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December 27, 2023

Mary Alice Evans, Director
Office of Planning and Sustainable Development
Environmental Review Program
235 S. Beretania Street, Room 702
Honolulu, Hawaii 96813

SUBJECT: Transmittal of the Final Environmental Impact Statement for the Puna Geothermal Venture Repower Project

Dear Director Evans,

With this letter, the County of Hawaiʻi Planning Department, hereby transmits this Final Environmental Impact Statement (FEIS) for the "Puna Geothermal Venture Repower Project" proposed by Puna Geothermal Venture (PGV) located at TMK(s) (3) 1-4-001:001, (3) 1-4-001:002, and (3) 1-4-001:019 in Puna District, on the Island of Hawaiʻi. The FEIS has been prepared pursuant to Chapter 343, Hawaii Revised Statutes (HRS), and Title 11, Chapter 200.1, Hawaii Administrative Rules (HAR).

Pursuant to the requirements of Section 11-200.1-4(8) and 11-200.1-27, HAR, we hereby transmit the accompanying FEIS for the Proposed Action for publication in the next edition of *The Environmental Notice* on January 8, 2024.

The FEIS includes copies of all written comments received during the 45-day public consultation period for the Draft EIS, as well as responses to all comments.

If there are any questions regarding this letter, please contact April Surprenant at (808) 961-8288 or via email at planning@hawaiicounty.gov or our consultant Michele Lefebvre (808) 791-9872 or via email at michele.lefebvre@stantecgs.com.

Sincerely,

Zendo Kern
Zendo Kern (Dec 27, 2023 11:20 HST)

ZENDO KERN
Planning Director, County of Hawaiʻi

From: webmaster@hawaii.gov
To: DBEDT OPSD Environmental Review Program
Subject: New online submission for The Environmental Notice
Date: Wednesday, December 27, 2023 5:22:57 PM

Action Name

Puna Geothermal Venture Repower Project

Type of Document/Determination

Final environmental impact statement (FEIS)

HRS §343-5(a) Trigger(s)

- (1) Propose the use of state or county lands or the use of state or county funds

Judicial district

Puna, Hawaiʻi

Tax Map Key(s) (TMK(s))

(3) 1-4-001: 001, 002, and 019

Action type

Applicant

Other required permits and approvals

Building Permit (County), Grading Permit (County)

Discretionary consent required

DOH noncovered source permit (for Phase 2, upgrades to 60 MW)

Approving agency

County of Hawaii Planning Department

Agency contact name

April Surprenant

Agency contact email (for info about the action)

planning@hawaiicounty.gov

Email address or URL for receiving comments

planning@hawaiicounty.gov

Agency contact phone

(808) 961-8288

Agency address

101 Pauahi Street
Suite 3
Hilo, Hawaii 96720
United States
Map It

Accepting authority

County of Hawaii Planning Department

Applicant

Puna Geothermal Venture

Applicant contact name

Michael Kaleikini

Applicant contact email

mkaleikini@ormat.com

Applicant contact phone

(808) 369-9094

Applicant address

P.O. Box 30
Pahoa, Hawaii 96778
United States
Map It

Was this submittal prepared by a consultant?

Yes

Consultant

Stantec Consulting Services Inc.

Consultant contact name

Michele Lefebvre

Consultant contact email

michele.lefebvre@stantecgs.com

Consultant contact phone

(808) 791-9872

Consultant address

P.O. Box 191
Hilo, Hawaii 96721
United States
Map It

Action summary

Puna Geothermal Venture is currently authorized for and operating a geothermal power plant in the Puna District and proposes to replace the current 12 operating power-generating units with up to four energy converters. The project would increase the production of renewable energy at the existing facility (within the current site fence line) using new, more efficient units on a smaller land footprint compared to the existing units. The project would increase power production from 38 to 46 megawatts in Phase 1 and further increase production to 60 megawatts in Phase 2. The overall property size would remain the same. Most of the existing infrastructure and buildings would remain for the Project including administration buildings, the control room, maintenance areas, well pads, and the gathering system. The proposed new units would continue to safely supply reliable power from renewable geothermal resources with more efficient and quieter equipment.

Attached documents (signed agency letter & EA/EIS)

- PGV_Final_EIS_Volume-1_12272023.pdf
- PGV-FEIS-Transmittal-OPSD-Signed.pdf
- PGV-Draft-EIS-Comment-Mtg-Audio.m4a

Shapefile

- The location map for this Final EIS is the same as the location map for the associated Draft EIS.

Action location map

- PGV_Parcels.zip

Authorized individual

Michele Lefebvre

Authorization

- The above named authorized individual hereby certifies that he/she has the authority to make this submission.

