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Energy Sector Plan

Introduction

The infrastructure of the energy sector is vulnerable to climate change impacts such as extreme events, wildfires, sea level rise (SLR), and heat waves. This document will serve as a plan to implement the State of California's climate adaptation strategy, which the California Natural Resources Agency updated with the report *Safeguarding California: Reducing Climate Risk* in July 2014. This chapter provides new information about potential vulnerabilities; highlights some of the progress being made to implement *Safeguarding California*; identifies next steps to substantially advance climate preparedness for the energy sector; and suggests new indicators for monitoring and evaluating adaptation in the energy sector. This implementation plan surveys the efforts already undertaken and necessary actions of those who plan, regulate, generate, transmit, or use energy.

At a workshop[12] jointly hosted by the California Energy Commission (Energy Commission) and the California Public Utilities Commission (CPUC) on July 27, 2015, four investor-owned California utilities (IOUs) and one municipally-owned utility outlined their current and future efforts to adapt to climate change. Even though this workshop targeted the electricity sector, it provided information to develop a framework to advance adaptation efforts for the entire energy sector which also includes the natural gas and petroleum sectors, and other nontraditional parts of the energy system that may become more important in the future, such as bio-refineries and their supporting infrastructure.

Vulnerability Assessment

California's energy system is vulnerable to a variety of climatic changes, including impacts from temperature, precipitation patterns, extreme events (including drought, wildfire, inland flooding, and severe storms), and sea level rise (Franco and Wilson, 2005; Stoms et al, 2013; California Energy Commission 2013). Some of these impacts are particularly significant to the energy sector, including more frequent and severe extreme heat episodes and decreasing snow-water content in the Sierra Nevada that are already becoming evident (*Indicators of Climate Change in California*, OEHHA, 2013). Moreover, historical climatic data will not suffice to support future management of energy systems and other

[12] http://www.cpuc.ca.gov/PUC/energy/CPUC_and_Energy_Commission_to_Hold_Climate_Adaptation_Workshop.htm

human concerns, as the climate is diverging from its historical "envelope"— in other words, key climate parameters are starting to move outside of historically observed variability—at a rate that makes historical data a poor predictor of future climate. For example, 2014 was the hottest year on record in California; and annual temperature moved far outside the envelope of natural variability as recorded in the last 120 years. It is also important to note that most of the warming in California occurred during the winter season, contributing to snowpack reduction in the Sierra Nevada.

Recent findings of climate impacts on California's energy system are briefly summarized below. It should be noted, however, that significantly more research has been done to date on electricity than other aspects of the energy sector, such as natural gas or transportation fuels. Additional background on climate vulnerability of the energy sector can be found in *Safeguarding California: Reducing Climate Risk*.

ELECTRICITY

The impacts of climatic changes on California's electricity system include: decreased efficiency of thermal power plants, substations, and some renewable generation technologies; decreased capacity of transmission lines; increased risk to electricity infrastructure of extreme events, including sea level rise, coastal flooding, and wildfires; less reliable hydropower resources; and increased peak electricity demand (Stoms et al., 2013; California Energy Commission, 2013).

Electricity infrastructure is vulnerable to sea level rise along the coast. About 25 coastal power plants may be exposed to high water levels during what is considered a 100-year flood event, which would become more frequent with sea level rise. Prior research has shown that the increased frequency and severity of wildfires as a result of a warming climate will increase the risks of grid disruptions in our transmission lines. For example, hundreds of poles and lines were damaged and thousands of customers experienced outages as a result of the Butte and Valley fires in September 2015.

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The 2015 Integrated Energy Policy Report (IEPR) included a preliminary peak electricity demand forecast that accounted for climate change. The forecast used climate scenarios developed for California by Scripps Institution of Oceanography for the Energy Commission based upon climate models used for the 2014 IPCC Assessment (IPCC, 2014). Higher projected annual maximum temperatures derived from the scenarios increased the statewide peak demand forecast by over 600 MW in the mid

demand case by 2026. Staff also derived projected changes in heating and cooling degree days from the scenarios, which affect electricity consumption. The impact on consumption was slight (around 60 GWh statewide in 2026) in the mid demand forecast, as heating degree days decreased at a much higher rate than cooling degree days increased. (Kavalec, 2015).

Renewable energy technologies help mitigate climate change, but they can also be vulnerable to the impacts of climate change. For example, solar photovoltaic systems tend to be less efficient at higher temperatures.[13] Projections for the Southwest suggest reductions of efficiency of the order 0.7 to 1.7 percent with anticipated higher temperatures in 2050 (Bartos and Chester, 2015). Information on changes in the probability and location of occurrence of excessive heat in California due to climate change can help inform research on solar photovoltaic system performance on hot days. Similarly, additional studies on changes in the probability and location of changes in wind patterns in California due to climate change[14] can help inform wind energy planning, forecasting, and integration as California increases the proportion of electricity generated from wind energy. Projections of changes in solar and wind regimes for the California region have not matured enough yet to provide a clear picture of potential changes. A recent paper noted, for example, that wind performance depends not only on wind speed but also on the density of the air; unfortunately, there are currently substantial uncertainties in the projections of both parameters (Bartos and Chester, 2015).

