.5 acres/MW
Geothermal	6.0 acres/MW
Solar	7.0 acres/MW
Small Hydro	7.5 acres/MW
Large Hydro	29.125 acres/MW
Wind	Ranges from 24.8 to 40 acres/MW

Sources: (1) California Energy Commission staff; (2) NREL Technical Report NREL/TP-6A2-45834, available at http://www.nrel.gov/docs/fy09osti/45834.pdf; (3) NREL Technical Report NREL/TP-6A20-56290, available at http://www.nrel.gov/docs/fy13osti/56290.pdf; and (4) DRECP Acreage Calculator at http://www.drecp.org/documents/docs/DRECP_Acreage_Calculator_Documentation.pdf

By multiplying the acres per MW presented in Table 10 by the MW of in-state generation capacity depicted in Chapter 3, Table 1, staff can estimate the amount of acreage that each technology type used from 2005-2015. The acreage impacts for wind shown in Figure 26 are a conservative estimate that assumes all wind capacity added between 2005 and 2015 is new and not replacement or repower capacity, so the acreage assumption is likely higher than the actual acres that were developed. As expected, Figure 26 shows that the number of acres that have been developed for solar and wind technologies has grown because of the large increase in solar and wind capacity.

These estimates of land use per MW reflect overall project footprints but not necessarily the intensity of the land use. For example, on average, a wind energy facility requires 40 acres per MW of capacity to ensure that the facility has adequate clearance between wind turbine blades, as well as strategic placement and spacing of turbines to capture maximum wind energy potential. The amount of spacing between wind turbines depends on the wind resource and topography of the site where a wind energy facility is developed. In some locations with certain configurations, wind energy facilities can provide 1 MW of power with 24 acres, which is why there is a range in Table 10.

Figure 26: Change in Acreage of Installed In-State Capacity by Fuel Type, 2005-2015



Source: California Energy Commission, Siting, Transmission, and Environmental Protection Division

Though the space required between turbines drives up the amount of land used per MW, the spacing also means that wind energy facilities use land less intensely than solar technologies. Solar technologies have minimum spacing between solar collectors to minimize shading of the collectors by equipment; otherwise, solar collectors tend to be developed densely and use land intensively.

There may be opportunities to develop both wind and solar technologies in ways that retain some level of ongoing habitat or agricultural land value where conditions allow. In addition, these technologies may be in areas where they support other local or regional land-use objectives, such as groundwater recharge, soil stabilization, dust control, and economic opportunities on otherwise degraded land.[211] [212] Furthermore, while all utility-scale renewable energy facilities require large amounts of water during construction for dust control and grading, the fact that both wind and solar PV technologies use virtually

211 See the August 5, 2014, IEPR Update workshop comment from Andy Horne of the County of Imperial on pages 142-143 of the workshop transcript, available at http://www.energy.ca.gov/2014_energypolicy/documents/2014-08-05_workshop/2014-08-05_transcript.pdf.

212 See the March 30, 2016, letter from Westlands Solar Park to the RETI 2.0 Docket, available at http://docketpublic.energy.ca.gov/PublicDocuments/15-RETI-02/TN210903_20160330T140735_Daniel_Kim_Comments_WSP_comments_to_RETI_20_plenary_group_meeti.pdf.

no water during operation makes them potentially attractive land uses in areas with highly constrained water supplies.[213] [214]

Inevitably, the growth of renewable energy as a land use in California over the last decade has impacted natural lands and resources, especially (though not exclusively) in the California desert. Loss of agricultural land from the conversion to energy generation has also increased, in agricultural areas such as the San Joaquin Valley and parts of Imperial and Riverside Counties. The California Department of Conservation's Farmland Mapping and Monitoring Program (FMMP) has created a database of commercial solar developments within its survey area that are proposed, under construction, or completed. As of summer 2015, at least 205,000 acres are within this database. [215]

Given the amount of land needed for renewable energy now and in the future, it will be increasingly important to look for opportunities to reduce conflicts with other land uses and to incorporate renewable energy technologies into the landscape in ways that provide multiple benefits where possible. It would be valuable for agencies to work with renewable energy project developers and stakeholders to identify new and creative ways that renewable energy facilities of all technology types can be designed, built, and operated in a manner compatible with adjacent land uses, including agricultural lands and species habitat, to minimize environmental effects at renewable energy facilities. As described in Chapter 6, the primary approach in California to balance the need for renewable energy growth with other environmental and land-use opportunities and constraints is through multistakeholder and multiagency landscape planning, coupled with close coordination with local governments.

Biological Impacts

California has 218 state- and 187 federally protected native plants[216] and 85 state- and 132 federally protected wildlife species, an increase since the *2005 EPR*.[217] This increase

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213 See, for example, the June 14, 2016, letter from Lorelei Oviatt (Kern County Planning and Natural Resources Department) to CPUC President Picker, et al., titled *Request for Transmission Special Study Area – Solar: Kern County Indian Wells Valley, Ridgecrest, California*, available at http://docketpublic.energy.ca.gov/PublicDocuments/15-RETI-02/TN211992_20160627T160721_Kern_County_Planning__Natural_Resources_Comments_Request_for_Tr.pdf.

214 Lawrence Berkley National Laboratory, 2016, reports that a high penetration of solar in the United States could greatly reduce water use for power generation. *The Environmental and Public Health Benefits of Achieving High Penetrations of Solar Energy in the United States*, available at https://emp.lbl.gov/publications/environmental-and-public-health.

215 California Department of Conservation's *2015 California Farmland Conversion Report*, available at http://www.conservation.ca.gov/dlrp/fmmp/Pages/FMMP_2010-2012_FCR.aspx.

216 California Department of Fish and Wildlife. 2016. "State Federally Listed Endangered, Threatened, and Rare Plants in California." April 2016. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109390&inline

217 Ibid.

is due mainly to impacts and habitat loss associated with human development and climate change, though several species that have been listed as special status species since 2005 are sensitive to impacts associated specifically with energy development.[218] California has more endemic[219] and federally protected species than any other state and is the most biologically diverse state within the continental United States.

This diversity is a result of the wide range of climates and habitats within California. Many rare or sensitive species in California have localized distributions, increasing their potential to be negatively impacted by energy development. While existing policies on avoidance, minimization, and reduction of environmental impacts have been effective at offsetting many of these impacts, many of the various habitats encompassed by California are rare or sensitive, increasing the potential for negative cumulative impacts.

Biological Trends Over the Last 10 Years

Since 2005, more than 10,000 MW of new conventional generation larger than 1 MW has been added to California's electricity generation mix. This addition was entirely in the form of natural gas-fired power plants and is estimated to have affected about 600 acres. While natural gas-fired power plants have generally well-understood environmental effects, the impacts from those plants built since 2005 are varied and largely related to the habitats that they were built on or near. Vernal pools and seasonal wetlands were among the habitats negatively impacted by natural gas-fired plants, with mitigation typically involving purchasing land for permanent conservation and/or payment to conservation foundations. Although the number of natural gas-fired power plants has increased, technology improvements have increased efficiency and decreased nitrogen emissions,[220] decreasing the potential impact of these facilities on a per-unit basis.

As shown in Chapter 3, Table 1, over the same period, over 11,000 MW of renewable generation has been added to California's electrical generation capacity. These projects have affected roughly 200,000 acres in a variety of general and technology-specific ways. While many of the effects observed since 2005 were predictable and similar to those discussed in the *2005 EPR*, the scale and locations of renewable projects raised new issues and highlighted land-use concerns associated with large-scale renewables. The following section discusses the general and technology-specific impacts observed

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218 Townsend's big-eared bat (http://www.fgc.ca.gov/CESA/Townsends_Big-eared_Bat/tbebpetition.pdf) and the flat-tailed horned lizard (http://www.fgc.ca.gov/CESA/Flat-tailed_Horned_Lizard/fthl_petition_reduced.pdf) are both state candidates for special-status species listing that may be sensitive to impacts associated with energy development.

219 481 endemic species. (https://dfg.ca.gov/SWAP/2005/docs/SWAP-2005.pdf,).

220 Nitrogen emissions can cause shifts in the species composition of ecosystems that are found in nitrogen-sensitive areas. Nitrogen is the primary limiting factor to plant growth in nitrogen-poor soils, and excess nitrogen can alter soil toxicity or encourage the growth of nonnative or invasive species.

due to renewable energy development from 2005-2015, with an emphasis on impacts not discussed in the *2005 EPR* or the *2007 EPR*.

The effects associated with renewable development from 2005 to 2015 include habitat loss, degradation, and alteration. Due to factors such as resource availability, transmission availability, and efforts to avoid known environmental and land-use conflicts, large renewable projects of similar technology types tended to be built in clusters. For example, wind farms are built in wind resource areas such as on ridgelines, and solar plants are often built in areas with flat ground and high levels of insolation[221] and access to transmission.

Since 2005, numerous direct and indirect impacts to ecosystems from the development of large-scale solar projects and associated facilities in the desert have been observed. Communities that depend upon sand dune habitat were disrupted by the elimination or modification of sand transport systems. Sand dune-dependent species such as Mojave fringe-toed lizards and several special-status plants were impacted by large-scale solar development through reduced sand transport, leading to deflation of the dunes, plant successional shifts,[222] and other related events that degraded habitat for these species. There are also situations where foraging areas and habitats for raptors have been reduced because of large-scale solar and wind project development. Furthermore, the first cases of canine distemper in desert kit fox were detected near solar development areas in 2011. Potential causes of the outbreak include added stress on the foxes from passive relocation efforts for development of solar facilities, as well as relocating foxes to areas where they were potentially exposed to the canine distemper virus.

Development of energy projects also has presented the challenge of attracting species that would otherwise not be found in the area, or increasing the concentration of predatory species. For example, ravens can be attracted to water or trash present at solar projects in the desert. These ravens may prey upon desert tortoises and other prey species. Moreover, issues have arisen related to bird collisions with reflective solar panels.[223]

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221 *Insolation* is the amount of solar radiation that reaches the Earth's surface. Cloud cover and airborne particulate matter negatively impact insolation, and solar plants are typically built in areas (for example, the desert) that minimize these conditions.

222 Successional shifts occur after disturbance or a change to the physical environment of an ecosystem. They are characterized by a shift in the plants present in the ecosystem, and can have implications for both the short- and long-term makeup of the ecosystem as a whole.

223 "There is growing concern about 'polarized light pollution' as a source of mortality for wildlife, with evidence that photovoltaic panels may be particularly effective sources of polarized light. A desert environment punctuated by a large expanse of reflective, blue panels may be reminiscent of a large body of water. Birds for which the primary habitat is water, including coots, grebes, and cormorants, were over-represented in mortalities at the Desert Sunlight facility (44%) compared to Genesis (19%) and Ivanpah (10%)." (Kagan, R. A., T. C. Viner, P. W. Trail, and E. O. Espinoza (2014). *Avian Mortality at Solar Energy Facilities in*

Because of the technical requirements of many renewable energy projects, large areas of landscape had to be graded, and roads and supporting infrastructure had to be built. This landscape alteration changed drainage patterns and the flow of water to surrounding areas, further altering landscapes and affecting biological resources. Projects access roads built in or near habitat for species such as desert kit fox, desert tortoise, and Mojave fringe-toed lizard had the potential to cause high rates of road injury and mortality during construction and operation, and site perimeter or wildlife exclusion fencing along these roads potentially interrupted migration routes of sensitive species.

In its power plant licensing process, the Energy Commission requires a variety of mitigations for impacts to habitats and special status species, including project reconfiguration or size reduction to avoid habitats and secured compensatory replacement habitat acreages to compensate for those removed by development. Ratios of compensatory mitigation acreages depend on the specific value of the resources being impacted and typically range from 1:1 to as much as 5:1. Assurance that the replacement habitat is financed (for procurement) is required before a project is built. That replacement habitat is then secured (through a conservation instrument) and endowed (for continual maintenance) within 18 months after the start of construction. Thousands of acres in compensatory mitigation habitat were required in the conditions of certification for the various desert renewable projects. Some federal and state agencies have issued guidance on the application of mitigation for impacts on specific resources or habitats. Examples include the U.S. Army Corps of Engineers' (USACE) guidance on compensation for aquatic resources and California Department of Fish and Wildlife's (CDFW) guidance on compensation for various special status plants and animals.[224] [225]

In addition to the general impacts discussed above, the following technology-specific impacts were identified.

Biological Impacts From Wind Energy Development

From 2005-2015, the Energy Commission estimates that wind energy accounted for about 75 percent of the estimated acreage impacted by energy development in California. However, this acreage estimate includes the area between the turbines, as well as the turbine pads. The biggest biological resource issue for wind energy development has been avian mortality, for both migratory and resident birds, due to collisions with wind turbine blades. Bat mortality is also a concern, as bat species have

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Southern California: A Preliminary Analysis. National Fish and Wildlife Forensics Laboratory, Ashland, Oregon. Pp. 16-17. http://alternativeenergy.procon.org/sourcefiles/avian-mortality-solar-energy-ivanpah-apr-2014.pdf).

224 http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/final_mitig_rule.pdf.

225 https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=83843&inline=true.

experienced impacts due to direct strikes with turbine blades. Wind developers have focused pursuing new development in areas with very high wind resource potential and repowering existing facilities, by redeveloping existing sites and replacing older technologies with new technologies.[226] Repowering should continue as a focus in California, as there is a high degree of opportunity to repower existing facilities. As new wind turbines have been deployed and existing sites are repowered, the industry has moved to the use of larger and more efficient turbine technology, resulting in a significant reduction in the number of turbines per facility. These new turbines also incorporate a solid pillar type of support column, instead of a lattice tower. These improvements help reduce the collision risk by reducing the number of turbines on the landscape and discouraging perching and occupancy of wind facilities by vulnerable birds.

In 2005, the Energy Commission adopted a recommendation that "statewide protocols should be developed for studying avian mortality to address site-specific impacts in each individual wind resource area."[227] This recommendation led to the 2007 Commission adoption of the voluntary *California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development*. The Energy Commission, working with the California Department of Fish and Wildlife, developed this document to recommend methods to assess bird and bat activity at proposed wind energy sites; design prepermitting and operations monitoring plans; and develop impact avoidance, minimization, and mitigation measures. In March 2012, the U.S. Fish and Wildlife Service (USFWS) followed suit, issuing the *Land-Based Wind Energy Guidelines*, which provided similar siting, impact reduction, mitigation guidance at a national level. Together, these guidelines provide information to help guide best management practices for decreasing the impacts associated with wind facility siting.

Despite these efforts, collisions remain an issue at wind facilities. However, the wind industry, federal and state agencies, academia, and private consultants are working cooperatively to identify ways of reducing or avoiding these impacts. Research is focusing on reducing the potential for collisions and other impacts by deploying more efficient technologies, improving micrositing[228], and installing automated radar radio

226 Highest wind resource areas are those with wind speed of 7 m/s or above.

227 California Energy Commission, *2005 Integrated Energy Policy Report,* CEC-100-2005-007CMF, November 2005, p. 117.

228 During the site design and development for wind energy, *micrositing* refers to the selection of wind turbine types and determining the precise position of individual wind turbines to maximize energy output within surrounding environmental and site constraints.

systems that can trigger turbine shutdown to help avoid imminent collisions, as well as other areas.[229]

Recent efforts to better understand avian mortality from wind energy development has focused on standardizing mortality data collection to enable comparison of mortality data across wind energy generation types and locations. Both state and federal guidelines provide information to help guide best management practices for decreasing avian impacts.[230] As new scientific information is created and as California learns more from current data collection, the state should consider updating its guidelines.

Wind energy projects can be a major concern and conflict with military testing and training missions. The state has worked closely with the U.S. Department of Defense to limit potential conflicts with and encroachment on military installations and important testing and training that could arise from developing renewable energy and transmission projects.

Biological Impacts From Solar PV Development

Solar PV has relatively few technology-specific effects aside from habitat loss, degradation, and alteration. Direct mortality may result from construction or equipment, loss or modification of habitat, and stress due to relocation. Relocation of some species – such as burrowing owl, desert tortoise, and desert kit fox – can be time- and labor-intensive, causing construction delays and scheduling constraints.

Nesting birds, protected under Fish and Game Code as well as the federal Migratory Bird Treaty Act, may cause significant construction delays. Issues have arisen related to bird collisions with solar panels. Birds flying over a project may mistake the reflective surfaces of the solar panels for bodies of water and fly into those panels.

Since 2005, a significant portion of new solar PV development has occurred on agricultural lands. While the primary concern of solar PV on agricultural lands is the potential displacement of agricultural resources, certain types of agricultural lands also support specific biological resources. For example, the burrowing owl relies on agricultural lands in Southern California, and the Swainson's hawk is supported by agricultural resources in Northern California.

Biological Impacts From Solar Thermal Development

Solar Flux

229 See http://www.energy.ca.gov/contracts/epic.html#GFO-15-309.

230 The Energy Commission, working with the California Department of Fish and Wildlife, developed the voluntary *California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development* and the U.S. Fish and Wildlife Service issued the *Land-Based Wind Energy Guidelines.*

Power towers[231] have been subject to increased public scrutiny over bird deaths due to the effects of f*lux.*[232] Solar flux impacts birds by singeing feathers, leading to whole or partial loss of flight capability; potential short- or long-term ocular effects such as "bright spots," and nonlethal loss of flight capability resulting in "grounded" birds, which may then suffer delayed mortality due to predation, hyper- or hypothermia, or other causes. In addition to these effects, avian mortality at solar power towers has been observed due to birds colliding with reflective heliostat arrays.

Parabolic troughs concentrate flux onto receiver tubes that run the length of the trough, and the total volume of space filled by the flux reflected off each heliostat is significantly less at parabolic trough facilities than power towers plants.[233] While flux is present at parabolic trough facilities, the avian deaths that have been documented at these locations have been the result of collisions with the troughs and perimeter fencing, not solar flux.

Furthermore, insect mortality due to solar flux has been documented.[234] Insects are attracted to the bright glare of the solar flux and can be killed by flux-induced hyperthermia or the delayed effects of singed wings.

Heat Rejection and Water Disposal

Solar power towers and parabolic troughs employ similar technologies for cooling their equipment and disposal of wastewater. Sites that employ air-cooled condensers (ACC) have impacted birds and bats, as the ACC provides an attractive roosting location, and birds and bats that find themselves inside the ACC risk death due to overheating or entrapment.

Moreover, a significant number of avian mortalities have been recorded in evaporation ponds at solar thermal plants since 2005. The evaporation ponds are filled with “process” water, which comes from various sources on-site but primarily from cooling tower blow down. The water can contain toxins, salts, oils, or other substances that pose a risk to birds. Avian mortalities in evaporation ponds have been linked to poisoning from ingestion of chemicals or salts, drowning in oil-rich evaporation pond fluids, hyper- or hypothermia due to feathers being coated by oily substances or salt crystals,

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231 Power towers use large fields of flat, sun-tracking mirrors known as heliostats to focus and concentrate sunlight onto a receiver on the top of a tower. A heat-transfer fluid heated in the receiver is used to generate steam, which, in turn, is used in a conventional turbine generator to produce electricity.

232 *Solar flux* is the concentrated sunlight that is reflected off the heliostats, measured in kW/m^2. The sun emits the equivalent of 1 kW/m^2.

233 For additional discussion of flux impacts, please refer to “Solar Thermal Development” in the Visual Resources Section.

234 Kagan et al. P. 20.

entrapment in exclusionary netting encircling evaporation ponds, and predation from avian and terrestrial predators who are attracted to the water and the birds who use it.

Biological Resources Impacts of Transmission and Interconnection

Since 2005, new transmission lines, substations, and ancillary infrastructure were built for the power generated by conventional and renewable power plants to be delivered to the grid. The transmission lines and related corridors, by far the largest component of this development, had lengths typically ranging from 1 mile to well over 100 miles and widths ranging from 60 to 200 feet. The development and construction of these transmission lines led to temporary and permanent loss of habitat, with impacts similar to those associated with other terrestrial development. There were also several unique impacts to biological resources, such as habitat fragmentation and loss or death through collisions or electrocution.[235] While efforts were made to avoid these impacts by conducting comprehensive biological surveys and carefully siting transmission poles, towers, and substations, impacts did occur to biological resources due to transmission and interconnection development in California from 2005 to 2015.

Avian Species Impacts of Transmission and Interconnection Lines

Transmission and interconnection lines impacted avian species through two primary mechanisms: collisions and electrocutions. Collisions occur when birds strike power poles or lines, causing injury or death. Electrocution occurs when large birds, such as raptors, simultaneously contact two active phases of the power line. These impacts are well-understood, and best management practices to avoid these impacts are a standard part of the construction of transmission lines. Energy projects typically have avian protection plans or bird and bat conservation strategies specifically focused on avoiding and minimizing these impacts. Avian protection plans and bird and bat conservation strategies frequently refer to and rely upon guidance from the Avian Powerline Interaction Committee, a coalition of private interest groups and agencies that collaborate to design power lines with specifications that avoid and minimize the risk of electrocution and collision. The committee has published documents on how to implement these design elements,[236] and most, if not all, of the transmission line development that occurred in California from 2005 to 2015 relied on this guidance.

Terrestrial Impacts From Transmission and Interconnection Lines

The length of a new transmission line typically correlates to the potential impacts that may occur. Commercial-scale renewable projects, due to the remote sites and long

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235 For a more in-depth discussion of the impacts associated with transmission lines, please refer to the *2005 EPR* and the *Assessment of Avian Mortality From Collisions and Electrocutions*, 2005. CEC-700-2005-015.

236 Avian Powerline Interaction Committee. 2006. *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006.* Edison Electric Institute, APLIC, and the California Energy Commission, Washington, D.C. and Sacramento, California.

distances to the nearest point of interconnection, had a higher likelihood of affecting habitat. Furthermore, due to the locations where renewable power plants were sited in California from 2005 to 2015, the transmission lines had a greater potential for significant impacts than those of conventional power plants built during the same period.

Terrestrial impacts from transmission lines and associated access roads in the desert can result in temporary and permanent loss of habitat for species such as burrowing owl, desert tortoise, and desert kit fox. Moreover, the slow and often difficult recovery for desert-dwelling plants means that any restoration efforts may take much longer than they would have in other ecosystems. Due to this, impact avoidance, minimization, and mitigation were chief concerns when siting transmission lines in California's deserts. Efforts were made to avoid impacts to special status habitat such as desert washes by planning power pole siting to span sensitive habitats, or mitigation by purchase of compensatory habitat.

