CHAPTER 8

POWER

This chapter focuses on power assets and facilities that are owned by the Pacific Gas and Electric (PG&E), and the relationship between PG&E and SFPUC. PG&E is an investor-owned utility that owns and maintains the local power grid in San Francisco and for most of the northern two-thirds of California. SFPUC and PG&E partner together to deliver cleaner energy to residents and businesses. SFPUC is responsible for providing power to municipal facilities and public transportation, while PG&E provides most of the power to residents and businesses.

This chapter provides an assessment of the PG&E assets where information is available for dissemination to the public. Information on some PG&E assets is not publicly available for security reasons. However, PG&E is conducting its own SLR assessment to ensure that power assets are resilient to SLR, coastal flooding, and other climate hazards. The City coordinates with PG&E, and will include its findings, as appropriate, as adaptation projects move forward toward towards planning, design, and implementation. A safe and reliable power distribution system is one of the most critical components to maintaining public safety, and many of the assets described throughout this Assessment, including public transportation, water supply, wastewater services, and healthcare facilities, rely on power to sustain their critical functions that, in turn, allow us to survive and thrive in San Francisco.

The following sections describe the power assets and their potential vulnerability to SLR and coastal flooding.

8.1 SFPUC POWER

SFPUC owns and operates the Hetch Hetchy Power System (Photo 8.1). Power is generated primarily through hydroelectricity. When San Francisco's Hetch Hetchy Reservoir releases drinking water for the City, the water passes through hydroelectric turbines and creates electricity, which is transmitted to the Bay Area. San Francisco also generates local, renewable energy from City-owned solar, wind, and biogas facilities. SFPUC has been generating some of the cleanest energy available in California since 1918. In total, SFPUC provides about 17 percent of San Francisco's total electricity.

Photo 8.1 Dam at Hetch Hetchy Reservoir. Michael Macor, The Chronicle

San Francisco customers get 40 percent renewable energy, or they can opt to pay a little more through the CleanPowerSF Community Choice Aggregation program to get 100 percent renewable energy. Under this program, SFPUC procures the energy and PG&E continues to maintain the power grid, responds to outages, and handles the monthly billing for customers.

Large facilities, and all new facilities on City-owned land, can apply for 100 percent Hetch Hetchy Power. SFPUC provides power to San Francisco's most critical facilities, including SFO, SFMTA, San Francisco Unified School District, San Francisco General Hospital, the Salesforce Transit Center, and San Francisco's police and fire stations. SFPUC also provides power to San Francisco Housing Authority low-income housing developments and will provide power to some new developments such as Treasure Island and Candlestick/Hunters Point. Although power is transmitted across the PG&E distribution grid, the Hetch Hetchy Power System provides the power to meet the energy demand from these facilities.

8.1.1 Substations

Substations are generally locations in the power system where power can be pooled from generating sources and transformed for distribution to customers. Substations also control the flow of power to customers so that just the right amount is provided and the flow of power is unimpeded. Between the generating station and the customer, power may flow through several substations.

SFPUC is constructing a new substation on Quint Street within the SLR Vulnerability Zone. The design of the substation accommodates up to 36 inches of SLR. SFPUC owns two additional substations near SFO, one in the city of Millbrae, and one in the city of San Bruno. These electrical substations act as an interface between the transmission lines from PG&E to the distribution system. The substations contain equipment that step down the voltage that is suitable for the distribution system and various electrical safety equipment. The SFO Shoreline Protection Program (see Section 4.9), a multi-year program to address SFO's risk of flooding, is addressing existing future flood risks for the campus proper (e.g., airfield, terminals, campus buildings, and infrastructure). SFO is also coordinating with the SFPUC in an evaluation of current and future SFO electrical capacity needs to service SFO's future growth and changing electrical demands. Flood protection of critical power assets, including the two existing substations, will be addressed as this electrical capacity project moves forward.

8.1.2 Transformers and Switchgear

A transformer is an electrical device that transfers electrical energy between two or more electric circuits. Switchgear controls, regulates, and can switch on or off the electric circuit controlling the flow of electricity. Both transformers and switchgear are linked to the reliability of the power supply. When these assets are located at or below grade, they are vulnerable to localized flooding and would not perform their function as designed if flooded.

