Energy Sector Introduction:
Climate change can affect each stage of the energy cycle, including the extraction of raw fuel, refining, transport, generation, transmission, distribution, and demand. Given the sector’s critical importance to the Silicon Valley region, utilities and regulatory agencies will need to implement effective climate preparedness actions for energy infrastructure and related services. This section reviews existing plans, programs, and other initiatives that will help reduce the potential impacts of climate change on electricity supply and demand, and energy infrastructure (i.e., electrical sub-stations, electrical transmission and distribution lines, power generation facilities, natural gas distribution lines) within Santa Clara County.

The energy sector in Santa Clara County is comprised of various utilities and regulatory bodies. Pacific Gas and Electric Company (PG&E), City of Palo Alto Utilities (CPAU), and Silicon Valley Power (SVP) constitute the three major energy providers in the Santa Clara County region. PG&E, based in San Francisco, is one of the largest natural gas and electric investor-owned utilities in the United States. The company provides natural gas and electric services to approximately 15 million people throughout northern and central California. PG&E is regulated by the California Public Utilities Commission (CPUC). The City of Palo Alto is the only municipality in California that offers a full suite of City-owned utility services, which includes electricity and natural gas supply. The City of Palo Alto Utilities (CPAU) division supplies electricity and natural gas via PG&E-owned infrastructure for the transmission and distribution of both fuel types. In addition, CPAU owns and operates some sub-transmission lines, distribution lines, and 9 substations. Unlike PG&E, since CPAU is a municipally owned utility, it is regulated by various bodies including the Palo Alto City Council, a Utilities Advisory Commission appointed by the City Council, and a cross city-departmental Utilities Risk Oversight Committee. SVP is a municipal electric utility that provides electricity services to the City of Santa Clara, also via PG&E-owned transmission and distribution infrastructure. In addition, SVP owns and operate some transmission and distribution lines. Similar in structure to CPAU, SVP operates in accordance with rules and regulations approved by the Santa Clara City Council, and enforced by various city departments including the Department of Finance.

Subsequent sections in this chapter describe the various vulnerabilities faced by the energy sector as a result of climate change, and the extent to which these vulnerabilities have been addressed by the energy sector in the region.

Climate Change Vulnerabilities in the Energy Sector:
The energy sector in Santa Clara County is vulnerable to five climate change variables:

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changes in precipitation patterns
more extreme and frequent heat events
sea level rise
storm surge
wildfires

For more information on the nature and projected trends in these variables, refer to the Silicon Valley 2.0 Climate Variables Memorandum. The assets and services of the energy sector that are affected by these climate change variables, the nature of impacts on the assets and services, as well as the utilities affected by the impacts are summarized below in Table 1:

Table 1: Climate Change Variables and Impacts relevant to the Energy Sector in Santa Clara County

<table>
<thead>
<tr>
<th>Climate Change Variable</th>
<th>Assets/Services Affected</th>
<th>Nature of Impact</th>
<th>Relevant Utilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in precipitation patterns</td>
<td>Hydro-electricity generation</td>
<td>- Potential losses in hydroelectric power generation due to reduced snow-pack in the Sierra Nevada region</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Extreme and frequent heat events</td>
<td>Overall electricity supply</td>
<td>- Increased average electricity demand due to air conditioning load</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td></td>
<td>Electric transmission and distribution lines</td>
<td>- Power outages due to excessive peak load</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td></td>
<td>Electric transmission and distribution lines</td>
<td>- Reduced efficiency and reliability of equipment</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td>Sub-stations, electric transmission and distribution lines, power generation facilities</td>
<td>- Permanent inundation of coastal and low-elevation infrastructure</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Storm Surge</td>
<td>Sub-stations, electric transmission and distribution lines, power generation facilities</td>
<td>- Loss of function of coastal and low elevation infrastructure due to temporary inundation and/or physical damage, resulting in power outage</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Wildfires</td>
<td>Electric transmission and distribution lines</td>
<td>- Loss of function of electric transmission and distribution lines due to physical damage, resulting in power outage</td>
<td>PG&amp;E</td>
</tr>
</tbody>
</table>

Existing Efforts to Address Energy Sector Vulnerabilities to Climate Change:
This section provides an overview of existing energy sector climate change preparedness efforts in the county. The section is organized by climate change variable and the type of asset vulnerability. An overview of the asset vulnerability (e.g., losses in hydro-electricity generation due to reduced snowpack) is provided, followed by descriptions of the existing effort(s), the level of implementation (i.e.,
vulnerability assessment, risk assessment, strategy development, or strategy implementation), and the relevant organizations.

Efforts Addressing Changes in Precipitation Patterns

Description of Hydro-Electric Generation Vulnerability

Hydro-electricity forms a critical component of the electricity produced by utilities serving Santa Clara County. For example, PG&E owns and operates the nation’s largest investor-owned hydroelectric system, with a total generating capacity of 3,896 MW, which relies on nearly 100 reservoirs located primarily in the higher elevations of California’s Sierra Nevada and Southern Cascade mountain ranges. In 2012, hydro-electricity constituted approximately 11% of PG&E’s power mix. Similarly, hydro-electricity accounted for approximately 43% of CPAU’s power mix, and 12% of SVP’s power mix in 2012.