Conclusions: Outlook for Biological Resources

Despite the large land-use component of the renewables that will continue to be a large portion of California's energy infrastructure development, the outlook for energy development impacts on biological resources in California is mostly positive. Experience gained from the projects permitted and built in recent years will lead to improvements in avoidance, minimization, and mitigation. Continued advances in the efficiency of renewable technologies and impact monitoring methods will help decrease both the footprint of renewable power plants and the number of organisms impacted by them.

Most, if not all, impacts discussed in this section will continue to be a concern and will require attention and management. However, as staff gathers more data about renewable power plants, it will be able to draw conclusions with more certainty, allowing staff to refine strategies to address potential or observed impacts. Improving the implementation and efficiency of the technologies, as well as changing the technologies themselves, will reduce the impacts associated with these power plants. Some improvements are already evident, as wind turbine efficiency and micrositing have become more sophisticated, and turbine height and blade length have increased the efficiency of turbines.

Increased monitoring and observation aimed at improving staff's data sets may make it appear as though the impacts are increasing, as the number of reported impacts will increase. For example, the recent increase in wind farm-related bat injury/mortality may be due to an increase in monitoring and not turbine size. This does not necessarily mean that the actual impacts increased.

Regulatory and permitting agencies at local and state levels have instituted and followed policies aimed at protecting biological resources. Most, if not all, of the impacts that have occurred at power plant project sites have been offset by mitigation. Mitigation by permanently preserving habitat similar to the habitat disturbed by construction has become increasingly difficult. The amount of suitable habitat is decreasing, landowners are increasing prices in regions with high solar insolation, and finding contiguous parcels (which are preferred for mitigation) is becoming less likely. The California Advance Mitigation Act helped overcome this difficulty by authorizing CDFW to implement a program to create a mitigation bank in advance of project development by purchasing appropriate habitat within the desert that developers would then purchase as mitigation for their eligible renewable energy projects.[237] Even with effective, project-specific mitigation, there are concerns about compounding stressors or cumulative impacts to species and ecosystems, as well as additional stress to natural systems from future climate change

Landscape-scale planning, like the *Desert Renewable Energy Conservation Plan (DRECP)*, attempts to address this concern by identifying the most appropriate areas for large-scale renewable energy development within the desert landscape by designing a conservation framework to foster and maintain species resiliency across desert ecosystems, with explicit consideration of the impacts of climate change. Furthermore, CDFW and U.S. Bureau of Land Management (U.S. BLM) signed a durability agreement in 2015 that allows BLM-managed federal lands to be used for a variety of conservation actions that will contribute to achieving the goals of the overall DRECP conservation framework and, in specific circumstances, for project-level mitigation.[238] The state should continue working with federal agencies as well as with local governments to ensure that renewable energy development that occurs in the DRECP is consistent with the overall DRECP conservation framework.

To support the design and implementation of the DRECP, the Energy Commission's Research and Development Division initiated research projects to compile or model biological data on where species exist, their habitat needs, and how and where they use the desert landscape.[239] Other studies investigated how renewable energy development might impact species or developed tools to predict impacts. For example, one project is quantifying desert fox movements in parts of the desert with solar energy development to better understand the impacts of solar development on desert kit fox. New data were also collected to better monitor actual impacts of projects during construction and operation to better understand how species react to energy development. Many of these science-based tools and methods are available to strengthen renewable energy

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237 California Advance Mitigation Act, SBX8 34, Padilla, Chapter 9, Statutes of 2009-2010 Eighth Extraordinary Session,

238 http://www.drecp.org/documents/docs/2015_Durability_Agreement_BLM_CAFW.pdf

239 For a summary of research supporting the DRECP see: http://www.energy.ca.gov/2014publications/CEC-500-2014-091/CEC-500-2014-091-BR.pdf

development and planning strategies in other regions, and highlight the importance and benefits from the state's public-interest energy research program.

Cultural Resources

Cultural resources are "those aspects of the environment—both physical and intangible, both natural and built—that have cultural value of some kind to a group of people."[240] Cultural resource specialists commonly categorize those cultural resources considered historical resources into three broad classes: prehistoric, ethnographic, and historic.[241] State laws, notably CEQA, establish legal definitions for these cultural resources.

Historical resources are defined under state law as buildings, sites, structures, objects, areas, places, cultural landscapes, tribal cultural resources, and records and manuscripts.[242] Under federal and state requirements, historical resources must be at least 50 years old to be considered of potential historical significance unless it is of "exceptional importance." In addition, historical resources must retain enough integrity to convey significance and therefore retain eligibility to the California Register of Historical Resources. Although cultural resource managers possess specialized knowledge bearing on the significance and integrity of cultural resources, the values that imbue significance are determined by human communities, be they Indian tribes, local municipalities or neighborhoods, segments of the wider scientific community, or the public. The views of concerned communities are therefore important considerations in cultural resources management work (CRM).

Tribal cultural resources are a type of historical resource, defined as sites, features, places, cultural landscapes, sacred places, and objects with cultural value to a California

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240 King, Thomas F. 2008. *Cultural Resource Laws and Practice* (3rd ed.). Lanham, MD: Alta Mira Press, p. 3.

241 *Prehistoric archaeological resources* are those materials relating to prehistoric human occupation and use of an area. These resources may include sites and deposits, structures, artifacts, rock art, trails, and other traces of Native American cultures. In California, the prehistoric period began more than 12,000 years ago and extended through the 18th century until 1769, when the first Europeans settled in California.

Ethnographic resources are those materials and places important to the heritage of a particular ethnic or cultural group, such as Native Americans or African, European, or Asian immigrants. They may include tribal cultural resources, traditional resource collecting areas, ceremonial sites, topographic features, value-imbued rural and urban landscapes, cemeteries, shrines, or ethnic neighborhoods and structures. Ethnographic resources are variations of natural resources and standard cultural resource types. They are assigned cultural significance by traditional users. The decision to call resources "ethnographic" depends on whether associated peoples perceive them as traditionally meaningful to their identity as a group and the survival of their life ways.

Historic-period resources are those materials, archaeological and architectural, usually associated with Euro-American exploration and settlement of an area and the beginning of a written historical record. They may include historical archaeological deposits, historic sites, structures, buildings, neighborhoods, traveled corridors, artifacts, or other evidence of human activity.

242 California Code Of Regulations, Title 14, Sections 4852a, 5064.5(A)(3); Public Resources Code, Sections 5020.1(h, j), 5024.1(e)(2, 4).

Native American tribe that are either included or eligible for inclusion in the California Register of Historical Resources or a local register of historical resources or determined to be significant by the lead agency (Pub. Resources Code, § 21074[a]). Historical resources can be directly impacted by physical disturbance to the land and related archaeology, as well as indirectly impacted by visual, sound, and olfactory intrusion upon otherwise pristine and culturally imbued landscapes.

Findings From the *2005* and *2007 EPRs*

The *2005 EPR* made three principal findings regarding cultural resources:

- **Increasing Recognition of Native American Interests**: Native Americans were becoming more involved—and were being asked to become more involved—in project planning and energy-sector CRM. This trend was formalized in a new tribal consultation policy for the Federal Energy Regulatory Commission and in a California state law, Senate Bill 18 (Burton, Chapter 905, Statutes of 2004) (SB18), which requires local governments to consult with Native Americans whenever general plans are altered.
- **The Power Plant Siting Process Addresses Cultural Resource Issues**: Between 1999 and 2004, no power plant had been denied a license due to the presence of cultural resources in the vicinity of the proposed plant, which was credited to developing ways to reduce most impacts to cultural resources.
- **California Tribes Are Exploring Environmental Justice**: Native Americans who wish to continue to use contemporary cultural resources in traditional ways had started expanding the understanding of the intersection of cultural resources and environmental justice.[243]

Cultural resources were not addressed in the *2007 EPR*.

Cultural Resource Trends Over the Last 10 Years

Over the past decade, construction of conventional generation power plants concentrated in coastal and Southern California urban centers. The *2005 EPR* disclosed that more than 1,000 resources were identified because of Energy Commission licensing processes from 1998 to 2005.[244] [245] Although the *2005 EPR* cultural resources analysis

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243 California Energy Commission. 2005. *Environmental Performance Report of California's Electrical Generation System*. CEC-700-2005-016. June. Sacramento, California, p. 197.

244 California Energy Commission. 2005. *Environmental Performance Report of California's Electrical Generation System*. CEC-700-2005-016. June. Sacramento, California, p. 202, Figure 10-1.

245 Some of California's oldest power plant facilities now qualify as built-environment cultural resources and may possess historical significance under CEQA and other laws. For example, the potential removal or reconstruction of Southern California steam-generating plants from the 1950s to 1970s—such as the Huntington Beach, Alamitos, El Segundo, and Redondo Beach generating stations—have the potential to add to the loss of information associated with the development of electric steam power generation in the mid-twentieth century in California. However, all of these postwar power plants have been recorded and evaluated

does not isolate the types of generation projects responsible for identification of cultural resources, the number of such resources affected by future conventional energy generation is likely to be similar to or greater than 1998–2005 figures.

The expansion of renewable energy generation drove project scale into the thousands of acres and moved energy generation from urban industrial sectors to rural lands such as the California deserts. Larger energy projects in the state's open spaces have resulted in the identification of vast amounts of cultural resources. For example, during the BLM and Energy Commission's review of the Blythe Solar Power Project,[246] 204 cultural resources were identified in the project footprint: one archaeological district, two cultural landscapes, and 201 archaeological resources.[247] As this demonstrates, there has been a considerable increase in the number of cultural resources affected by utility-scale renewable energy development in intact desert areas compared to smaller-scale energy project development in previously disturbed urban areas.

The growth of renewable energy development in the California deserts led to a high degree of engagement on the part of California Native American tribes and communities. Numerous tribes—including Kawaiisu, Cahuilla, Kamia, Kumeyaay, Paiute, Shoshone, Chemehuevi, Mojave, Quechan, and Serrano—have called the inland desert home for millennia, continue to live there, and maintain cultural practices that served their bearers for generations.

Energy Commission siting cases such as the Blythe Solar Power Project and Genesis Solar Energy Project and the now-withdrawn/terminated Rio Mesa, Palen, and Hidden Hills solar projects saw intense tribal involvement in all aspects of the proceedings: resource identification, government-to-government consultation, staff-level consultations, review of and comment on environmental impact reports, expert witness testimony, legal intervention, design and implementation of mitigation measures, and construction monitoring. Cultural and landscape preservation values pervaded expressed tribal concerns. Tribes have also expressed concerns over effects on biological resources, water, air quality, and view aesthetics, linking these types of impacts to ongoing impacts on their communities. This engagement has increased tribal knowledge of energy siting procedures and Energy Commission staff knowledge of tribal values, interests, personnel, and methods of engagement.

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at a basic level, and through the respective licensing processes, that historical information has been made public.

246 California Energy Commission, Docket Unit No. 09-AFC-6C.

247 California Energy Commission. 2010. *Blythe Solar Power Project: Commission Decision*. September. CEC-800-2010-009-CMF. Sacramento, California, pp.370, 394. California Energy Commission. 2013. *Blythe Solar Power Project: Staff Assessment – Part B, Amendment to the Blythe Solar Power Project*. October. CEC-700-2013-004-FSA-PTB. Sacramento, California, p.4.3-82.

This increased knowledge of cultural resources and recommendations in the state guidelines for implementing CEQA that lead agencies plan for the mitigation of inadvertent discoveries of cultural resources (see Cal. Code Regs., tit. 14, §15064.5[f]) have led Energy Commission staff to derive a set of "standard conditions." The standard conditions define the minimum qualifications for project cultural resources personnel, the content requirements of an avoidance and archaeological mitigation plan (cultural resources monitoring and mitigation plan), construction monitoring procedures, Native American involvement, and reporting intervals. These conditions are applied to those licensing cases where cultural resources are not identified within the project site, but inadvertent discoveries could occur during construction. The standard conditions prioritize avoidance, minimization, and compensation (the latter through the scientific excavation, recovery, documentation, and curation of archaeological resources). Where energy facility projects would cause impacts on known cultural resources, the standard conditions are modified and amplified by mitigation measures tailored to cultural resources identified during licensing.

Recent large-scale renewable energy projects in the California deserts (Blythe Solar Power Project and Genesis Solar Energy Project) were notable for cumulative impacts mitigation. During these licensing cases, Energy Commission staff identified significant and unavoidable impacts on Native American cultural landscapes necessary for the perpetuation of several Native American communities. Both of the cultural landscapes and solar energy projects were too expansive for avoidance, minimization, reduction, and rectification strategies, leaving Energy Commission staff to craft compensatory mitigation. A fund was established and deposits received from those solar energy projects contributing to the cumulative impacts for documenting cultural landscapes in the desert. The mitigation included detailed documentation of off-site archaeological districts and other cultural properties in compensation for impacts that otherwise could not be reduced in severity, similar to the practice in biological resources management of creating off-site wetlands or other habitat in lieu of onsite preservation. Documentation included technical reports and interpretive videos.

Cultural Resource Impacts From Transmission and Interconnection

The construction and operation of both conventional and renewable energy facilities occasion the need for transmission lines and interconnections. Transmission lines and interconnections can be long linear projects that cross several governmental jurisdictions, land uses, and habitats. As such, transmission line projects share some characteristic effects on cultural resources with utility-scale renewable energy projects. First, the scope of the potential of a transmission project to affect cultural resources can be large, spanning up to hundreds of miles. Transmission line effects differ from utility-scale renewable energy impacts in that the area of potential disturbance is comparatively narrow (large rights-of-way being 200–1,000 feet wide). Ground disturbance such as mowing the right-of-way, grading, installation of transmission towers, building access roads, grading helicopter fly yards and staging areas, and installing pull sites for electrical cable can result in direct damage to cultural resources. Second, construction of transmission towers and lines can present visual and auditory intrusions to historical districts, cultural landscapes, and other types of cultural resources. Furthermore, existing transmission lines can be of sufficient age to qualify as built-environment cultural resources.

Cultural Resources and Landscape Planning

In addition to consulting with California Native American tribes on specific projects, the Energy Commission has also engaged formally and informally with tribes on a series of landscape planning efforts, including *DRECP*, San Joaquin Least Conflict Planning for Solar PV, and the Renewable Energy Transmission Initiative (RETI) 2.0. These processes offer tribes an opportunity to inform government agencies, developers, and the public about potential conflicts with cultural resources at the landscape scale so that cultural resource sensitivity can be considered at the planning level.

For the *DRECP,* the Energy Commission, along with its federal partner the U.S. BLM, participated in several tribal leadership forums. In addition, Energy Commission staff participated in a working group to develop a BLM Section 106 programmatic agreement. For those aspects of the *DRECP* that were exclusively state functions, the Energy Commission engaged in state-tribal consultations with 38 tribes culturally affiliated with the *DRECP* area. A salient message provided by tribes to the Energy Commission was to consider the large-scale renewable energy facility siting, construction, and operation impacts on tribal cultural landscapes and the indigenous communities that rely upon such landscapes.

In the San Joaquin Least Conflict Planning for Solar PV initiative, the Energy Commission and OPR worked with tribes living in and near the valley to incorporate information about tribal cultural resource sensitivity in the planning area in the planning process.[248] Energy Commission and OPR staff integrated the tribes' data into the planning area geographic information system (GIS) and overlaid the data onto those of other planning stakeholders to derive a picture of least-conflict areas with tribal areas of concern taken into account.[249]

For the RETI 2.0 process, staff has made an early effort to notify all California tribes of an introductory workshop where the RETI 2.0 process was discussed. Midway through the process, staff is re-engaging with tribes throughout the state to review and comment

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248 The consulted tribes included the Miwok, Yokuts, Mono, Costanoan, Kitanemuk, and Kawaiisu tribes.

249 Pearce, Dustin, James Strittholt, Terry Watt, and Ethan N. Elkind. 2016. *A Path Forward: Identifying Least-Conflict Solar PV Development in California's San Joaquin Valley*. May. Conservation Biology Institute, Goleta, California, and Corvallis, Oregon; Terrell Watt Planning Consultants, San Francisco, California; and Center for Law, Energy & the Environment, UC Berkeley School of Law, University of California, Berkeley, pp. 37–46. Available at https://db-static-content.s3.amazonaws.com/versions/387/img/gateways/sjvp/report.pdf and https://db-staticcontent.s3.amazonaws.com/versions/387/img/gateways/sjvp/appendices.pdf.

on the relative merits of Draft Transmission Assessment Focus Areas (TAFAs) and related transmission corridors needed to connect California renewable energy resource opportunities with a broader region.

Cultural Resources Sensitivity Model

Through its work on the *DRECP*, Energy Commission staff is developing a cultural resources sensitivity model for the DRECP area to provide a tool that will allow Energy Commission staff and potentially tribal government staff, renewable energy developers, other agency personnel, and perhaps the public to better understand cultural resource sensitivity across the plan area.[250]

Cultural resources staff at the Energy Commission compiled statistically representative data from the California Historical Resources Information System (CHRIS) and other sources into a GIS. Staff applied geospatial models relevant to the distribution of cultural resources in the DRECP area to the raw data, such that the plan area is spatially ranked according to the variable likelihood to contain cultural resources.

The results can be graphically displayed as a "heat map," in which color gradations represent the degree of cultural resource sensitivity or constraint across the DRECP area. (Red, for instance, represents areas known to contain numerous cultural resources or where such resources are expected.) Staff is vetting the modeling results with tribes and exploring how this tool can be used to help inform users of potential cultural resource sensitivity for high-level planning without the need for accessing confidential information.

Protecting California's Cultural Resources

Senate Bill 18, New State Consultation Policies, and CEQA Amendments

Consultation with California Native American tribal governments is the responsibility of local, state, and federal agencies and is detailed in several sections of federal and state law and policy. Most such authorities on tribal consultation apply to general plans and specific project proposals, not long-range conceptual planning and advisory programs. A prime example within California was SB 18.[251] The *2005 EPR* observed that the law and guidance for SB 18 implementation set a positive model by which state and local agencies could consult with California Native American tribes. Six to 10 years after the advent of SB 18, the state adopted new consultation policies and formalized a consultation procedure specifically for CEQA.

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250 While one outcome of the *DRECP* was an amendment to the BLM's land-use plans to accommodate renewable energy facility siting and related biological mitigations, the *DRECP* also identified nonfederal lands considered suitable for energy development or related mitigation throughout the seven-county area covered in the study area.

251 California Energy Commission. 2005. *Environmental Performance Report of California's Electrical Generation System*. CEC-700-2005-016. June. Sacramento, California, pp. 197–200.

New State Consultation Policies

For state agencies, Governor's Executive Order B-10-11 (signed in September 2011) encourages state agency collaboration with California tribal governments.[252] The executive order directs state agencies to afford California Native American tribes, both federally recognized and nonrecognized, the opportunity to "provide meaningful input into the development of policy on matters that affect tribal communities." The CNRA also has a policy that exhorts state agencies under its jurisdiction to provide California Native American tribes and tribal communities the opportunity to provide meaningful input into state agency plans and policies that may affect tribal communities.[253] The Energy Commission also uses a tribal consultation policy that implements the CNRA's consultation policy, for Energy Commission programs and projects.[254]

Assembly Bill 52 and CEQA

Assembly Bill 52 (Gatto, Chapter 535, Statutes of 2014) amended CEQA to define California Native American tribes, lead agency responsibilities to consult with California Native American tribes, and tribal cultural resources. Lead agencies implementing CEQA are responsible for conducting tribal consultation with California Native American tribes about tribal cultural resources within specific time frames and observant of tribal confidentiality. AB 52 also amended CEQA to state that a project with an impact that may cause a substantial adverse change in the significance of a tribal cultural resource is a project that may have a significant effect on the environment (Pub. Resources Code, § 21084.2).

Environmental Justice and Tribal Governments

The Energy Commission has integrated EJ into its environmental impact analyses under CEQA and the Commission's siting regulations since 1995.[255] Among other guidance, the *Final Guidance for Incorporating Environmental Justice Concerns in EPA's Compliance Analyses*[256] informs staff's EJ analyses, which may include outreach to tribal

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252 Governor's Executive Order B-10-11, September 19, 2011, available at https://www.gov.ca.gov/news.php?id=17223.

253 California Natural Resources Agency. 2012. *California Natural Resources Agency Consultation Policy*. November 20. Sacramento, California, available at http://resources.ca.gov/docs/tribal_policy/Final_Tribal_Policy.pdf.

254 California Energy Commission. 2014. *California Energy Commission Tribal Consultation Policy* (Executive Order B-10-11). December. Order No. 14-1210-3. Sacramento, California, available at http://www.energy.ca.gov/tribal/documents/2014-12-10_Tribal_Consultation_Policy_and_Order.pdf.

255 California Energy Commission. 2016. *Environmental Justice*. Sacramento, California. Available at http://www.energy.ca.gov/public_adviser/environmental_justice_faq.html.

256 Environmental Protection Agency. 2016. *Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analyses*. April. Available at https://www.epa.gov/sites/production/files/2015-04/documents/ej-guidance-nepa-compliance-analyses.pdf.

governments to identify those minority groups who use or depend upon natural and cultural resources that could be affected by the proposed action. The Energy Commission's cultural resources staff consults with tribal governments to discern whether a proposed energy facility may affect cultural resources and related Native American practices.

Historically, the Energy Commission's EJ impact assessments focused on resident minority and low-income populations in a given project vicinity across several resource categories (including cultural resources). With the advent of utility-scale solar projects in the California deserts and the landscape-scale impact potential, Energy Commission cultural resources staff recognized that the resident EJ population was not the only appropriate analytical unit in all energy development siting cases. Energy Commission staff identified cultural landscapes essential to tribal cultural practices and uses that extended far beyond the community boundaries of tribal governments. In analyzing the potential EJ impacts of energy development on tribal governments, Energy Commission staff consults with tribal governments known to use proposed project vicinities for subsistence and traditional cultural practices, instead of treating only tribal governments living in the project vicinity.