NATURAL GAS

The natural gas system in the Bay Area, the Delta, and the California coast is vulnerable to potential impacts of an extreme storm event coupled with sea level rise on natural gas pipelines. A recent study led by University of California Berkeley used high-resolution hydrodynamical modeling to investigate the dynamic impacts of SLR, tides, and freshwater flows (Radke et al., 2015). The research concludes that the Delta levees are nominally "prepared" for an extreme storm event (ca. 100-year event) under current sea level conditions, inasmuch as modeling indicates that extensive overtopping would not be expected. However, substantial levee failures due to overtopping would be expected due to an extreme storm event under conditions of more than about one meter of sea level rise. For example, if such a storm event were paired with a 1.4 m SLR, which is a possible high-end 2100 estimate for California, then the storm would pose extensive risk to critical natural gas infrastructure as well as other energy related and transportation infrastructure. Such risks include inundation of approximately 200 miles of natural gas transmission lines in the Bay-Delta,

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13 http://energy.gov/eere/energybasics/articles/photovoltaic-cell-conversion-efficiency-basics

14 http://iopscience.iop.org/1748-9326/6/2/024008/fulltext/

including backbone transmission at Antioch, key transmission on Sherman Island, and transmission loops in San Jose, San Francisco, and Sacramento. Additionally, under such conditions, inundation of natural gas storage at MacDonald Island is indicated (Radke et al., 2015). As pointed out by this study, additional work is needed to clarify flood risks to the Delta associated with climate change. For example, subsidence of Delta levees exacerbates vulnerability to sea level rise by lowering levee crests (Brooks and Manjunath, 2012). Due to subsidence-induced acceleration of the rate of *relative* sea level rise, extreme storm events are expected to pose substantial risks due to overtopping sooner than expected on the basis of absolute sea level rise alone.

California currently imports about 90 percent of the natural gas that it consumes, and, for this reason the integrity of large transmission lines is of high importance for the State. Thousands of miles of natural gas transmission and distribution lines cross California, bringing natural gas from producing regions. Due to the particulars of California's geography, many of the key lines and related natural gas storage units run through the Central Valley, which has subsided dramatically in the past decade. The subsidence in the Valley has been exacerbated by unprecedented groundwater pumping in response to drought related shortages of surface water. Subsidence can affect the integrity and safety of natural gas pipelines. However, it is not yet known exactly how and where the unusually rapid rate of drought-related subsidence has affected natural gas pipelines and storage in the Central Valley.

Observations of heating degree days[15] (HDD) in California in the last few decades show a declining trend. For example, the decline of HDD was about 15 percent from 1960 to 2014 in the San Joaquin Valley, which would be expected to decrease the amount of natural gas consumed for space heating in a more or less proportional way. The overall downward trend in HDD, at least in the Central Valley, seems to be linked to reported reductions of Tule fog in the same region (Baldocchi and Waller, 2014).

PETROLEUM TRANSPORTATION FUELS

Given the proximity of most of California's refineries to the ocean, they may be at risk of saltwater intrusion and damage from SLR and storm surges (Perez et al., 2009). Additionally, most refineries in the state consume electricity from the electricity grid and, therefore, are vulnerable to grid disruptions, which may be due to weather-related events associated with climate change. Finally, water availability is also a concern for oil refineries. Refineries in California use a great deal of water to create steam used in their industrial processes. To the extent that potable water sources may have limited availability for use by refineries, other potential sources would have to be pursued along with strategies and technologies

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[15] A unit that measures the space heating needs during a given period of time

aimed at reducing their water intensity.

Oil pipelines may also be sensitive to SLR at port facilities. California's petroleum and transportation fuels infrastructure normally involves the movement of raw and finished transportation fuel products via marine vessels and a network of pipelines that connect wharves to refineries, storage tank farms, distribution terminals, and associated structures. The wharf structures used to unload and load marine vessels are designed to accommodate a wide range of tidal variation on a daily and annual basis. An increase in the mean average sea level, however, would significantly raise the maximum high tide levels, such that the existing wharf system used for moving petroleum products and other waterborne commerce may need to be adjusted. There are two railroads operating in California transporting crude oil: Burlington Northern Santa Fe and Union Pacific. Climate change is expected to increase landslides, which may have safety implications.

Current Actions to Prepare for Climate Impacts

This section briefly describes ongoing activities preparing the energy system for a changing climate using the four overall strategies identified in *Safeguarding California*.

PROTECT EXISTING ENERGY FACILITIES AND CONSUMERS FROM IMPACTS OF CLIMATE CHANGE

Several steps are being taken to improve the current energy system and to protect consumers from the near-term impacts of climate change. For example, after the 2006 heat wave, the CPUC required the electric utilities to start upgrading their transformers and other related equipment to be able to cope with both increased demand and relatively high temperatures at night that did not allow adequate cooling of the transformers during that event.

The San Diego Gas & Electric (SDG&E) South Bay Substation is a good example of existing infrastructure that has been upgraded with adaptation in mind. The substation was moved and the new site was graded to withstand sea level rise of up to 8 feet. Utilities are also increasing their ability to track, monitor, and predict wildfires, they are upgrading and hardening infrastructure to withstand fires. For example, all three electricity IOUs have filed applications to replace wood utility poles with steel poles in areas with a significant fire threat. The Energy Commission's Siting, Transmission, and Environmental Protection Division assesses sites proposed for thermal power plants larger than 50 megawatts (MW) for risks from sea-level rise and increased flooding as part of the reliability analysis of the project and equipment required under the Energy Commission's power plant certification process.

[16] http://energy.gov/epsa/partnership-energy-sector-climate-resilience

[17] SCE's vulnerability assessment is due in Spring, 2016, because they joined the Partnership a few months after its founding.

Pacific Gas & Electric (PG&E), SDG&E, Southern California Edison (SCE), and Sacramento Municipal Utility District (SMUD) recently signed on to the Department of Energy (DOE) Climate Resilience Partnership, a voluntary effort run by the DOE to promote best resilience practices across the country.[16] As part of the member agreement, each of the utilities will be required to produce a vulnerability report by late January, 2016,[17] followed by a resilience plan. These reports will help formalize the information and the internal processes that the utilities have been undertaking over the last several years. It will also facilitate a gap analysis for what additional efforts need to be undertaken and highlight coordination opportunities with the energy agencies and research community. Importantly, these plans will help stakeholders and regulatory agencies better understand and approve necessary expenditures related to adaptation efforts.