Changes in precipitation patterns (both in the form of snowfall and rainfall) directly impact hydro-electricity generation. Studies indicate that on average, the Bay Area will experience little annual change in total precipitation by mid-century. However, despite no change in overall annual precipitation, models project significant changes in seasonal precipitation patterns and the intensity of individual rain events in the region. Winter precipitation is projected to increase by mid-century, with more precipitation falling during winter in the form of more frequent and intense storm events. On the other hand, precipitation in spring and fall is projected to decrease. Moreover, winter precipitation events in the Sierra Nevada Mountains are projected to have a greater proportion of rain vs. snow, which will result in decreased snowpack, increased runoff, and potential for reduced water supply availability. Additionally, higher temperatures are anticipated to cause earlier spring snowmelt. Currently, under baseline conditions, snowpack effectively increases the water storage capacity of a watershed by holding on to the water in high elevations locations until later in the year. Earlier snowmelt and higher altitude rains could dramatically reduce this form of storage, which will directly impact hydro-electric generation.

In summary, changes in precipitation patterns may directly disrupt hydro-electricity generation, which is a critical service provided by the energy sector in Santa Clara County.

Existing Climate Change Preparedness Efforts

In order to ensure the viability of hydro-electricity as an energy source, utilities operating in Santa Clara County have put in place the following policies, procedures, and actions consistent with typical stages in a climate change adaptation planning process.

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9 Ibid.
**Snowmelt Runoff Monitoring/Measuring/Tracking**
- **Description**: PG&E has initiated several efforts to monitor climate change impacts on watersheds and aquifers. The company has developed a standardized procedure to track snowmelt runoff in watersheds, and conducted detailed analyses of individual watersheds as deemed necessary. PG&E is working with the U.S. Geological Survey (USGS) and the California Department of Water Resources (DWR) to better understand the potential impacts of mountain snowpack loss on three watersheds in Northern California (e.g. Northern Sierra Nevada and Southern Cascade watersheds).
- **Implementation level**: Climate Variable Data Collection and Analysis
- **Relevant agencies**: PG&E, DWR, USGS

**Education/Communication/Outreach**
- **Description**: As an outcome of PG&E’s research on watersheds, PG&E has presented and published several scientific papers on the company’s research and investigations into how climate change is impacting watersheds in Northern California. Additionally, PG&E has worked with local communities in Northern California to increase awareness of decreasing water flows so that these communities can explore local adaptation measures.
- **Implementation level**: Adaptation Strategy Implementation
- **Relevant agencies**: PG&E, Local Governments

**Increased Storage of Water in Reservoirs**
- **Description**: In anticipation of reduced snowpack in the Sierra Nevada region and its impacts on natural water storage, PG&E has taken measures to maintain higher winter carryover reservoir storage levels. Additionally, PG&E has put in place procedures to reduce conveyance flows in canals and flumes during storm events and the winter period in response to an increased portion of precipitation falling as rain. Lastly, the company has reduced discretionary reservoir water releases during the late spring and summer. PG&E will continue to monitor impacts of reduced snowpack on the company’s hydro-power generation over time, and will consider additional adaptation options if necessary.
- **Implementation level**: Adaptation Strategy Implementation
- **Relevant agencies**: PG&E

**Land-Based Cloud Seeding**
- **Description**: PG&E is exploring the viability of land-based cloud seeding through pilot projects as an option to increase spring-time precipitation, such that stream-flow in water bodies used for hydro-power generation can be maintained\(^\text{10}\). Given the preliminary stages of this research, it is

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currently not possible to draw conclusions about the mid-term and long-term effectiveness of land-based cloud seeding as an adaptation strategy.

- **Implementation level**: Adaptation Strategy Development
- **Relevant agencies**: PG&E

**Parallel Efforts with Climate Change Preparedness Benefits**

Utilities are implementing initiatives to diversify their portfolios of electricity generation sources, which while not specifically focused on responding to climate change will result in climate preparedness benefits for the region. These parallel efforts are described below.

**Diversification of Energy Sources**

- **Description**: Utilities operating in Santa Clara County acknowledge the need for diversification of energy sources in order to minimize disruptions in energy supply. In fact, efforts to diversify energy sources are already underway among utilities in compliance with the requirements of the California Renewable Portfolio Standard (RPS), which require utilities to procure 33% of its retail electricity sales from renewable energy sources by the year 2020. Although the primary goal of the California RPS is to promote renewable energy sources, efforts to comply with RPS will also result in ancillary climate change adaptation benefits. It should be noted, however, that utilities serving Santa Clara County intend to rely on small hydro-electric generation to meet their RPS targets, and if hydro-electricity generation potential is reduced as a result of climate change, other eligible renewable energy sources will be relied upon more heavily to meet these targets. Specific examples of utility programs aimed at diversification of energy sources and source augmentation are described in the section on extreme heat events. In addition to general diversification efforts aimed at ensuring compliance with RPS, utilities serving Santa Clara County have also taken other actions specifically to address the unpredictability of hydro-electric systems. For example, CPAU manages hydro-electric generation uncertainty by building up a cash reserve during high-precipitation years to purchase electricity during dry years.