Conclusions: Outlook for Cultural Resources

In addition to the climate change outlook trends mentioned above, the outlook of energy development effects on cultural resources are the following.

- The Energy Commission and other energy regulators will be giving increasing attention to potential effects on coastal built-environment energy facilities and surrounding built environment resources.
- Large-scale renewable development will increase the frequency and severity of effects on cultural resources, including cultural landscapes.
- Regulators and energy developers can expect increased tribal engagement in energy development projects and planning, especially concerning cultural landscapes, biological resources, environmental justice, and mitigation monitoring.
- As agencies contribute to federal and state renewable energy portfolio targets, and the scale of energy projects and the cost of cultural resources mitigation expand, there will be a prominent role for cultural resources sensitivity mapping and related data-sharing agreements.
- Nonproject-related studies, conducted in collaboration with potentially affected tribes, will likely lead to proactive dialogues that will identify subject areas of mutual benefit, as well as subject areas that will require ongoing informal and formal consultations.

Visual Resources

This section discusses the environmental performance trends and evolving mitigation strategies for visual impacts from utility-scale renewable energy power plants since around 2005. As with conventional generation, the extent of visual impacts vary between one project and another generally depending on the setting and the possibility that a project could alter views in areas where visual sensitivity is an issue. Compared to projects using conventional generation technologies, the visual sphere of influence (VSOI) (in other words, the area within which visual impacts may occur) is typically much greater for utility-scale renewable projects, and particularly for projects using a solar power tower technology.

In general, the visual impact assessments for utility-scale renewable energy projects subject to the Energy Commission's jurisdiction have required expanding the scope of the analyses overall due to the increased size of the facilities and the vast and open desert landscapes where these facilities have been licensed. Each project site covers thousands of acres in areas that are frequently surrounded by low mountain ranges and public lands used for a variety of recreational activities. Most of the project acreage for solar thermal projects is covered by solar collector arrays that cause diffused or direct reflected glare when transitioning between the downward-facing stow position and tracking the positions. The more diffuse glare from solar PV power plants can also present a visual quality impact or a distraction to pilots or an intrusive visual nuisance to sensitive viewer groups such as residents, recreationists, and motorists.

Glare from PV power plant modules (solar panels) can be reduced by using textured glass, using antireflective coatings, and installing site blinds and screening. Glare from concentrated solar power plants with mirrors for projects that are reviewed by the Energy Commission (such as solar power tower and solar parabolic trough projects) can be reduced by altering heliostat or trough positioning and by fence construction to partially shield views. Concentrated solar power plants with mirrors (such as solar power towers and solar parabolic troughs, which are reviewed by the Energy Commission) can also potentially cause glare to pilots and motorists. The Energy Commission continues to investigate this impact and determine the best methods for mitigation. Mitigation options include siting to reduce glare, alterations in heliostat or trough positioning, and/or fence construction to shield any nearby motorists. It is possible that the glint and glare impacts to aircraft from solar power towers may be reduced by the move to salt storage technology, which allows more mirrors to focus on the tower and not skyward.

In addition to the issues discussed above, the following technology-specific considerations are identified:

Wind Energy Development Visual Impacts

Wind energy projects are typically highly visible on the landscape and have resulted in significant visual impacts. Various siting and design mitigation strategies are available to reduce visual impacts:

- Involve the public in the decision-making for site design.
- Integrate turbine arrays and the turbine design with the surrounding landscape, and create visual order and unity among clusters of turbines to reduce visual disruptions and perceptions of disorganized clutter.
- Insert breaks or open zones to create distinct visual units or groups of turbines.
- Use tubular towers to present a simpler profile and less complex surface characteristics and reflective/shading properties.
- Size components in proper proportion to one another and select colors to reduce visual impacts. Use nonreflective paints and coatings to reduce reflection and glare.
- Avoid placing large operations buildings on high land features and along the skyline where they may be viewed from sensitive viewpoints.
- Bury power lines in a way that minimizes additional surface disturbance.
- Design the site to make security lights nonessential.

The visual effects of projects using wind power to generate electricity are sometimes minimized when projects are in areas with lower visual sensitivity, such as large acreage ranchlands that are not near recreation areas. Impacts are also reduced by avoiding installations of wind turbines along ridgelines.

Even with implementing these and other mitigation strategies, the visual impacts from wind power projects often have remained significant with no feasible mitigation measures identified to reduce impacts to less than significant.

Solar PV Development Visual Impacts

The visual effects of PV projects compared to solar thermal electric and wind projects are often less severe than due to the much lower vertical scale of the technology, lower reflectivity of the PV modules compared to the mirrored solar collectors for solar thermal projects, and overall reduced visual intrusion in the VSOI. Large PV installations are sometimes difficult to see from a distance and may appear as a narrow dark band across an open space grassland area (for example, inland grasslands along the South Coast Ranges). PV modules are designed to absorb light rather than reflect it and are typically black or dark grey. Although PV modules are relatively nonreflective, instances of higher reflectivity have occurred at some installations.

In addition to siting projects away from visually sensitive areas, mitigation strategies include constructing the PV modules using “high-transmission, low-iron” glass, which absorbs more light and produces smaller amounts of glare and reflectance than normal glass.[257] Also, many PV suppliers use stippled solar glass for panels, which textures the surface with small indentations. Stippling allows more light energy to be

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257 SunPower. 2010. *PV Systems: Low Levels of Glare and Reflectance vs. Surrounding Environment,* Executive Summary. By Mark Shields. Available at https://us.sunpower.com/sites/sunpower/files/media-library/white-papers/wp-pv-systems-low-levels-glare-reflectance-vs-surrounding-environment.pdf.

channeled/transmitted through the glass while diffusing (weakening) the reflected light energy.

Solar Thermal Development Visual Impacts

Power Tower Technology

Solar thermal electric power plants using power tower technology have introduced a new visual impact mechanism relating to the highly reflective surfaces of the solar collectors (mirrored surfaces of the heliostats) and the intense luminance of the solar receivers at the tops of the towers. The towers topped by the luminescent solar receivers stand several hundred feet tall and are highly visible and intrusive from all directions. No feasible mitigation measures have been identified to reduce the severity of this type of visual impact.

Another visual effect of projects using solar power tower technology is the bright illumination of the air space between the solar collectors and the receivers at the tops of the towers, which creates a tent-like sunlit form over each solar array field. Although this effect may be considered visually interesting by some viewers, it is also considered a visual distraction or annoyance in an otherwise mostly natural environment. Because solar power tower projects do not require completely flat or level ground for construction of the solar array fields, a several-thousand-acre project site may be highly visible across a region and from surrounding public use areas.

Parabolic Trough Technology

Projects using parabolic trough technology have an overall lower vertical profile compared to projects using solar power tower technology. Parabolic trough projects must be constructed on very flat and level terrain and may appear from a distance as a thin contrasting line across the landscape. Similar to the heliostats for power tower projects, the mirrored surfaces of the parabolic trough solar arrays can cause diffused or direct reflected glare when the troughs are rotated to and from stow and tracking positions. Site perimeter fencing may reduce visual impacts.

Visual Impacts From Transmission and Interconnection

The high-voltage transmission lines associated with utility-scale power plants require installation of transmission structures and power lines that can impact visual resources in areas near the transmission line route. The goal is to reduce the visual intrusion and contrast with the environment in areas where a new transmission line could be highly visible. For some Energy Commission siting case proceedings, visual impacts were determined to be temporary and to occur only during construction.

The type of transmission structure selected for a project may be perceived to reduce potential visual impacts. For example, steel monopoles are generally less visually intrusive compared to lattice-type transmission structures.

Integrating electric transmission facilities with the visual setting requires different methods depending on the project location and whether the transmission line route is in a natural or urban setting. In general, self-weathering steel transmission structures are especially suitable in natural settings, where the dark brown color and rough texture of the weathered steel relate well to the colors and textures of the landscape. In more urban settings where structures may be seen at near distances and in relationship to features with more refined surfaces, the dark, mottled color and rough texture of self-weathering steel can appear out of place. For projects in urban settings, a better approach is to use galvanized structures that have been dulled to reduce reflectivity (such as a matte patina finish) and darkened to the right level to reduce contrast, or by using structures with a powder-coat finish.

Best Management Practices for Renewable Energy Development

In December 2010, the Renewable Energy Action Team (REAT) issued the *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects*, which help inform developers and regulatory agencies of best practices when preparing and reviewing development applications to accelerate renewable energy project permitting. The best management practices contributed to the development of the *DRECP*, and REAT uses the best practices to accelerate permitting of solar projects in the desert. REAT should continue to use the best management practices and consider updating them so that they reflect the current state of technology and incorporate lessons learned from the permitting and development process. Updates to the best management practices should include strategies on how to achieve environmental and land use benefits from renewable energy development, where appropriate.

CHAPTER 5: Emerging and Transformative Technologies

The energy sector constantly evolves and transforms. Over the last 10 years, the sector has witnessed dramatic technological change. As California looks toward using 50 percent or more renewable energy, it will depend on integrated technologies and revisions to existing systems to meet climate and energy transformation goals. The Energy Commission anticipates technological advancements that will offer flexible generation, assist with integrating renewable energy, provide energy storage, and harmonize demand with supply. These emerging energy technologies will support higher penetration of renewables and promote low-GHG emissions.

In this chapter, staff highlights some emerging technologies that could contribute to the transformation of California's energy system as the state continues to implement its climate and energy policies. Energy Commission staff does not endorse or advocate the use of any technology presented in this section, and information presented in this section is information from existing sources. The Energy Commission continues to remain technology neutral and supports a competitive marketplace for energy technologies, especially emerging technologies.

Generation

Evolution of Utility-Scale Solar Technologies

Solar energy has been a tremendous part of California's achieving its near-term RPS and climate goals. One enabling factor was the dramatic drop in cost of photovoltaic systems, from $4.10 per watt in 2010 to $1.80 per watt in 2015 for utility-scale systems, with comparable declines for rooftop systems.[258] [259] This cost decline has driven investment in both utility-scale PV generation and distributed rooftop systems in California. The solar energy conversion efficiency for PV is also improving, which should similarly increase land-use efficiency, in other words, smaller footprint per MW or per MWh.

Concentrating solar power (CSP) has not seen anywhere near the same level of cost declines. The opportunity to incorporate thermal energy storage into the design of these

258 Barbose, Galen, and Naim Darghouth, Lawrence Berkeley National Laboratory, *Tracking the Sun VIII: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States*, August 2015, http://eetd.lbl.gov/sites/all/files/lbnl-188238_0.pdf.

259 https://emp.lbl.gov/sites/all/files/lbnl-1006037_report.pdf.

plants may make them more attractive as California moves to higher penetrations of renewable energy.

Emerging Onshore Wind Technologies

Wind turbines have become dramatically more cost-effective as a result of improvement in turbine manufacturing processes and increases in wind turbine size. From 2003 to 2010, wind power capital costs increased due to rising commodity and raw materials prices, increased labor costs, improved manufacturer profitability, and turbine upscaling, pushing the levelized cost of electricity (LCOE) for wind upward in spite of continued performance improvements. DOE reported that the price of power purchase agreements for onshore wind dropped from rates up to $70/MWh to around $2/MWh between 2009 and 2015.[260]

Today, the average LCOE for onshore wind is approximately $70/MWh. According to U.S. DOE and National Renewable Energy Laboratory (NREL) projections[261], the estimated U.S. average LCOE for onshore wind plants in 2020 will be about $60/MWh (representing a decrease of 14 percent) with a range from $30/MWh and $80/MWh, depending on the quality of the wind resources and installed technology.

Wind energy technology is evolving in two directions: building larger turbines to capture more powerful and reliable wind speeds at higher altitudes, and making small turbines more aerodynamically efficient with higher capacity factors.

At an Energy Commission workshop for Identifying Challenges and Effective R&D Paths for Promoting Repowering Wind Energy on January 28, 2016,[262] participants recommended new wind resource maps at higher hub height, for instance, at around 200 meters (656 feet) compared to the 100 meter height wind maps that are being produced. Higher hub height could help improve the capacity factor. Workshop participants also suggested that some legacy projects might not be suitable for big turbines and components when repowering. Therefore, the alternative is to support small wind turbine modernization that achieves a high aerodynamic efficiency (gain through aerodynamic research) and modern small turbines with high capacity factors.

Bioenergy

Bioenergy from forest biomass could help alleviate the growing threat of wildfires while providing renewable baseload energy. This energy resource remains mostly untapped, largely due to regulatory and financial barriers. Current financial incentives for

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260 *August 2015 Wind Technologies Market Report*. http://energy.gov/sites/prod/files/2016/08/f33/2015-Wind-Technologies-Market-Report-08162016.pdf.

261 http://en.openei.org/apps/TCDB/.

262 http://www.energy.ca.gov/research/notices/index.html#01282016wind.

renewable power do not adequately monetize the many benefits of bioenergy; some have been inconsistently funded or discontinued, while others have failed to account for the additional costs and benefits of biomass. Environmental, waste disposal, public health, and pipeline safety regulations often complicate bioenergy permitting and development and sometimes contradict each other. In addition, access to transmission lines, pipelines, and other distribution networks also poses significant challenges to bioenergy development.

Due to consecutive years of severe drought, a devastating bark beetle infestation has plagued California forests in the Sierra Nevada, causing unprecedented tree mortality. The U.S. Forest Service estimates that more than 22 million trees have died in California during the multiyear drought. As noted in the Governor's 10-30-2015 Proclamation of a State of Emergency:[263] [264]

> "State agencies, utilities, and local governments to the extent required by their existing responsibility to protect the public health and safety, shall undertake efforts to remove dead or dying trees in high hazard zones that threaten power lines, roads and other evacuation corridors, critical community infrastructure, and other existing structures…"

In June 2016, the estimated number of dead trees was updated to 66 million, underscoring the need for immediate action.[265]Fire is a natural and beneficial part of many forest ecosystems. Forests with millions of dead trees, however, have an increased likelihood of catastrophic wildfires, which burn at much higher temperatures than prescribed fires. Because of these higher temperatures, catastrophic wildfires do not offer the benefits of naturally occurring or prescribed burns and can destroy entire forests and sterilize soils, even alter forestland to scrubland. Further, catastrophic wildfires emit black carbon,[266] a component of fine particulate matter, which has been identified as a leading environmental risk factor for premature death.

Sustainable forest management can help reduce the chances of catastrophic wildfires and associated black carbon emissions while providing energy, wood products, and

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263 https://www.gov.ca.gov/docs/10.30.15_Tree_Mortality_State_of_Emergency.pdf.

264 The U.S. Forest Service recently identified an additional 26 million dead trees in California since its last inventory in October 2015, bringing the total to a record 66 million dead trees. For more information, see http://www.usda.gov/wps/portal/usda/usdahome?contentid=2016/06/0150.xml&navid=NEWS_RELEASE&navtype=RT&parentnav=LATEST_RELEASES&edeployment_action=retrievecontent.

265 http://www.usda.gov/wps/portal/usda/usdahome?contentid=2016/06/0150.xml.

266 Black carbon from wildfires has been identified by the ARB as a short-lived climate pollutant (SLCP) and, by far, the largest source of black carbon emissions in California. Recent studies have also shown that black carbon emissions play a far greater role in global climate change than previously believed.

other uses. Bioenergy from woody biomass could provide an important source of renewable baseload energy and, for some technologies, perhaps even flexible generation. However, technological breakthroughs are needed to make bioenergy systems environmentally sustainable and economically viable.

To help address climate adaptation efforts in state forests, California was awarded more than $70 million in federal funding for an innovative disaster recovery and resilience program in Tuolumne County following the devastating 2013 Rim Fire. The funding, part of the U.S. Department of Housing and Urban Development's National Disaster Resilience Competition, will be used to help restore forest and watershed health, support local economic development through job training programs and development of a bioenergy and wood products, and increase disaster resilience in the rural mountain areas affected by the fire. This model program has been developed to be replicated in other forests and will fund restoration and reforestation of the burn area, development of a bioenergy and wood products facility, job training, and development of a community resilience center.[267]

Enhanced Geothermal Power

California has vast amounts of known and producing geothermal resources that offer significant opportunities to expand the share of geothermal in the state's renewable resource mix. A geothermal power plant must have three things: heat, fluid, and permeability. Historically, geothermal plants have been built where all three of these have existed naturally and relatively close to the surface. These ideal areas, called *hydrothermal reservoirs*, are relatively rare and have a limited capacity. The reservoirs can exist as high temperature and pressure brine (liquid), steam, or both. The electricity generating technology used depends on the type and temperature of the resource. Enhanced geothermal systems (EGS) are engineered reservoirs created to produce energy from geothermal resources that lack natural permeability and/or fluid. The United States Geological Survey estimated that California has a mean of 48,100 MW of potential power generation from EGS systems in low-permeability rocks.[268] Such potentials offer a major contribution to the state's climate and renewable energy goals but would require addressing policy issues that prevent or delay the development and purchase of geothermal power by electric utilities.

Geothermal energy is a renewable energy source that can provide a full range of both ancillary services and baseload power to the energy generation system. Geothermal power plants produce electricity reliably, day and night, and have very high capacity factors that are often above 90 percent. Geothermal power plants have one of the

267 http://www.hcd.ca.gov/nationaldisaster/resiliencecompetition.html.

268 Williams, Colin F., Reed, Marshall J., Mariner, Robert H., DeAngelo, Jacob, Galanis, S. Peter, Jr., 2008, "Assessment of Moderate- and High-Temperature Geothermal Resources of the United States: U.S. Geological Survey Fact Sheet 2008-3082, "4 p.

smallest land surface footprints per kW and provide low-carbon energy to the electric grid.

Recent advancements in power plant and control technology allow geothermal plants to provide flexible power in addition to baseload power. One example is the Puna Geothermal Venture plant in Hawaii. It has a capacity of 38 MW, which includes 16 MW of contracted flexible capacity.[269] The Energy Commission is supporting research to investigate how operation of Geysers geothermal facilities in Sonoma County may be modified to address the greater demands imposed on the grid by the significant addition of intermittent resources. Management and mitigation strategies needed to address specific flexible generation objectives will be identified and tested at a variety of representative problem areas. Geothermal production fields have also been associated with induced seismicity, where the net volume of fluid extracted and injected at geothermal sites was correlated with recent earthquakes.[270]

In 2015, an NREL report estimated the renewable energy potential in the Salton Sea area along with the potential for revenues to contribute to Salton Sea restoration costs. The report detailed some informative findings. By 2030, Salton Sea geothermal development is estimated at 1.05 GW to 1.81 GW. In addition to this, potential mineral recovery of lithium from Salton Sea brine is estimated at 51,000 to 122,000 metric tons annually. The resulting geothermal land lease royalties that could be usable for Salton Sea restoration ranges between $7 million - $15 million annually. It appears that any additional “restoration” tax could disadvantage the development of these resources compared to other regions.[271]

Power-to-Gas

Power-to-gas (or P2G) is an emerging approach for addressing both the long-term energy storage needs to help balance the grid and options for alternative fuel production for either on-site use or pipeline injection. In simple terms, P2G uses energy to power an electrolysis process to split water into hydrogen and oxygen, thereby converting electrical energy into chemical energy (from hydrogen). This approach allows a virtual integration of the natural gas pipeline system with the power or electricity grid through direct pipeline injection and blending of produced hydrogen or via a subsequent methanation (the production of methane, especially from carbon monoxide and hydrogen) process to turn the hydrogen into methane, followed by pipeline injection.

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269 Matek, Benjamin, 2015. “Flexible Opportunities With Geothermal Technology: Barriers and Opportunities.” *The Electricity Journal*, Vol. 28, Issue 9, 45-51.

270 Brodsky, E. E., and Lajoie, L. J. 2013. “Anthropogenic Seismicity Rates and Operational Parameters at the Salton Sea Geothermal Field. *Science* 341: 543-546.

271 National Renewable Energy Laboratory, 2015, *The Potential for Renewable Energy Development to Benefit Restoration of the Salton Sea: Analysis of Technical and Market Potential.*

Methane produced through this process may also be used for transportation fuel, electricity generation, or other purposes. The ability of P2G to operate flexibly and convert electricity into fuel positions the technology as a potential strategy to integrate renewable energy and reduce GHGs.

Many ongoing efforts of P2G focus on improving efficiency and reducing the cost of electrolysis. Alkaline electrolysis is considered the cheapest and most reliable technology, although emerging systems such as proton exchange membrane (PEM) electrolysis and solid oxide electrolysis show benefits of high performance, with the latter having a high potential for steady-state operations.[272] Water consumption of a P2G process could be small. For instance, one study estimates about 50 gallons of water and 1 MWh of energy can produce 20 kg of hydrogen.[273] In spite of these developments, cost-competitiveness of P2G remains a major challenge relative to other options for energy storage. NREL's study asserts that the total system cost to convert electricity to gas and then to transport and use the gas requires higher revenues to cover cost than those of comparable technologies and alternative fuel production.[274]

SoCalGas, in collaboration with NREL and UC Irvine, is assessing P2G technologies through two projects that employ three electrolyzers: a 7 kW pilot unit and two larger 60 kW and 150 kW electrolyzers. The SoCal Gas project with NREL converts electricity from a simulated PV system into hydrogen and oxygen, where hydrogen is mixed with CO_2 and injected into a methanogen-filled liquid medium to produce methane. Methane will be converted back to hydrogen, which will be used to produce electricity to study the entire round-trip renewable electricity storage cycle. On the other hand, the SoCalGas project with UC Irvine operates two electrolyzers using PV power generated on campus to experiment and model the dynamics of integrating renewable power generation with energy storage in the form of hydrogen production.[275] P2G efforts, such as the SoCalGas projects, leverage results from the DOE P2G initiatives and contribute to the technology development and demonstration needed to address technological and cost challenges.

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272 Gotz et al, 2016. "Renewable Power to Gas: A Technical and Economic Review." *Renewable Energy.* 85:1371-1390. http://www.sciencedirect.com/science/article/pii/S0960148115301610.

273 California Hydrogen Business Council. 2015. *Power-to-Gas The Case for Hydrogen White Paper.* https://californiahydrogen.org/sites/default/files/CHBC%20Hydrogen%20Energy%20Storage%20White%20Paper%20FINAL.pdf.