Puna Geothermal Venture Repower Project
~~Draft~~ Final Environmental Impact Statement

Prepared for: County of Hawaiʻi Planning Department

~~May~~ December 2023

Text that has been added to the Final EIS since the publication of the Draft EIS appears bold and double underlined (e.g., **new text**) and text that has been deleted is struck out (e.g., ~~deleted text~~).

Contents

List of Tables

List of Appendices

Appendix A: Figures

Project Information Summary

Project Name:	Geothermal Repower Project
Applicant:	Puna Geothermal Venture P.O. Box 30 Pāhoa, HI 96778 Contact: Mike Kaleikini Phone: 808-369-9094 Email: mkaleikini@ormat.com
Accepting Authority:	County of Hawaiʻi Planning Department Aupuni Center 101 Pauahi Street, Suite 3 Hilo, HI 96720 Phone: 808-961-8288
Planning Consultant:	Stantec Consulting Services Inc. P.O. Box 191 Hilo, HI 96721 Contact: Michele Lefebvre Phone: 808-494-2039 Email: michele.lefebvre@stantec.com
Location:	14-3860 Kapoho-Pāhoa Road Pāhoa, HI 96778
District:	Puna
Tax Map Keys:	(3) 1-4-001: 001, 002, and 019
Land Area:	815 acres
Recorded Fee Owner:	Kapoho Land & Development Co. Ltd.
Existing Use:	Portions include Puna Geothermal Venture facility and portions undeveloped
State Land Use District:	State Land Use Agricultural District
Lava Flow Hazard Zone:	LF1
Special Management Area:	Not within the Special Management Area
Zoning:	A-10a (Agricultural District, minimum building site of 10 acres)
Flood Zone Designation:	Zone X
Proposed Action:	See **Section 2.0**
Chapter 343, HRS Trigger(s):	Under a recent new interpretation of statutory definitions of "state land" by the Public Utilities Commission, the heat extracted from the geothermal fluid beneath the site, a resource to which the State of Hawaiʻi claims title, is "state land," so the Project's continued use of the geothermal resource triggers environmental review. (1) Propose the use of state or county lands or the use of state or county funds.
Agencies to Be Consulted:	See **Section 6.0**

List of Acronyms and Abbreviations

°C	Degrees Celsius
°F	Degrees Fahrenheit
AAQS	Ambient Air Quality Standards
AEGL	Acute Exposure Guideline Level
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
ARPPA	Amended and Restated Power Purchase Agreement
ATSDR	Agency for Toxic Substances and Disease Registry
BLNR	Board of Land and Natural Resources
BMP	Best management practice
BOP	Balance of plant
CDA	Hawaiʻi Civil Defense Agency
CDP	Census Designated Place
CFR	Code of Federal Regulations
CIA	Cultural Impact Assessment
CO	Carbon monoxide
CO_2	Carbon dioxide
DBEDT	Department of Business, Economic Development & Tourism
DIC	Dissolved organic carbon
DLNR	Hawaiʻi Department of Land and Natural Resources
DOH	Hawaiʻi Department of Health
EA	Environmental Assessment
EGS	Enhanced geothermal systems
EIS	Environmental Impact Statement
EISPN	Environmental Impact Statement Preparation Notice
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
ESRF	Emergency Steam Release Facility
FEMA	Federal Emergency Management Agency
FIT	Formation integrity test
GCCU	Geothermal combined cycle unit
GHG	Greenhouse gas
GRP	Geothermal Resource Permit
H_2	Hydrogen gas
H_2S	Hydrogen sulfide
HAP	Hazardous air pollutant
HAR	Hawaiʻi Administrative Rules
Hawaiian Electric	Hawaiian Electric Company
HCEI	Hawaiʻi Clean Energy Initiative
HELCO	Hawaiian Electric Light Company, Inc.
Hg	Mercury
HMP	Hydrologic Monitoring Program
HRS	Hawaiʻi Revised Statute
ITLU	Integrated two-level unit
km	Kilometer
kph	Kilo-pounds per hour
kV	Kilovolt
LERZ	Lower East Rift Zone
MCL	Maximum concentration limit
mg/L	Milligrams per liter
MRL	Minimal Risk Level
MW	Megawatts
MWh	Megawatt-hour
N_2	Nitrogen gas
NAAQS	National Ambient Air Quality Standards
NCG	Non-condensable gas
NHD	National Hydrography Dataset
NO_x	Nitrogen oxides
NSP	Noncovered source permit
OEC	Ormat energy converter
OPSD	Office of Planning and Sustainable Development
Ormat	Ormat Technologies, Inc.
PGV	Puna Geothermal Venture
PPA	Power Purchase Agreement
ppb	Parts per billion
ppm	Parts per million
PUC	Public Utilities Commission
Rn	Radon
RPS	Renewable portfolio standard
SERC	Hawaiʻi State Emergency Response Commission
SO_2	Sulfur dioxide
TDS	Total dissolved solids
TSP	Total suspended particulates
TTHM	Total trihalomethane
U.S.	United States
UIC	Underground Injection Control
USGS	U.S. Geological Survey
VOC	Volatile organic compound
VP	Viewpoint
VRMU	Vapor Recovery Maintenance Unit
VRU	Vapor Recovery Unit