Finally, *Safeguarding California* called for new vulnerability and adaptation studies in the energy sector. The California Natural Resources Agency (CNRA) is leading the preparation of California's Fourth Climate Change Assessment that will be submitted to the Governor in 2018. The Energy Commission recently initiated a comprehensive portfolio of studies to be conducted for the energy-sector part of the Assessment. The energy (Energy Commission) and non-energy studies (CNRA) will use a common set of climate, sea level rise, and socio-economic scenarios. The project developing climate change and sea level rise scenarios has already begun. Details of the energy-related research for the Fourth Assessment are provided in the Enhance Energy-Related Climate Change Research section below.

DIVERSIFY ENERGY SUPPLY TO REDUCE CLIMATE VULNERABILITY

Several studies have been conducted to examine how the energy system in California should evolve to drastically reduce greenhouse gas (GHG) emissions (mitigation) in the next 35 years. Past studies have not investigated the link between mitigation and adaptation for the energy system. A study that started in July 2015 supported by the Energy Commission is, for the first time, making this connection. The study will investigate how to develop the energy system to drastically reduce GHG emissions while at the same time making it less vulnerable to climate impacts. The final results of the study will be available in 2017 and will provide further insights about options to drastically reduce greenhouse gas emissions from the energy sector by 2050, the potential costs associated these options, and promising technology/policy pathways.

> *"California's energy system must change drastically over the next few decades in response to policy goals to reduce GHG emissions and increase the amount of renewable energy in the electricity mix.* ***This evolution will require information that helps create a more climate-resilient energy system."*** *2013 IEPR, p.322*

[16] http://energy.gov/epsa/partnership-energy-sector-climate-resilience

[17] SCE's vulnerability assessment is due in Spring, 2016, because they joined the Partnership a few months after its founding.

The CPUC is continuing to implement its Self-Generation Incentive Program (SGIP) that provides incentives to support existing, new, and emerging distributed energy resources through rebates for qualifying distributed energy systems installed on the customer's side of the utility meter.[18] **Qualifying technologies include wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells, and advanced energy storage systems.** Decision 14-12-033 adopted $83 million annual SGIP collections through 2019.

As a result of AB 327, the CPUC is also in the process of creating a successor tariff for the Net Energy Metering (NEM) program to ensure that customer-sited renewable distributed generation continues to grow sustainably.[19] Other efforts to increase the number of renewables on the grid include CPUC-approved changes to Rule 21 interconnection tariffs in December, 2014, that will allow utilities to interconnect inverters with advanced capabilities and establish a study period to see how they perform.

The 1939 MW of distributed solar photovoltaic (PV) deployed through the California Solar Initiative[1] is fully subscribed, but efforts to continue the low-income programs for both single family and multi-family residential markets were renewed at $108 million over the next five years. The New Solar Homes Partnership, administered by the Energy Commission, continues to provide incentives for solar PV systems installed on highly energy efficient new homes and has a goal of installing 360 MW of additional solar capacity. In addition to solar PV, the solar thermal program to promote solar water heaters is authorized through 2017. In 2014, the CPUC initiated a new rulemaking to provide guidance for utility Distribution Resource Plans (DRP) that were filed in July 2015.[20] The goal of the DRPs is to accommodate greater deployment of distributed renewable generation, energy storage, electric vehicles, and energy efficiency and demand response technologies. This process will result in a far-reaching change to traditional distribution planning by the utilities, and it will influence investment decisions in future General Rate Cases.

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In August, 2015, the CPUC released a proposed decision, the "Decision Adopting an Expanded Scope, a Definition and a Goal for the Integration of Demand-Side Resources."[21] While the DRPs could set values for distributed energy resources

[18] http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/

[19] (R.) 14-07-002

[20] http://www.cpuc.ca.gov/PUC/energy/drp/

[21] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M153/K740/153740896.PDF

(DER) as part of their grid investments, the Integration of Demand-Side Resources will turn the DRP locational data into mechanisms for procuring DERs as alternatives to traditional grid projects, or creating new tariffs that could reward existing DERs for performing grid-supportive tasks. The proposal stakes out a series of decisions to be made in Phase 1 of the new proceeding, including "the development of an end-to-end framework for integrating demand-side resources, including relevant valuation methodologies and sourcing mechanisms. The final step in Phase 1 will entail developing objectives for the adopted framework."

At the utility scale, the CPUC and the Energy Commission continue to implement the Renewable Portfolio Standard (RPS), which requires retail sales of 33 percent renewable energy. The energy agencies are now investigating ways to achieve the Governor's call for 50 percent renewables,[22] which will likely be mandated by statute under SB 350 (De Leon, 2015), which is currently awaiting the Governor's signature.

Through the Electric Program Investment Charge (EPIC), the Energy Commission is making investments in Technology Demonstration and Deployment activities that will demonstrate microgrid technologies, specifically microgrids that serve critical facilities. Microgrids are a technology option for making the electric grid more resilient and adaptable to climate change impacts such as increased fires, severe storms, and heat waves. Microgrids are able to disconnect from the larger electric grid and provide stable independent power for facilities or entire communities. In 2015 the Energy Commission announced grant awards for seven microgrid demonstrations. These projects will demonstrate the ability of microgrids to utilize locally available renewable energy with energy storage and energy management systems that when coordinated together increase reliability and reduce greenhouse gases.

Of the seven microgrid grants, four of the grants are demonstrating microgrid systems for critical facilities that include a designated American Red Cross Emergency Center, fire stations, a wastewater treatment plant, and a hospital. One of the projects is being developed in Humboldt County by the Schatz Energy Research Center (SERC) at the Blue Lake Rancheria—a designated American Red Cross Emergency Center for surrounding communities in the county. SERC is incorporating a high penetration of renewable resources into the project. They are designing the microgrid to be able to island from the larger utility grid for up to seven days, which is especially important because this region of California is identified as a Local Reliability Area and is served by two transmission lines that are vulnerable to

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[22] http://gov.ca.gov/news.php?id=18828

climate change impacts. Coastal communities in Humboldt County must also be ready to respond to tsunami events, which will be more severe with rising sea level.

