# JOINT COMMITTEE ON EMERGENCY MANAGEMENT

## ASSEMBLYMEMBER FREDDIE RODIGUEZ, CHAIR
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**OVERSIGHT HEARING**

Monday, April 8, 2024
State Capitol, Room 112
3:00 pm (approx.)

## Critical Lifeline Disruptions: How California is Prepared for Extreme Incidents – Electricity, Gas and Public Safety Power Shutoffs

# Executive Summary:

This backgrounder describes the operation, planning and preparedness of the state's emergency management system, and its partners, if and when an extreme or catastrophic incident occurs that results in disruptions to critical electricity and gas lifelines. It provides an overview of the various statewide entities responsible for managing critical lifeline-related disasters, discusses regulatory oversight and causes of utility-related emergencies, addresses mitigation efforts, and describes disaster incident and catastrophic event management protocols, including response, restoration of services, recovery and system resiliency.

**In broad strokes:**

- The Office of Energy Infrastructure Safety (OEIS) and the California Public Utilities Commission (CPUC) coordinate closely together. Wildfire and Emergency Mitigation plans are formulated and submitted by utility providers to OEIS for review and are ratified by CPUC. CPUC also provides enforcement oversight and rule making for utility prices.
- Utility providers seek out the latest in technology and techniques to formulate their mitigation plans and spend millions of dollars a year improving the safety and resiliency of their systems. The cost of these improvements can be passed onto customers in the form of rate increases.
- The California Department of Forestry and Fire Protection (CAL FIRE) provides guidance on forest management and fire prevention, and contributes leadership in times of crisis.

- In the event of an emergency, the California Office of Emergency Services (CalOES) will be the agency which coordinates the response and recovery process with all statewide and federal partners.
- The likelihood of a damaging earthquake occurring somewhere in California before 2043 is nearly 100%. The chance of a damaging earthquake in the Bay Area is nearly 75% and in Southern California is 93% in that same time period.
- The occurrence of a major earthquake would have somewhat different effects in Northern and Southern California, due to their geographical differences and the arrangement of utilities relative to the risky faults. In either part of the state, power loss is expected to be widespread and expensive to repair. Access to broken equipment will be hampered by damaged conveyances.
- The most prominent secondary effect of broken power and gas infrastructure is the simultaneous ignition of hundreds of fires sparked by ruptured gas lines and down power lines.
- Other downstream effects could include, insecurity of the refrigerated food and medicine supply, challenges providing medical care and powering medical devices, the inability to operate gas pumps to pull fuel for alternative power generation, the sudden spike in demand for petroleum, and impacts to critical infrastructure like wastewater treatment and airport operations.
- With CalOES at the helm, the California Utility Emergency Association, FEMA, the Army Corps of Engineers, the US Department of Energy, utility companies and others will need to cooperate to restore service quickly and safely, and to ration resources for critical functions in the interim.
- While the utility providers estimate that the majority of service will be able to be restored within days or weeks, significant supply challenges will hamper full restoration, including the manufacturing of critical parts, which can take a year or more.
- Private utility providers are not eligible for all forms of federal recovery dollars, which will limit the resources available for reconstruction.

# The Statewide Stakeholders:

### California Office of Emergency Services (CalOES):

CalOES is responsible for addressing natural, technological, or manmade disasters and emergencies, and preparing the State to prevent, respond to, quickly recover from, and mitigate the effects of both intentional and natural disasters. As part of their overall preparedness mission, CalOES is required to develop a State Emergency Plan (SEP), State Hazard Mitigation Plan (SHMP), and maintains Standardized Emergency Management System (SEMS) and the Emergency Management Mutual Aid System (EMMA). CalOES, in coordination with FEMA and local partners, has developed four Catastrophic Plans to augment the State Emergency Plan. In the event of a catastrophe, Cal OES is the designated lead agency for coordinating response and recovery.

### California Department of Forestry and Fire Protection (CAL FIRE):

CAL FIRE’s most vital mission is preventing wildfires in the State Responsibility Area, but the department's Fire Prevention Program consists of multiple activities including wildland pre-fire

engineering, vegetation management, fire planning, education and law enforcement. Typical fire prevention projects include brush clearance, prescribed fire, defensible space inspections, emergency evacuation planning, fire prevention education, fire hazard severity mapping, and fire-related law enforcement activities. Beyond its wildland firefighting role, CAL FIRE is an "all-risk" department by also responding to medical aids; hazardous material spills; swift water rescues; search and rescue missions; civil disturbances; train wrecks; floods, earthquakes and more. In light of the department's extensive size and wealth of experience in managing major incidents, it is routinely called upon to provide invaluable assistance and assume leadership roles during times of disaster.

### The California Public Utilities Commission (CPUC):

The CPUC oversees programs and regulations to promote both natural gas and electricity reliability, resilience, and safety. Safety functions of CPUC include both backward-looking investigations and analysis of safety incidents and utility performance, and forward-looking risk analytics to mitigate emerging threats and identify necessary regulatory rule reform.

CPUC performs operation and maintenance audits, outage inspections, mitigation reviews, and investigations of incidents at electric generation facilities and coordinates closely with state public safety agencies to further resilience initiatives. CPUC's safety oversight also includes enforcing public utility wildfire safety and Public Safety Power Shutoffs (PSPS) violations. CPUC is the lead investigator for utility incidents relating to wildfire events and recommends policy to strengthen PSPS guidelines. In addition to CPUC opening formal investigations, CPUC imposes fines for natural gas, electric infrastructure, and wildfire safety-related violations.

CPUC conducts reviews of utility operations every four years to determine just and reasonable rates for energy services. CPUC provides guidelines for investor-owned utilities to follow when purchasing electricity and natural gas on behalf of their customers to ensure that sufficient amounts of electricity are procured when and where needed in the state.

As the primary regulator of investor-owned electric utilities in California, CPUC must approve the rates utilities charge customers for providing power. To ensure that utilities are operating in the public interest, CPUC has established a variety of requirements that utilities must meet to justify their rates, including that utilities must undertake a comprehensive review of the risks associated with running their operations and their proposed actions to mitigate those risks. As part of that review, CPUC assesses whether the utility was a "prudent manager" of its infrastructure and operations – known as a prudency review or prudent management standard. Generally, the utility submits an application for cost recovery to CPUC, and the burden of proof is on the utility to demonstrate it has behaved reasonably.