- **Implementation level**: Parallel Effort with Climate Preparedness Benefits
- **Relevant agencies**: PG&E, CPAU, SVP, CPUC
- **Documentation of efforts**:
Efforts Addressing More Extreme and Frequent Heat Events

Description of Energy Supply and Peak Demand Vulnerability
The energy sector in Santa Clara County faces a rise in electricity demand due to increasing temperatures resulting from climate change. Specifically, summer-time extreme heat events are expected to become more frequent and intense in the Santa Clara region in addition to an increase in average temperatures. Given that air conditioning is the primary driver of increased peak electricity demand in the region during the summer, a rise in the frequency, intensity and duration of extreme heat events will directly result in a significant increase in peak summer-time electricity demand. A sudden increase in electricity demand for air conditioning as a result of extreme temperatures can overload electric lines, transformers, and other equipment, leading to potential power outages.\(^\text{11}\)

In summary, an increase in the frequency, intensity and duration of extreme heat events in Santa Clara County may lead to significant increases in peak electricity demand, and possibly result in reduced power reliability, including outages.

Existing Climate Change Preparedness Efforts
During the preparation of this Gap Analysis, no specific initiatives were identified that explicitly address preparing energy supply for a climate-change related increase in extreme heat events.

Parallel Efforts with Climate Change Preparedness Benefits
While no climate-change explicit initiatives were identified, the utilities have put in place policies, procedures, and actions to minimize the power outages resulting from peak electricity demand resulting from existing extreme heat events. These efforts include focus on outreach, demand reduction, and supply diversification/augmentation.

Education/Communication/Outreach
- **Description:** PG&E closely monitors Flex Alerts – warnings issued by the California Independent System Operator (ISO) to conserve energy – and in turn, communicates these alerts with customers through various means such as PG&E currents, newsletters, and social media outlets such as Twitter, Facebook, and YouTube.\(^\text{12}\) Additionally, PG&E offers guidance to customers on reducing energy consumption and managing costs during periods of extreme heat.\(^\text{13}\) This

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guidance includes suggestions for no-cost actions and low-cost actions to reduce energy consumption, as well as payment options to manage the cost of increased energy consumption.

- **Implementation level:** Parallel Effort with Climate Preparedness Benefits
- **Relevant agencies:** PG&E, CAL-ISO
- **Documentation of efforts:**

**Energy Demand Reduction: Demand Response Programs**

- **Description:** PG&E’s Demand Response programs offer financial incentives to businesses to reduce the energy use of their facilities during times of peak demand.
- **Implementation level:** Parallel Effort with Climate Preparedness Benefits
- **Relevant agencies:** PG&E, Business Owners in Santa Clara County

**Energy Demand Reduction: Energy Efficiency Programs**

- **Description:** While energy efficiency programs have historically focused on overall reduction in energy consumption, and not on peak load management, studies confirm that such programs have also achieved significant peak demand reductions.\(^{14}\) Therefore, any energy efficiency programs run by utilities serving Santa Clara County are also an indicator of their efforts to reduce peak demand. PG&E has partnered with the City of San Jose and Ecology Action to form the Silicon Valley Energy Watch, a program that offers resources on energy efficiency, including free audits, retrofits, technical assistance, education, training, and other forms of assistance for community-wide residential, commercial, and industrial sectors.\(^{15}\) The Bay Regional Energy Network (BayREN), a local government coalition of the Bay Area counties, has been approved and funded by the CPUC to offer residential and commercial energy efficiency programs throughout the region, as well as Codes and Standards and Energy Efficiency Financing subprograms. The County of Santa Clara is a member of the BayREN, representing 25% of the population and the largest share of energy customers (25% of the residential and 24% of the

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commercial) from the total of all 9 Bay Area counties.\textsuperscript{16} Also, the County of Santa Clara implements a comprehensive energy renewables and efficiency program, as well as a water-energy nexus program for water conservation and efficiency measures, throughout its government facilities and sites.

- Similarly, CPAU's 10-Year Energy Efficiency Plan for 2011-2020 aims to reduce energy consumption by 7.2\%\textsuperscript{17} by 2020 through a variety of demand management strategies. These include home energy diagnostic reports for residential customers,\textsuperscript{18} and rebates for energy efficient appliances. Lastly, SVP also offers various financial and technical energy efficiency incentives to residents and businesses in the City of Santa Clara, which include rebates on energy efficient appliances, and energy audits.

- **Implementation level:** Parallel Effort with Climate Preparedness Benefits
- **Relevant agencies:** PG&E, CPAU, SVP, Santa Clara County Residents and Business Owners
- **Documentation of efforts:**
  - Bay Regional Energy Network, [www.bayren.org](http://www.bayren.org)

\textsuperscript{16} The BayREN was formed among the following 9 counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma; and also covers 101 cities.


**Energy Supply Diversification/Augmentation/Decentralization**

- **Description:** Utilities serving Santa Clara County offer numerous ratepayer-funded programs to residential, commercial, and industrial customers to increase the use of decentralized energy sources.\(^\text{19}\)
- **Implementation level:** Parallel Effort with Climate Preparedness Benefits
- **Relevant agencies:** PG&E, CPAU, SVP, Santa Clara County Residents and Business Owners
- **Documentation of efforts:** Table 2 lists various programs offered by utilities in Santa Clara County, which promote distributed energy generation.