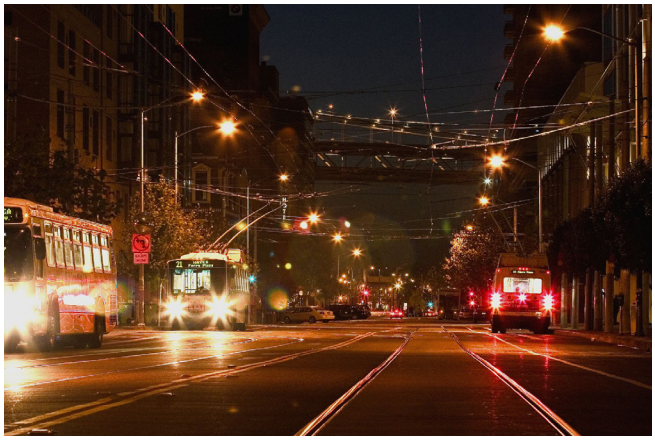


Photo 8.2 San Francisco street lights. Thomas Hawk (CC BY-NC 2.0)

SFPUC owns multiple transformers and switchgear that are located along the Embarcadero to provide power to Port facilities(see Chapter 11, *Port of San Francisco*), within Hunters Point (to provide power to San Francisco Housing Authority low-income apartments and future new developments), and at the Salesforce Transit Center, Laguna Honda Hospital, and San Francisco public schools. Transformers and switchgear are typically contained within an enclosure. Although the enclosures provide protection during rainfall events, they are generally not flood proof.

8.1.3 Streetlights

Streetlights (a.k.a., light poles, lampposts, streetlamp, light standard) are elevated lights that are typically found along roadways, sidewalks, and trails (Photo 8.2). Most streetlights have light-sensitive photocells that turn the light on at dusk and off at dawn. Streetlights are critical for pedestrian, bicycle, and traffic safety.

In San Francisco, most streetlights are connected to underground power. If the streetlights are flooded temporarily for a short period, limited damage is likely to occur, and the streetlight will remain functioning. The electrical infrastructure is designed and rated to endure bad weather and heavy rainfall. However, if streetlights are flooded for a prolonged period, the electrical infrastructure is likely to fail, rendering the streetlight inoperable and the roadway or sidewalk dark during the night.

8.1.4 Exposure Assessment

The exposure of the SFPUC power assets was evaluated relative to the 10 SLR scenarios (see Chapter 2). The exact number and location of the transformers and switchgear are currently being evaluated; however, most of these assets are located within the SLR Vulnerability Zone based on their location along the Embarcadero and in the Hunters Point area. The location of the streetlights was available in GIS and the exposure information is presented in Table 8.1.

8.1.5 Consequence Summary

The SPFUC Power Enterprise power assets and PG&E power assets are closely intertwined to provide a reliable and consistent power supply for all San Francisco residents, businesses, and City facilities. Because of the interrelation between the two systems, the consequences of power disruptions due to sea level rise or coastal flooding cannot be separated into distinct consequences related to SFPUC assets verses PG&E assets. The potential consequences related to both systems are summarized in Section 8.2.6 after a discussion of PG&E assets.

Table 8.1 Transmission Line Exposure Summary

Neighborhood	Number of Streetlamps (x 1000) Inundated within Each SLR Scenario									
	1	2	3	4	5	6	7	8	9	10
Bayview South	-	-	0.9	1.2	1.2	1.50	1.5	1.8	2.4	3.1
Bayview North	-	-	-	-	1.6	6.9	9.2	11.5	15.8	19.4
Potrero Hill	-	-	-	-	-	-	1.0	1.0	1.7	3.9
South of Market	-	-	3.8	13.0	24.1	73.4	93.0	104.0	117.5	127.0
Financial District	-	-	1.1	9.2	14.6	37.8	42.7	46.0	49.7	54.5
North Beach	-	-	-	0.1	0.4	31.5	43.5	46.1	49.3	52.0
Russian Hill	-	-	-	-	-	0.2	0.4	0.4	0.4	0.4
Marina	-	-	-	0.1	0.1	1.7	4.3	6.2	9.3	13.7

8.2 PG&E POWER

PG&E provides power and natural gas to approximately 16 million people throughout a 70,000 square mile service area in Northern and Central California. The San Francisco Gas and Electric Company merged with the California Gas and an Electric Company to form PG&E in 1905. In total, PG&E operates 106,681 miles of electric distribution lines and 18,466 miles of transmission lines. PG&E's transmission lines and high-voltage substations in San Francisco are shown in Figure 8.1.