The state of California is also diversifying the supply of electricity to its facilities. For example, the Department of General Services (DGS) manages the statewide Power Purchase Agreements program. Under these agreements, the solar provider develops designs, installs, operates, and maintains solar photovoltaic systems using third-party financing, and then sells the generated renewable electricity to the host facility at or below utility tariff rates. This program facilitates the installation of solar power systems with no up-front cost to state departments. Since the program's inception in 2005, DGS has worked with several state agencies to implement over 38 MW of renewable energy throughout the state. With the current momentum, the state is on track to have 100 MW installed by the end of 2017. In addition to wind-powered systems, which are anticipated to be installed soon, other types of renewable energy are being examined, including solar thermal and fuel cells.

Planning for increased penetration of renewable energy in California's energy system as a long-term investment also considers climate change impacts on other resources, such as species and ecosystems. The Desert Renewable Energy and Conservation Plan (DRECP), for example, is taking an innovative approach to incorporate climate change into this plan for both preferred zones for energy and for biological conservation. Part of that effort is to select climate-resilient areas to protect species (Flint, 2015). The DRECP is helping stakeholders understand the adaptation needs by hosting an online data platform referred to as the DRECP Climate Console with the relevant climate information.[23]

Whereas the DRECP will designate Development Focus Areas that are preferred for renewable energy development in the southeast desert areas in California, the recently convened San Joaquin Valley Solar Study is intended to identify areas of least conflict that would be appropriate for solar development in this region. Five stakeholder groups are participating: 1) Environmental and Conservation; 2) Agriculture; 3) Counties; 4) Industry; and 5) Transmission. The goal is to expedite permitting of new renewable projects to deploy clean energy more quickly.

Cross-Sector Opportunity: Bioenergy

The Governor's Proclamation of a State of Emergency on the epidemic of tree mortality released in October 2015 in California will lead to ongoing work to ensure that bioenergy production will help manage the large volume of forest management residue and help meet the state's long-term climate change adaptation goals. A working group on bioenergy has been assembled by CALFIRE to implement actions to address the immediate tree mortality and identify longer term solutions. These actions will take into account many sectors, including energy, forestry, and habitat. Their work will spur actions that deal with tree mortality at hand as well as the projected increases in warm and dry climatic conditions in California.

PROMOTE ENERGY DEMAND SIDE MEASURES THAT FACILITATE CLIMATE ADAPTATION

Maintaining a reliable energy system is vital to the health and well-being of California's residents

[23] http://drecp.consbio.webfactional.com/climate

and its economy. Reliable grid operation depends on meeting demand with adequate supply and ensuring uninterrupted delivery to customers. As climate change could increase electricity demand and threats to grid reliability, strategies on the customer (or demand) side can help counter those impacts. For example, energy efficiency can be a very cost-effective tool that minimizes demand all the time. Demand response (DR), in contrast, provides a strategy to rapidly decrease electricity usage temporarily when the grid is stressed from high demand, such as during extreme heat events. Zero net energy (ZNE) buildings combine efficiency with clean, on-site renewable energy generation. Because water and energy systems are tightly coupled, strategies to conserve water, particularly during drought, also reduce electricity demand. Energy storage, including that provided by electric vehicles (EVs), helps with grid reliability by supplying stored electricity during peak demand. Specific efforts in each of these categories are described below.

Energy Efficiency

Energy efficiency is a preferred energy resource under the state's loading order, which was developed in 2003 to guide investment decisions to meet California's future electricity needs in the best, long-term interest of consumers, ratepayers, and taxpayers. However, California has long been a proponent of reducing the unnecessary waste of energy for decades. For example, the Energy Commission adopted the first energy efficiency standards for appliances in 1976 and for buildings in 1978. Since then, Californians have saved $75 billion in electricity costs.[24] California's per person electricity consumption has remained relatively flat, in part due to California's long-term energy efficiency efforts, while electricity consumption in the rest of the United States has increased by roughly 40 percent. Building upon these efforts, the state's Long Term Energy Efficiency Strategic Plan[25] updated in 2011, set forth a roadmap to achieve maximum energy savings across all major groups and sectors in California. This plan is the state's first integrated framework of goals and strategies for saving energy. The plan includes government, utility, and private sector actions, and holds energy efficiency to its role as the highest priority preferred energy resource. The CPUC is in the process of updating the plan and broadening the scope to integrate energy efficiency with other demand-side efforts including demand response, time-of-use rates, and distributed generation.

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[24] http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf

[25] http://www.energy.ca.gov/ab758/documents/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

Assembly Bill 758 (Skinner, Chapter 470, Statutes of 2009) requires the Energy Commission, in collaboration with the California Public Utilities Commission and stakeholders, to develop a comprehensive program to capture more energy savings from California's existing building stock. The Energy Commission approved the *Existing Buildings Energy Efficiency Action Plan*,[26] on September 9, 2015. This action plan provides a 10-year roadmap to dramatically reduce energy use in California's existing residential, commercial, and public buildings. The Energy Commission will work in collaboration with the CPUC, local governments, industry stakeholders, and various state and local agencies to achieve the action plan's objectives, and help the state achieve Governor Edmund G. Brown's doubling of energy savings in existing buildings by 2030, as stated in his 2015 State of the State address.

In June 2015, the Energy Commission approved the 2016 Building Energy Efficiency Standards that, when in effect, will reduce energy costs, save consumers money, and increase comfort in new and upgraded residential and nonresidential buildings. These new standards include features such as high performance attics and walls, instantaneous water heaters, and highly efficient lighting. Single-family homes built to the 2016 standards will use about 28 percent less energy for lighting, heating, cooling, ventilation, and water heating than those built to the 2013 standards. Based on a 30-year mortgage, the Energy Commission estimates that these standards will add about $11 per month for the average home, but save consumers $31 on monthly heating, cooling, and lighting bills. This brings the state one step closer toward achieving the state's 2020 Zero-Net Energy (ZNE) goal for all new residential buildings. The basic premise for designing and constructing ZNE buildings is to integrate and optimize energy efficiency measures with on-site renewable generation so that a building produces and/or offsets as much energy as it consumes annually. ZNE buildings can provide consumers and building owners long-term cost savings and other non-energy benefits, such as improved comfort. These buildings can also help reduce greenhouse gas and criteria pollutant emissions by avoiding the long-term need to generate electricity from fossil-fueled electric generation facilities. In addition, ZNE buildings can help improve local electric service reliability due to the proximity of load to on-site electric generation, and can help reduce the need to expand the electric system, benefiting all ratepayers from reduced infrastructure expansion costs, while reducing the systems overall environmental impact.