Table 2: Utility Programs Promoting Energy Supply Diversification, Augmentation, and Decentralization

<table>
<thead>
<tr>
<th>Utility</th>
<th>Program Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG&amp;E</td>
<td>California Solar Initiative Program</td>
<td>This program provides financial incentives for the installation of solar photovoltaic panels on existing homes or businesses.</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>Multifamily Affordable Solar Housing Program</td>
<td>This program provides incentives to offset the costs of installing solar systems on multi-family affordable housing buildings in California such as apartment buildings.</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>New Solar Housing Partnership</td>
<td>This program offers financial incentives and other support to builders, developers, and home-owners encouraging the construction of new energy efficient, solar homes.</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>Single Family Affordable Solar Housing Program</td>
<td>This program provides incentives to offset the costs of installing solar systems on low-income single family homes in California.</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>Self-Generation Incentive Program</td>
<td>This program provides financial incentives to large customers for the installation of new, qualifying self-generation equipment using both renewable as well as non-renewable energy sources.</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>Emerging Renewables Program</td>
<td>This program provides financial incentives to customers who purchase and install small wind systems and fuel cells for on-site generation.</td>
</tr>
<tr>
<td>CPAU</td>
<td>Photovoltaic Partners Program</td>
<td>This program offers rebates and technical assistance to residential CPAU customers on photovoltaic installation.</td>
</tr>
<tr>
<td>CPAU</td>
<td>Palo Alto Green</td>
<td>This program offers CPAU residential and commercial customers the option to match up to 100% of their electricity consumption with renewable energy a slight premium.</td>
</tr>
<tr>
<td>SVP</td>
<td>SVP Residential Solar Electric Rebate Program</td>
<td>This program offers rebates to residential SVP customers on photovoltaic installation.</td>
</tr>
<tr>
<td>SVP</td>
<td>SVP Commercial Solar Electric Rebate Program</td>
<td>This program offers rebates to commercial SVP customers on photovoltaic installation.</td>
</tr>
<tr>
<td>SVP</td>
<td>Santa Clara Green Power</td>
<td>This program offers SVP residential and commercial customers the option to match up to 100% of their electricity consumption with renewable energy a slight premium.</td>
</tr>
<tr>
<td>SVP</td>
<td>SVP Neighborhood Solar Program</td>
<td>This program uses individual and corporate sponsorships to install solar systems at non-profit facilities.</td>
</tr>
</tbody>
</table>

Description of Energy Infrastructure Vulnerability

In addition to the expected increase in electricity demand, higher temperatures may also cause equipment damage/failure, or reduced efficiency in the operation of equipment, which in turn, leads to power outages\(^\text{20}\). For example, during extreme heat events, transformers may not have adequate time to cool down overnight, causing them to damage electrical equipment\(^\text{21}\). Similarly, if the insulation covering underground electric lines expands from heat, it can cause a short circuit.\(^\text{22}\) Overloaded above-

\(^{22}\) Ibid.
ground lines may sag into tree branches from the heat, also causing a short circuit. Sometimes, PG&E may deliberately shut down power supply using circuit breakers or other protective equipment to prevent further damage to equipment from extreme heat events.\(^{23}\)

**Existing Climate Change Preparedness Efforts**

PG&E has implemented infrastructure improvements, to make its transmission and distribution infrastructure more resilient to current and future climate change induced extreme heat events. While these initiatives were originally implemented to address current extreme heat events, they improve preparedness for future increases in average and peak temperatures resulting from climate change.

**Infrastructure Improvements**

- **Description:** In recognition of its aging infrastructure, PG&E has proposed a $20.1 billion dollar plan over the next three years to expand and upgrade the generation and distribution infrastructure that provides gas and electric services in its territory, including Santa Clara County. The details of this plan are described in PG&E’s General Rate Case for the period 2014 – 2016.\(^{24}\) PG&E has determined these infrastructure improvements will contribute to meeting the expected increase in energy demand as a result of extreme heat events, and protect infrastructure from physical damage caused by extreme heat as well as other climate change variables such as storm surge or flooding. The proposed investments include:
  - A capital investment of $11.9 billion to upgrade and expand electric and gas facilities Operations and Maintenance (O&M) to maintain existing power generation, electricity and natural gas distribution systems, safety systems, customer care and computer systems.

- **Implementation level:** Adaptation Strategy Implementation

- **Relevant agencies:** PG&E, CPUC

- **Documentation of efforts:**

**Parallel Efforts with Climate Change Preparedness Benefits**

Utilities operating in Santa Clara County have put in place operations frameworks in order to make transmission and distribution infrastructure more resilient to extreme heat events. While these initiatives were implemented to address current extreme heat events, they may set the stage for preparedness for future increases in average and peak temperatures resulting from climate change.

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\(^{23}\) Ibid.

Emergency Response

- **Description**: Since power outages are a common cascading impact affecting the energy sector as a result of higher temperatures and extreme heat, PG&E, CPAU, and SVP have in an existing framework for power restoration, which consists of standard policies, procedures, and a team of trained PG&E field staff. PG&E has a company-wide Emergency Preparedness and Response organization that is working to strengthen emergency processes and procedures. While the focus is on catastrophic hazards like earthquakes, the processes and procedures are designed to enable PG&E to respond to a full range of emergencies, regardless of their nature.

- **Implementation level**: Parallel Effort with Climate Change Preparedness Benefits
- **Relevant agencies**: PG&E, CPAU, SVP
- **Documentation of efforts**:

Efforts Addressing Sea Level Rise and Accompanying Storm Surge

**Description of Energy Infrastructure Vulnerability**

Utilities serving the Santa Clara County region own and operate various types of energy infrastructure in the county, which includes electrical sub-stations, electrical transmission and distribution lines, power generation facilities, and natural gas distribution lines. Some of this infrastructure (particularly sub-stations, transmission lines, and distribution lines) is located in low-elevation and coastal zones in the County and is physically and functionally vulnerable to flooding from sea level rise as well as storm surge accompanying sea level rise. For example, equipment in power plants and sub-stations is sensitive to water. Salt water, in particular, may cause corrosion, especially if the plant or station has not been shut down in advance of flooding. Underground electrical or mechanical equipment may be sensitive to groundwater intrusion. The force of strong currents can knock down power poles and lines. All of these factors can lead to wide-spread power outages.