### The Office of Energy Infrastructure Safety (OEIS):

According to an analysis by the Legislative Analyst's Office, electric utility power lines caused at least eight of the twenty most destructive fires in Californian's history. Given that wildfire represents the single most significant threat to all of California's investor-owned electric utilities, the state created a separate state agency known as the Office of Energy Infrastructure Safety

(OEIS) under the Natural Resources Agency, to specifically focus on reducing this one key risk (see: AB 1054 (Holden, Chapter 29, Statutes of 2019) and AB 111 (Budget Committee, Chapter 81, Statutes of 2019).

The mission of OEIS is, in part, to advance long-term utility infrastructure safety through data-driven, wildfire mitigation evaluation and compliance in collaboration with local, state, and federal agencies, and in support of improved utility infrastructure, safety culture, and innovation. OEIS became the successor to the Wildfire Safety Division of the CPUC as of July 1, 2021, and is charged with reviewing, approving or denying, and overseeing compliance with Wildfire Mitigation Plans developed by utilities. CPUC, on the other hand, evaluates the reasonableness of costs associated with utilities implementing the Wildfire Mitigation Plans for purposes of cost recovery and exercises enforcement authority over utilities' performance of their mitigation plans and utility-caused wildfire.

In addition, OEIS is required, among other things, to consult with CalOES in the management and response to utility public safety power shutoff events and to work with CAL FIRE in assessing the safe operation of electrical infrastructure.

### Utility Providers:

In California, electricity is provided through investor-owned (privately owned and publicly traded) utilities (IOUs), publicly owned utilities, or rural electric cooperatives. There are six investor owned utilities include Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE) Company, San Diego Gas and Electric Company (SDG&E), Pacificorp, Liberty Utilities, and Bear Valley Electric Services. These utilities provide the majority of electric power to the state.

The primary natural gas utilities include PG&E, Southern California Gas Company (SoCalGas), SDG&E, and Southwest Gas. There are also several smaller natural gas utilities as well as independent gas storage operators including Lodi Gas Storage, Wild Goose Storage, Central Valley Storage, and Gill Ranch Storage.

In addition, California has two active nuclear power plants: Diablo Canyon in San Luis Obispo County (operated by PG&E) and San Onofre Nuclear Generating Station in San Diego County (in the process of being decommissioned by SCE). Spent nuclear rods are stored at two decommissioned nuclear plants: Humboldt Bay in Humboldt County and Rancho Seco in Sacramento County. The most recent nuclear accident was in 1999 when one alert was issued due to a suspected degradation of plant safety. Only the onsite population was threatened.

## Utility-Caused Wildfire and Mitigation:

### History:

Over the last decade, California has experienced increased, intense, and record-breaking wildfires that have resulted in the devastating loss of life and billions of dollars in damage to property and infrastructure. Electric utility infrastructure has historically been responsible for less than ten percent of reported wildfires; however, nine of the fires attributed to power

equipment are among the 20 most destructive fires in California's history. Among the 20 most destructive wildfires are the Thomas Fire (2017), Camp Fire (2018), and Dixie Fire (2021).

The Thomas Fire ignited when power lines came into contact with each other due to high winds. This fire burned a total of 281,893 acres in 40 days; destroying 1,063 structures and resulting in one civilian and one firefighter fatality. At its height, 9,000 fire personnel were activated for the response.

The Camp Fire ignited due to a faulty electrical transmission line. This fire nearly destroyed the towns of Paradise and Concow in Butte County. The wildfire was the deadliest and most damaging in the State's history with over 18,000 homes and businesses destroyed, 50,000 people displaced, 85 fatalities, several injuries, and more than $12 billion in insurance losses. The Camp Fire clean-up of 22,000 sites was the largest debris removal mission in California's history.

The Dixie Fire ignited when a tree made contact with an electrical line. This fire was the largest single source fire and the second biggest fire in the state's history, burning 963,309 acres across five counties and destroying much of the town of Greenville in Plumas County.

Six of California's most destructive wildfires since 2015 have been power line-initiated wildfires. California's susceptibility to wildfires and the high frequency of power outages are partly attributed to the extensive network of nearly 40,000 miles of exposed power lines in high-risk fire areas. According to a State Auditor Report in 2021, utilities completed hardening projects on only about 1,540 miles of these lines to bolster fire resistance or reduce ignition risks as of 2020. Utilities have since been forced to harden more of their lines but the vast majority still remain at risk. The costs associated with extending these upgrades across all 40,000 miles of exposed power lines in fire-prone zones are substantial. As these expenses are factored into utility rates, ratepayers typically face a significant financial burden. Furthermore, wildfires sparked by utilities often occur in more rural areas during high wind events, which enable a fire to spread more rapidly before reaching areas with easier access to respond.

## Risk-Based Decision-Making Framework:

CPUC now requires energy utilities to submit a risk-based decision-making framework (RDF) as part of their Rate Case Plan, which outlines the procedure by which the energy utility may apply to request increases in their rates. The addition of the RDF is intended to prioritize safety, reliability, and security while keeping rates fair for ratepayers. The RDF must be applied in two filings as described below in order to assess whether utilities are allocating resources appropriately to wildfire and safety risks:

> **Risk-Assessment and Mitigation Phase (RAMP)**: In this phase, CPUC examines safety-risk threat assessments of energy IOUs as well as evaluates mitigation plans, the estimated costs, and spending requests. This assessment informs applications and the approval of system-wide IOU operating and capital spending. These risk assessments are submitted to the CPUC every four years.
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> According to the CPUC, "The RAMP has proven to be a pivotal utility-safety reform backed by rigorous new rules and guidance to ensure that California's

energy utilities carefully consider and fully disclose those safety risks associated with their service and activities, and explain how utilities are equipped to detect, quantify, and contain those risks at the lowest practicable cost."

**Safety Model Assessment Proceeding (S-MAP)**: This proceeding occurs in cycles to regularly update policies for risk assessment with current risk-modeling technologies. This is achieved by comparing the four major utilities' approaches, innovations, and capabilities as they address their respective RAMP obligations. The first S-MAP began in 2015 and ended in 2019. Through this proceeding, CPUC now requires utility risk assessment and mitigation frameworks. A second S-MAP began in 2020 and is still underway.