8.2.1 Transmission Lines

PG&E maintains a network of transmission lines that move electrical energy from power generation plants to electrical substations located near demand centers (Photo 8.3). The lines that distribute the energy from the substations to the customers are generally called distribution lines. The distribution lines were not evaluated in this Assessment.

Most of the transmission lines within the SLR Vulnerability Zone run overhead on utility poles (see Table 8.1), reducing the vulnerability of the transmission lines to SLR and coastal flooding. The utility poles are managed by the Joint Pole Association, a combination of the electric utilities, telephone and wireless companies, and municipalities. Although utility poles are more resilient to flooding, they can be damaged by high winds that often accompany large storm events. Utility poles can also be damaged by falling trees and waterborne debris during a flood event. The overhead lines and utility poles are first exposed under Scenario 5 (52 inches of SLR, or 12 inches of SLR coupled with a 100-year extreme tide).

Underground transmission lines are present in the South of Market neighborhood and are first exposed under Scenario 6 (66 inches of SLR, or 24 inches of SLR coupled with a 100-year extreme tide). Underground power lines are more vulnerable to flooding; however, many communities prefer underground power lines for aesthetic reasons.

8.2.2 Trans Bay Cable

The Trans Bay Cable, owned by Trans Bay Cable LLC, a subsidiary of NextEra Energy Transmission LLC, is a 53-mile direct current electrical transmission cable with fiber optic communication cables bundled together and buried in San Francisco Bay. The cable extends from Pittsburg, California, to San Francisco, connecting to PG&E's Potrero substation. The cable can transmit 400 megawatts (MW) of power, enough to provide approximately 40 percent of San Francisco's peak power needs. The Trans Bay Cable is a federally identified critical asset in the Northern California electric grid. The submarine nature of the cable reduces its vulnerability to SLR and coastal flooding. The cable is most vulnerable at its connection with the Potrero substation.