**Existing Climate Change Preparedness Efforts**

Utilities serving Santa Clara County have recognized the need for regional collaboration to prepare for sea level rise and increased storm surge.

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26 Based on consultation with PG&E

Regional Collaboration

- **Description**: Utilities in Santa Clara County agree that certain impacts of climate change need to be addressed on a regional scale, and in the short term, continue to participate in regional planning processes focusing on climate change adaptation. For example, PG&E has actively participated in the Adapting to Rising Tides project led by the San Francisco Bay Conservation and Development Commission (BCDC) and the National Oceanic and Atmospheric Administration’s Coastal Services Center (NOA CSC), which is exploring adaptation to sea level rise in a portion of Alameda County in California. Additionally, PG&E has been an engaged stakeholder in the Silicon Valley 2.0 project, and serves on the Technical Advisory Committee for this project. Similarly, SVP and CPAU have also been active participants in the Silicon Valley 2.0 stakeholder meetings and sector-based working group efforts.

- **Implementation level**: Overall Climate Change Adaptation Planning
- **Relevant agencies**: PG&E, SVP, CPAU
- **Documentation of efforts**:

Parallel Efforts with Climate Change Preparedness Benefits
Santa Clara County has a history of periodic coastal flooding, and as a result, utilities in the region have an existing framework to address flooding-related impacts. This framework is primarily focused on emergency response actions, which aim to restore power after outages from flooding. Other efforts initiated by utilities include proposed upgrades to infrastructure that will provide an opportunity to increase their resilience against natural disasters including storm surge.

Emergency Response

- **Description**: Since power outages are a common cascading impact affecting the energy sector in the aftermath of coastal flooding, PG&E, CPAU, and SVP have in place an existing framework for power restoration, which consists of standard policies, procedures, and a team of trained PG&E field staff.\(^{28}\)

- **Implementation level**: Parallel Effort with Climate Preparedness Benefits
- **Relevant agencies**: PG&E, CPAU, SVP
- **Documentation of efforts**:

Infrastructure Improvements

- **Description:** In recognition of its aging infrastructure, PG&E has proposed a $20.1 billion dollar plan over the next three years to expand and upgrade the generation and distribution infrastructure that provides gas and electric services in its territory, including Santa Clara County. The details of this plan are described in PG&E’s General Rate Case for the period 2014 – 2016.\(^\text{29}\) PG&E has determined these infrastructure improvements will contribute to meeting the expected increase in energy demand as a result of extreme heat events, and protect infrastructure from physical damage caused by extreme heat as well as other climate change variables such as storm surge or flooding. The proposed investments include:
  - A capital investment of $11.9 billion to upgrade and expand electric and gas facilities
  - Operations and maintenance (O&M) to maintain existing power generation, electricity and natural gas distribution systems, safety systems, customer care and computer systems.

- **Implementation level:** Parallel Effort with Climate Preparedness Benefits
- **Relevant agencies:** PG&E, CPUC
- **Documentation of efforts:**

Efforts Addressing Wildfires

**Description of Energy Infrastructure Vulnerability**

Wildfires in Santa Clara County are expected to increase in frequency and intensity, and the duration of the fire season is expected to lengthen. This can impact the energy sector in several ways.\(^\text{30}\) Wildfires can cause physical damage to transmission and distribution infrastructure. For example, they can burn down wooden transmission poles. Moreover, the associated heat, smoke, and particulate matter can reduce the capacity of transmission infrastructure. Soot from wildfires can accumulate on insulators that attach transmission lines to towers, causing leaked currents and subsequent power outages. Additionally, ionized air from wildfire smoke can cause electric arcing between lines, which can also lead to power outages. Even fire suppression activities can cause damage to energy infrastructure. For example, fire suppressants can foul transmission lines.

**Existing Climate Change Preparedness Efforts**

No specific initiatives were identified that prepare the sector for climate change-related increases in wildfire frequency or extent.

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Parallel Efforts with Climate Change Preparedness Benefits
While no climate change explicit initiatives where identified, utilities serving Santa Clara County have been addressing current wildfire risk. This includes a combination of preventive measures, emergency response measures, and proposed upgrades to infrastructure.

Vegetation Management
- **Description:** PG&E’s existing Vegetation Management program is responsible for minimizing wildfire risks via periodic inspections of vegetation in close proximity with PG&E transmission/distribution lines, pruning/removal of vegetation, and maintaining adequate clearance around transmission poles. These activities are carried out in compliance with various State and National laws and regulations governing vegetation management, which are briefly described below, in Table 3:

<table>
<thead>
<tr>
<th>Name of Regulation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Resource Code 4292: Firebreak Clearing</td>
<td>Requires maintenance of firebreaks around poles located in wild land areas during fire season that have equipment with the potential to emit sparks when operating properly.</td>
</tr>
<tr>
<td>Public Resource Code 4293: State Responsibility</td>
<td>Requires maintenance of clearance between vegetation and high voltage power lines during fire season in wild land areas to prevent wild fires. Also requires removal of dead, diseased or dying trees that could fall into power lines.</td>
</tr>
<tr>
<td>General Order 95: Utility Vegetation Management Requirements</td>
<td>Requires maintenance of clearance between vegetation and high voltage power lines at all times in all areas for public safety and electric system reliability.</td>
</tr>
<tr>
<td>North American Electric Reliability Council (NERC) Standard FAC-003-1: Transmission Vegetation Management Standard</td>
<td>Requires preventative action to reduce widespread outages caused by vegetation conflicts on high voltage electric transmission lines. Requires the development and implementation of a formal vegetation management program.</td>
</tr>
</tbody>
</table>