## Wildfire Mitigation Plans:

IOUs are required to submit Wildfire Mitigation Plans (WMPs) every year, which outline how they are constructing, maintaining, and operating their electrical lines and equipment to minimize catastrophic wildfire risk. OEIS is responsible for evaluating these plans as well as enforcing utilities' compliance with wildfire safety regulations and statutes. CPUC uses WMPs to determine fair rate allocation and cost recovery.

## Power Line Undergrounding Program:

According to CPUC, California has approximately 25,526 miles of transmission lines, and approximately 239,557 miles of distribution lines, of which approximately 147,000 miles of distribution lines are overhead. Estimates provided to the CPUC from PG&E, SDG&E and SCE indicate that the costs for undergrounding overhead distribution infrastructure can range anywhere from $1.8 million to $6.1 million per mile. These costs represent all costs associated with the undergrounding effort: trenching, conduit, substructures, cabling and connections, meter panel modifications, cutover work, and finally removal from service of poles and wires.

In March of 2024, CPUC established a long-term electric distribution infrastructure undergrounding program. This program is intended to produce a highly organized and efficient process for IOUs to submit detailed 10-year undergrounding plans to CPUC and OEIS for approval. CPUC notes the program is designed to create an opportunity to facilitate system hardening, achieve economies of scale, and drive down costs.

To participate in the program, large electrical corporations must submit a distribution infrastructure undergrounding plan for projects located in high fire-threat districts or rebuild areas it intends to construct within a ten-year period to OEIS. After receiving the plan, OEIS must approve or deny the plan within nine months. Upon OEIS' approval of its plan, the large electrical corporation must submit a copy and an application requesting review and conditional approval of the plan's costs to CPUC. CPUC must then approve or deny the plan within nine months. CPUC may assess penalties on electrical corporations for failing to substantially comply with a commission decision approving its plan.

## PG&E and Undergrounding:

Soon after notifying CPUC that their lines likely sparked the Dixie Fire in 2021, Pacific Gas and Electric announced a new initiative to underground 10,000 miles of power lines over the following 10 years in the most high-risk fire areas. While undergrounding was previously viewed as cost prohibitive, the rising liability costs likely played a role in moving forward with this new initiative. However, these costs are expected to be passed along to ratepayers. PG&E's WMPs specify that the majority of the 10,000 miles of power lines moved underground would be distribution lines and not transmission lines. Distribution power lines transport electricity over shorter distances and with lower voltage, such as between homes, while transmission lines transport electricity over long distances and have higher voltage.

According to PG&E, as of December 2023, over 600 miles of power lines have been placed underground in California. The 350 miles completed in 2023 alone represents the most ever in a single year by PG&E and nearly twice as many miles as were completed in 2022.

Undergrounding eliminates nearly 98% of the risk of wildfire ignition from electrical equipment, according to PG&E. PG&E has also added 600-plus weather stations and high-def cameras with artificial intelligence capability for early fire detection to safety shutoff programs in order to further prevent ignitions that could lead to catastrophic wildfires.

PG&E notes that, in recent months, crews energized an average of 20 miles of undergrounded line each week. In all, customers on circuits in 20 counties now benefit from underground power lines, extending from Trinity and Shasta counties in the north to Fresno County in the south.

In addition to reducing the likelihood of an electric-line-sparked wildland fire, PG&E cites other benefits to undergrounding, such as reduced maintenance and vegetation management costs and improved reliability that reduces the need for safety-related power outages.

### SDG&E and Undergrounding:

San Diego Gas and Electric reports that more than 10,500 miles of its electric distribution lines, or about 60% of the regional distribution system, is underground.

SDG&E's approach to undergrounding initially involves focusing on areas with higher historical power outages, extreme weather patterns and risk for wildfire. Wildfire Next Generation Systems is one of the tools used by SDG&E to determine the priority of where future undergrounding should occur based on factors such as historical ignitions, wind speeds, public safety power shutoffs probability and duration and critical customers

Instead of having to shut down the power of an entire circuit of several thousand people during a public safety power shutoff, the undergrounded areas allow for almost everyone to keep their power. SDG&E estimates, based on the improvements done in San Diego over the last two years, the impact of public safety power shutoffs has been reduced by 20,000 customers and another 10,000 will no longer be impacted by the end of 2023.

According to SDG&E, some of the benefits of overhead-to-underground conversion include beautification of local neighborhoods and commercial districts, increased grid resiliency, and reduced likelihood of power outages caused by vehicle accidents that damage power poles.

### SCE and Risk Mitigation:

SCE states that covered conductor, also referred to as coated electrical wire, significantly reduces the possibility of a power line arcing or sparking if contact occurs with an object, such as a tree branch or metallic balloon. SCE estimates that the cost per mile for installing covered conductors and steel poles in its High Fire-Threat District areas is approximately $438,000 while the cost per mile of undergrounding is approximately $3 million. SCE states that investing in covered conductors is the most economical option for fire threat mitigation in these areas and notes that a dollar spent reconductoring with covered conductor provides over four times as much value in wildfire risk mitigation as a dollar spent on underground conversion.

SCE plans to install more than 2,850 additional miles of covered conductor between 2023-25. By the end of 2025, SCE expects to have replaced more than 7,200 miles, or about 75%, of overhead distribution power lines in high fire risk areas with covered conductor. The utility also plans to complete about 100 miles of undergrounding by 2025 to address extreme high risk factors such as limited exit and entry points to communities.

## Risk-Cost Tradeoffs of Various Mitigation Strategies:

A study published in 2024 by the Energy Institute at Haas, titled Risk-Cost Tradeoffs in Power Sector: Wildfire Prevention, evaluated the cost, reliability, and wildfire risk implications of mitigation measures deployed by PG&E. They developed a model which made very specific estimates of baseline ignition risk across 25,000 miles of high-risk distribution lines owned by PG&E and made comparisons to areas that have implemented wildfire mitigation measures but still have a similar baseline risk. They identified two strategies as the most effective: undergrounding and “fast-trip” settings. “Fast-trip” settings, which increases how quickly the protective equipment can sense and shut off the powerline when a potential failure is detected, was determined to be significantly more cost effective than undergrounding per avoided ignitions and per avoided structures burns. This held true after also incorporating the cost of outages to customers. However, they found undergrounding to be more cost effective than vegetation management and, from a safety perspective, the only way to virtually remove the risk of ignition while “fast-trip” settings reduce ignition risk by 72%. Intensive vegetation management was found to reduce ignition risk by 52%. According to the authors, “Our analysis underscores the importance of carefully evaluating the social costs and benefits of alternative wildfire risk mitigation measures, particularly in cases where less cost-effective measures may be preferred by utilities due to regulated returns on capital investment and more certain risk reductions.”