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[27] http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-05/TN203806_20150310T093903_California%E2%80%99s_Existing_Buildings_Energy_Efficiency_Action_Plan.pdf

Governor Brown specifically cited ZNE as one of several effective methods to combat climate change by achieving the goals of AB 32. In his 2012 Executive Order B-18-12[27] and the accompanying Green Building Action Plan,[28] Governor Brown directed executive branch departments to design, construct, and upgrade buildings to meet ZNE building requirements, where possible. Fourteen state buildings were chosen to pilot ZNE building concepts; however, due to state budget constraints, only a handful of projects are complete or under construction. Executive Order B-18-12 also mandates that state buildings benchmark their energy and water use using ENERGY STAR Portfolio Manager. Benchmarking is the process of collecting building performance data and comparing that data to a standard metric, usually the best building practices. Building owners and operators can then use this information to better manage their building energy and water use, and improve a building's overall performance. In 2014, the state reduced water use by 22 percent compared to 2010, meeting the Executive Order's reduction goal of 20 percent by 2020, and is well on its way toward meeting the energy goal of 20 percent by 2018. State department energy use dropped by 14 percent compared to the 2003 baseline. In addition, 2014 saw an increase in on-site renewable generation, now accounting for 12 percent of total state energy use. In April 2015, the Governor's Sustainable Buildings website was launched to publically disclose the state's progress towards reducing its environmental footprint by improving state building performance.

The CPUC has many ongoing programs to promote energy efficiency, authorizing spending of about $1 billion per year across the state's investor-owned utilities for all end-use electricity and natural gas consumers. A 2014 decision committed funding at that level for a ten-year period as part of their new Rolling Portfolio design, whereby energy efficiency targets will be updated annually rather than tri-annually and evaluations will be integrated within the portfolio rather than at fixed time intervals. The long-term, committed funding will provide a longer-term perspective and could enhance market transformation for deeper and longer lasting energy savings. California's publically-owned utilities are also committed to reducing energy consumption, investing close to $140 million in energy efficiency programs per year.

Cross-Sector Opportunity: Green Infrastructure

Urban greening can have many benefits that ameliorate impacts from climate change. Communities can improve the sustainability of existing built environments by incorporating greening components that provide a myriad of benefits. For example, investments in green streets and alleys, green roof projects, and greening of schools grounds and other public spaces can greatly reduce heat island effects and promote energy and water conservation, while also providing environmental and public health benefits. Investing in urban greening projects is a cross-sector priority, especially to respond to the risks faced by disadvantaged communities. The Governor's budget recognizes the need for continued investment, which will incorporate the positive impacts that urban greening projects can have on energy use.

In addition to the low-income energy efficiency programs offered through the state's investor-owned and publically-owned utilities, the Department of

[27] http://gov.ca.gov/news.php?id=17508

[28] http://gov.ca.gov/docs/Green_Building_Action_Plan_B.18.12.pdf

Community Services and Development (DCSD) invests in energy efficiency upgrades and on-site renewable generation for vulnerable and disadvantaged communities. For example, the Low-Income Weatherization Assistance Program administered by DCSD and funded by the state and the United States Department of Energy for decades, has assisted low-income households in disadvantaged communities install rooftop solar photovoltaic systems, solar hot water heater systems, and weatherization measures, such as wall and attic insulation and duct sealing. This program demonstrates the state's commitment to leverage funding to ensure that the communities who will be most impacted by climate change are prepared and have the tools and resources to adapt to its effects.

Water Efficiency

Water will become more precious as the climate changes. Droughts are expected to become longer and more severe. Therefore water efficiency is a key adaptation strategy with a co-benefit of reducing energy demand. In response to California's severe drought, Governor Brown's Executive Order B-29-15 outlines bold steps to save water, increase enforcement of water use standards, streamline the state's drought response, and invest in new water energy technologies. To accelerate the deployment of innovative water and energy saving technologies in the agricultural, residential, industrial, commercial, and desalination sectors, the California Energy Commission, jointly with the Department of Water Resources, and the State Water Resources Control Board, will implement a Water Energy Technology (WET) program if funding is provided by the Legislature. WET will provide funding for innovative technologies that meet the following criteria:

- display significant on-site water savings, energy savings, and greenhouse gas emission reductions;
- demonstrate actual operation beyond the research and development stage;
- document readiness for rapid, large-scale deployment (but not yet widely deployed) in California;
- deploy technologies that are commercially available; and
- apply funds in existing facilities.

Executive Order B-29-15 also ordered the California Energy Commission to establish standards that improve the efficiency of water appliances, including toilets, urinals, and faucets available for sale and installation in new and existing buildings. In addition, on August 12, 2015,

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the Energy Commission approved new standards for showerheads that are expected to save more than 2.4 billion gallons of water in the first year and 38 billion gallons after full stock turnover in 10 years. Another of the four Energy Commission responsibilities in the Executive Order calls for a short-term, statewide rebate program for water-efficient appliances and devices. Pending funding, the Energy Commission is proposing two separate programs to save water: a clothes washer residential rebate program and a targeted disadvantaged community direct install program. The programs will help residents capture water and energy savings while reducing greenhouse gas emissions.