Since 2007, PG&E’s vegetation management program has incorporated a Public Safety and Reliability (PS&R) element, which takes a more proactive and strategic approach to vegetation inspection, pruning, and removal based on historical occurrences of wildfires in PG&E territory. Under the Vegetation Management program, PG&E started a pilot project in 2011 called the Outage Risk Reduction (ORR) project, which focuses on fire-risk-reduction by using specific vegetation management techniques employed by specialists in the industry. Another pilot

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project introduced by the company employs livestock grazing as a mechanism to reduce vegetation in order to minimize wildfire risks.  

- **Implementation level**: Parallel Effort with Climate Change Preparedness Benefits  
- **Relevant agencies**: PG&E, CPUC, Cal-FIRE  
- **Documentation of efforts**:

**Fire Risk Modeling**

- **Description**: PG&E is piloting a new fire risk computer model, which determines fires risks near PG&E owned infrastructure based on factors such as weather, winds, slope, and fuel load.  
- **Implementation level**: Parallel Effort with Climate Change Preparedness Benefits  
- **Relevant agencies**: PG&E  
- **Documentation of efforts**:

**Emergency Response**

- **Description**: Since power outages are a common cascading impact affecting the energy sector in the aftermath of wildfires, PG&E, CPAU, and SVP have in an existing framework for power restoration, which consists of standard policies, procedures, and a team of trained PG&E field staff.  
- **Implementation level**: Parallel Effort with Climate Change Preparedness Benefits  
- **Relevant agencies**: PG&E, CPAU, SVP  
- **Documentation of efforts**:

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Infrastructure Improvements

- **Description:** In recognition of its aging infrastructure, PG&E has proposed a $20.1 billion dollar plan over the next three years to expand and upgrade the generation and distribution infrastructure that provides gas and electric services in its territory, including Santa Clara County. The details of this plan are described in PG&E’s General Rate Case for the period 2014 – 2016.\(^\text{36}\) PG&E has determined these infrastructure improvements will contribute to meeting the expected increase in energy demand as a result of extreme heat events, and protect infrastructure from physical damage caused by extreme heat as well as other climate change variables such as wildfires. The proposed investments include:
  - A capital investment of $11.9 billion to upgrade and expand electric and gas facilities
  - Operations and maintenance (O&M) to maintain existing power generation, electricity and natural gas distribution systems, safety systems, customer care and computer systems.

- **Implementation level:** Parallel Effort with Climate Change Preparedness Benefits
- **Relevant agencies:** PG&E, CPUC
- **Documentation of efforts:**

Efforts Addressing Multiple Climate Change Variables

While the previous sections of this chapter discuss efforts to address impacts from individual climate variables, overall integration of climate change preparedness planning into utility operations and planning processes is required. One existing effort to do this is described below.

Institutionalization of Climate Change Considerations into Operations

- **Description:** PG&E has taken steps to evaluate and address the wide variety of impacts climate change could have on its operations and finances. In 2006, PG&E identified climate change as a top company risk and it was assessed through PG&E’s enterprise risk management process.\(^\text{37}\) In 2008, PG&E created a cross-departmental Climate Change Operational Impact Team to more specifically identify the potential physical risks of climate change to PG&E assets and to facilitate

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The Team has since conducted bi-annual reviews of the most relevant scientific literature on climate change variables such as sea level rise, temperature changes, rainfall and runoff patterns, and storm frequency and intensity affecting the company’s territory in California. The Team communicates the results of these reviews to affected business units so that the units can re-evaluate the risks and impacts to their facilities, and develop the necessary adaptation strategies.\textsuperscript{39}

- **Implementation level:** Overall climate change adaptation planning
- **Relevant agencies:** PG&E
- **Documentation of efforts:** PG&E Corporation Report, Carbon Disclosure Project, 2013.

**Key Actors and Decision Makers for Climate Change Adaptation Planning and Implementation**

The energy sector consists of a complex network of public and private agencies, each of which will have key roles to play in advancing climate change preparedness planning. These agencies are identified below, along with a description of their roles.

**Federal Regulatory Agencies:**

- **Federal Energy Regulatory Commission (FERC):** This agency regulates the interstate transmission of electricity, natural gas, and oil. FERC oversees the North American Electric Reliability Corporation (NERC), an agency whose mission is to ensure the reliability of bulk power systems in North America. While much of FERC’s regulatory authority applies to interstate transmission services and infrastructure, this agency will play a particularly critical role in the future adaptability of hydro-power generation to climate change. FERC is responsible for licensing and inspecting private, municipal, and State hydro-electric projects, and may need to consider the impacts of climate change on hydro-electricity generation potential in its licensing criteria.