### Public Safety Power Shutoffs (PSPS):

According to CPUC data, there were 67 PSPS events between 2013 and 2021 that impacted over 3.6 million ratepayers. The effort to reduce the risk of fires caused by electric infrastructure by temporarily turning off power to specific areas is called a PSPS. While a helpful tool in preventing fires or preserving the overall safety of the electrical grid in an extreme heat event, an extended PSPS can leave communities and essential facilities without power, which brings its own risks and hardships, particularly for vulnerable communities and individuals. Prolonged loss of power can increase risk of injury or death to disabled individuals who rely on devices powered by electricity and those who rely on life support devices.

In 2012, CPUC ruled that California Public Utilities Code Sections 451 and 399.2(a) give electric utilities authority to shut off electric power to protect public safety when strong winds, heat events, and related conditions are present. In response to the 2017 wildfires and SB 901 (Dodd, Chapter 626, Statutes of 2018), CPUC revised earlier guidelines on de-energizing power lines and adopted a new set of PSPS guidelines governing the notification process. Additionally, the CPUC established the PSPS Citation to cite utilities for lack of compliance with PSPS guidelines, when deemed appropriate, in order to encourage compliance with the new guidelines. As of January 2022, utilities are required to identify which sections of their electrical grid are most frequently subject to PSPS events and share their plans/subsequent actions to reduce future shutoffs in the identified locations.

### Rotating Electricity Outages (Rolling Blackouts):

On August 14 and 15, 2020, the California Independent System Operator Corporation (CAISO) initiated rotating electricity outages, also known as rolling blackouts, when California experienced an extreme heat wave. Nearly 800,000 consumers lost power between 15 minutes and several hours. These outages can be life threatening in similar ways as PSPS events, but also by exposing consumers to unavoidable extreme heat conditions. CAISO, CPUC, and the California Energy Commission identified three major causes to the rolling outages: 1) the extreme heat wave causing demand for electricity which outpaced available resources and previous planning targets, 2) existing gaps in sufficient resources while the state transitions to reliable, clean, and affordable energy, and, 3) issues with the day-ahead energy market. They noted that the Governor's statewide notification calling for consumer energy conservation as well as consumer compliance, helped prevent an additional two days of rotating outages.

Just over two years later, California faced an extreme heatwave worse than the one in 2020. However, there were no rotating outages. This was largely prevented due to battery storage that had increased significantly over the previous two years, activating demand response resources by paying large scale consumers to reduce their usage, and sending out a statewide alert stating the need for instituting outages if the grid demand was not reduced and the nearly instant drop of thousands of megawatts of demand. While more efforts are necessary to secure the grid long term as the state transitions to only clean energy, avoiding any outages in 2022, the continuous investment in multiple clean energy sources, and the deployment of battery storage indicates a positive direction for future extreme heat events.

### State Mitigation Programs:

Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. Mitigation means taking action now, before the next disaster, to reduce human and financial consequences later. Effective mitigation requires understanding local risks and investing in long-term community well-being and resilience. Without mitigation actions, communities jeopardize residents' safety, financial security, and self-reliance. Federal Hazard Mitigation Grant Program funds are administered by CalOES to support plans and projects that reduce the effects of future natural disasters.

In conjunction with the state's plan for forest and wildfire resilience, CalFIRE administers the Wildfire Prevention Grants program, which includes up to $117 million in funding for 2024, to

provide communities the support they need to reduce wildfire risk. These grants allow the state to invest in local projects that protect, engage, and educate individuals and entire communities in order to increase prevention and preparedness efforts across California. Funded activities include hazardous fuel reduction, wildfire prevention planning, and wildfire prevention education with an emphasis on protecting communities and improving public health and safety, while reducing greenhouse gas emissions. Funded projects are expected to be announced in the summer of 2024.

To further strengthen community-wide resilience against wildfires, CalOES has partnered with CalFIRE to develop a state home hardening initiative, known as the California Wildfire Mitigation Program, to retrofit, harden, and create defensible space for homes at high risk to wildfires, focusing on high socially-vulnerable communities and providing financial assistance for low- and moderate-income households. The Governor's proposed 2024-25 Budget maintains $55 million in one-time General Funds for grants for these community hardening efforts.

## Disaster Incident Management:

CalOES conducts catastrophic planning to prepare for disasters. They have a "Incident Base Plan", which names standard considerations for most types of disasters, and upon which hazard scenario-specific plans can be laid. In terms of power supply, the Base Plan names the following threats:

- Earthquakes
- Wildfire
- Flood
- Weather, particularly windstorms, plus rare hurricanes and tornadoes
- Extreme heat requiring rolling power outages
- Landslides
- Tsunami
- Volcanic eruptions

As the lead emergency response agency, CalOES is responsible for coordinating and keeping track of utility provider response efforts to outages and other disruptions after an event. The California Utilities Emergency Association (CUEA), a point-of-contact for critical infrastructure utilities, CalOES, and other governmental agencies before, during, and after an event, is based out of the CalOES operations center in Mather. A Utilities Operations Center will bring together all the relevant authorities and providers to coordinate a unified response.

Critical information about the status of the power supply is expected to flow to CalOES through the Department of Energy, the CUEA, the Nuclear Regulatory Commission, and from the investor-owned utilities and municipal utility districts. "Critical" information includes the number of households without functional gas or electricity service, the status of power generation facilities and distribution grid, the status of natural gas transmission facilities and distribution pipelines, and the status of gasoline and oil distribution systems. The expected interval for receiving information is within 6 hours of the initial incident, updated every 12 hours thereafter.

Information on the restoration of power is expected to flow from elected officials, emergency support function reports, community relations field reports, rapid needs assessment reports, and coordination center reports, and be tracked by CalOES operations. The initial estimate is expected within 6 hours of the initial incident and updated every operational period.