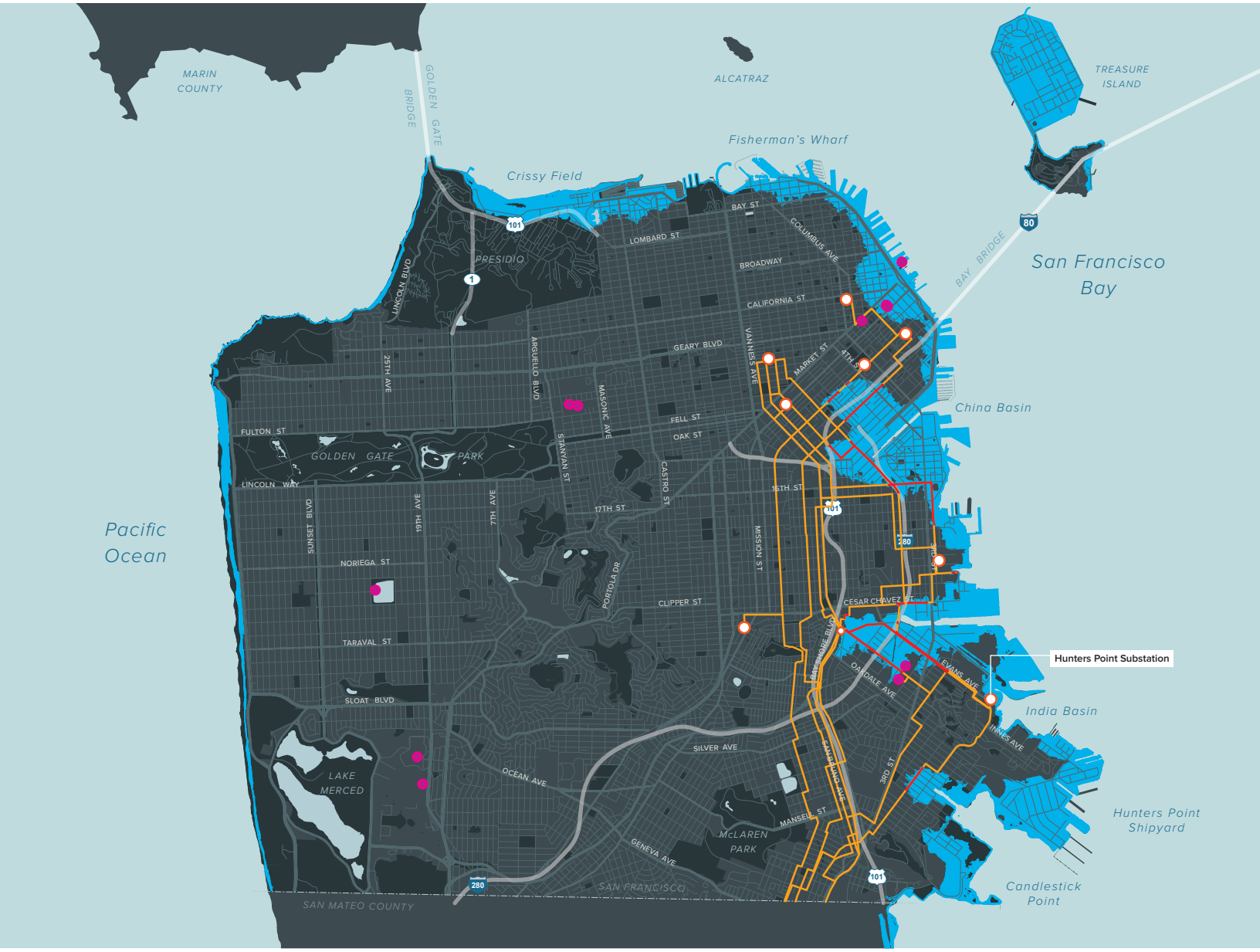
8.2.3 Substations

PG&E owns or maintains nine substations within San Francisco (see Figure 8.1). Only one substation, the 110 – 161 kilovolt Hunters Point substation (Photo 8.4) is within the SLR Vulnerability Zone (see Table 8.2). Electric substations are extremely vulnerable to SLR and coastal flooding, and flooding of any type could interrupt power service for hours to weeks depending on the extent of damage. The Hunters Point substation is first exposed at Scenario 8 (84 inches of SLR, or 42 inches of SLR coupled with a 100-year extreme tide).

Photo 8.3 PG&E transmission lines. Lynn Friedman (CC BY-NC-ND 2.0)

Photo 8.4 PG&E Hunters Point substation. Salim Virji (CC BY-SA 2.0)

Figure 8.1 PG&E Assets in San Francisco



Inundation at 108" Sea Level Rise

PG&E Substation

Solar Power Generation Source

Transmission Line

Transmission Line Exposed to Innundation

0 0.5 1.0 2.0

Miles

Photo 8.5 Solar roof installation in downtown San Francisco. Flickr user Luminalt

8.2.4 Solar Energy Generation

San Francisco has more than enough sunlight throughout the year to make solar electricity feasible. Between 2010 and 2012, nine photovoltaic power systems were installed in San Francisco, adding 15.9 MW of power generation (see Figure 8.1). Three photovoltaic systems with a combined power generation capacity of 3.7 MW are located within the SLR Vulnerability Zone, all located within the Financial District.

The solar arrays are generally installed at high elevations on the roof tops of buildings and are integrated within the building's infrastructure to meet the building's power demand (Photo 8.5). However, the systems are connected to the overall power grid, excess generated power (i.e., above the building's demand) can be provided to the City's power grid. If insufficient power is generated to meet the building's demand, the building can draw power from the City's grid. The photovoltaic systems themselves are not vulnerable to SLR and coastal flooding. Depending on its location and connection type, the connection to the existing power grid can be the most vulnerable part of the photovoltaic system.

8.2.5 Exposure Assessment

The exposure of the PG&E power assets was evaluated relative to the 10 SLR scenarios (see Chapter 2) and is presented in Tables 8.2 and 8.3.