**State Regulatory Agencies**

- **The California Public Utilities Commission (CPUC):** This agency regulates privately owned energy utilities in California. Its responsibilities include ensuring energy safety and reliability, setting aggressive renewable energy and energy efficiency goals, advancing climate change response strategies, setting fair energy rates, and inspecting/auditing utility infrastructure. With regards to unplanned outages, the CPUC has standards for operation, reliability, and safety during emergencies and disasters to ensure that utilities are prepared in order to minimize damage and inconvenience to the public resulting from an electric system failure. Utilities must submit an annual report to the CPUC regarding their reliability and preparedness. The CPUC also reviews utility performance following every major outage.\textsuperscript{40} The CPUC can levy penalties if these emergency standards are not met.

\textsuperscript{38} Ibid.
\textsuperscript{39} Ibid.
The California Energy Commission (CEC): This agency develops and implements California’s energy policy. It is responsible for forecasting statewide energy needs, energy source acquisition planning, supporting energy related research, siting and licensing of power generation facilities, promoting energy efficiency through building and compliance codes, developing renewable energy resources, and developing state responses to energy emergencies. Additionally, many of the CEC’s responsibilities listed above can indirectly support climate change adaptation planning and implementation in the energy sector. For example, the CEC can incorporate climate change considerations in its siting and licensing criteria for power generation facilities to incentivize climate change preparedness in existing and proposed facilities. Lastly, the CEC’s role in facilitating state responses to energy emergencies is also extremely relevant to climate change adaptation planning, given that power outages are a common cascading impact of natural disasters like storm surge, flooding, wildfires, and extreme heat events—all of which are likely to become more frequent and intense as a result of climate change.

California Department of Water Resources (DWR): This agency is responsible for the conservation, management, development, and sustainability of California’s watersheds, and water resources. DWR also partners with other agencies to prevent and respond to water-related natural disasters such as floods and droughts. DWR plays in important role in advancing climate change adaptation in the energy sector. As discussed previously in this chapter, DWR has been partnering with utilities and federal agencies to understand the potential impacts of mountain snowpack loss on watersheds in Northern California, which directly impacts hydroelectricity generation. Additionally, DWR’s collaboration with the CEC and the CPUC on reducing the energy intensity of water use assists the energy sector in reducing energy demand, which also contributes to the energy sector’s climate preparedness efforts.

California Independent System Operator (CAISO): This organization manages the flow of electricity across the high voltage electric grid in California and operates the wholesale power market that determines when and which power plants input electricity on the grid. CAISO also conducts an annual transmission planning process that identifies grid expansions needed to maintain reliability, lower costs, or meet future infrastructure needs. The long-term comprehensive transmission plan takes into account wide-ranging scenarios, such as high demand days coupled with wildfire and future growth in electricity demand. Lastly, CAISO provides warnings of possible electricity outages, which allow the public to better prepare for interruptions and encourages conservation that may help prevent the blackout from occurring.

Utilities
- As described in the introduction, Santa Clara County receives electricity and natural gas services from three utilities:
  - Pacific Gas and Electric Company (PG&E)
  - City of Palo Alto Utilities (CPAU)
  - Silicon Valley Power (SVP)
Local Governments
- Local governments have the ability to advance climate change adaptation planning at the community scale, and a majority of the municipalities as well as the County itself, have existing climate action plans. Local governments also incorporate climate change considerations into their locally enforceable general plans. Specifically with regard to the energy sector, local governments can influence energy use in their communities by making revisions to building codes and zoning codes, and by adopting specific ordinances that encourage renewable energy installation. Along with Santa Clara County, the cities in the County will play a crucial role in the implementation of local level adaptation strategies that will be identified as part of the Silicon Valley 2.0 process.

Summary of Existing Efforts to address Vulnerabilities
Table 4 summarizes existing energy sector efforts to address anticipated impacts from climate change in the region. Efforts to address climate change impacts vary across the different energy providers in Santa Clara County, which include PG&E, CPAU, and SVP. To date, PG&E has made the most robust climate change preparedness efforts. While CPAU and SVP have also implemented parallel efforts that will benefit climate change preparedness, these utilities have not made explicit efforts to address additional threat of climate change.

Table 4: Existing Efforts to Address Energy Sector Climate Change Vulnerabilities