274 Eichman and Melaina, 2015. *Hydrogen Energy Storage and Power-to-Gas.* NREL/PR-5400-65386. http://www.nrel.gov/docs/fy16osti/65386.pdf

275 SoCal Gas 2015. Comments on the Draft AB 1257 (Bocanegra, Chapter 749, Statutes of 2013) Natural Gas Report, Docket No. 15-IEPR-04. http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-04/TN206274_20151002T155341_Tamara_Rasberry_Comments_Comments_from_Southern_California_Gas.pdf.

Since P2G involves hydrogen that will possibly be injected in the natural gas pipeline, there were renewed questions on the impact of hydrogen on pipeline durability and integrity. Hydrogen transport and storage may use steel pipelines for economic reasons. The durability of some metal pipes can degrade when exposed to hydrogen over long periods in a process known as *hydrogen embrittlement,* whereby metals become brittle and eventually fracture due to introduction and subsequent diffusion of hydrogen into the metal. This phenomenon is of particular concern when hydrogen at a state of high concentration and high pressure is injected into existing high-pressure natural gas transmission lines.

In a study conducted for NREL, the Gas Technology Institute (GTI) found that the impact of hydrogen on the natural gas distribution systems depends on the hydrogen concentration.[276] It found that if 20 percent hydrogen is introduced into the distribution system, the overall risk is not significant. Beyond 20 percent, the overall risk in service lines can significantly increase, and the potential hazards can become severe, while the overall risk in distribution mains can still be moderate, up to 50 percent. Taking into consideration the GTI results, NREL, in its 2013 study on blending hydrogen into natural gas pipeline networks, concluded that the effect depends highly on the type of steel and must be assessed on a case-by-case basis, although metallic pipes in U.S. distribution systems are generally not susceptible to hydrogen-induced embrittlement under normal operating conditions. NREL also did not find major concerns about the aging effect of hydrogen on polyethylene or polyvinylchloride pipe materials and most elastomeric materials used in distribution systems.[277]

Offshore Renewable Energy Technologies

Offshore renewable energy includes wind, wave, tidal, and ocean thermal technologies. The first U.S. offshore wind project is scheduled to be on-line in 2016 near Block Island, Rhode Island.[278]The Block Island Wind Farm uses fixed platform structures suitable to the relatively shallow outer continental shelf (OCS) off the East Coast and mid-Atlantic. Meanwhile, Europe has seen a boom in offshore wind development, with 11 GW installed

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276 GTI, 2010. “GTI Review Studies of Hydrogen Use in Natural Gas distribution Systems.” GTI Project Number 21029. An Appendix A to NREL 2013 *Blending Hydrogen Into Natural Gas Pipeline Networks: A Review of Key Issues*. http://energy.gov/sites/prod/files/2014/03/f11/blending_h2_nat_gas_pipeline.pdf.

277 NREL. 2013. *Blending Hydrogen Into Natural Gas Pipeline Networks: A Review of Key Issues.* http://energy.gov/sites/prod/files/2014/03/f11/blending_h2_nat_gas_pipeline.pdf.

278 http://dwwind.com/project/block-island-wind-farm/.

at the end of 2015.[279] Globally, there is an estimated 248 GW of offshore fixed-bottom wind in the development pipeline, the bulk of which is in Europe and Asia.[280]

In January 2016, Trident Winds, LLC submitted an unsolicited lease request to the federal Bureau of Ocean Energy Management (BOEM) for a floating wind energy project off the Pacific coast at Morro Bay,[281] the first formal request for a lease for wind development in federal waters off California. BOEM has confirmed that Trident Winds is legally, technically, and financially qualified to hold an offshore wind energy lease in federal waters and has begun to determine whether there is competitive interest in the area requested.[282] The project would be the first U.S. commercial project to use floating wind technology rather than fixed-bottom turbines. If approved, the project would begin construction in 2021-2022 and commercial operations in 2025.[283]

In response to a request from Governor Brown,[284] BOEM announced on May 31, 2016, that it will work with the State of California to establish a Federal-California Marine Renewable Energy Task Force to collaborate on planning, permitting, and coordination related to offshore renewable energy development off the California coast. BOEM has established similar task forces in 13 other coastal states to examine how to resolve potential conflicts between renewable development and environmental concerns and other uses.[285]

The Energy Commission held a workshop on May 25, 2016, to discuss issues surrounding development of offshore renewable energy in California.[286] Estimates presented at the workshop of offshore wind energy potential[287] along the state coastline

279 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211636_20160524T153307_Morro_Bay_Offshore_a_1000_floating_offshore_wind_farm.pptx.

280 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211749_20160608T080633_Offshore_Wind_Energy_Briefing.pdf.

281 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211636_20160524T153307_Morro_Bay_Offshore_a_1000_floating_offshore_wind_farm.pptx.

282 http://www.boem.gov/press03212016a/.

283 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211636_20160524T153307_Morro_Bay_Offshore_a_1000_floating_offshore_wind_farm.pptx.

284 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211458_20160513T085713_51216_Letter_from_Gov_Brown_to_Honorable_Sally_Jewell.pdf.

285 http://www.boem.gov/press05312016/.

286 http://www.energy.ca.gov/2016_energypolicy/documents/index.html#05252016.

287 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211627_20160524T153236_OffShore_California_Wind__Wave_Resources_and_Implications_for_1.pdf.

ranged from 59-76 GW of delivered power potential to 159 GW of technical resource potential.[288] [289] There is also an estimated 7,500 MW of offshore wave energy potential in California; the California Polytechnic State University in San Luis Obispo is conducting a two-year feasibility study under a U.S. DOE grant of siting a national wave energy test center off the California coast.[290]

Workshop participants stated that the focus of the offshore wind industry appears to be shifting to larger projects farther from shore and on deeper areas of the OCS. There is also a trend toward floating platform technologies that could take advantage of higher wind resources farther offshore and potentially pose fewer conflicts with the ocean environment and other ocean uses. These technologies could be used in areas like the West Coast, where the continental shelf drops quickly to a seabed hundreds of feet underwater, making it difficult to install conventional turbine platforms.[291] Only about 15 MW of floating wind capacity has been installed to date worldwide, but there are projections that, by 2020, more than 200 MW could be installed in the United Kingdom, Portugal, Japan, and France.[292] Costs for floating wind technologies remain high, but there is potential for cost reductions from reduced marine operations and increased economies of scale as the technology and market develop further.[293]

Wave technologies are not yet commercially available, but there are multiple companies developing technologies to use the kinetic energy in ocean waves to generate electricity or pump desalination projects. Workshop participants indicated that wave energy is consistent and forecastable; could complement variable renewable resources, including offshore wind; and provide the advance information needed by California grid operators to plan for and maintain grid reliability.[294]

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288 The technical resource potential refers to the technology-specific estimates of energy generation potential based on renewable resource availability and quality, technical system performance, topographic limitations, environmental, and land-use constraints only.

289 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211749_20160608T080633_Offshore_Wind_Energy_Briefing.pdf.

290 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211629_20160524T153252_CalWave_Update.ppt.

291 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211749_20160608T080633_Offshore_Wind_Energy_Briefing.pdf.

292 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211636_20160524T153307_Morro_Bay_Offshore_a_1000_floating_offshore_wind_farm.pptx.

293 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211749_20160608T080633_Offshore_Wind_Energy_Briefing.pdf.

294 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211629_20160524T153252_CalWave_Update.ppt.

At the May 25, 2016, IEPR workshop, several themes emerged regarding development of offshore renewable energy in California. A predominant concern was the need to ensure coordination and communication between permitting and licensing agencies, and for agencies to encourage early and ongoing input from all stakeholders while providing clear and understandable information to stakeholders. Other important issues included:

- The importance of identifying available data and data gaps.
- The need to conduct comprehensive and consistent environmental project review, using a science-based, landscape-level planning process to identify sensitive offshore areas.
- Uncertainties about identifying and implementing mitigation measures in an ocean.
- Addressing ongoing challenges faced by developers.
- The importance of establishing robust pre- and postmonitoring of projects to ascertain and manage impacts.

Workshop participants agreed that the multiple governmental agencies with permitting roles for offshore energy must establish strong connections and lines of communication and provide staff with experience and expertise on the issues likely to arise during permitting and licensing. It will also be important for agencies to clearly understand each agency's roles and responsibilities, commit to sharing data and information, and work toward streamlining the process and reducing duplication. Several stakeholders encouraged regulatory agencies to clearly define their jurisdictions and roles so that participants know which agencies to work with and how to participate in the process, and for agencies to convey complex information in understandable terms so that participants can understand the issues.

It was acknowledged that interagency agreements – such as a memorandum of understanding – can be helpful, but agencies generally agreed that many of the crucial relationships and connections among agencies are already in place from past permitting efforts. Participants noted there has been some experience with joint documents prepared for offshore oil and gas development off the Santa Barbara coast, as well as coordination on dredging activities in San Francisco Bay, both of which could help guide future coordination efforts for offshore renewable development.

Participants also emphasized the importance of developing strong relationships with the scientific community to allow agencies to integrate what is learned into their planning processes. Because of the novelty of offshore energy development in California and the uncertainty about what technologies will be proposed, participants agreed that it is difficult to identify data gaps. BOEM is organizing a conference in late 2016 in Northern California to discuss offshore renewable technologies and environmental information sharing and hopes to have a better sense of what additional data needs will be at that time. There were various potential data sources identified in the workshop, including offshore data from the U.S. Department of the Navy; environmental documents prepared for proposed offshore projects in Oregon; transects of ocean data by the California Department of Fish and Wildlife; mapping of the territorial sea floor by the U.S. Geological Survey; marine scanning data of Southern California by the Nature Conservancy; and data from offshore wind projects developed in other parts of the world, as well as from offshore oil and gas development off the California coast and elsewhere.

There were concerns, however, that data from other development projects might not be relevant to California's unique situation, which includes proposed deep water development, aggressive environmental laws and regulations, and the novelty of the technologies being analyzed. Some specific areas participants identified as requiring additional data included the types of vibration, noise, and electromagnetic fields produced by offshore energy projects and the related impacts on species and habitats; the potential for interactions between ocean life and submerged project infrastructure; ways to conduct remote monitoring of projects located far offshore; the potential cumulative impacts of offshore wind projects with multiple turbines, as well as multiple projects; the determination of how far projects should be from biologically rich and sensitive areas, where most impacts could occur; and the effects of wave energy removal on shore environments and surfers.

More than one participant noted it would be helpful to develop a preconstruction baseline before any projects are approved to provide an accurate picture of existing species, habitats, and resources. Others emphasized that consistent data gathering standards are essential. Several participants pointed out that because offshore energy development is relatively new and these technologies have not yet been tested in California, it is unclear how mitigation of species impacts would play out.

Some stakeholders at the workshop expressed concerns about potential impacts of offshore renewable energy development that must be considered when evaluating new projects.[295] Sport and commercial fishing groups noted the difficulty of providing adequate representation of their members due to the lack of experience with ocean energy projects, the cost of taking unpaid time from work to participate in proceedings, and the inability of a single representative to speak for multiple fisheries since each port has specific issues and challenges. There were also concerns that with commercial fishing already declining, development of ocean energy could further fragment fisheries already affected by marine protected areas,[296] stringent fishing regulations, and navigation restrictions. Another issue is the potential impact of offshore wind turbines

295 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211641_20160524T153357_Ocean_Energy_Development_and_Regulation_Issues_and_Concerns.pdf.

296 Executive Order 13158 defines a marine protected area as "...any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein."

on certain bird species, particularly given that seabirds have been identified as one of the most threatened groups of organisms globally.[297] Potential avian impacts that were identified included collision with offshore wind turbines and onshore transmission lines; effects on migratory pathways, foraging habitat, and forage fish; and impacts on coastal zones and sea beds where birds nest and forage. Moreover, there were concerns about how offshore renewable development might impact ocean-dependent recreation.

There was discussion at various points during the workshop about identifying areas in the ocean and coastal environment where development would have the least impact. Agencies noted there are no plans for such a programmatic approach at this time. One of the challenges with such an approach noted by participants is the location-specific nature of offshore renewables, which can depend on resource availability and the existence of infrastructure to bring the energy to shore. The advantages of a landscape-level planning process were raised by multiple participants, particularly environmental groups, who cited the success of the DRECP and the effort to identify least-conflict lands for solar development in the San Joaquin Valley, both of which are helping ensure smart planning, reduce project impacts, and provide opportunities for robust stakeholder and industry participation.

There was also discussion about the impacts of climate change on ocean environments and the need for future planning for ocean energy development to consider the type of ocean environment being planned for. Participants talked about ocean acidification and warming as a result of climate change, acknowledged the often difficult tradeoffs between policies to reduce dependence on fossil fuels by promoting renewable energy and policies to protect the environment from the impacts of energy development (including renewable energy), and agreed that planning needs to account for potential changes in the ocean environment.

Developers at the workshop discussed the opportunities and constraints of constructing and operating offshore renewable energy projects in California and the types of offshore wind technologies that might be used. There was general agreement that floating wind technologies are moving rapidly to commercialization scale, and that the United States is increasingly seen as a priority market.[298] Permitting of offshore projects will be a challenge, with a representative for Trident Wind, LLC noting that the project will need 33 permits and licenses to be completed.[299] Another developer noted that it takes at least two years for preconstruction studies to evaluate environmental effects on

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297 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211642_20160524T153357_Offshore_renewable_energy_in_california_and_birds.pptx.

298 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211639_20160524T153351_Enabling_a_paradigm_shift_in_offshore_wind.pptx.

299 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211636_20160524T153307_Morro_Bay_Offshore_a_1000_floating_offshore_wind_farm.pptx.

marine life and emphasized the importance of working with environmental organizations to determine exactly what studies are needed and where data gaps exist. Other challenges that developers identified included the need for policy certainty regarding California's support for offshore technologies and regulatory certainty and a transparent and workable regulatory process that developers can understand and comply with. It remains to be seen whether utilities will be interested in PPAs for offshore projects. However, the CalWave project has an agreement in place with Vandenberg Air Force Base for onshore operations and for negotiating a power sales agreement.[300]

Distributed Energy Resources

As described in Chapter 3, the electricity system is evolving into a more decentralized system that integrates more distributed energy resources (DER) than before. DERs encompass a broad range of combinations of small-scale clean energy resources. Assembly Bill 327 (Perea, Chapter 611, Statutes of 2013) defines DER to include distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies. AB 327 also added Public Utilities Code Section 769, which directs the IOUs to prepare and submit distribution resource plans (DRPs) to the CPUC for review, modification, and approval.

In August 2014, the CPUC opened a DRP proceeding to guide IOUs to develop plans to comply with Section 769 and to evaluate the capability of existing IOU infrastructure and planning processes to integrate DER into how the electric system is planned and operated.[301] In July 2015, the IOUs submitted their DRP applications, and the CPUC, working with parties and the public, has been reviewing, modifying, and approving portions of the DRPs.

Before the CPUC initiated the DRP proceeding, in September 2013, Caltech's Resnick Sustainability Institute and the California Governor's Office created the More Than Smart (MTS) initiative to "provide an engineering/economic framework for state regulators to consider complex changes needed to electric distribution company operations, infrastructure planning and oversight with high penetrations of DER."[302] Through a series of working group meetings with a diverse group of experts, MTS

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300 http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211629_20160524T153252_CalWave_Update.ppt.

301 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M103/K223/103223470.pdf.

302 http://morethansmart.org/.

released *More Than Smart: A Framework to Make the Distribution Grid More Open, Efficient and Resilient* (the "More than Smart" paper).[303]

The More than Smart paper is included in the scoping memo for the CPUC's DRP proceeding as "a useful framework" for developing DRPs. The integrated framework that More than Smart recommends for integrating more DER is based on these principles:

- Distribution planning should start with a comprehensive, scenario-driven, multistakeholder planning process that standardizes data and methods to address locational benefits and costs of distributed resources.
- California's distribution system planning, design, and investments should move toward an open, flexible, and node-friendly network system (rather than a centralized, linear, closed one) that enables seamless DER integration.
- California's electric distribution service operators[304] (DSO) should have an expanded role in utility distribution operations (with California ISO) and should act as a technology-neutral marketplace coordinator and situational awareness and operational information exchange facilitator while avoiding any operational conflicts of interest.
- Flexible DER can provide value today to optimize markets, grid operations, and investments. California should expedite DER participation in wholesale markets and resource adequacy, unbundle distribution grid operations services, create a transparent process to monetize DER services[305], and reduce unnecessary barriers for DER integration.

Also in response to AB 327, the CPUC rescoped its integrated demand-side management proceeding to focus on developing mechanisms to procure a broader set of distributed resources as integrated distributed energy resources (IDER). The IDER proceeding focuses on establishing the ways in which DER is competitively sourced from locations that the IOUs identify in their DRPs. The CPUC is coordinating the DRP and IDER proceedings together.[306]

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303 The report *More Than Smart: A Framework to Make the Distribution Grid More Open, Efficient and Resilient* is available here: http://morethansmart.org/wp-content/uploads/2015/06/More-Than-Smart-Report-by-GTLG-and-Caltech-08.11.14.pdf.

304 A Distribution Service Operator (DSO), as described in the "More Than Smart" paper, refers to an entity responsible for providing safe and reliable electric service to customers, such as an electric utility or third party service provider. The More Than Smart framework describes a DSO as possibly having an expanded role within distribution system operations, including reliability coordination with balancing authorities and transmission operators and potentially supporting energy transactions across the distribution grid.

305 Monetizing distribution services, as described in the "More Than Smart" paper, refers to the creation of new markets for DER, above and beyond traditional demand response services, that will determine the multiple values of DER and compensate DER owners and operators for distribution services.

306 For more on the IDER proceeding see http://www.cpuc.ca.gov/General.aspx?id=10710.

In general, DER, especially renewable DER, has less environmental impact per MW than conventional generation and utility-scale renewable energy development. DER, being typically close to load centers, is often on or near developed sites (for example on rooftops and brownfields) rather than greenfields.[307] Some DERs, like energy efficiency or automated demand response that operates with sensors and small controllers, have very little impact on the environment. Nevertheless, some small facilities, especially smaller wholesale solar PV projects, may be developed on lands with wildlife habitat or agricultural values or may have other localized environmental impacts related to visual resources or other issues. Therefore, DER isn't without potential environmental impacts, and, as described above, the state is working on strategies to overcome integration and operational challenges associated with a high deployment of DER.

Integration of Distributed Energy Resources

As described in Chapters 2 and 3, the installation of distributed PV systems has grown dramatically in California, and this trend is only expected to accelerate as costs continue to decline. Due to the variable and mostly unpredictable nature of solar resources at any given location, because of cloud cover and other atmospheric phenomena, these PV systems require support from the electricity grid in the form of increased operating reserves and ancillary services. Thus, distributed PV systems need complementary technologies to integrate fully them into the grid. Through net energy metering, it is possible for consumers to access the operating reserves and ancillary services with high reliability and very little consumer cost. Essentially, NEM customers are able to use the electric grid as energy storage, which can drive up the cost of maintaining and operating the electric system for electric consumers without NEM. As described in Chapter 2, with the passage of AB 327, the CPUC updated rules and policies that better balance the cost of integrating distributed generation. These rules will apply to new NEM customers no later than July 2017.

Some emerging strategies may help lessen the impacts that widespread deployment of PV systems is expected to have on the grid. For example, improved distribution system planning like that described by More than Smart and being proposed in the IOU DRPs can help improve the locational impacts of solar PV on the grid and the environment. Also, packaging distributed PV with other DER at the building and/or community scale may help address this issue by smoothing short-term ramps in generation output, providing needed grid services to the local distribution grid (such as reactive power, voltage support, and frequency regulation), and shifting oversupply to meet evening peak demand and effectively level the net-load "duck curve." These combined DER products can potentially participate in California ISO markets as bundled DER

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307 In this context, *brownfields* are those places that have previously been developed and *greenfields* are lands not previously developed or polluted..

products.[308] DERs can include energy efficiency measures, demand response, energy storage technologies, distributed generation resources, electric vehicles, and a range of other energy resources connected at the distribution level, often behind the customer meter.

Initial studies have suggested that the operational value of distributed PV can be dramatically increased by the inclusion of energy storage,[309] advanced inverters,[310] and other enabling technologies at or near the site of generation. Strategic installation of distributed PV and energy storage with other DER at specific locations on the distribution grid may reduce the need for other system upgrades, which can translate to less spending for utilities and savings for electricity customers.[311] To this point, the value of combined DER portfolios and the services they may be able to provide have not been adequately quantified or demonstrated, but current and planned research will provide better data and information that can be factored into grid modeling and integrated resource plans. For example, smart inverters[312] have the potential to support the grid by providing reactive power, voltage regulation, and frequency regulation.[313] However, additional investigation is needed to determine the most effective ways to use

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308 To learn more about the California ISO initiative to open markets to DER, see *Expanded Metering and Telemetry Options Phase 2: Distributed Energy Resource Provider*, http://www.caiso.com/Documents/DraftFinalProposal_ExpandedMetering_TelemetryOptionsPhase2_DistributedEnergyResourceProvider.pdf.

309 Rocky Mountain Institute. October 2015. *The Economics of Battery Energy Storage*. http://www.rmi.org/Content/Files/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf.

310 National Renewable Energy Laboratory. November 2014. *Advanced Inverter Functions to Support High Levels of Distributed Solar*. http://www.nrel.gov/docs/fy15osti/62612.pdf.

311 Tierney, Susan F. Ph.D. March 2016. The Value of "DER" to "D": The Role of Distributed Energy Resources in Supporting Local Electric Distribution System Reliability. http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/Thought_Leaders_Events/Tierney%20White%20Paper%20-%20Value%20of%20DER%20to%20D%20-%203-30-2016%20FINAL.pdf.

312 An *inverter* is an electronic device that converts direct current to alternating current. For an inverter to be considered smart, it must have a digital architecture, bidirectional communications capability, and robust software infrastructure.