The next section details the expected impacts and response plan for earthquakes:

# The Earthquake Problem:

### USGS Earthquake Rupture Forecast:

A forecast issued by the US Geological Survey (USGS) reported the probability of various sized earthquakes occurring over a thirty-year period beginning in 2014. These included earthquakes in specific regions of the state and in the state as a whole. Because the statewide forecast is functionally an addition of the regional risks, the probabilities statewide are much higher. The forecasts are based on a combination of physical measurements of accumulated stress and historical patterns found in the geologic record.

Earthquakes of a magnitude 6.7 or greater are expected to be strong enough to incur significant damage in California. In places where the average architecture is not adapted for shaking, such as Oklahoma, this threshold would be lower. The earthquake magnitude scale is multiplicative; a magnitude 8 earthquake releases 32 times as much energy as a magnitude 7. A magnitude 8 earthquake will also rupture a much larger portion of a fault and affect a larger region. As such, the occurrence of small earthquakes does not do much to decrease the likelihood of larger ones, both because it would take many, many small earthquakes to release as much energy, and because sometimes earthquakes can actually shift stress onto other parts of a fault, unintentionally making a big earthquake on that section *more* likely.

The below forecast is for a thirty year period between 2014 – 2043. These values should be taken as a minimum; because it has been ten years and the largest of the forecast earthquakes in the Bay Area and on the Southern San Andreas have not yet occurred, a forecast using an estimation period beginning in 2024 would have even higher likelihoods.

**Likelihood of a damaging earthquake occurring before 2043:**

- Los Angeles area: 60%
- Southern California: 93%
- San Francisco area: 72%
- Northern California: 95%
- Statewide: 99+%

In the Bay Area, the Hayward and Rodgers Creek faults, which run from Santa Rosa to Richmond and down to Fremont, carry the highest likelihood (a 14% chance) of producing a significant earthquake. The last major earthquake on this fault was in 1868. Geologic records show the fault has ruptured with a major earthquake once every 140-170 years on average, putting us squarely in the expected range for a recurrence today. In Southern California, the

Mojave section of the San Andreas fault carries the highest likelihood (a 19% or one-in-five chance) of producing a serious quake.

### Summary of Hazard from CalOES Catastrophic Planning:

The San Andreas Fault System is a major structural feature in the region and is located at the boundary between the North American and Pacific tectonic plates. The San Andreas and Hayward faults, both elements of the San Andreas Fault System, are two of the faults considered to have the highest probabilities of causing a significant seismic event in the Bay Area. A major seismic event on these faults could cause significant ground shaking, liquefaction, landslides, and surface fault rupture. Of the earthquake fault risks in the Bay Area, the Hayward Fault is especially dangerous due to several factors. The first is its location in the heart of the region; the Hayward Fault is the single most urbanized earthquake fault in the United States. In 1868 only 24,000 people lived near the fault, while today there are more than 2.4 million. Hundreds of homes and other structures are built directly on the fault's trace, and mass transit corridors and major freeways and roadways cross it at numerous locations. Critical regional gas and water pipelines and electrical transmission lines also cross the Hayward Fault.

The unique geography of the Bay Area, with its network of earthquake faults underlying the entire region, compounds the earthquake risks to life, health, and property. Large population centers are located parallel to and surrounding both the San Andreas and Hayward faults. Additionally, communities in the Bay Area are serviced by infrastructure that is susceptible to damage from earthquakes, as nearly all the infrastructure connections that the area depends on for water, electric power, fuel, and transportation services cross one of these faults.

## Southern California Catastrophic Earthquake Plan (SCCEP):

The scenario model used for the SCCEP is based on a risk assessment of 21 major fault rupture zones in Southern California. While a M7.8 is not the largest earthquake that the Southern San Andreas Fault (SSAF) can produce nor is the San Andreas Fault the only fault to threaten the populated areas of southern California, it is the largest potential catastrophic earthquake due to its overdue recurrence interval. That risk includes:  A 93% chance of a M6.7 or larger earthquake somewhere in Southern CA before 2043 and a 17% chance of a M7.7 or larger occuring on the SSAF specifically before 2043.

### Catastrophe Model Estimates of Impacts

A 2008 exercise called the California ShakeOut Scenario simulated the effects of a M 7.8 earthquake on the southern San Andreas fault. This was integrated into CalOES's SCCEP. In 2008 dollars, the scenario estimated $200 billion in damages and loss, 1,800 deaths and 50,000 injuries. Several hundred thousand people are likely to be displaced. The 2022 HAZUS model used by CalOES for catastrophic planning finds even greater casualties, including 12,750 deaths, 178,000 casualties, 45,000 rescues. The catastrophic plan assessed the likely impact to several key factors, including housing stock, emergent human needs, and lifeline continuity. HAZUS estimates include:

- Out of a 2008 total population of 24.3 million people, 19.3 million are impacted. This includes 65% of the Native American population, 11.7 million daily commuters, and 633,000 tourists.
- 2.25 million people are expected to be displaced, with 10% of those seeking shelter. Populations requiring shelter include 56,250 with Access and Functional Needs and over 15,750 toddlers and infants. 580,000 pets would be displaced, with 58,000 of those needing shelter.
- 104,955 people would be rendered homeless in directly impacted counties.
- Initial economic impact estimates $232 billion ($68 billion business interruption, $51 billion lost economic activity and $113 billion in property damage across eight counties).
- 1,046,534 damaged buildings
- Essential facilities being reduced to less than 50% functionality on Day 1: 325 hospitals, 7,952 schools, 112 Emergency Operation Centers, 405 police stations, 1,299 fire stations.
- Debris removal totaling an estimated 80,207,500 tons requiring 3,208,300 truckloads (at 25 tons per truck): 29,676,775 tons of brick/wood and 50,530,725 tons of reinforced concrete/steel.