<table>
<thead>
<tr>
<th>Climate Change Variable</th>
<th>Asset</th>
<th>Macro-category of Effort</th>
<th>Description of Effort</th>
<th>Climate Change Preparedness Category</th>
<th>Implementation Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in Precipitation</td>
<td>Hydro-electricity systems</td>
<td>Monitoring/Measuring</td>
<td>Standardized procedure to track snowmelt runoff in watersheds</td>
<td>Climate Variable Data Collection and Analysis</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Changes in Precipitation</td>
<td>Hydro-electricity systems</td>
<td>Education/Communication/Outreach</td>
<td>Publication of scientific papers on climate change impacts on watersheds Outreach to local communities in Northern California to increase awareness of decreasing water flows</td>
<td>Adaptation Strategy Implementation</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Changes in Precipitation</td>
<td>Hydro-electricity systems</td>
<td>Increased Storage of Water in Reservoirs</td>
<td>Maintenance of higher winter carryover reservoir storage levels Reductions in conveyance flows in canals and flumes in response to increased portion of precipitation falling as rain. Reduction in discretionary reservoir water releases during the late spring and summer.</td>
<td>Adaptation Strategy Implementation</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Changes in Precipitation</td>
<td>Hydro-electricity systems</td>
<td>Land-based Cloud Seeding</td>
<td>Increase precipitation by seeding clouds with chemical products</td>
<td>Adaptation Strategy Implementation</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Changes in Precipitation</td>
<td>Power supply</td>
<td>Diversification of Energy Sources</td>
<td>Addition of renewable as well as non-renewable energy sources to fuel mix</td>
<td>Parallel Effort with Climate Preparedness Benefits</td>
<td>PG&amp;E, CPAU, SVP</td>
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</tr>
<tr>
<td>Extreme Heat</td>
<td>Customers</td>
<td>Education/Communication/Outreach</td>
<td>Communication of extreme heat alerts through multiple modes of communication</td>
<td>Parallel Effort with Climate Preparedness Benefits</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Extreme Heat</td>
<td>Power supply</td>
<td>Energy Demand Reduction</td>
<td>Demand response programs</td>
<td>Parallel Effort with Climate Preparedness Benefits</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Extreme Heat</td>
<td>Power supply</td>
<td>Energy Supply Diversification/Augmentation/Decentralization</td>
<td>Addition of renewable as well as non-renewable energy sources to fuel mix</td>
<td>Parallel Effort with Climate Preparedness Benefits</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Extreme Heat</td>
<td>Physical infrastructure</td>
<td>Infrastructure Improvements</td>
<td>Proposed capital investments and operations/maintenance investments to upgrade and expand energy infrastructure</td>
<td>Adaptation Strategy Implementation</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Extreme Heat</td>
<td>Power supply</td>
<td>Emergency response plans and procedures</td>
<td>Standardized plans and procedures to respond to power outages and conduct repairs</td>
<td>Parallel Effort with Climate Preparedness Benefits</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td>Coastal infrastructure</td>
<td>Regional Collaboration</td>
<td>Active participation in regional efforts to understand and adapt to anticipated sea level rise</td>
<td>Overall climate change preparedness planning</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Storm Surge</td>
<td>Power supply</td>
<td>Emergency response plans and procedures</td>
<td>Standardized plans and procedures to respond to power outages and conduct repairs</td>
<td>Parallel Effort with Climate Change Preparedness Benefits</td>
<td>PG&amp;E, CPAU, SVP</td>
</tr>
<tr>
<td>Storm Surge</td>
<td>Physical infrastructure</td>
<td>Infrastructure improvement</td>
<td>Proposed capital investments and operations/maintenance investments to upgrade and expand energy infrastructure</td>
<td>Parallel Effort with Climate Change Preparedness Benefits</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Wildfires</td>
<td>Power Supply</td>
<td>Vegetation management</td>
<td>Periodic inspections and pruning of vegetation</td>
<td>Parallel Effort with Climate Change Preparedness Benefits</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Wildfires</td>
<td>Physical Infrastructure</td>
<td>Fire risk modelling</td>
<td>Identification of high risk zones based on historical occurrences of wildfires in PG&amp;E territory</td>
<td>Parallel Effort with Climate Change Preparedness Benefits</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Multiple Climate Variables</td>
<td>Multiple</td>
<td>Policy/Planning/Operations</td>
<td>Inclusion of climate change as a risk in enterprise risk management process; Creation of a climate change operational impact team; Periodic review of scientific literature on climate variables</td>
<td>Overall Climate Change Preparedness Planning</td>
<td>PG&amp;E</td>
</tr>
</tbody>
</table>
### Summary of Gaps in Energy Sector Climate Change Preparedness Efforts

Table 5 provides a summary of existing gaps in energy sector climate change preparedness efforts. The level of preparedness varies between the utilities and per climate variable and asset type. PG&E has initiated substantial efforts related to anticipated changes in precipitation and impact on power supply and changes in extreme heat and transmission infrastructure. For the other utilities and other variables there is a need for additional planning.

**Table 5: Level of Climate Change Preparedness Efforts in the Energy Sector**

<table>
<thead>
<tr>
<th>Climate Change Variable</th>
<th>Assets/Services Affected</th>
<th>Nature of Impact</th>
<th>Existing Climate Change Preparedness Efforts?</th>
<th>Level of Climate Change Preparedness Efforts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in precipitation patterns</td>
<td>Hydro-electricity generation</td>
<td>- Potential losses in hydroelectric power generation due to reduced snow-pack in the Sierra Nevada region</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Extreme and frequent heat events</td>
<td>Overall electricity supply</td>
<td>- Increased average electricity demand due to air conditioning load</td>
<td>No</td>
<td>None, but Parallel Efforts Exist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Power outages due to excessive peak load</td>
<td>No</td>
<td>None, but Parallel Efforts Exist</td>
</tr>
<tr>
<td></td>
<td>Electric transmission and distribution lines</td>
<td>- Reduced efficiency and reliability of equipment</td>
<td>Yes</td>
<td>Medium (PG&amp;E) N/A (CPAU,SVP)*</td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td>Sub-stations, electric transmission and distribution lines, power generation facilities</td>
<td>- Permanent inundation of coastal and low-elevation infrastructure</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Storm Surge</td>
<td>Sub-stations, electric transmission and distribution lines, power generation facilities</td>
<td>- Loss of function of coastal and low elevation infrastructure due to temporary inundation and/or physical damage, resulting in power outage</td>
<td>No</td>
<td>None, but Parallel Efforts Exist</td>
</tr>
<tr>
<td>Wildfires</td>
<td>Electric transmission and distribution lines</td>
<td>- Loss of function of electric transmission and distribution lines due to physical damage, resulting in power outage</td>
<td>No</td>
<td>None, but Parallel Efforts Exist</td>
</tr>
</tbody>
</table>

* CPAU and SVP are municipal utilities and do not own electric transmission and distribution lines, rather they use PG&E’s equipment.