313 *Reactive power* is the portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers. It also must supply the reactive losses from transmission facilities. Reactive power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors and directly influences electric system voltage. *Voltage support* is a service provided by generating units or other equipment such as shunt capacitors, static VAR compensators, or synchronous condensers that is required to maintain established grid voltage criteria. *Frequency regulation* is an ancillary service category that provides support for maintaining grid stability within a defined range above or below 60 Hertz. Source: California Public Utilities Commission, Key Definitions for Energy Storage Proceeding R.10-12-007, http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=3155

standardized advanced inverter capabilities to enhance system performance.[314] Nonvariable renewables, including small hydroelectric, biomass, geothermal, and CSP, could operate more flexibly to be responsive to system needs.[315]

To this end, the Energy Commission's Energy Research and Development Division will support development of a roadmap on enabling high-penetration renewables, including DERs. The roadmap will investigate research conducted to date, barriers, and research gaps, and identify future research needs.

As described above, California's utilities are undertaking several efforts to unlock the value of DER to the grid, including the DRP proceeding, IDER proceeding, and the Rule 21 update Smart Inverter Working Group (SIWG). Most recently, on September 29, 2016, the CPUC released a discussion draft titled *California's Distributed Energy Resources Action Plan: Aligning Vision and Action* to help align the CPUC's vision and actions to advance DER.[316] The DRPs submitted by the IOUs to the CPUC identify the best locations for deploying distributed resources through what is called a locational net benefits analysis (LNBA) and an integration capacity analysis (ICA).[317] Both analyses are the first steps in the state's push toward a more decentralized electric grid. The Energy Commission is also assessing the extent to which DER technologies may meet future load growth and replace utility-scale generation that must be connected to load centers with transmission.[318] There are many challenges with planning for multiple variables and developing a highly distributed electric grid, especially challenges related to balancing unpredictable consumer choice with system reliability.[319]

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314 As described in *San Joaquin Valley Distributed Energy Resource, Regional Assessment,* the Energy Commission plans to assess the effects of smart inverters on the energy system at the distribution feeder level. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-200-2016-004.

315 California Energy Commission. 2016. *2015 Integrated Energy Policy Report*. CEC-100-2015-001-CMF http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN212017_20160629T154354_2015_Integrated_Energy_Policy_Report_Small_File_Size.pdf.

316 CPUC, *California's Distributed Energy Resources Action Plan: Aligning Vision and Action*, September 29, 2016, http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Commissioners/Michael_J._Picker/2016-09-26%20DER%20Action%20Plan%20FINAL3.pdf.

317 The SIWG is in charge of developing recommendations for smart inverter functions that would best allow for efficient management of the distribution system. However, the locational values and assumptions of smart inverter functions used for LNBA and ICA in the DRPs need to be verified, and many of the advanced inverter functions recommended by the SIWG have not yet been demonstrated in the field.

318 See the Energy Commission report *San Joaquin Valley Distributed Energy Resource, Regional Assessment* which evaluates the impacts of distributed energy resources at a regional scale on SCE's electricity system in the Southern San Joaquin Valley. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-200-2016-004.

319 See the Energy Commission staff paper *Customer Power, Decentralized Energy Planning and Decision-Making in the San Joaquin Valley*, which describes consumer challenges to overcoming barriers to DER deployment. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-200-2016-005.

The remainder of this section provides overviews of DER technologies.

Energy Efficiency

To achieve the state's goals of zero-net energy (ZNE) for residential and commercial buildings by 2020 and 2030, respectively, and the SB 350 energy efficiency goals by 2030 will require a combination of existing and emerging energy efficiency technologies. Areas of focus will include lighting, plug loads, climate-appropriate HVAC systems, integrated hybrid (heating/cooling/hot water) systems and controls, and combined emphasis on water- and energy-saving technologies. On January 27, 2016, the Energy Commission adopted energy efficiency standards for light–emitting diode (LED) bulbs.[320] The new standards, which are the first in the nation, apply to general purpose lighting and small-diameter directional lamps and require that the bulbs have minimum efficiency and lifetime, and quality requirements.[321] The new standard will go into effect on January 1, 2018, will save consumers more than $4 billion over the first 13 years, and will conserve enough electricity to power all of the households in Santa Barbara and Ventura Counties (about 400,000 average homes.)[322] Plug loads, the energy used by products powered by an ordinary AC plug, represent the largest uncontrolled load and can include consumer electronics, appliances, and electric vehicles. Future technology improvements could focus on improved methods for controlling the standby energy used by these devices and scaling the power use to operational needs. Future advanced HVAC, appliance, and LED lighting technologies could focus on solid-state systems that bypass DC to AC conversion and could be operated directly off PV systems without the need for inverters, reducing conversion efficiency losses. Also, cost-effective and efficient methods of tightening building envelopes minimize the need for air conditioning and heating, which would reduce energy and GHG emissions. While all these technologies and approaches apply to both new construction and existing buildings, the strategies for successful implementation may follow different paths—and focus on different technologies and approaches to achieve the greatest potential impact.

Demand Response

Traditional demand response (DR) involves a change in how customers consume electricity. The objectives of such a change are to better align the timing of electricity supply and demand to enable customers to reduce costs and, in the process, lessen the environmental impacts of electricity production. Demand can respond in a variety of ways: shifting consumption from higher-priced to lower-priced periods, reducing

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320 "Energy Commission Adopts Lighting Standards to Save Californians More than $4 Billion in Electricity Costs," http://www.energy.ca.gov/releases/2016_releases/2016-01-27_adoption_of_lighting_standards_nr.html

321 Ibid.

322 Ibid.

consumption when the electricity system or the natural gas system face emergencies or contingencies, and even increasing consumption when an electricity system faces a potential imbalance due to excessive supply.

The technologies that enable demand response are numerous, ranging from sophisticated real-time telemetry and communications control of energy management systems to manual operation of devices. Advances in communication and control technologies have lowered the cost of demand response significantly.

Demand response holds the promise—particularly if expanded to include large numbers of small loads—of being able to better balance supply, especially intermittent renewable generation, with customer demand. In the process, demand response could help the state meet its environmental and renewable energy goals.

The California ISO's 2012 *Demand Response and Energy Efficiency Roadmap*[323] set out a plan for how DR and EE could become integral, dependable, and familiar resources that will promote DER integration, serving as critical substitutes for fossil generation in balancing supply and demand. The roadmap highlights specific areas where coordination and communication will build new market opportunities for DR and EE solutions to meet the needs of both end-use customers and the power system as a whole through four concurrent paths: load reshaping, resource sufficiency, operations, and monitoring. The Energy Commission, CPUC, and California ISO have made significant progress along those paths. As reported in the *2015 IEPR*, the CPUC, IOUs and other stakeholders worked to expand participation in California ISO demand response market by clarifying categorical definitions tied to performance, participation, and verification criteria that would allow DR to be compensated according to the benefit it provided to the system. DR was split into *supply-side* and *load-modifying* demand response to account for the ability of a resource, or combining of resources, to be compensated as capacity resources. The Demand Response Auction Mechanism[324] approved by the CPUC in 2015 enables aggregation of loads by third parties to provide DR in ISO markets. A November 2015 CPUC decision[325] aligns the value of demand response with integration of IOU demand response into the California ISO markets.

In addition, the potential for integrating demand response and the evolution of DR in conjunction with storage and other DERs to meet grid needs and minimize carbon

323 California Independent System Operator. 2013. *Demand Response and Energy Efficiency Roadmap.* http://www.caiso.com/documents/dr-eeroadmap.pdf.

324 California Public Utilities Commission, Energy Division, *Resolution E-4728. Approval with Modification to the Joint Utility Proposal for a Demand Response Auction Mechanisms Pilot Pursuant to Ordering Paragraph 5 of Decision 14-12-024.* http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M153/K436/153436367.pdf.

325 California Public Utilities Commission, Decision Addressing the Valuation of Load-Modifying Demand Response and Demand Response Cost-Effectiveness Protocols, *Decision 15-11-042,* November 19, 2015. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M143/K313/143313500.PDF.

emissions are being evaluated as part of the Electric Power Investment Charge (EPIC) Program research and development portfolio.

Microgrids

There are many definitions of microgrids, and California doesn't have a specific definition. However, the state held a workshop in May 2016 to initiate a microgrid roadmap that will work with stakeholders to develop a definition of a microgrid and identify recommendations to overcome regulatory, market, and technical barriers to developing microgrids.[326] Generally, a microgrid includes a group of interconnected loads and distributed energy resources that can easily connect and disconnect from the larger electric grid while acting as a controllable entity to maintain operations during grid outages and/or provide a range of services to the larger grid. Microgrids allow for balancing energy supply and demand at a local level and for a facility or community to operate independently of the larger grid. This ability enables microgrids to improve grid resiliency and provide relief during grid outages, which can occur during extreme weather or natural disasters. For example, the Borrego Springs microgrid in San Diego County has demonstrated on multiple occasions that the operator of the microgrid, SDG&E, can maintain electric power in the community of Borrego Springs without the larger electric grid. Microgrids also allow for facilities or communities to achieve a higher penetration of renewable energy because microgrids are able to self-balance supply and demand, as well as control export to the larger electric grid.

Transportation Electrification

With the Governor's Executive Order B-16-2012 calling for 1.5 million zero-emission vehicles by 2025, a large portion of which are expected to be plug-in electric vehicles (PEVs), and the pending Volkswagen settlement expected to bring $800 million to California to support zero-emission vehicle infrastructure, the successful integration of these vehicles into the electric grid is critical. The Energy Commission and the California utilities invest in transportation electrification through programs and investments that promote greater PEV charging infrastructure, more consumer options for charging equipment and services, and deployment of PEVs to assist in grid management and renewable generation integration that minimize cost and maximize benefits. The CPUC also has established ongoing proceedings to simplify PEV charging infrastructure and transportation electrification implementation for the California IOUs and PEV stakeholders.[327]

To help achieve the Governor's executive order goal of reaching 1.5 million zero-emission vehicles (ZEVs) on California roads by 2025, continued research related to

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326 http://www.energy.ca.gov/research/notices/index.html#05242016.

327 http://www.cpuc.ca.gov/General.aspx?id=5597.

PEVs will be needed, including advancements for charging systems, communications for bidirectional power flow, recycling of PEV batteries, and integration of PEV fleets. The state also needs to develop advanced methods of smart[328] and efficient charging for "aggregated PEVs"[329] that help address intermittency and overgeneration issues associated with supply- and demand-side renewable generation.

Vehicle-to-Grid

Vehicle-to-grid (V2G) is defined as the bidirectional power flow between the electric grid and a plug-in electric vehicle (PEV). The electric grid will supply power to charge the PEV battery to satisfy the owner's mobility needs, while the V2G technologies will enable the PEV to send power back to the grid during critical peak demand times. V2G-enabled PEVs can offer a promising and potentially revolutionary alternative for meeting the state's transportation energy and electrical grid balancing needs.

The California ISO partnered with the Energy Commission and the CPUC to develop a *Vehicle-Grid Integration Roadmap*[330] that develops pathways to enable electric vehicle grid services while maintaining user mobility needs. The roadmap pathways aim to address unmanaged charging of electric vehicles, which could lead to an increase in peak demand. V2G technologies and strategies can be used to encourage PEV drivers to charge during times when grid demand is low and/or renewable sources are abundant. Charging PEVs during times of low electricity demand or high renewable generation will address two problems simultaneously. It will shift vehicle charging away from peak demand times, and it will productively use renewable electricity when it is most abundant and thus help reduce the possibility of overgeneration from renewable electricity sources on the electric grid. V2G technologies have the potential to support the stability and reliability of the electricity grid when control and communication between the vehicles and electricity grid operators are effectively operated.

The U.S. Department of Defense, in partnership with the Energy Commission and other agencies, is demonstrating V2G services at the Los Angeles Air Force Base on more than 40 nontactical PEVs. This project will provide critical data on the ability of electric vehicles to provide frequency regulation as an ancillary service while fulfilling base personnel mobility needs. It will also provide the PEV marketplace with information on the impacts of V2G services on the battery life and warranty. This groundbreaking project will also help provide business cases for civilian fleets to benefit from future V2G operations.

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328 Charging PEVs when the grid is less congested to complement peak electricity consumption.

329 Grouped or networked PEVs that demonstrate the benefits of their combined energy resource capabilities.

330 http://www.caiso.com/documents/vehicle-gridintegrationroadmap.pdf.

Microturbines, Fuel Cells, and Other Advanced Generation Technologies

Microturbines and fuel cells present viable alternatives to reciprocating internal combustion engine generators due to moderately higher efficiencies and significantly lower emissions.

Microturbines were originally used as auxiliary power units to generate electricity on-board aircraft. They extract useful work from the combustion of fuel through the Brayton thermodynamic gas cycle. Air is compressed, mixed with fuel and burned in a combustor, and then expanded across a turbine to produce torque for driving a generator before being exhausted. The exhaust gas has a relatively high temperature and is often used to reduce fuel consumption by preheating the compressed air before passing to the combustor. Further exhaust heat recovery allows use in combined heat and power (CHP) applications.

Commercial microturbine systems can be as small as a refrigerator to as large as a shipping container and range from 35 kW to 1 MW in capacity. Multiple microturbines can be installed in parallel to meet higher capacities. Microturbines can be fueled by a wide variety of gaseous and liquid fuels but are typically fueled by natural gas or biogas. As of late 2014, there are nearly 200 microturbine CHP system installations generating more than 45 MW in California.[331]

Compared to reciprocating engine-based systems, microturbines tend to require less maintenance and are highly reliable. The efficiency of microturbines, however, is only marginally better in most cases, and the upfront cost is much higher. Technology research for microturbines focuses mainly around increasing system efficiency. The large difference in inlet versus exhaust temperatures (which range from about 500 °F to 1200 °F) presents an opportunity for efficiency gains through various heat recovery schemes. However, these methods are challenging to employ cost-effectively on such small systems. Other research centers around extreme fuel flexibility that allows microturbines to operate on dirty or otherwise unusable fuels.[332]

The Energy Commission has supported research into advanced microturbine systems. One project developed and demonstrated a biogas-fueled microturbine with ultra-low emissions, accomplished by integrating a low-swirl combustor with a Capstone 60 kW

331 https://doe.icfwebservices.com/chpdb/state/CA.

332 http://energy.gov/eere/amo/downloads/fuel-flexible-microturbine-and-gasifier-system-combined-heat-and-power-0.

microturbine.[333] Another project developed a 100 kW integrated microturbine-boiler CHP system and demonstrated it in a real-world setting at a hotel.[334]

Like the microturbine, fuel cells owe the origin to aerospace applications, where they were used to supply electricity and clean water on-board spacecraft. Unlike combustion-based generators, fuel cells convert fuel directly into electricity through an electrochemical reaction. This reaction requires a fuel and oxidizer on opposite sides of a fuel cell *stack*. A reformer supplies the stack with hydrogen stripped from the primary fuel and with an inverter to convert the fuel cell output from DC to AC to serve local load and to enable grid interconnection. Although fuel cells do not directly burn fuel to generate electricity, they still produce waste heat that may be used in a CHP system, depending on the type of fuel cell and reformer deployed in the system.

Various fuel cell types exist on the market, distinguished by the electrolyte material. These include alkaline fuel cells, proton exchange membrane fuel cells, phosphoric acid fuel cells, molten carbonate fuel cells, and solid oxide fuel cells. Commercial fuel cell systems can be a small as a desktop computer to as large as a shipping container and range from 1 kW to 5 MW in capacity. As with microturbines, multiple systems can be installed in parallel to meet higher capacities. Fuel cells are fueled by hydrogen, natural gas, and even biogas, if sufficiently cleaned and upgraded before being fed to the fuel cell. As of late 2014, there are more than 200 stationary fuel cell system installations generating more than 100 MW in California; about half of this capacity is CHP installations.[335]

Compared to reciprocating engine- and microturbine-based systems, fuel cells exhibit the highest efficiency and lowest emissions but at a much higher cost. Fuel cells that use natural gas or biogas produce almost no NO_x, CO, or VOCs, while those that use hydrogen produce no emissions. Technology research for fuel cells focuses mainly on reducing system cost and increasing stack life and durability. Fuel cell electrodes are plated with expensive precious metal catalysts to create the anodes and cathodes, while the electrolyte materials are often specialized and expensive. In addition, fuel cell stacks tend to degrade over time, requiring regular (and costly) replacements. Stack materials are also extremely vulnerable to low levels of contaminants, such as those found in biogas or polluted air. Alternate fuel cell materials or advances in durability could substantially increase the viability of fuel cells in the future.

Recent developments in emission control systems have led to lower emissions from some reciprocating internal combustion engine-based systems. Reciprocating engine-

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333 http://www.energy.ca.gov/2016publications/CEC-500-2016-037/CEC-500-2016-037.pdf.

334 http://www.energy.ca.gov/2013publications/CEC-500-2013-112/CEC-500-2013-112.pdf.

335 http://www.casfcc.org/STATIONARY_FC_MAP/default.aspx.

based systems are the dominant technology due to technological maturity, low upfront cost, and customer familiarity, among other reasons. However, they typically exhibit low efficiency and high emissions relative to microturbine and fuel cell systems. The high emissions, in particular, is a barrier with regard to air permitting and aligning with state clean energy goals. Emissions control research funded by the Energy Commission, such as Tecogen's two-stage exhaust after-treatment catalyst, has enabled ultra-clean generation from reciprocating engine-based systems. Advancements in emissions control technology will be critical to bring low-cost, clean generation to market.[336]

The Energy Commission has long supported the development and deployment of clean and efficient advanced generation technologies such as the microturbine, fuel cell, and advancements in reciprocating engines and other emerging technologies. The Advanced Generation Roadmap developed in 2009 has guided research and development in this area.[337] An update to this roadmap, focused on advanced distributed generation roadmap, is being developed, and key recommendations were discussed at a workshop.[338]

Energy Storage

Energy storage has the potential to play an important role in California's transition to a more sustainable grid. To implement Assembly Bill 2514 (Skinner, Chapter 469, Statutes of 2010), the CPUC established an energy storage procurement target of 1,325 MW for IOUs by 2020, with installations required no later than the end of 2024.[339] Expansion of energy storage capacity will help optimize grid operations by levelizing power generation from intermittent renewables, reducing peak power demand, and reducing the need for additional power plants and transmission and distribution upgrades.[340]

In the first round of the AB 2514 energy storage procurement, the California IOUs selected more than 300 MW of energy storage systems. Among these projects are the use of a 100 MW battery storage system to replace a peaker plant, 50 MW of buildings and energy storage combinations that provide fast grid storage, and the assessments of new energy storage technologies like flywheels, zinc air battery technology, and a range of applications for lithium ion battery technologies. The IOUs are preparing for the

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336 See http://www.energy.ca.gov/2013publications/CEC-500-2013-087/CEC-500-2013-087.pdf and http://www.energy.ca.gov/2010publications/CEC-500-2010-006/CEC-500-2010-006.PDF.

337 http://www.energy.ca.gov/2012publications/CEC-500-2012-079/CEC-500-2012-079.pdf

338 http://www.energy.ca.gov/research/notices/2015-11-18_workshop/2015-11-18_Presentation_Adv_Dist_Gen_Research_Workshop.pdf

339 CPUC, *Decision Adopting Energy Storage Procurement Framework and Design Program* Decision 13-10-04, http://www.cpuc.ca.gov/General.aspx?id=3462.

340 http://www.energy.ca.gov/research/energystorage/tour/.

second round of competitive bids for future energy storage projects and will announce their selections in 2017. With this large increase in the application of energy storage, California is becoming a key state in evaluating and assessing the performance and value of energy storage to support the rapidly changing needs of the California grid.

Many emerging energy storage technologies could be integrated into the grid.[341] Some are already beginning to be applied. Pumped hydro energy storage (PHES) has historically been the largest-capacity form of grid energy storage; however, as more energy storage awards are provided under the CPUC energy storage procurement targets, the future of energy storage is much more diverse. PHES involves storing energy in the form of water pumped from a lower elevation reservoir to a higher elevation reservoir by using pumps running on abundant low-cost, off-peak electric power. During periods of high electrical demand or less available power, the stored water is released through turbines to produce electric power to meet demand. Despite some energy losses during this process, the overall system increases available power and revenue by selling more electricity during periods of peak demand, when electricity prices are highest. The Energy Commission and the CPUC held a joint workshop on November 20, 2015 to discuss the merits, plans, and value of bulk energy storage to support the future needs of the grid as higher penetrations of renewables are integrated on the grid. The results of this workshop also helped the CPUC assess the value of bulk energy storage in the CPUC's Long-Term Procurement Plan (LTPP).

Compressed air energy storage uses pressurized air as an energy storage medium. An electric motor-driven compressor is used to pressurize the storage reservoir using off-peak energy, and air is released from the reservoir through a turbine during on-peak hours to produce energy. The turbine can also be fired with natural gas or distillate fuel. Ideal locations for large compressed air energy storage reservoirs are empty aquifers, abandoned conventional hard rock mines, and abandoned hydraulically mined salt caverns.[342]

Solid-state batteries include a range of electrochemical storage solutions, where electricity is stored in solid electrode materials separated from each other by a solid electrolyte (for example, lead acid battery, nickel-cadmium, lithium ion battery, sodium sulfur, capacitors). Flow batteries store energy directly in the electrolyte solution (for example, vanadium redox, iron-chromium, and zinc-bromine). Flywheels are mechanical devices that harness rotational energy to deliver instantaneous electricity. Lastly, thermal batteries capture heat and cold to create energy on demand (for example, pumped heat electrical storage, hydrogen energy storage, liquid air energy storage).

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341 H. Ibrahim et al., *Renewable and Sustainable Energy Reviews*, 2008, 12, 1221–1250.

342 http://www.energy.ca.gov/research/integration/storage.html.

Supercapacitors[343], flywheels, and many electrochemical energy storage technologies, particularly lithium ion batteries, can serve the need for very fast ancillary services such as frequency regulation. Flow batteries and some flywheel technologies can provide long-duration storage up to four hours. Pumped hydropower and compressed air storage technologies can address the need for extremely large-scale bulk storage technologies and provide power for durations beyond six or eight hours.

Utility-Scale Storage

Historically, the only cost-effective storage has been pumped hydroelectric storage. There is a limited supply of pumped hydroelectric storage in California because these systems require an upper reservoir and lower reservoir that has the potential to meet this need; few areas of California have suitable geography. Furthermore, these systems are impacted by seasonal water supplies during wet years or dry years and are one of the areas that continue to be impacted by the California drought. Therefore, the actual energy supply provided by these systems is not always consistent. There are three operating utility-scale hydroelectric pumped storage facilities in operation and a fourth that has received federal approval but has not started construction.