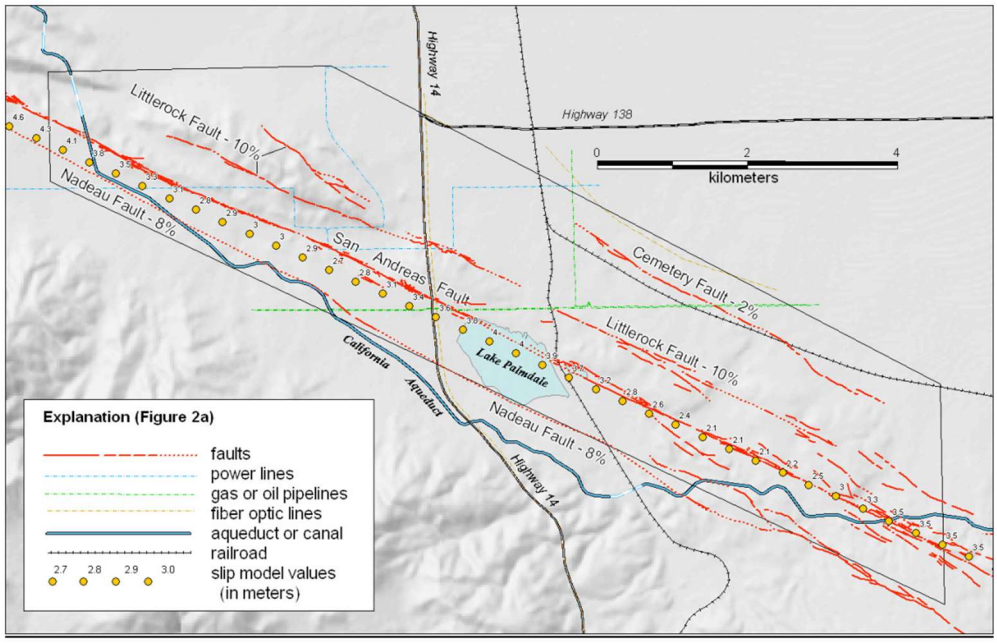
### Outages and Damage to Power Lifelines

Earthquake damage to the region's power generation facilities and natural gas infrastructure could result in long-term power supply interruptions. Potentially all components of the electrical system could suffer injury in a severe earthquake. The electrical grid is often the first system restored in earthquake response. Substations, however, have historically been the most vulnerable, requiring more extensive repair, often 6 to 12 months to replace.

Analyses for power and gas lifelines included consideration of the integrity of production facilities, near-customer transmission lines, and long distance transmission lines. The scenario earthquake ruptures approximately 200 miles of the San Andreas fault, beginning from the eastern shore of the Salton Sea, unzipping up through the Coachella Valley, and continuing northwestward to near Lake Hughes in the southwestern Mojave Desert. Objects on one side of the fault would be suddenly and violently offset by an average of 30 feet from objects on the other side, ripping up freeways, aqueducts, fiber optic cables, railroads and pipes. 6 utility systems (electric power, communications, potable water, wastewater, natural gas, crude & refined oil) have 524,530.95 miles of lines and pipes that cross the fault. In terms of power and gas, the rupture is anticipated to affect an estimated 39 petroleum and natural gas pipeline crossings and 142 overhead powerline crossings. 20% of the powerline crosses are anticipated to incur damage and 19 electrical power facilities are expected to be at least moderately damaged. Substations near fault lines will experience failures to switches, breakers, transformers, bushings, and movement of the transformer foundations. Los Angeles, San Bernardino, and Riverside counties will immediately lose all electric power. The Los Angeles Department of Water and Power (LADWP) will have roughly 80% pre-earthquake capacity if natural gas supplies are available.

Additionally, lifeline infrastructure will be impacted by the estimated tens of thousands of individual landslides triggered by the earthquake shaking, particularly where lifelines cross the

mountains through narrow passes. Transmission towers located in high-liquefaction zones will collapse.




The map above provides a zoom into the Palmdale area, showing lifelines crossing the affected fault. The colored lines represent the track of various lifelines and the gold dots mark how much fault displacement is expected at that location in meters.

In terms of residential power, an estimated 7,571,905 of households will lose power immediately. Widespread power outages can result in cascading failures that extend the power outage area east, south, and northeast of Cajon Pass to the cities of San Diego, California; Phoenix, Arizona; and Las Vegas, Nevada. These power failures could affect as many as 15 million people. Fortunately, HAZUS estimates a rapid recovery arc. In Kern and San Diego counties, 90% of power is restored within 24 hours. Out of the 7.5 million initial total, the following quantities of households will continue to be without power over time:

- Day 1: 566,000
- Day 3: 370,000
- Day 7: 170,000
- Day 30: 38,856
- Day 90: 757

**Interstate Natural Gas Supply Pipeline –** Compromised natural gas supply basins serving southern California will have cascading effects including in the Rocky Mountain production region, San Juan Basin in northern New Mexico, Permian Basin in western Texas, Western Canadian Sedimentary Basin, and in-state California production. If gas transmission service is lost, restoration could take 3 weeks to accommodate integrity testing for re-pressurizing lines. Full restoration of the natural gas distribution system could take 6 months. Interdependencies include that 90.9 % of California natural gas supply is sourced from interstate pipelines, and 43.9% of southern California electricity generation was from natural gas in 2019.

### Downstream Effects of Damage to Power and Gas:

**Fires Following the Earthquake:** Damage from the earthquake is compounded by the fires that occur due to downed power and communication lines, and ruptured gas lines. Nearly 1,600 ignitions occur, 1,200 of which require more than one engine. Paths of ingress and egress are cut off due to debris from landslides, damaged buildings and roads, and downed power lines. Responder movement is further hampered by traffic gridlock as survivors try to reunite with their families. In addition, many water mains are ruptured or damaged, requiring firefighters to rely on alternate sources of water to fight fires. A minimum of $40 billion was estimated in building damages plus $25 billion in property contents loss.

**Critical Facilities:** Power may be lost to airfields, hospitals and other health care facilities, public safety and security infrastructure, wastewater/water treatment facilities, commodity supply/distribution centers, agriculture and commercial food facilities, and public and financial service facilities, and backup power may need to be rationed.

**Aid Logistics:** Damage to transportation networks and power outages may lead to the isolation of large population areas and require immediate establishment of an airbridge for response movement, resupply, and temporary power. Shelters in outage areas will struggle to procure enough alternate power to provide safe temperatures, safe food, and communications.