8.2.6 Consequence Summary

KEY ISSUE: A reliable and consistent power supply is critical for the operation and functioning of most City assets and facilities, including wastewater, public transit (e.g., electric buses, Muni, BART), traffic lights, and public safety and emergency operations (e.g., police stations, fire stations, hospitals, schools, shelters, etc.). If power assets are inundated and service is interrupted for any length of time, cascading consequences can occur across the City.

Many City facilities have backup power generation; however, the power supplied by backup generators is often limited and not intended to last for more than a few hours of downtime. Power service interruptions due to SLR and coastal flooding would most likely be localized to specific areas of the City, such as areas served by the Hunters Point substation, or areas served by the underground transmission lines in the South of Market neighborhood. With enough warning before a large storm event, potentially impacted facilities could be better prepared to withstand a potential power outage.

Society and Equity: Disruptions in power service would impact all residents and businesses within the impacted area. Business closures can occur, resulting in lost wages for employees. People may become trapped in elevators, and residents and workers in high-rise buildings will be required to climb flights of stairs. Residents, particularly the elderly and infirm, that rely on home medical equipment will have interrupted medical service. Access to local services, such as grocery stores and gas stations, will be impacted. Commuters and others that rely on the public transit system will need to rely on alternate transportation methods during the outage, and some commuters will become stranded if the outage occurs while on electric-powered public transit, such as Muni. Power outages can increase traffic and congestion due to non-operational traffic lights, which can also increase ambulance and other emergency response times. PG&E's one power substation in the SLR Vulnerability Zone is in the Bayview/Hunters Point neighborhood adjacent to several vulnerable communities. Impacts to this station could disproportionately impact these communities.

Table 8.2 Transmission Line Exposure Summary

Asset Type	Miles Inundated within Each SLR Scenario									
	1	2	3	4	5	6	7	8	9	10
Transmission Lines (Underground)										
South of Market	-	-	-	-	-	0.2	0.3	0.4	0.4	0.6
Transmission Lines (Overhead)										
Bayview North	-	-	-	-	0.2	0.9	1.2	1.4	1.8	2.6
Bayview South	-	-	-	-	-	-	-	-	0.1	0.3
Potrero Hill	-	-	-	-	-	0.1	0.3	0.4	0.6	0.9
South of Market	-	-	-	-	-	0.1	0.4	0.6	0.7	0.9
Trans Bay Cable										
Potrero Hill	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 8.3 Substation and Energy Generation Exposure Summary

Asset Type	MW	Number of Assets Inundated within Each SLR Scenario									
		1	2	3	4	5	6	7	8	9	10
Substation											
Bayview North	N/A	-	-	-	-	-	-	-	1	1	1
Solar Energy Generation											
Financial District	1.5	-	-	-	-	-	-	1	1	1	1
Financial District	1	-	-	-	-	-	-	1	1	1	1
Financial District	1.2	-	-	-	-	-	-	1	1	1	1

Economy: Power outages can cause significant cascading economic consequences, including lost revenue for both public agencies and private business and tremendous indirect economic costs in lost work time and limited services to some San Francisco neighborhoods. The longer the power outage, the larger the direct and indirect economic costs. Emergency response personnel, PG&E repair workers, and other City staff may be required to work long hours to repair the impacted facilities and bring the power service back online. If a substation is flooded, it likely cannot be brought back online until after the floodwaters reside. If the repair time is estimated to be lengthy, mobile substations can be brought in as a backup to reduce customer downtime.

Environment: Although flooding of power assets may not cause direct environmental consequences, cascading consequences can occur, including reduced air quality due to increased traffic and congestion, and potential impacts to the Bay and other waterways due to wastewater overflows if power is disrupted at wastewater treatment facilities or pump stations.

Governance: Managing response to power outages caused by flood events requires coordination between PG&E, the SFPUC Power enterprise, emergency responders, and other City agencies. In 2017, a fire at PG&E's Larkin substation caused a large-scale power outage that disrupted traffic, impacted 21 schools, shut down the Montgomery BART station, and required hospitals to operate on emergency power backup systems. Improving the City's response plan is a critical governance step that can help avoid disaster and aid recovery.

Photo by Todd Lappin (CC BY-NC 2.0)