- Castaic Power Plant is operated by Los Angeles Department of Water and Power and is in the Tehachapi Mountains of Los Angeles County. It has a capacity of 1,247 MW with a head (vertical difference between the upper and lower reservoirs) of 1,060 feet. Castaic units were placed in operation in the 1973 to 1978 period.
- The Helms Pumped Storage Facility is east of Fresno with a capacity of 1,212 MW with a head of 1,625 feet. It began operation in 1984 and is owned by PG&E.
- The Lake Hodges Pumped Storage Project began operating in San Diego County in 2012. It provides up to 40 MW of storage capacity to San Diego Gas & Electric Company. It has a head of nearly 770 feet. The San Diego County Water Authority and City of San Diego have also filed a FERC license application for additional pumped storage at the San Vicente Dam facility.[344]
- The Federal Energy Regulatory Commission approved Eagle Mountain Pumped Storage on June 19, 2014. The project would have a capacity of 1,300 MW with a head of 1,393 feet. The developer expects construction to begin in 2018.
- Burbank Water and Power (BWP) is investigating compressed air energy storage (CAES) at the Intermountain Power Project (IPP) site in Delta, Utah. The geology of this site, featuring a major underground salt deposit capped by solid rock, is

343 Supercapacitors are direct current energy sources and must be interfaced to the electric grid with a static power conditioner. A supercapacitor provides power during short duration interruptions and voltage sags.

344 http://docketpublic.energy.ca.gov/PublicDocuments/15-MISC-05/TN207146_20151229T135932_San_Diego_County_Water_Authority_Comments_on_PostWorkshop.pdf.

particularly well-suited to CAES. A CAES project at this site has the potential to access low-cost, high-quality wind resources in Wyoming; store that energy and make it dispatchable through CAES; and transmit it down the existing direct current transmission line that currently brings the output of IPP to Southern California. Such a project also has the potential to relieve solar-driven, over-generation issues in California, by absorbing that overgeneration and then retransmitting it back to California when needed. Among other BWP efforts in support of this concept over the last few years, the Western Electricity Coordinating Council (WECC), which oversees the Western U.S. electrical grid, recently approved a BWP proposal to study CAES at IPP. Other market participants joined BWP in this proposal, including Wyoming wind project developer Pathfinder Wind, transmission developer Duke American Transmission Company (DATC), salt cavern developer Magnum Resources, and technology provider ABB. BWP and its partners are working to support this study with planning models and assumptions.[345]

In the past few years, California has begun to see proposals for other utility-scale storage options beyond pumped hydroelectric storage, including solar thermal storage and electric battery storage. Four proposals are discussed below.

1. The Rice Solar Energy Project was approved by the California Energy Commission in December 2010, and limited site-preparation construction work began in August 2013; however, major facility construction has not yet begun. The approved project has an electric capacity of 150 MW, with thermal energy storage enabling extended operations of 8.5 hours per day.

2. Mission Rock Energy Center has proposed to build a 255 MW natural gas-fired facility with a limited amount of battery electric storage in Ventura County. The battery component of this proposed project would be able to produce 25 MW of electricity for 4 hours (that is, 100 MWh of energy from storage) using one of two types of chemical batteries. The application was submitted by Mission Rock Energy Center in December 2015 and deemed complete by the Energy Commission in May 2016, which initiated a 12-month (nominal) permit review for the facility.

3. AES Corporation announced in November 2014 that it had entered into a 20-year power purchase agreement with Southern California Edison (SCE) to provide 100 MW of capacity that can produce electricity for 4 hours (400 MWh). It plans to build this capability at the site of the existing Alamitos Power Center in Long

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345 City of Burbank Water and Power. 2014. *Energy Storage Procurement Target Setting Pursuant to Assembly Bill 2514.* Staff Report from Ron Davis to Mark Scott. November 25, 2014. http://www.energy.ca.gov/assessments/ab2514_reports/Burbank_Water_and_Power/Burbank_Water_and_Power_Staff_Report_Re_AB2514_2014-11-25.pdf.

Beach. Once operational, California will have the largest energy storage system in the world.[346]

4. PG&E has investigated the potential for a CAES facility on King Island, San Joaquin County, and this effort was partially funded by DOE. PG&E issued a Smart Grid Compressed Air Energy Storage Demonstration Project Request for Offers on October 2015, and it plans on downselecting to a short list of participants in early 2017.[347] SMUD has also done a preliminary study for CAES colocated with the Solano Wind Farm near Rio Vista.[348]

Distributed Storage

In addition to the growth of utility-scale storage technologies, many companies have developed distributed energy storage systems. Increasingly common are energy storage systems for home and business use. Electric customers typically use energy storage to improve energy reliability, shift their use of grid electricity, or store excess electricity generated with their solar PV systems. Electric customers use energy storage mostly as a way to more efficiently use electricity from the electric grid and reduce electric costs. This is done either by charging energy storage during times when electric prices are low or by charging energy storage with onsite distributed generation, like solar PV. Combining energy storage with solar PV allows electric customers to store their excess electricity generated at midday for their use during peak demand periods as the sun sets. Most energy storage systems are designed to offer electric customers more options to reduce use of grid electricity and to manage how and when electricity is consumed.

One company that is moving into both the residential and commercial storage markets is Tesla Energy. Tesla is amplifying its efforts to accelerate the move away from fossil fuels to a sustainable energy future with Tesla batteries, enabling homes, business, and utilities to store sustainable and renewable energy to manage power demand, provide backup power, and increase grid resilience. Tesla is already working with utilities and other renewable power partners around the world to deploy storage onto the grid to improve resiliency and cleanliness of the grid as a whole. Tesla is expected sell 168.5 MWh of energy storage systems to the nation's leading residential solar system installer, SolarCity, this year, according to an SEC filing.[349] That is 60 percent larger than the entire 2015 U.S. behind-the-meter market and more than six times what Tesla sold to

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346 Fialka, John. 2016. "World's Largest Storage Battery Will Power Los Angeles." *Scientific American Climate Wire*. July 7. http://www.scientificamerican.com/article/world-s-largest-storage-battery-will-power-los-angeles/.

347 http://www.netl.doe.gov/File%20Library/Library/Environmental%20Assessments/PG-E_CAES_Concurrence_Final-EA_04-30-2014.pdf.

348 http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001023617.

349 http://ir.tesla.com/secfiling.cfm?filingID=1193125-16-543341&CIK=1318605.

SolarCity last year, according to a note by GTM Research.[350] Tesla expects revenues from SolarCity to increase from $8 million to $44 million this year – a 450 percent annual growth rate.

In one landmark project using Tesla systems, San Francisco-based Advanced Microgrid Solutions (AMS) will oversee the design, installation, and operation of a 1,000 kW/6,000 kWh energy storage system at the CSU Long Beach campus. AMS will install two storage systems at the CSU Office of the Chancellor and the Dominguez Hills campus, for a total of 2,000 kW/12,000 kWh of energy storage. Additional CSU campuses will be able to enroll in the advanced energy storage project through a standardized contract and offering.

"The CSU is setting the standard for sustainability among higher education institutions, both statewide and across the nation," said Susan Kennedy, chief executive officer of AMS. "We are proud to work with them and provide Southern California Edison with critical capacity during this time of emergency [reliability concerns resulting from the uncertain future of the Aliso Canyon natural gas storage facility]."[351] AMS will break ground at CSU Long Beach in the summer of 2016, and the system is expected to be completed by October 2016. Construction at the Office of the Chancellor is anticipated to begin in early 2017 and be completed by mid-2017.

AMS Hybrid Electric Buildings® use Tesla Powerpack commercial batteries to store energy during nonpeak hours, typically at night. During times of high demand, AMS's advanced analytics software shifts buildings from the electric grid to the AMS energy storage system, reducing grid congestion and easing the need to build additional peaker plants.

AMS uses Tesla to provide battery technology for its storage projects and has agreed to install up to 500 MWh of battery capacity to provide grid support in Southern California. "Tesla's focus on performance and design makes them the stand out technology choice for our projects," Kennedy said in a statement.[352] This is equivalent to installing tens of thousands of Tesla's new "battery wall" systems, which Tesla started selling in May 2016. Last year, AMS secured a contract with SCE to provide 50 MW of storage.[353] AMS will install the batteries at commercial and industrial buildings in the West Los Angeles service territory to provide large-scale grid support to the utility.

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350 http://www.greentechmedia.com/articles/read/How-Much-Storage-Does-Tesla-Expect-to-Sell-to-SolarCity-in-2016.

351 http://advmicrogrid.com/assets/docs/press/pr-ams-csu-joint-announcement.pdf.

352 http://www.prnewswire.com/news-releases/advanced-microgrid-solutions-signs-500-mwh-energy-storage-deal-with-tesla-300094291.html.

353 http://www.utilitydive.com/news/inside-sce-and-oncors-big-plans-to-deploy-utility-scale-storage/331838/.

"This is all about building resilience into the grid," said Jackalyne Pfannenstiel, cofounder of AMS. "Energy storage turns traditional demand response into firm, reliable capacity – it changes everything about the way the grid is operated."[354]

In 2014, SCE awarded contracts to Ice Energy totaling 25.6 MW for behind-the-meter thermal energy storage.[355] The contract resulted from an open and competitive process under SCE's Local Capacity Requirements (LCR) Request for Offers (RFO). The goals of the LCR RFO and California's Storage Act Mandates are to improve grid reliability, support renewables integration to meet the 2020 portfolio standards, and support the goal of reducing GHG emissions to 20 percent of 1990 levels by 2050.

354 http://www.utilitydive.com/news/advanced-microgrid-solutions-taps-tesla-in-huge-battery-buy-for-ca-grid/400296/.

355 http://www.energy.ca.gov/research/energystorage/tour/ice/

CHAPTER 6: Policy Development and Planning Going Forward

California leads the nation in GHG emissions reduction through the Cap-and-Trade Program, energy efficiency innovation, and renewable energy deployment. California continues to be a leader in the technology innovation needed to meet the state's aggressive GHG reduction goals as evidenced by patent filings and investments in clean technologies in California.[356] The state also leads in climate change research and adapting its infrastructure to these changes. Continuing to advance California's GHG reduction goals will require increasing the use of renewable resources; improving planning and coordination, and supporting research, development, and deployment of emerging technologies that will ultimately transform the energy system.

In his 2015 inaugural address, Governor Edmund G. Brown Jr. laid out his vision for reducing GHG emissions by setting the following goals for 2030:

- Increase from one-third to 50 percent the state's electricity derived from renewable sources.
- Reduce today's petroleum use in cars and trucks by up to 50 percent.
- Double the efficiency of existing buildings and make heating fuels cleaner. Reduce the release of methane, black carbon, and other potent pollutants across industries.
- Manage farm and rangelands, forests, and wetlands so they can store carbon.[357]

The Governor said that meeting these goals "means that we continue to transform our electrical grid, our transportation system and even our communities." On April 19, 2015, Governor Brown put forward Executive Order B-30-15 that set a GHG reduction goal of 40 percent below 1990 levels by 2030.[358] Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) put the Governor's goal into law by requiring the state to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030. The companion bill, Assembly Bill 197 (Garcia, Chapter 250, Statutes of 2016), assures continued

356 Next10, 2016 California Green Innovation Index, 8th Edition, http://www.next10.org/sites/next10.org/files/2016-california-green-innovation-index-1.pdf.

357 Governor Brown's 2015 inaugural address, January 5, 2015, https://www.gov.ca.gov/news.php?id=18828.

358 It also set a long-term goal to reduce GHG emissions 80 percent below 1990 levels by 2050. https://www.gov.ca.gov/news.php?id=18938.

transparency and accountability in the state's implementation of its climate change policies.

This transition to a cleaner energy system and economy will create new markets and opportunities while improving the environment by reducing the state's dependence on fossil fuels, which should reduce some of the environmental issues associated with energy production.

This report has traced the way key policy drivers, primarily in confronting climate change using renewable energy technologies, have effected significant changes in the physical infrastructure and environmental footprint of the state's electricity system. After a decade of implementing these policies, the state has a much cleaner and more efficient electrical generation system. The state has reduced GHG emissions, is on track to exceed the 33 percent RPS requirement by 2020, and is phasing out generating plant that use ocean water for cooling. The state has also significantly lowered water use from the power sector and increased the efficiency as well as the flexible capabilities of the natural gas fleet.

The state has also seen new environmental issues emerge over the past decade, especially with the rapid deployment of renewable energy projects throughout California. This has been one of the greatest challenges and success stories of the past decade. California has a unique opportunity to learn from and build upon successful past efforts to permit renewable energy projects and related transmission. These efforts include interagency coordination, permitting best practices, and the series of landscape planning initiatives that were implemented to identify renewable energy opportunities in the context of other environmental and land-use considerations. Today, California is implementing a new set of energy policies and goals, including SB 350 and AB 802 (Williams, Chapter 590, Statutes of 2015).

In this chapter, staff describes the current set of policy drivers that will shape the future development and operation of the electricity generation system. Staff also describes the steps California is taking to improve long-term energy planning for renewable energy resources by planning for new infrastructure (both generation and transmission) at the landscape-scale level. The chapter also includes an overview of how the state plans to adapt to climate change effects on the electricity system and the natural systems in which it operates.

Clean Energy and Pollution Reduction Act of 2015 – Senate Bill 350

As discussed, SB 350 continues California's trajectory to meet its long-term GHG reduction goals by setting in statute some of the key tenets of Governor Brown's April 29, 2015, Executive Order B-30-15. Both Executive Order B-30-15 and SB 350 build on the mandatory target originally set by AB 32 and strengthen the state's position to meet its 2050 goal of reducing GHG emissions 80 percent below 1990 levels.

Potential Transformation of the California ISO Into a Regional Organization

SB 350 notes that it is the Legislature's intent to provide for the evolution of the current California ISO into a regional organization to promote development of regional electricity market in the western states and to improve the access of consumers served by the current California ISO to those markets. This voluntary evolution would require approval by each affected state and its local regulatory authorities, as well as require modifications to the current California ISO governance structure.

Public Utilities Code Section 359.5(a) of the legislative authorization to analyze the possibility of transforming the California ISO to a regional organization establishes that it is the Legislature's intention that this "transformation should only occur where it is in the best interests of California and its ratepayers."[359] To that end, the California ISO is studying the economic, environmental, socioeconomic, reliability, and integration (of renewable energy) impacts of a regional market. In September 2016, the California ISO transmitted final study results to the Governor that estimate the impacts of a transformation to a regional market and found that California ratepayers stand to save $55 million per year under a limited expansion with only PacifiCorp fully participating in a regional grid in 2020.[360] The final studies also estimate that California ratepayers would save up to $1.5 billion per year assuming a larger regional footprint that includes all of the U.S. balancing authorities in the Western Interconnection except for the two federal power marketing administrations. While the CO_2 emissions in the Western Electricity Coordinating Council (WECC) are estimated to decrease from 331.3 million metric tons in 2020 to 307.3 million metric tons in 2030, even without a regional market, an additional reduction in 2030 to below 300 million metric tons is estimated in 2030 with a regional market. A regional market in 2030 is estimated to create between 9,900 and 19,300 additional jobs in California, primarily due to the reduced cost of electricity.

With a more efficient renewable resource expansion to meet California's RPS, implementing a regional market would result in reduced impacts on WECC-wide land use, biological resources, and water use (even with an expected shift in some land use and biological resource impacts from California to out of state). With a regional market's more efficient generator dispatch across the WECC, water use for thermal generators is reduced for natural gas-fired combined-cycle units in California, as well as for gas-fired and coal-fired units in the rest of the WECC. Reduced generation from gas-fired

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359 Section 359.5 of Chapter 2.3 of Part 1 of Division 1 of the Public Utilities Code. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.

360 The California ISO transmittal letter to the Governor is available here: http://www.caiso.com/Documents/ISOSB350StudiesTransmittalLetter_20160915.PDF

generators in California also provides benefits to disadvantaged communities by decreasing power plant emissions in the San Joaquin Valley and South Coast air basins.[361]

On August 8, 2016, Governor Brown sent a letter to the California Legislature in which he noted while there has been significant progress made by the California ISO on a transition proposal that meets the criteria in SB 350, there are important unresolved questions, including the governance structure, that cannot be answered before the end of the current legislative session. Governor Brown directed his staff, the Energy Commission, the CPUC, and the California ARB to continue to work with the Legislature, the California ISO, interested parties, and other state and energy regulators to develop a proposal for the Legislature to consider in January 2017.[362]

Energy Efficiency

SB 350 requires the Energy Commission to establish annual targets for statewide energy efficiency savings and demand reduction that will achieve a cumulative doubling of statewide energy efficiency savings in electricity and natural gas end uses of retail customers by January 1, 2030. SB 350 requires the CPUC, for electrical and gas corporations, and the POUs to establish targets consistent with this statewide goal.

Over the last 40 years, California has implemented cost-effective building and appliance energy efficiency standards and energy efficiency programs that have saved consumers billions of dollars. Past successes in energy efficiency have helped limit the state's electricity consumption growth to roughly 1 percent annually and natural gas consumption growth to nearly zero. However, a clear focus on improving the efficiency of existing building stock[363] offers great potential to reduce current levels of energy usage.

AB 802, like SB 350, recognizes the need for the Energy Commission to focus on meter-based energy savings. It directed the CPUC to increase the energy efficiency of existing buildings based on all estimated energy savings and energy usage reductions, taking into consideration the overall reduction in normalized metered energy consumption as a measure of energy savings. The CPUC was directed to include energy usage reductions resulting from the adoption of a measure or installation of equipment required for modifications to existing buildings to bring them into conformity with, or exceed, the

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361 The final SB 350 study results are available at http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=4C17574F-73AE-40E3-942C-59C3A13BBDF1.

362 The August 8, 2016, letter from Governor Brown to the leaders of the California State Legislature is available at http://www.caiso.com/Documents/GovernorBrownsLetterToLegislativeLeadersRegardingRegionalISOGovernance.pdf.

363 Commercial and residential buildings account for nearly 70 percent of California's electricity consumption and 55 percent of its natural gas consumption.

requirements of Title 24 of the California Code of Regulations, as well as operational, behavioral, and retrocommissioning activities reasonably expected to produce multiyear savings.

AB 802 also establishes authority for the Energy Commission to acquire utility customer usage and billing data for use in studies that will improve demand forecasting and for technical knowledge of the role of energy efficiency in reducing customer demand. These data would also provide characterizations of specific energy demands that will promote energy efficiency market actions. The *2015 IEPR* recommended that the Energy Commission work with utility resource planners and stakeholders to determine what data will be needed for further forecast granularity, particularly hourly forecasts, to support the planning needs as well as SB 350.[364] It also recommended the energy agencies cooperate as part of the *2016 IEPR Update* to ease methodological improvements associated with the demand forecast. This should including solar PV and efficiency modeling and the potential influences of other load-modifying resources through the Demand Analysis Working Group and Joint Agency Steering Committee discussions.[365] As part of the *2016 IEPR Update*, the Energy Commission is holding workshops on improving demand forecasting methods.[366] [367]

Renewable Energy Resources

SB 350 established more aggressive renewable energy goals for 2030. All LSEs, including electrical corporations, community choice aggregators, electric service providers, IOUs, and POUs, must achieve 40 percent renewables by December 31, 2024; 45 percent by December 31, 2027; and 50 percent by December 31, 2030. SB 350 also changed several other aspects of California's RPS program.[368]

Study on Barriers to Energy Efficiency and Renewable Energy

In addition to the above, SB 350 also finds that there is insufficient understanding of the barriers for low-income and disadvantaged communities to access energy efficiency investments, renewable energy generation, weatherization, and contracting

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364 California Energy Commission, *2015 IEPR*, 2016, p. 145, http://www.energy.ca.gov/2015_energypolicy/index.html.

365 Ibid., p. 145.

366 Notice of IEPR Commissioner Workshop on Methodological Improvements to the Energy Demand Forecast for 2017 and Beyond, *2016 IEPR Update*, Thursday, June 23, 2016, and Notice of Joint Agency IEPR Workshop on Energy Demand Forecasting and Doubling of Energy Efficiency – Data and Analytical Needs, 2016 IEPR Update, July 11, 2016, https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=16-IEPR-05.

367 For more information on the Energy Commission's role implementing SB 350 and AB 802, see http://www.energy.ca.gov/sb350/index.html.

368 For a description of the changes made by SB 350 to the RPS program, see http://www.energy.ca.gov/sb350/index.html.

opportunities. One of the requirements of SB 350 is for state agencies to evaluate the barriers for low-income customers, including those living in disadvantaged communities, to access clean energy technologies and provide recommendations for how to address these barriers. The Energy Commission is reporting on energy efficiency and renewable energy,[369] while the ARB is reporting on clean transportation, in consultation with other state agencies, by January 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. [370]

Integrated Resource Plans

SB 350 further requires the Energy Commission and CPUC to establish a process for LSEs to prepare integrated resource plans (IRPs). IRPs are comprehensive electric system planning documents intended to ensure that state's load-serving entities (LSEs) adequately meet customer electric demand and GHG emission reduction targets that will be established by the California Air Resources Board, as required by SB 350. LSEs are also required to identify a diverse and balanced portfolio of resources needed to ensure a reliable electricity supply that provides integration of renewable energy cost-effectively. The portfolio shall rely upon zero-carbon-emitting resources as much as possible and be designed to achieve statewide GHG emissions limits. These plans will provide a framework to evaluate how LSEs will align with the energy and other policy goals outlined in SB 350.

The Energy Commission will produce guidelines for and review IRPs from POUs with an average annual load greater than 700 GWh (in the 2013-2015 period). Based on historical data, 16 POUs are expected to be required to file an IRP. The Energy Commission may review and advise on the plans, and may adopt guidelines to "govern the submission of information" for this review. The Energy Commission held a workshop on April 18, 2016, to gather input from POUs on IRP activities that may be used to develop the IRP guidelines for POUs.[371] A second workshop to preview draft guidelines is scheduled for November 10, 2016.