**Sudden spike in fuel needs to provide power generation:** Power generation may be one of the essential fuel requirements, including power generation for critical infrastructure, health and medical facilities, shelters, RBCs, and other designated locations. A response unit co-lead by The California Department of General Services and United States Army Corps of Engineers, supported by FEMA/DOD will coordinate to provide bulk power generation capabilities for unmet needs with the ability to provide fuel support for deployed generator assets. The Governor can also sign an Emergency Order No. 6, which empowers the California Energy Commission to "hold control of petroleum stocks" as needed to ensure the health, safety, and welfare of the public. Local, state, and FEMA power generation equipment may also require fuel support from outside vendors. Deliveries must be assured 24/7.

## Bay Area Catastrophic Earthquake Plan:

### Catastrophe Model Estimates of Impacts

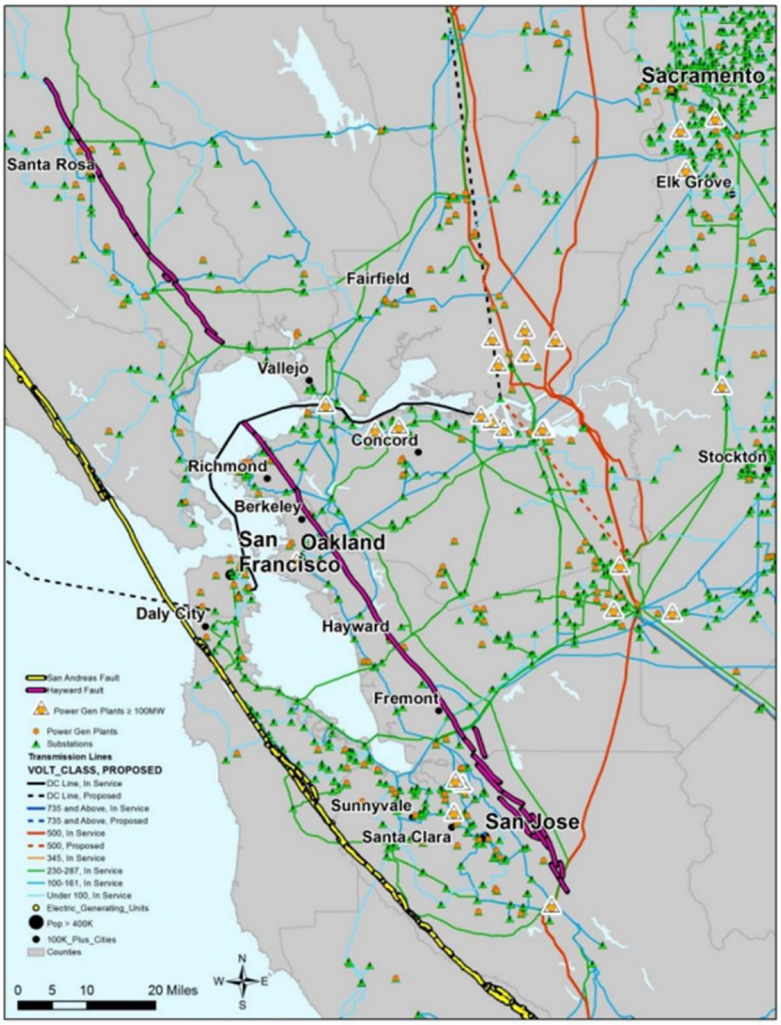
A 2017 exercise created the Haywired Scenario, a similar exploration as the ShakeOut but considering the effects of a M 7 earthquake on the Hayward Fault. The Hayward fault is considered one of the most dangerous faults in California because it both carries a high likelihood of producing a powerful earthquake and is also proximal to an urban population of 7 million people. Critical regional gas and water pipelines and electrical transmission lines also cross the Hayward Fault. The Haywired Scenario estimates 800 deaths and 16,000 nonfatal injuries resulting from shaking alone; over $82 billion in property and direct business interruption losses from shaking, liquefaction, and landslides; over 22,000 people trapped in elevators and requiring rescue; over 2,400 people requiring rescue from collapsed buildings; and loss of water service in the East Bay for 6 weeks to 6 months.

In CalOES's 2016 creation of their Bay Area Earthquake Catastrophic Plan, they also included analysis of a HAZUS model of a M 7.8 on the San Andreas Fault, approximating a repeat of the 1906 earthquake.

## Outages and Damage to Power Lifelines:

**Electrical Power**: Electrical transmission lines and towers will likely fail as a result of ground shaking from the earthquake, resulting in a loss of power for communities for weeks. HAZUS modeling indicates over half of households in the affected area would be without power for 24 hours with over 14% still without power a week later. Energized, downed electric lines will present an immediate safety hazard.

A map of electrical power distribution infrastructure included in the plan:




**Natural Gas**: Gas pipeline breaks and leaks will occur, creating hazardous conditions and fires. Gas service restoration could take longer, as many residents will unnecessarily turn off their gas service coming into their homes. Gas service personnel will have to inspect each property for leaks and relight pilot lights. Natural gas may be cut off in some communities for longer periods

of time due to difficulties in making repairs caused by limited access to damaged pipes and how the prioritization of restoration is set.

### Downstream Effects / “Secondary Hazards":

**Fires following the earthquake -** While the Southern California scenario spent time analyzing critical lifeline bottlenecks coming through the mountains to serve the LA basin, the Haywired Scenario was concerned with the local effects on power and gas delivery infrastructure. Over 400 simultaneous fires are expected to be ignited as a result of ruptured gas and electric lines, causing $30 billion in housing and commercial property loss. A report published by Mission Local in 2021 identified mass non-compliance with requirements to above-ground gas lines leading into soft-story residential buildings in San Francisco, with thousands of pipes instead being encased in concrete when foundations are poured as part of, ironically, the local seismic retrofit program. This puts gas lines out of reach for normal repairs and also massively increases the chances that they will break during a major earthquake and create explosions. Beleaguered by months-long wait times to get PG&E on site to adjust the piping, contractors have routinely opted to simply pour the concrete with the old, sometimes corroded, pipes in place in order to stay on schedule.