The CPUC initiated R.13-12-011 to look into policies to promote a partnership framework between energy IOUs and the water sector to promote water-energy nexus programs. The CPUC recently adopted a water-energy calculator to quantify how much electric energy is required to move and treat water in order to calculate the energy savings of various water conservation programs and allow water utilities to tap energy efficiency funding for water conservation programs. The calculator also calculates the water resource benefits associated with water savings. A second tool is the Avoided Water Capacity Cost Model (water tool). The water tool calculates an avoided water system capacity cost associated with water savings. Water tool output is an essential input into the water-energy calculator.

Demand Response

DR is a climate-resilience strategy in that it facilitates rapid load drops when grid reliability is jeopardized or demand is higher than expected. Although DR was not originally designed for the purpose of preparing for climate risks, it presents a powerful strategy for reducing peak energy demand and thereby boosting grid resilience when, for example, extreme heat waves raise peak demand. CPUC is evaluating DR in resource planning needs and operational requirements. It has recently contracted with Lawrence Berkeley National Laboratory to conduct a study to assess the technical potential of residential, commercial, industrial end uses to provide DR, plus economic and market potential of DR products to help establish DR goals. In addition, the CPUC has an interim target of meeting 5 percent of peak demand with price-responsive DR and has also made participation of DR in the wholesale markets possible as a flexible ramping resource and ancillary service. Passage of a new decision calling for time-of-use rates by 2018 will further help with peak load reduction and conservation. All three electricity IOUs have nearly

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completed the installation of smart meters across their territory, which will facilitate both customer ability to participate in current time-of-use pricing plans and future pilot programs.

Automated demand response (AutoDR) is triggered by a signal from a utility or grid operator to automatically reduce a user's load to a pre-agreed level. The Energy Commission has supported the development of OpenADR, which is a communication standard protocol to increase demand response availability in California. ADR substantially increases participation compared to manual systems. OpenADR has been adopted as both a national and international standard for DR and distributed energy resource operations, allowing large numbers of loads to participate reliably in DR in other states and countries. Investments by the Energy Commission to fund development of AutoDR and Open AutoDR at the Demand Response Research Center at the Lawrence Berkeley National Laboratory are already showing results. Using AutoDR and Open AutoDR is already avoiding 260 MW of peak load in California annually. The annual net benefits (savings minus technology costs) of these technologies in California are projected to increase from $16.5 million in 2012 to between $39 million and $118 million by 2020.

Energy Storage and Electric Vehicles

Energy storage technology is being hailed globally as the game-changer toward reliably managing low-carbon, greener electricity grids. California, a national leader in advancing energy storage, envisions this technology as a critical component in reducing global warming, improving air quality, promoting energy independence, and building climate resilience. The state currently has several pilot projects, and is working toward commercialization of energy storage. By supporting technology demonstrations and bringing energy storage innovators and investors together, California Energy Commission-funded storage projects provide data and real-world experience that will help reduce investment costs and prove which solutions work best in specific applications. The passage of Assembly Bill 2514 and the resulting California Public Utilities Commission decision set energy storage procurement targets for each of the IOUs totaling 1,325 MW to be online by 2024. In December, 2014, the California Independent System Operator (ISO), the California Public Utilities Commission (CPUC), and the California Energy Commission unveiled a comprehensive roadmap to assess the current market environment and regulatory policies for connecting new energy storage technology to the

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state's power grid.[29] The roadmap culminates years of work and input from more than 400 interested parties, including utilities, energy storage developers, generators, environmental groups, and other industry stakeholders. This roadmap will be used by the CPUC, Energy Commission, and the ISO to inform future regulatory proceedings, initiatives, and policies and lays a foundation to integrate energy storage technologies that benefit grid reliability and consumers.

The Energy Commission and CPUC continue to support the Governor's Zero Emissions Vehicle Action Plan.[30] Significantly, in December, 2014, the CPUC issued a Decision that would allow the electric utilities to take a larger role in the deployment of electric vehicle (EV) charging stations and electrical equipment, while the Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program is funding the expansion of public fueling stations for hydrogen fuel cell vehicles throughout the state. In addition, CPUC staff initiated a pilot program in August, 2014, to test the possibility for utilities to deploy sub-meters, which are capable of separately measuring and billing EV charging using a second meter on the customer's side of the utility meter. Deployment of sub-meters is a critical step in allowing the utilities to offer EV-specific rates that can allow EV drivers to access low-cost energy at night and mitigate the impacts of EVs on the electric grid. As technology improves, sub-meters may eventually allow vehicles to offer energy services to the utilities, providing an additional source of revenue to the drivers. The pilot program is divided into two phases to test different sub-metering scenarios and is expected to conclude in 2016. The Energy Commission supports EV charging R&D, and through the Alternative and Renewable Fuel and Vehicle Technology Program, supports EV charger R&D, and through the Alternative and Renewable Fuel and Vehicle Technology Program, supports EV charger and hydrogen fueling station deployment.

Enhance Energy-related Climate Change Research

Climate change research is one of the cornerstones of the state's climate policies. A 5-year research agenda for the energy sector was prescribed in the recent *Climate Change Research Plan for California* (Climate Action Team, 2015). It was designed to answer policy-relevant questions that support strategies and technological innovations

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[29] http://www.caiso.com/Documents/Advancing-MaximizingValueofEnergyStorageTechnology_CaliforniaRoadmap.pdf

[30] http://www.opr.ca.gov/s_zero-emissionvehicles.php

necessary to significantly reduce GHG emissions and climate risk and their economic, public health, and environmental impacts; identify synergies and trade-offs between mitigation and adaptation strategies; and assess the vulnerability of the energy sector to climate change. The Energy Commission is implementing this agenda through the EPIC (for electricity) and Natural Gas Research and Development programs and their respective investment plans. California's Fourth Climate Change Assessment is the first major part of implementation of the research plan in the energy sector.