On February 11, 2016, the CPUC established an order instituting rulemaking (OIR) to develop an IRP framework for IOUs and to coordinate and refine LTPP requirements. In April 2016, the CPUC held a prehearing conference inviting comment on IRP

369 Scavo, Jordan, Suzanne Korosec, Esteban Guerrero, and Bill Pennington. 2016. *A Study of Barriers and Solutions to Energy Efficiency, Renewables, and Contracting Opportunities Among Low-Income Customers and Disadvantaged Communities.* California Energy Commission. Publication Number: CEC-300-2016-009-SD.

370 More information about the SB 350 barriers report can be found at http://www.energy.ca.gov/sb350/barriers_report/index.html

371 To learn more about the Energy Commission's activities related to IRPs that will be submitted by POUs to the Energy Commission, see http://www.energy.ca.gov/sb350/index.html.

development and timing, and on May 26, 2016, the CPUC issued the scoping memo describing the activities and schedule for the IRP proceeding.[372]

Planning for Transportation Electrification

Transportation electrification is a key element of the state's strategy to reduce GHG emissions, petroleum use, and air emissions in the transportation sector. In March 2012, Governor Brown issued an executive order calling for 1.5 million zero-emission vehicles (ZEVs) to be on California roads by 2025 and adequate infrastructure to support 1 million ZEVs by 2020.[373] To chart a path toward meeting the Governor's ZEV executive order, the *2013 ZEV Action Plan* outlines four broad goals for government to help expand the ZEV market, including:

- Complete needed infrastructure and planning.
- Expand consumer awareness and demand.
- Transform fleet.
- Grow jobs and investments in the private sector.

It delineates specific actions for California agencies to simplify deployment and adoption of ZEV-related fueling and charging infrastructure.[374]

In July 2015, Governor Brown also called on state agencies to work together to develop an integrated action plan that establishes targets to improve freight efficiency, increase adoption of zero-emission technologies, and increase competitiveness of California's freight system.[375] Achieving Governor Brown's goal to reduce petroleum use in cars and trucks by up to 50 percent by 2030 will require a transformation of the transportation sector. Changes needed include increasing the use of cleaner vehicles with zero and near-zero technologies in all vehicle categories, reducing the carbon content of motor vehicles, reducing the use of rail and aviation fuels, reducing vehicle travel demand, and improving system efficiencies.

California's electric utilities are expected to play an integral role in state's efforts to accelerate the transformation of the transportation sector by increasing access to electricity as a transportation fuel. SB 350 calls for widespread transportation electrification.[376] SB 350 requires the CPUC, in consultation with the ARB and Energy

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372 For more information on the CPUC's IRP and LTTP proceeding, see http://www.cpuc.ca.gov/LTPP/.

373 Executive Order B-16-12, https://www.gov.ca.gov/news.php?id=17463.

374 The Governor's Office of Planning and Research, *ZEV Action Plan*, 2013, https://www.opr.ca.gov/s_zero-emissionvehicles.php.

375 Executive Order B-32-15, https://www.gov.ca.gov/news.php?id=19046.

376 SB 350 defines *transportation electrification* to include the use of electricity from external sources of electrical power, including the electrical grid, for all or part of vehicles, vessels, trains, boats, or other

Commission, to direct electrical corporations to file applications for programs and investments to accelerate transportation electrification, reducing California's dependence on petroleum. Three IOUs (Southern California Edison, San Diego Gas & Electric Company, and Pacific Gas and Electric Company) submitted applications for electric vehicle charging infrastructure in 2015. The CPUC approved the pilot programs for San Diego Gas & Electric Company for $45 million and Southern California Edition for $22 million. They are evaluating Pacific Gas and Electric Company's proposal for $160 million. These IOU programs are just beginning, and no infrastructure has been installed. Finally, SB 350 requires the ARB, in consultation with the Energy Commission, other state agencies, and the public, to report on barriers and recommendations for increasing access to zero-emission and near-zero-emission transportation options to low-income customers, including those in disadvantaged communities. The report is due January 1, 2017.

Transportation electrification is likely to have a profound impact on the electricity system, maybe greater than the emergence of solar PV. Adequate planning for this transition will be necessary to ensure GHG reduction benefits for the electricity sector, as well as the transportation sectors. The IRP processes for the state's load-serving entities outlined in SB 350 will be especially important in implementing transportation electrification.

Planning for Renewable Development

This section reviews the various planning activities that the state is taking to promote development of renewable energy generation across the state. As described in Chapter 4, renewable energy development can have impacts on a variety of resources, like visual, cultural, and biological. This section summarizes the planning activities occurring at the local, state, and federal levels to address these impacts, including cumulative impacts that renewable energy development can have throughout California. Meeting the state's 2030 GHG reduction goals and RPS requirements will require additional utility-scale generation and new investments in the state's electric transmission system.

Landscape Planning to Achieve California's Goals

Landscape-level approaches, also known as *landscape-scale planning,* take into consideration a wide range of potential constraints and conflicts, including environmental sensitivity, conservation and other land uses, tribal cultural resources, and more when considering future renewable energy development. Previous *IEPRs* and *IEPR Updates* have discussed the variety of landscape-level approaches and related

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equipment that are mobile sources of air pollution and GHGs and the related programs and charging and propulsion infrastructure investments to enable and encourage this use of electricity.

benefits when used for renewable energy and transmission planning.[377] Furthermore, in his *Clean Energy Jobs Plan,*[378] Governor Brown set a goal to dramatically reduce the permitting time for transmission projects needed to deliver clean energy to no longer than three years.

Through previous and current efforts, such as the first and second Renewable Energy Transmission Initiative (RETI) processes, the joint Renewable Energy Action Team (REAT) agency work on the *DRECP*, and the stakeholder-led San Joaquin Valley Identification of Least-Conflict Lands study, California agencies, local governments, tribes, and stakeholders have gained experience with planning approaches that seek to identify the best areas for renewable energy development. In a letter to the California ISO initiating the second RETI process, Energy Commission Chair Robert Weisenmiller and CPUC President Michael Picker noted that there is proven value in using landscape-scale planning to assess the relative potential of different locations for renewable energy, especially in the context of identifying policy-driven transmission lines.[379] [380]

This experience in various planning and permitting activities, along with the strong relationship among agencies that have worked together to help achieve these goals, the state is prepared to continue planning efforts, regulatory and nonregulatory, to achieve California's renewable energy and climate goals. Unfortunately, the permitting process for major, high-priority transmission projects can take six to eight years to plan and permit.[381] As noted in the Energy Commission's *2012 Renewable Action Plan*,[382] options to help the timely development of transmission projects include implementing a programmatic CEQA review program for transmission facilities, completing the environmental component of a certificate of public convenience and necessity for policy-driven transmission facilities prior to the California ISO finding of need, or leveraging the Energy Commission's environmental expertise to reduce analysis time without compromising quality.

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377 The Nature Conservancy studied the costs and impacts of integrating ecological information into long-term energy planning and found that a 50 percent renewable portfolio could be achieved with low impacts to natural areas. See http://www.scienceforconservation.org/downloads/ORB_report.

378 https://www.gov.ca.gov/docs/Clean_Energy_Plan.pdf.

379 http://www.energy.ca.gov/reti/reti2/documents/2015-07-30_Letter_to_CAISO_RE_RETI_2_Initiative_from_CEC_and_CPUC.pdf.

380 David J. Hayes, former deputy secretary of the U.S. Department of the Interior, suggests that landscape-scale initiatives can assist the siting of new renewable projects and offer project opportunities for project mitigation. See http://www.eli.org/sites/default/files/docs/elr-na/44.elr_.10016.pdf (pp. 10018-10020).

381 General Information on Permitting Electric Transmission Projects at the California Public Utilities Commission, Slides 8-9, June 2009, available at: http://www.cpuc.ca.gov/CEQA/

382 California Energy Commission, 2012. 2012 Integrated Energy Policy Report Update. Publication Number: CEC-100-2012-001-CMF.

California has an opportunity to learn from and build upon successful past efforts to permit renewable energy projects and related transmission. These efforts include interagency coordination, permitting best practices, and various landscape planning initiatives that were implemented in the context of other environmental and land-use considerations.

The Renewable Energy Transmission Initiative (RETI)

In 2007, the state implemented a renewable energy target of 20 percent, anticipating a future 33 percent renewable energy goal. Key challenges to meeting these goals included understanding the quality of renewable resources in various locations around the state, the potential environmental impacts to developing in these areas, and the lack of transmission to reach these resource areas. RETI, a nonregulatory statewide planning process, was established in 2008 to identify resource areas and the transmission projects needed to meet the 33 percent target.

RETI established the precedent for incorporating land-use planning into the statewide transmission planning process by bringing together state, federal, and local agencies and entities responsible for permitting transmission projects, as well as representatives from the environmental community, developers of renewable technologies, investor- and publicly owned utilities, Native American tribes, U.S. military, and consumers. The primary goals of RETI were to (1) help identify the transmission projects needed to accommodate California's renewable energy goals, (2) ease the designation of corridors for future transmission line development, and (3) promote transmission line and renewable generation siting and permitting.[383]

The RETI collaborative analytical effort resulted in identifying 30 competitive renewable energy zones (CREZs) throughout the state that were most favorable for cost-effective and environmentally responsible generation development with corresponding transmission interconnections and lines. The CREZs included about 80,000 MW of potential statewide renewable resource development, including nearly 66,000 MW in California's Mojave and Colorado Deserts. The outputs of the RETI process were further refined in the DRECP.

Desert Renewable Energy Conservation Plan

As noted in the *2015 IEPR*, the Energy Commission, CDFW, the U.S. BLM, and the USFWS signed a memorandum of understanding (MOU)[384] in late 2008 to formalize the REAT to expedite development of renewable energy resources in California's desert region to help meet the state's renewable energy goals. The agencies worked closely with local agencies, conservation and environmental groups, the public, tribes, and other

383 For more information on RETI, see http://www.energy.ca.gov/reti/.

384 Available at http://www.energy.ca.gov/siting/2008-11-17_MOU_CEC_DFG.PDF.

interested stakeholders to develop the *DRECP*, a landscape-scale, multiagency, science-based renewable energy and conservation plan covering 22.5 million acres in California's desert. The *DRECP* identified the most appropriate areas for renewable energy development and related transmission projects while conserving important biological and natural resources.

In March 2015, the REAT agencies announced that the DRECP planning process would move forward in a phased manner, in part to provide additional time for counties that received Renewable Energy and Conservation Planning Grants to complete their planning activities.[385] Phase I of the DRECP is focused on completing a BLM land-use plan amendment (LUPA) to implement the renewable energy and conservation plan on public federal lands by amending existing land designations. The BLM land-use plan amendment and final environmental impact statement (EIS) were released on November 10, 2015.[386] The LUPA was completed, and the record of decision was approved on September 14, 2016.

The Energy Commission and REAT Agency partners will build off the draft *DRECP* and the DRECP BLM LUPA in continuing work with local governments on county and regional approaches that advance and help balance the goals of the *DRECP* with local or regional priorities and diverse stakeholder perspectives. To support these and other energy planning processes, the Energy Commission continues to assemble the best available energy resource, environmental, and land-use data and to develop tools that promote and support the transparent use of the best available data and analytical work in these efforts. Extending the data, environmental logic models, and applications developed for the *DRECP* to support energy planning at a statewide level is a focus of the Energy Commission's energy planning in 2016.

San Joaquin Least Conflict Planning for Solar PV

Because of the San Joaquin Valley's abundant sunshine and hot, dry climate, the region attracts solar development, and many solar projects have been sited there. The region is also an important agricultural production area for California and the world, and home to many threatened species and habitats. Given this, OPR launched a stakeholder-driven, nonregulatory planning process in June 2015 to identify and recommend least-conflict areas for solar PV development. The process also identified barriers to project development and provided recommendations to address them. Four main stakeholder groups participated in the process, including (1) environmental conservation; (2) agricultural farmland conservation; (3) the solar industry; and (4) transmission owners, developers, and advocates, including the California ISO. An agricultural rangeland stakeholder group also participated, and outreach to tribal governments and military

385 http://drecp.org/documents/docs/2015-03-10_DRECP_Path_Forward_News_Release.pdf.

386 http://drecp.org/documents/docs/2015-11-10_BLM_LUPA_final_EIS_news_release.pdf.

representatives took place. State and federal agency advisors supported the effort by providing data, advice, and technical assistance to the stakeholder groups. The California ISO also evaluated existing and approved transmission projects in the area and identified system constraints based on previous studies.

Over several months, the stakeholder groups worked independently with their members to identify and collect land use information that reflected their perspectives regarding areas of concern, least-conflict lands, or areas of potential opportunity. An online San Joaquin Valley Gateway was established at https://sjvp.databasin.org/ to simplify the sharing of information and mapping work of each group. When the stakeholder groups finished their respective work, information from each group was then assembled into a composite map identifying more than 471,000 acres of least-conflict lands within the 9.5 million-acre planning area.

The data and stakeholder perspectives developed through the process report have informed Version 6.2 of the CPUC's RPS Calculator and the RETI 2.0 planning process.[387]

Renewable Energy Transmission Initiative 2.0

Developing the transmission needed to support increasing amounts of renewable resources to the goals of achieve SB 350 and Executive Order B-30-15 will be critical to meeting these goals and will require careful planning and coordination across the West. Beginning in September 2015, the CNRA, Energy Commission, CPUC, California ISO, and BLM initiated the RETI 2.0 effort to promote the long-range planning, interagency coordination, and stakeholder engagement necessary to support these goals. RETI 2.0 is a proactive, statewide and western regional, nonregulatory planning forum intended to identify the constraints and opportunities for new transmission that may be need to help meet the state's long-term GHG and renewable energy goals.

The scope of analytical activities and goals for RETI 2.0 included:

- Exploring renewable generation resources in California and throughout the West that can help meet California's long-term energy and GHG reduction goals.
- Identifying land use and environmental opportunities and constraints to accessing these resources.
- Building understanding of transmission options for accessing and integrating renewable resources.
- Informing future planning and regulatory proceedings.

387 University of California, Berkeley, Center for Law, Energy, and the Environment, *A Path Forward: Identifying Least Conflict Solar PV Development in California's San Joaquin Valley*, May 2016, is available at https://db-static-content.s3.amazonaws.com/versions/383/img/gateways/sjvp/report.pdf.

While RETI 2.0 is not a regulatory proceeding, the insights, and recommendations developed through the stakeholder process will frame and inform future transmission planning proceedings. The RETI 2.0 conclusions and recommendations will be presented in a report that will be available by the end of 2016. Information on the RETI 2.0 stakeholder activities and findings can be found at http://www.energy.ca.gov/reti/.

Transmission Planning

Transmission infrastructure projects have been and will continue to play an important role in achieving California's renewable energy and GHG reduction goals from the energy sector. However, because they are long linear infrastructure that intersect broad geographic landscapes and typically cross multiple jurisdictions, ecoregions, and land uses, they can have significant environmental effects. The scale and routing of transmission projects require a variety of local, state, and federal environmental reviews and permits. Because these projects can take years to plan, develop, and build, it is important to consider the need and routing options for these projects as early as possible.

As discussed above, landscape planning for renewable energy was initiated largely to inform transmission planning by identifying high-potential renewable energy areas[388] and assessing available transmission capacity and the potential for upgrades to the transmission system to add capacity.[389] Unlike most conventional generation, renewable energy projects are often located far from load centers and may require costly and time-consuming transmission upgrades. By locating renewable projects in preferred areas near existing transmission infrastructure, potential environmental impacts

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388 High-potential renewable energy areas were similar, but named and defined slightly differently in different planning processes. For example, the RETI process used the term "California Renewable Energy Zones," or CREZ, which were defined as areas that hold the greatest potential for cost-effective and environmentally responsible renewable development. *DRECP* used the term "Development Focus Areas," (DFAs), which are designated areas within the DRECP that have high-quality renewable energy potential and access to transmission in locations where renewable energy development impacts can be managed and mitigated. The San Joaquin Valley planning process identified "least conflict" areas based on input received from multiple stakeholder groups. RETI 2.0 uses the term "Transmission Assessment Focus Areas" (TAFAs) to identify high-value renewable resource areas both in and out of state that could help meet California's 2030 GHG reduction goals.

389 Electric transmission planning has been a key component of the RETI, DRECP, San Joaquin Valley, and RETI 2.0 collaborative planning processes. RETI sought to identify major electric transmission facility upgrades in the state necessary to access competitive renewable energy zones (CREZ) sufficient to meet California's renewable energy policy goals while minimizing economic costs and environmental impacts. In the DRECP process, a Transmission Technical Group (TTG) consisting of representatives of transmission owning utilities developed conceptual information about the transmission additions and associated amounts of acreage likely to be needed to serve renewable energy development within the Development Focus Areas (DFAs). In the San Joaquin least-conflict planning process, the California ISO identified the transmission system in the San Joaquin Valley in relation to least-conflict areas and identified reliability upgrades, large generator interconnection agreement projects, and policy-driven projects previously approved in the California ISO transmission planning process that could accommodate renewable resource development in the region. In the RETI 2.0 process, a Transmission Technical Input Group composed of North American Electric Reliability Corporation-registered transmission planners operating in California assembled relevant in-state and westwide transmission capability and upgrade cost information to inform resource development and transmission system implications, and to assist in identifying potential corridor scenarios.

and permitting costs and timelines can be reduced, resulting in better and timelier projects.

Senate Bill 2431 (Garamendi, Chapter 1457, Statutes of 1988) recognized the value of the transmission system and the need for coordinated long-term transmission corridor planning to maximize the efficiency of transmission rights-of-way and avoid single-purpose lines. The bill established four principles, commonly referred to as the *Garamendi Principles*, for the planning and siting of new transmission facilities.[390] The transmission projects needs to interconnect the generation to meet the 33 percent RPS mandate largely follow these principles by considering reconductoring[391] where possible, maximizing the use of existing rights-of-way to the extent possible, and relying on collaborative transmission planning results/efforts where new rights-of-way are necessary.

Transmission Right-Sizing

Consistent with the Garamendi Principles, the *2015 IEPR* recommended that the state develop a set of right-sizing policies through the *2016 IEPR Update* process, informed by the RETI 2.0 process (discussed above). Transmission right-sizing[392] was first discussed in the *2011 IEPR* and raised again by stakeholders in the *2014 IEPR Update*.[393] Where appropriate, right-sized projects can reduce future costs and environmental impacts of transmission facilities. The right-sizing concept was used throughout the Tehachapi Renewable Transmission Project (TRTP),[394] where SCE built transmission facilities to 500 kilovolt (kV) specifications but energized the lines only at 220 kV. Developing the Tehachapi area this way allowed SCE meet the immediate needs of the region while allowing for straightforward future expansion without major environmental or economic costs. California needs a consistent right-sizing policy that can be consistently applied to transmission planning and licensing processes throughout the state.

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390 The four Garamendi Principles should be pursued in the following order: 1) Encourage the use of existing rights-of-way (ROW) by upgrading existing transmission facilities where technically and economically feasible; 2) when construction of new transmission lines is required, encourage expansion of existing ROW, when technically and economically feasible; 3) provide for the creation of new ROW when justified by environmental, technical, or economic reasons defined by the appropriate licensing agency; and 4) where there is a need to construct additional transmission capacity, seek agreement among all interested utilities on the efficient use of that capacity.

391 Reconductoring a transmission line involves replacing the existing conductors with newer conductor designs with better design features and/or increased current-carrying capacity.

392 Transmission right-sizing refers to building transmission facilities that have greater capacity than needed over the short-term planning period (10 years) to accommodate longer-term electricity growth and/or connect new generation development for the future.

393 California Energy Commission. 2015. *2014 Integrated Energy Policy Report Update*. Publication Number: CEC-100-2014-001-CMF. http://www.energy.ca.gov/2014publications/CEC-100-2014-001/CEC-100-2014-001-CMF-small.pdf, pp. 153-154.

394 More information on the Tehachapi Renewable Transmission Project is available at http://www.sce.com/tehachapi.

The right-sizing policy helps ensure that when a large transmission project is built, it doesn't have to be replaced or upgraded shortly after it is completed. A good right-sizing policy essentially expands the analysis of large transmission facilities and looks beyond a 10-year planning time frame to determine whether a proposed transmission line or project should be sized larger to meet needs more than 10 years out. A right-sizing policy could be applied in the transmission planning processes by expanding the analysis past 10 years or, in the licensing of transmission projects, by including alternatives that are larger than the proposed project.

Any expansion of the transmission planning process would likely be implemented through development of the California ISO's annual transmission plan. A blanket extension of the California ISO's transmission plan beyond the current 10 years is not reasonable. Transmission planning requires location-specific load and resource forecasts that are less accurate as the planning horizon is extended; therefore, it makes little sense to spend the resources completing studies whose results are so uncertain. Instead, the right-sizing analysis in transmission planning should be limited to an examination of large transmission projects found needed in the 10-year plan to see if there could be a need for a larger project beyond 10 years. A reasonable threshold for the longer-term analysis could be projects 200 kV and above or 115 kV in areas with corridor constraints. Limiting any analysis to specific types of projects would help ensure the state's long-term transmission needs are met without overburdening transmission planning agencies. These large transmission projects require environmental licensing and usually CPUC approval.

Right-sizing could also be included through the alternatives analysis of an environmental licensing or certificate of public convenience and necessity (CPCN) process. The identification of alternatives to specific projects is largely determined by the project objectives. A right-sizing policy for the licensing phase of transmission facilities would require project objectives to be defined such that they include transmission needs beyond 10 years. The careful crafting of project objectives during licensing would expand the analysis of alternatives options and provide for the long-term transmission needs of the California.

In the case of either right-sizing through expanded transmission planning or alternatives analysis, the right-sizing options would be limited to changes in the specific transmission project that either enlarge the proposed project or build in an option to easily enlarge the project later.

California has already used the concept of expanded right-sizing extensively in the TRTP and more recently in the Gates-Gregg 230 kV Line (Central Valley Power Connect). These projects included the construction of 230 kV double-circuit towers initially strung with only one circuit and, in the case of TRTP, the construction of towers built to 500 kV specifications but initially energized at 220 kV. A consistent right-sizing policy applied in either planning or licensing would help ensure that the state's valuable corridor resources are used efficiently without overburdening planning agencies.