**Damage to petroleum infrastructure –** In a severe earthquake, the oil refining infrastructure in the Bay Area may not be fully operational, although one or more refineries may be partially functional to process and provide fuel. Partial or complete failure of refinery storage tanks is possible in areas of peak ground acceleration (PGA) or liquefaction. Oil pipelines might rupture through displacement at points where pipelines cross faults, such as the four locations where East Bay pipelines cross the Hayward Fault: Richmond, Oakland, Hayward, and Fremont. Pipelines will also be damaged by ground shaking in liquefaction areas. Jet fuel pipelines to airports could be damaged (airports have limited fuel storage capacity). Interruption of public fuel supplies through commercial gas stations is also probable due to power failure and degraded infrastructure. Although retail gas stations may have fuel in underground tanks, they will be unable to pump fuel without electric power.

**Infrastructure and Transportation Systems:** A severe Bay Area earthquake will affect all major infrastructure systems in the region. Transportation networks—including road, rail, air, and marine transportation systems—will be damaged by ground shaking, landslides, liquefaction and/or surface rupture and fault after-slip, disrupting the region’s critical supply chain. This will impede the ingress of repair crews and create lags in shipping and supply of needed parts. Also, all transportation that requires electricity to run, such as trains and electric buses, will be inoperable until power is restored.

**Logistics and Supply Chain Management:** Damage to transportation networks may lead to the isolation of large population areas and the degradation of the region’s supply chain that serves millions of residents. Affected areas will be without power, water, and communications systems for weeks or months.

The restoration of one infrastructure system is often interdependent with the restoration of others. Roadways, for instance, must often be cleared and at least minimally repaired to enable personnel and resources to access and repair other infrastructure. An organizational structure to enable information sharing and project coordination is essential for capturing opportunities for

long-term recovery presented by the disaster. The responsibility for the rebuilding/repair of infrastructure systems lies with individual public and private infrastructure owners.

**Compromised Food and Medicine Security**: Hospitals and other critical care facilities will suffer outages, limiting service delivery and the availability of medicine and medical supplies. Food supplies will dwindle rapidly and fresh food and produce will not be available in communities due to loss of electricity at grocery stores and at perishable item facilities.

**Situational Assessment:** Damage to transportation networks and communications infrastructure will pose significant barriers to being able to measure the scope of damage and needs. Public communications systems and 911 dispatch centers will be adversely impacted. The number, complexity, and magnitude of simultaneous crisis incidents will make the establishment of accurate and timely situational awareness in the first 24 hours problematic.

# Response Plans:

### Who's who:

Immediately following the incident, CalOES activates CUEA/California Energy Commission staff, who form a state multiagency coordination (MAC) group in an effort to stabilize and restore key infrastructure systems, including power and fuel. This joint group addresses specific issues that require extensive coordination, planning, prioritization of scarce resources. The goal is to enhance the effectiveness of response capabilities by sharing resources and exchanging information with private, municipal, and state players. A key enabler for restoring critical infrastructure is gaining access. Credentialing and information coordination enable physical access when travel restrictions and roadblocks are in place. The state Utility Operations Center (UOC) also establishes a regional MAC Group coordination call of executive management from infrastructure industries, who are responsible for the planning, coordination of activities, information sharing, identifying key resource shortages, etc. related to stabilizing and restoring critical services.

CalOES also expects to activate contracts for Temporary Emergency Power, and the Emergency Power Planning and Response Teams (PRTs) will identify support from FEMA, the Department of General Services, DoD, the Army Corps of Engineers, and the interstate mutual aid system. Other federal partners are also brought in to assist with response, including integrations of the Department of Energy (DOE), Edison Electric Institute, and the American Public Power Association (APPA) to augment or supplement emergency response through the National Infrastructure Protection (NIP) program.

### Restoration of Service:

What follows is a general overview of CalOES's anticipated recovery activities, sourced from multiple catastrophe plans. Widespread power outages are expected, especially during the first 30 days post-earthquake. Aftershocks will continue to break or damage infrastructure after services have been restored or repaired. In addition, damaged underground pipelines, cables, and other infrastructure components will take longer to repair than those above ground; most of San Francisco's electrical distribution system, along with portions of the systems in surrounding

areas, is underground. Despite this, for an M 7.9 San Andreas earthquake, PG&E estimates that 25 percent of power would be restored in San Francisco within 48 hours, 95 percent would be restored within one week, and 100 percent would be restored within a month.

CalOES anticipates that infrastructure repair requirements generated by a major earthquake will quickly exceed available resources and may exhaust the nation's inventory of specialized equipment. Infrastructure repair parts, such as transformers, pipes, and connectors, may be unavailable due to excess demand from multiple communities and due to manufacturing delays. The replacement of some equipment, such as equipment used for high voltage electrical transmission and distribution, may require custom manufacturing in other countries, often with substantial lead times—as long as 12 months for domestic producers, 16 months for foreign producers, and 1-5 years if there is high demand for or difficulty in obtaining specialized raw materials.

Furthermore, most energy infrastructure is privately owned and therefore ineligible for a large portion of federal funds.

# Recovery:

### Organization Plans for Recovery:

Infrastructure recovery includes more than just rebuilding existing infrastructure; it includes incorporating improvements, expanding systems to accommodate future population growth, and building in resiliency measures to mitigate damage from future earthquake events. State and federal coordination will therefore be needed to facilitate a common operating picture to maximize resources for infrastructure recovery projects that align with regional, state, and national priorities and to ensure continued communications throughout the recovery process.

Recovery will be a multimodal collaborative effort, from stakeholders and utility providers, on up to the state and federal levels. CalOES is the designated state Coordinating Agency for recovery efforts. Federal partners, including the Department of Energy (DoE) and the Department of Homeland Security (DHS), will assist in finding and issuing grants, provide technical assistance, mobilize greater regional coordination, and lower barriers to entry for additional manufacturers that can assist in increasing the production capability for manufacturing specialized equipment. The DOE and DHS can also utilize the national energy labs and private sector entities to support this type of technical assistance. It is also possible that conditions will be met to activate the Defense Production Act to prioritize manufacturing contracts and materials procurement that support disaster recovery operations.

State agencies that will be involved in rebuilding include the CPUC and the California Energy Commission. CUEA and the utilities constitute the other major players. CUEA will convene a Power Infrastructure Working Group to support strategy development, including connecting players at all levels to jointly identify opportunities for the redesign of electric systems (e.g., new technologies, increased efficiency, distributed systems); the private sector will leverage lessons learned for modular design and standardization of connections.