The Energy Commission manages several applied research projects that will enhance climate adaptation for the energy sector now and into the future. For example, Scripps Institution of Oceanography demonstrated that it is possible to develop probabilistic seasonal forecasts that can be used to prepare for the possibility of hot summer months (Alfaro et al., 2006). They also showed that using satellite data about coastal fog early in the morning can substantially reduce peak demand forecast errors in the same day (Pierce and Cayan, in preparation). Finally, a new research project with the University of California Riverside and NASA/JPL is developing a new hydrologic forecast for a major hydropower system operated by Southern California Edison (SCE). The new forecast system will take into account the important role that small particles in the air have on precipitation amounts and the form of precipitation (snow vs. rain) (Creamean et al., 2013). SCE is heavily involved in this project providing real world expertise on the actual management of their reservoirs.

The research portfolio for the energy sector addresses vulnerability and risk assessment of climate impacts and assessment of adaptation strategies. Studies will extend the assessment of the increasing risks of sea level rise and wildfires on the electricity system begun in preliminary research by Lawrence Berkeley National Laboratory for the Third Assessment. A similar study is planned to investigate the climate vulnerabilities to the petroleum system such as refineries and oil pipelines. Other researchers will gather new empirical data on near-surface temperatures within an urban heat island to improve understanding of the determinants of the effect and provide a foundation for location-specific options to reduce peak energy demand and adverse public health impacts. Bottom-up regional studies are planned to consider impacts from multiple climate change factors on the natural gas system. Communicating climate risks to stakeholders in California's electricity infrastructure is being enhanced through improvements in the Cal-Adapt visualization tool.[31]

The Energy Commission is also funding research targeted to specific adaptation strategies. These include innovative grid management and

[31] http://cal-adapt.org/

operation strategies to overcome limitations or potential disruptions in power transmission as well as limitations to the grid's ability to make use of intermittent renewable generation. A group of projects are developing long-term energy scenarios from the present to 2050 that include climate impacts on demand, generation, and transmission.

In addition, the Energy Commission is funding research to improve grid resiliency through efficiency and demand response; renewable energy, distributed generation, and energy storage; and clean fossil-fueled sources and infrastructure improvements. Complementing these technological innovations are investigations of consumer choice and civic engagement, as well as assessments of the cost-effectiveness of adaptation options.

The State of California has been supporting regional climate change research for more than a decade. These studies have complemented research at the national level and have been designed to inform climate policy deliberations and actions in California. The Energy Commission in collaboration with the Air Resources Board developed and supports the State Climate Change Research Catalog, which is now hosted through Cal-Adapt.[32] The Research Catalog provides basic information about past and ongoing climate change-related studies that state agencies have conducted or commissioned since the early 2000s. The purpose of this catalog is to document California's research efforts and to facilitate the exchange of information. This new version provides improved user interface and search capabilities, including graphical summaries.

Data access by researchers has been an ongoing challenge for climate vulnerability and adaptation studies. Utilities have often been naturally reluctant to share data that is either proprietary about their operations or could affect customer privacy. For example, studies have been hampered by lack of access to data on grid disruptions caused by wildfire, operations of hydropower units, or the precise locations of coastal energy infrastructure. Nevertheless there have been successful examples where arrangements were made to provide such data to researchers under a nondisclosure agreement under which aggregated results could be reported (Auffhammer and Aroonruengsawat, 2012; Radke et al., 2015). The agencies and utilities need to continue working out procedures by which sensitive data can be accessed by researchers without compromising privacy, security, or business interests.

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The CPUC created the EPIC in 2011 to ensure that sufficient investment would be made in research and development of emerging energy

[32] http://cal-adapt.org/research/

technologies. Funding for the EPIC program is set at approximately $162 million per year from 2012-2020, and is to be used to support each of the following areas: Applied Research and Development, Technology Demonstration and Deployment, and Market Facilitation. Proposals for investment in various research areas are included in three-year investment plans created by each of the administrators (Energy Commission, SCE, PG&E, and SDG&E) with input from the public and submitted to the CPUC for approval. The IOU investments are focused on technology demonstration and deployment and market facilitation.

Next Steps

It is clear from the prior sections that there is already a great deal of initial work on adaptation. However, these actions are more related to developing new information via research projects and less oriented towards the substantial investments that implementation of adaptation measures will require. This focus is due in part to the fact that decision makers in the energy sector must feel comfortable with their investment decisions, and action will require careful collaboration and dedicated funding by public and private entities. Energy utilities may not be willing to invest substantially in adaptation unless the investments also make sense under current climate conditions and the climate of the next 30 years. It may make sense in some cases to delay implementation of adaptation options because the risks are not imminent and/or there is time to implement adaptation measures when new major investments are required. For example, an analysis conducted by RAND Corporation for the Port of Los Angeles suggested that sea level rise in the next decades should not be a problem, but that it would be wise to start implementing adaptation measures in the next major improvement program for the port when it will be less costly (Lempert et al., 2012). As with this specific study, future adaptation studies for the energy sector will include consideration of costs. The end result will compare the cost of doing nothing with the cost of different adaptation measures.

The CPUC and the Energy Commission via their EPIC and Natural Gas Research and Development programs are supporting adaptation research for the electricity and natural gas sectors, respectively. There is now a one-time source of funding for the Energy Commission to start analyzing the climate vulnerabilities of the petroleum sector, but a steady stream of research funds for the petroleum sector is needed.

The following are the next steps that California will take to substantially increase its climate resilience

activities for the energy sector:

- Establish a Working Group between the Energy Commission and the California Public Utilities Commission to design, implement, and monitor the actions listed below. This group met for the first time by January 15, 2016 and will create a work plan by April 29, 2016.
- Work with the DOE, the IOUs, and the publically-owned utilities (POUs) on the vulnerability assessments and resilience plans that they have agreed to produce as part of their membership in the DOE Climate Resilience Partnership (see schedule for vulnerability assessments above). This collaborative effort will facilitate development of robust documents that can be the cornerstone of efforts to incorporate adaptation planning and measures into utility operations and relevant CPUC proceedings and Energy Commission research.
- Work with other California IOUs and POUs and other energy utilities and entities that are part of natural gas (CPUC and Energy Commission) and transportation fuel systems (Energy Commission only) to implement a program similar to the DOE Climate Resilience Partnership, when necessary.
- Collaborate on research needs and efforts within the Commissions to ensure that research produces actionable science and investment and operational parameters
- Formalize the Energy Commission climate and sea level rise scenarios as part of an effort to foster science-driven decisions by June 1, 2016.
- Encourage cooperation and collaboration among all utilities and the various regional climate resilience collaboratives.