The state should continue to work with stakeholders in comprehensive landscape-scale planning to identify and plan for renewable development and needed transmission, including the evaluation of transmission alternatives that consider potential upgrades to existing transmission facilities, the use of transmission corridors, and the "right sizing" of new transmission facilities, to accommodate current and potential long-term future needs. Right-sized projects would not be effective unless adopted by both planning and licensing agencies. The state should continue working with federal, state, and local agencies, governments, and stakeholders to collect information in the 2017 IEPR process and reflected in the Strategic Transmission Investment Plan, support process efficiencies, inform energy planning, and support robust decision making.

Full Capacity Deliverability vs. Energy-Only Generation Contracts

To date, most contracts for renewable energy have required full deliverability of renewable resources during peak conditions. This contractual requirement, which is a prerequisite for obtaining resource adequacy credit, has resulted in costly transmission projects that may result in little or no additional renewable energy being delivered into the system. Many interconnected generators are able to deliver full output most of the time, even without additional network upgrades beyond those required for interconnection. As renewable generation requirements grow, California energy agencies are exploring the value of "energy-only" renewable resources contracts instead of requiring full deliverability. This option has the potential to lower costs and increase the potential for renewable energy generation in many areas. Of course, it is necessary to have some level of commitment to deliver energy to maintain system reliability by ensuring that there are adequate energy supplies to serve load. While an energy-only resource mix may reduce costs for renewable energy by lowering infrastructure costs, it is still likely that energy-only renewable energy generators will have to curtail output to maintain system reliability.

Transmission Corridor Designation Opportunities

Senate Bill 1059 (Escutia and Morrow, Chapter 638, Statutes of 2006) linked transmission planning and permitting by authorizing the Energy Commission to designate transmission corridor zones on nonfederal lands to allow timely permitting of future high-voltage transmission projects. This law requires that any corridor proposed for designation must be consistent with the state's needs and objectives as identified in the latest adopted strategic transmission investment plan.

With regard to corridors that would be suitable for Energy Commission designation, the *2015 IEPR* references previous work from the *2013 IEPR* and *Strategic Transmission Investment Plan*, noting, "From a timing perspective, it makes sense to identify and designate, where appropriate, transmission corridors in advance of future generation development so that needed transmission projects can be permitted and built in an effective, environmentally responsible manner, contemporaneous with the generation development. The Energy Commission will work with the utilities; federal, state, and local agencies; and stakeholders to identify transmission line corridors that are a high priority for designation such as those corridors that would ease the development of renewable energy resources. Appropriate corridors could be identified as a result of the *Desert Renewable Energy Conservation Plan*, future examination of opportunities and needs in the San Joaquin Valley (southern area of the Central Valley), and the ongoing San Onofre transmission alternatives under consideration."[395] The ongoing RETI 2.0 work may also highlight potential corridor designation opportunities.

Coordinated Agency Infrastructure Planning

Collaboration among the Energy Commission, CPUC, and the California ISO, with appropriate stakeholder and public input, is crucial for meeting California's goals in a timely, cost-effective, and environmentally responsible way. Since the formation of the original RETI and *DRECP*, the Energy Commission, CPUC, and California ISO have worked to align their electricity infrastructure planning and to establish the analytical link among the different infrastructure studies conducted by different agencies. The coordinated agency planning activities have become more critical as higher levels of renewable generation capacity are expected to be developed for California.

Further work is needed to better characterize the environmental implications of proposed renewable generation and transmission projects throughout California and in other western regions. The Energy Commission continues to investigate environmental information sources developed for different landscape-level studies and consider geographic information system (GIS) mapping tools for energy stakeholder planning evaluations. The Energy Commission supports the inclusion of environmental information in interagency planning.

Local Agency Planning

Citing the passage of federal and state laws and policies, such as the federal Energy Policy Act of 2005 and California's SB 350, and in response to local policies and programs, local governments[396] have been approving new and revised ordinances and general plan amendments directing how renewable energy is developed in their jurisdictions. With a combination of local direction through general plans, zoning ordinances and combining districts, designation of suitable areas for renewable energy development, and permitting procedures, several local jurisdictions have provided direction on how renewable energy will develop in their jurisdiction. The intention

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395 California Energy Commission. 2015. *2015 Integrated Energy Policy Report*. Publication Number: CEC-100-2015-001-CMF, pp.99.

396 Office of Planning and Research. 2016. *Renewable Energy in California*. Accessed on April 29, 2016. Available at https://www.opr.ca.gov/s_renewableenergy.php.

behind the local planning actions taken by the counties includes the desire to identify the compatibility of different renewable energy systems in specific zones; to establish regulation and permit requirements that support and promote the responsible development of renewable energy in designated areas; and to protect the character and value of communities and neighborhoods, including the natural and scenic values of the landscape within the county.

Some local jurisdictions have adopted policies associated with solar energy generation to ensure that the local jurisdictions do not disproportionately bear the burden of providing public services to new renewable energy facilities, largely in response to the solar energy exclusion from property tax valuation. Section 73 of the California Revenue and Taxation Code implements provides a new construction exclusion for property tax reassessment for active solar energy systems.[397] [398]

The intent of excluding solar energy systems from the definition of newly constructed was to ensure that the addition of a solar energy system, whether to a rooftop or ground-mounted on hundreds of acres, does not trigger a reassessment of property value. This exclusion from reassessment is an incentive for developing utility-scale solar energy projects; however, some county officials refer to the developer incentive as “a disincentive” to local governments because local governments receive a significant share of their revenue from property taxes. The economic effect from this tax exemption can be exacerbated when large renewable energy projects, like solar, are developed in a remote location where county services are limited and it is more costly for the county or city to provide such services to the facility. In 2014, this exclusion was extended to 2023.

Because of the forgone lack of property tax revenue once land is developed with solar, local governments carefully consider the fiscal impact that new solar energy facilities may have on their county.[399] However, large-scale renewable energy projects do offer a variety of economic benefits, including construction and operations worker employment and payroll, purchases of materials and supplies during construction and operations, and payment of taxes (property and sales tax). Some counties have taken steps to maximize the economic activity and employment from renewable energy projects by incorporating measures such as designating the project site as the point of sale and use

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397 Board of Equalization. 2012. *Guidelines for Active Solar Energy Systems New Construction Exclusion.* November 2012. Available at http://www.boe.ca.gov/proptaxes/guideproc.htm.

398 An *active solar energy system* is a system that uses solar devices, which are thermally isolated from where the energy is used, to provide for the collection, storage, or distribution of solar energy.

399 Page 110, line 14 of 2015 IEPR transcript http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-08/TN205788_20150820T155922_Transcript_of_the_August_3_2015_Lead_Commissioner_Workshop.pdf.

for taxation purposes and incorporating local hiring preferences for the project workforce.[400]

Job creation is an important statewide and local benefit of renewable energy development. The University of California, Berkeley's, Donald Vial Center on Employment in the Green Economy conducted a study to assess California's workforce development needs as part of the *California Long Term Energy Efficiency Strategic Plan.*[401] [402] The study presents estimates of jobs created in California due to the construction of renewable energy generation since the first RPS was set and forecasts job creation from new renewable generation that would be needed to meet the target of 50 percent renewable energy by 2030.[403] This study estimates that between 2015 and 2030, an additional 354,000 (low scenario) to 429,000 (high scenario) direct jobs are forecasted to be created from the construction of new renewable generation. Including multipliers for indirect and induced jobs, additional renewable energy development in California would create 879,000 to 1,067,000 job years by 2030. These jobs are reported as *job years*, which are defined as one full-time job for one person for one year. If they were spread out evenly during this period, there would be about 23,600 to 28,600 direct full-time jobs per year and about 58,600 to 71,100 total full-time jobs per year.

Renewable Energy and Conservation Planning Grants

As noted in the *2015 IEPR*, California county governments are the permitting authority for most nonthermal power plants, such as wind and solar PV, located on private lands in California. They have permitted many of the renewable energy projects developed in California and will continue to be important partners in both permitting and planning as the state moves toward the 50 percent RPS by 2030 requirement.

Under Assembly Bill X1 13 (V. Manuel Pérez, Chapter 10, Statutes of 2011) and Assembly Bill 2161 (Achadjian, Chapter 250, Statutes of 2012), the Energy Commission

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400 See lines 16 through 23 on page 104 of the transcript from the 8/5/2016 IEPR workshop: http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-08/TN205788_20150820T155922_Transcript_of_the_August_3_2015_Lead_Commissioner_Workshop.pdf.

401 The *California Long Term Energy Efficiency Strategic Plan,* adopted by the California Public Utilities Commission, is a roadmap to achieve maximum energy savings across all major groups and sectors in California. The strategic plan was subsequently updated in January 2011 to include a lighting chapter.

402 University of California, Berkeley, Donald Vial Center on Employment in the Green Economy. 2015. *Job Impacts of California's Existing and Proposed Renewables Portfolio Standard.* By Betony Jones, Peter Philips, and Carol Zabin. August 28, 2015. Available at http://laborcenter.berkeley.edu/job-impacts-ca-rps/.

403 The estimated and forecasted job creation figures do not include jobs created from renewable self-generation, from energy efficiency investments, from operations and maintenance of new renewable power plants, and from new transmission infrastructure or increased energy storage, and assumes no major changes to the California ISO or RPS-eligible energy sources. Job creation estimates used as the baseline are from 2003 to 2014. Job creation forecast is from 2015 to 2030. **Source:** University of California, Berkeley, Donald Vial Center on Employment in the Green Economy. 2015. *Job Impacts of California's Existing and Proposed Renewables Portfolio Standard.* By Betony Jones, Peter Philips, and Carol Zabin. August 28, 2015. Available at http://laborcenter.berkeley.edu/job-impacts-ca-rps/.

established and administered Renewable Energy and Conservation Planning Grants (RECPG) between 2012-2014 to help qualifying counties plan for renewable resource development consistent with the state's long-term renewable energy, GHG reduction, and resource conservation goals. RECPG awards to Imperial, Inyo, Los Angeles, Riverside, San Bernardino, and San Luis Obispo Counties supported the development of renewable energy elements as part of county general plan updates, preparation and certification of environmental impact reports, identification of areas where renewable resources are prioritized and eligible for streamlined permitting, and the engagement of public, private, and tribal partners to plan for renewable energy development. The work funded by RECPG grants represents important steps toward achieving California's long-term GHG reduction, energy, and natural resource conservation goals.[404]

Climate Adaptation

California has long been a global leader in documenting climate adaptation for various sectors, releasing its first *California Climate Adaptation Strategy* in 2009.[405] Today, climate adaptation has grown to be an integral part of all resource sector planning. New laws and policies are empowering planning for climate impacts and adaptation to climate change. In the past three years, a suite of climate adaptation policies was enacted with implications for California's energy sector. These include state and national executive orders and state-level legislation. State energy agencies are responding swiftly to these changes and increased recognition of the dire distributional effects of climate change. These changes in policy context and early responses by the Energy Commission are briefly described here.

In 2015, Governor Brown issued Executive Order B-30-15. It mandates expansion of state adaptation, with the goal of making anticipating and considering implications of climate change a routine part of planning. Specifically, B-30-15 directs state government to 1) incorporate climate change impacts into the state's Five-Year Infrastructure Plan, 2) factor climate change into state agencies' planning and investment decisions, and 3) regularly update the Safeguarding California Plan—the state's adaptation plan—to identify how climate change will affect California infrastructure and industry and what actions the state can take to reduce the risks posed by climate change. The order provides four guiding principles: prioritizing win-win solutions for emissions reduction and preparedness, promoting flexible and adaptive approaches, protecting the state's most vulnerable populations, and prioritizing natural infrastructure solutions. Finally, the executive order directs maintaining strong support for state-supported regional climate science.

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404 For more information on the RECPG see: www.energy.ca.gov/renewables/planning_grants/.

405 http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf.

In the same year as the executive order, three adaptation bills from the California Legislature became law. An additional bill became law in 2016. Collectively, these bills will enhance California'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.

- Senate Bill 379 (Jackson, Chapter 608, Statutes of 2015) requires local hazard mitigation plans developed by cities and counties to address climate adaptation and resilience. SB 379 explicitly names Cal-Adapt[406] as a source of information to help cities and counties assess local vulnerabilities to climate change.
- Senate Bill 246 (Wieckowski, Chapter 606, Statutes of 2015) establishes a Climate Adaptation and Resiliency Program to be administered by OPR. This program will coordinate regional and local efforts with state adaptation strategies, require periodic reviews of the *California Adaptation Planning Guide*,[407] and establish a clearinghouse of information on adaptation.
- Assembly Bill 1482 (Gordon, Chapter 603, Statutes of 2015) requires CNRA to update the state's adaptation plan triennially and requires state agencies to integrate adaptation concerns into planning efforts, as well as consider the use of natural systems and natural infrastructure in adaptation. AB 1482 also expands the role of the Strategic Growth Council to foster implementation of the state's adaptation strategy.
- Assembly Bill 2800 (Quirk, Chapter 580, Statues of 2016) requires state agencies to take into account the current and future impacts of climate change when planning, designing, building, operating, maintaining, and investing in state infrastructure. The bill, by July 1, 2017, and until July 1, 2020, requires CNRA to establish a Climate-Safe Infrastructure Working Group for examining how to integrate scientific data concerning projected climate change impacts into state infrastructure engineering.

California's *Climate Change Research Plan*[408] articulates near- and midterm climate change research needs to ensure that the state stays on track to meet its climate goals. Since 2006, the state has produced three scientific climate change assessments, which have been instrumental in guiding state policy and supporting informed responses to climate change. California's *Fourth Climate Change Assessment,* to be released in late 2018, is the first interagency effort to implement a substantial portion of this *Climate*

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406 Cal-Adapt (http://cal-adapt.org/) is an interactive website developed under the Energy Commission's Public Interest Energy Research (PIER) Program that makes California climate science available and accessible to the public, utilities, and decision makers at multiple levels.

407 http://resources.ca.gov/climate/safeguarding/adaptation_policy_guide/.

408 *Climate Change Research Plan,* February 2015, http://www.climatechange.ca.gov/climate_action_team/reports/CAT_research_plan_2015.pdf.

Change Research Plan. As climate science and knowledge about local and regional vulnerabilities continue to evolve, it is critical that California continue to invest in regionally relevant climate science. Designed to complement local, federal, and international efforts, California's *Fourth Climate Change Assessment* will advance actionable science that serves the growing needs of state- and local-level decision makers from a variety of sectors.

The *Fourth Climate Change Assessment* is supported through two funding streams – one managed by the Energy Commission and another managed by the CNRA. The former focuses on energy-related research needs and the latter on non-energy research issues. Although the energy and non-energy sectors research draws on distinct funding streams, these sectors are closely coordinated to ensure that the *Fourth Climate Change Assessment* delivers a coherent product, based on consistent climate and sea level rise scenarios and a common set of assumptions about population and economic growth. This coherence is critical. It is designed to enable cross-sector integration of research results and development of mutually consistent adaptation strategies across private and public stakeholders and state and local agencies.

The Energy Commission supports research to ensure reliability and resilience of California's natural gas, electricity, and transportation fuels (petroleum) systems to climate change while meeting California's climate and environmental goals. Energy sector adaptation research has been designed to promote win-win strategies that deliver benefits under the current as well as expected future climate conditions, unify adaptation and mitigation strategies, and deliver practical results in collaboration with key stakeholders, including utilities.

At the national level, President Obama signed Executive Order 13563, "Preparing the United States for Impacts of Climate Change," on November 1, 2013, requiring federal agencies to begin preparing the nation for the potential impacts of a changing climate.[409] The U.S. DOE has implemented several actions. Notably, the agency created the Partnership for Energy Sector Climate Resilience.[410] This partnership is a voluntary group of electric utilities that will develop and pursue strategies to reduce climate and weather-related vulnerabilities. Several major utilities in California are participating in this effort, including, PG&E, Sacramento Municipal Utility District, and SDG&E. Finally, the Obama administration announced on May 10, 2016, the start of public and private

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409 Executive Order 15653, "Preparing the United States for Impacts of Climate Change" *Federal Register* Volume 38, No. 215, Part III (November 6, 2013). https://www.gpo.gov/fdsys/pkg/FR-2013-11-06/pdf/2013-26785.pdf.

410 http://energy.gov/epsa/partnership-energy-sector-climate-resilience.

sector efforts to increase community resilience through building codes and standards that would ease climate impacts.[411]

Early Implementation and Coordination of Adaptation Directives

In response to Executive Order B-30-15, the Energy Commission and the CPUC formed the Energy Sector Adaptation Working Group to coordinate efforts between the two agencies and integrate adaptation directives. At the same time, the Energy Commission is using the IEPR process to advance the scientific and policy basis for energy sector adaptation and to engage California energy utilities that have committed to preparation of voluntary climate vulnerability assessments for the Partnership for Energy Sector Climate Resilience.

To that end, the Energy Commission, the CPUC, the OPR, and the CNRA jointly convened a public IEPR workshop on "Climate Adaptation and Resiliency for the Energy Sector" in Sacramento on June 21, 2016. The workshop provided an opportunity for stakeholders and decision makers to discuss current climate adaptation policies and programs for the energy system in California. Presentations reviewed climate adaptation policies, new enhanced climate and sea level rise scenarios, and tools for energy planning that take climate change into account. The workshop engaged with publicly owned and investor-owned utilities to share approaches and consider best practices for boosting the resilience of the energy system to climate change. The Energy Commission plans to build off the IEPR workshop to strengthen the capacity of local, state, and regions to plan for and respond to climate impacts.

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411 https://www.whitehouse.gov/the-press-office/2016/05/10/fact-sheet-obama-administration-announces-public-and-private-sector.

Acronyms

AAQS	—	ambient air quality standards
AB	—	Assembly Bill
ACS	—	American Community Survey
AMS	—	Advanced Microgrid Solutions
ANPR	—	Advance Notice of Proposed Rulemaking
ARB	—	California Air Resources Board
AQMD	—	Air Quality Management District
BGD	—	billion gallons per day
BOEM	—	Bureau of Ocean Energy Management
CAES	—	Compressed Air Energy Storage
California ISO	—	California Independent System Operator
CDFW	—	California Department of Fish and Wildlife
CEQA	—	California Environmental Quality Act
CHP	—	Combined Heat and Power
CNRA	—	California Natural Resources Agency
CO_2	—	carbon dioxide
CPP	—	United States Clean Power Plan
CPUC	—	California Public Utilities Commission
CREZ	—	Competitive Renewable Energy Zones
CRM	—	Cultural Resources Monitor
CSI	—	California Solar Initiative
CSP	—	concentrating solar power
CSU	—	California State University
DER	—	distributed energy resources
Diablo Canyon	—	Diablo Canyon Power Plant
DOE	—	Department of Energy
DR	—	demand response
DRECP	—	Desert Renewable Energy Conservation Plan
DRP	—	distribution resource plan
DSO	—	distribution service operators
EAP	—	energy action plan
EDF	—	Environmental Defense Fund
EIM	—	energy imbalance market
EJ	—	environmental justice

EPIC	—	Electric Program Investment Charge
EPR	—	Environmental Performance Report
EPS	—	California's Emission Performance Standard
FAA	—	Federal Aviation Administration
FERC	—	Federal Energy Regulatory Commission
GHG	—	greenhouse gas
GSA	—	Groundwater Sustainability Agency
GSP	—	Groundwater Sustainability Plan
GTI	—	Gas Technology Institute
GWh	—	gigawatt hours
HVAC	—	heating, ventilation, and air conditioning
HVDC	—	high-voltage direct current
IDER	—	integrated distributed energy resources
IEPR	—	Integrated Energy Policy Report
IOU	—	investor-owned utility
IPCC	—	Intergovernmental Panel on Climate Change
IPP	—	Intermountain Power Project
IRP	—	integrated resource plan
ISFSI	—	independent spent fuel storage installations
kV	—	Kilovolt
L.A. Basin	—	Los Angeles Basin
LADWP	—	Los Angeles Department of Water and Power
lbs	—	Pounds
LSE	—	load-serving entities
LTPP	—	Long-Term Procurement Plan
LUPA	—	land use plan amendment
MOU	—	memorandum of understanding
MTS	—	More Than Smart
MW	—	megawatt
MWh	—	megawatt hour
NASA	—	National Aeronautics and Space Administration
NEM	—	net energy metering
NO_x	—	oxides of nitrogen
NO_2	—	nitrogen dioxide
NRC	—	Nuclear Regulatory Commission
NSR	—	New Source Review
NREL	—	National Renewable Energy Laboratory

OCS	—	Outer Continental Shelf
OEHHA	—	Office of Environmental Health Hazard Assessment
OPR	—	Governor's Office of Planning and Research
OTC	—	once-through cooling
P2G	—	power-to-gas
PEV	—	plug-in electric vehicle
PG&E	—	Pacific Gas and Electric
PM	—	particulate matter
POU	—	publicly owned utility
PSD	—	prevention of significant deterioration
PV	—	photovoltaic
REAT	—	Renewable Energy Action Team
RETI	—	Renewable Energy Transmission Initiative
ROW	—	right-of-way
RPS	—	Renewables Portfolio Standard
SACCWIS	—	Statewide Advisory Committee on Cooling Water Intake Structures
San Onofre	—	San Onofre Nuclear Generating Station
SB	—	Senate Bill
SCAQMD	—	South Coast Air Quality Management District
SCE	—	Southern California Edison
SCPPA	—	Southern California Public Power Authority
SCRP	—	Southern California Reliability Project
SDG&E	—	San Diego Gas & Electric
SGMA	—	Sustainable Groundwater Management Act
SLC	—	State Lands Commission
SoCalGas	—	Southern California Gas Company
SO_x	—	oxides of sulfur
SWRCB	—	State Water Resources Control Board
TRTP	—	Tehachapi Renewable Transmission Project
UMAX	—	underground maximum
U.S. BLM	—	United States Bureau of Land Management
USFWS	—	United States Fish and Wildlife Service
V2G	—	vehicle-to-grid
VOC	—	volatile organic compound
WECC	—	Western Electricity Coordinating Council
ZEV	—	zero-emission vehicle
ZLD	—	zero-liquid-discharge