The two Commissions will report progress on the above action items to the California Natural Resources Agency by June, 2016, as required by Executive Order B-30-15.

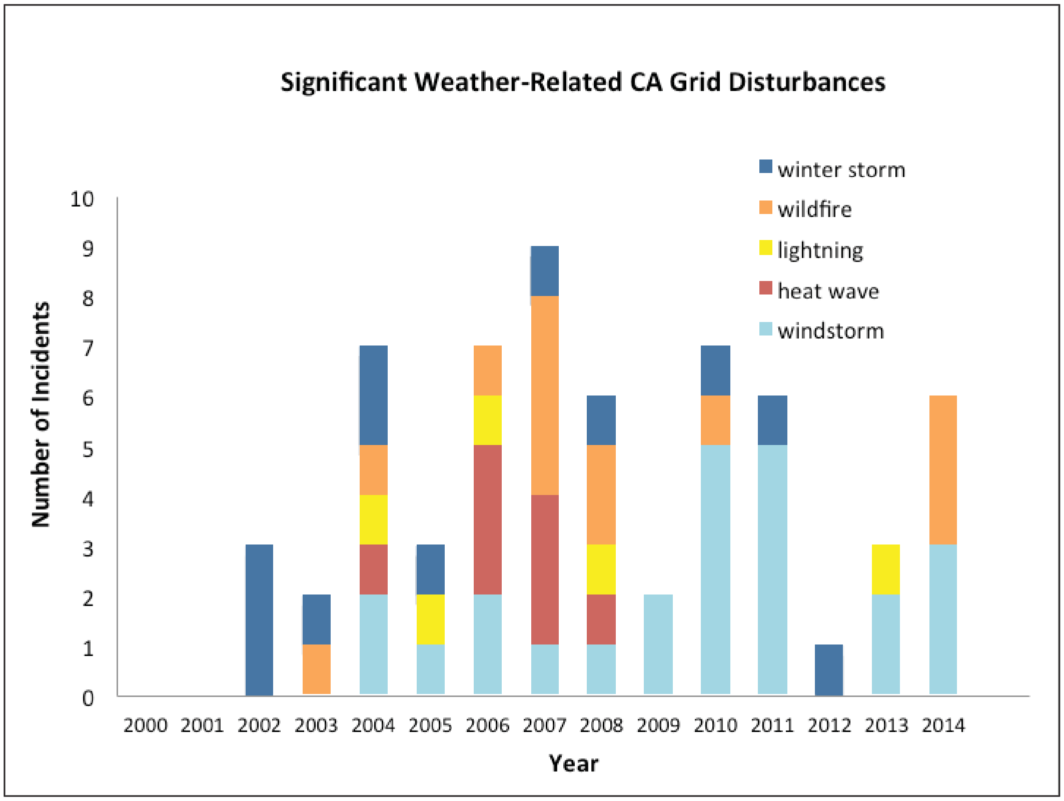
Monitoring and Evaluation

Energy indicators should: 1) be able to track progress on mitigation and/or adaptation while taking into account non-climatic features; 2) be easy to understand; and 3) be relevant at different levels of geographical detail from local to statewide levels.

Some of the energy indicators will be similar to the indicators needed for other sectors. For example, an indicator that tracks the fraction of winter precipitation that falls as snow will be very useful for hydropower operators but also for the water supply sector. For brevity this section does not discuss these indicators here but, obviously, local and regional indicators by hydrological units would be preferable than statewide indicators because the situation tends to be different in different regions in California (Franco, 2015).

Cooling degree days (CDD) and HDD are excellent indicators for the energy system. However, the definition of these indicators must be made relevant for California. For example, NOAA uses 65° F as the baseline temperature for the definition of HDD. This basically assumes that if ambient temperature falls below 65° F, people start to warm their homes and buildings, increasing energy demand for space heating. In practice, data from PG&E suggests that 60° F is a more realistic baseline temperature for their service territory (Franco, 2015). HDD and CDD data are available via NOAA but at a highly aggregated geographical resolution. Cal-Adapt will make this information available using a grid resolution of 3.5 miles using appropriate baseline temperatures for both historical data and climate projections.

Weather-related energy disturbances can become more frequent and damaging under a changing climate. For example, an increase in wildfire activities could increase disruptions of the electrical grid. However, the modernization of the electricity grid may reduce these events if this modernization is done considering climate change. The figure below shows the number of weather-related grid disturbances per year in California. This figure does not show a clear trend, but this may



Data Source: Energy Information Administration

To develop meaningful indicators, it will be necessary to create a repository of information about future disturbances, while at the same time trying to examine the historical record to see how far in the past trends can be tracked. For example, it may be possible to extend the historical period before 2002 in the above figure if information is available from governmental and/or energy entities.

[33] A unit of measure that indicates how heavy the air conditioning needs are under certain weather conditions

be due to the relatively short timeframe covered (12 years) and the fact that the electricity system is changing. However, some notable weather patterns are reflected in the length of the bars in the graph for particular weather-related sources of disturbances. As noted above, 2006 had an extreme heat wave, and heat waves caused a large fraction of the grid disturbances that year. Likewise, 2007 and 2008 were extremely bad years for wildfire, corresponding to larger than average number of grid disturbances. In contrast, 2009-2011 saw relatively small area burned and no fire-related outages. Regardless, it would be important to develop indicators of weather-related energy disturbances such as the one shown below to examine if the protective measures implemented for the energy system are effective.

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