1.0 Introduction

1.1 Project Introduction and Overview

Puna Geothermal Venture (PGV), a subsidiary of Ormat Technologies, Inc. (Ormat), is currently authorized for and operating a geothermal power plant in the Puna District on Hawaiʻi Island and proposes to replace the current 12 operating power-generating units with up to four upgraded power-generating units (the “Project”). The proposed Project would be constructed within the current PGV facility site boundaries, would have a smaller footprint of disturbance than the current units, and would increase power production from 38 to 46 megawatts (MW) in Phase 1 (replacing all 12 currently operating power-generating units with three upgraded power-generating units) and further increase production to 60 MW in Phase 2 (adding one additional upgraded power-generating unit). The location of the facility as well as existing and proposed Project features are shown on **Figures 1** through **3** (**Appendix A**). The facility site is located on private property and is leased by PGV.

Why This Environmental Impact Statement Is Being Prepared: History of PGV’s Power Purchase Agreements and Geothermal Resource Permit

To generate the proposed increase in power, PGV must receive approval from the Public Utilities Commission (PUC) of the Amended and Restated Power Purchase Agreement (ARPPA) consistent with the State of Hawaiʻi Public Utilities Law (Chapter 269, Hawaiʻi Revised Statutes [HRS]). This section provides the context of the approved Power Purchase Agreements (PPAs) for the Project.

According to the original PPA (signed on March 24, 1986), PGV agreed to provide a capacity of 25 MW of energy on-peak and 22 MW off-peak to Hawaiian Electric Light Company, Inc. (HELCO),[1] the utility company that serves Hawaiʻi Island. In August 1987, although there was no statutory trigger, an Environmental Impact Statement (EIS) for the now operating power plant was voluntarily prepared by PGV in accordance with Chapter 343, HRS (commonly referred to as HEPA), and the Hawaiʻi Administrative Rules (HAR) in effect at the time and submitted to the County of Hawaiʻi Planning Department. In November 1987, the EIS was published, and the Hawaiʻi County Planning Commission approved the original Geothermal Resource Permit (GRP) for the geothermal power plant in 1987. The GRP was amended in 2001, which allows PGV to generate up to 60 MW. PGV came online in 1993 with a generating capacity of 25 MW and expanded to 30 MW in 1995 without adding any new equipment or drilling additional geothermal wells. The additional 5 MW were produced only by the increased use of steam. An additional 8 MW were added in an Expansion PPA in 2012, which allowed PGV to provide a total of 38 MW to HELCO. New generating equipment was added at that time, but no additional geothermal wells were required because the equipment used to generate the additional 8 MW was designed to utilize the hot fluid (or brine) from the existing geothermal resource. PGV produced and provided to HELCO approximately 38 MW from 2012 until the eruption stopped production in May 2018.

PGV continued providing renewable geothermal energy to HELCO, which distributed the energy around Hawaiʻi Island until 2018. In May 2018, approaching lava from the 2018 eruption of Kīlauea on the Lower East Rift Zone (LERZ) inundated the main access road to the power plant, the wellheads of two geothermal wells, the substation of the complex, and an adjacent warehouse that stored a drilling rig. PGV restored the damaged access and facilities, and on November 5, 2020, electricity production partially resumed. PGV continued the geothermal field recovery work to increase the production of energy since then, and as of ~~early~~ **late** 2023, PGV currently produces approximately ~~24.2~~**30** MW and anticipates returning back to full contract obligation of 38 MW by the end of 2023 **or early 2024**. The LERZ is shown on **Figure 4**.

Since the previous PPA’s term was set to expire on December 31, 2027, PGV proposed to upgrade to more efficient equipment and make associated improvements to the original facility. PGV and HELCO reached

[1] Hawaiian Electric Company, Inc. (Hawaiian Electric) is the parent company of HELCO. Hawaiian Electric includes HELCO and Maui Electric Company, Ltd.

an agreement on the ARPPA that would combine the two existing PPAs into one PPA, repower the existing plant using the same amount of geothermal resource, extend the term until 2052, increase capacity of the geothermal plant to 46 MW, and decouple pricing for energy from oil costs with no escalation. The ARPPA was filed with the PUC on December 31, 2019, for its review and approval (Docket No. 2019-0333).

The PUC suspended the docket reviewing the ARPPA on March 31, 2021, pending Ormat's submittal of a Supplemental EIS pursuant to Chapter 343, HRS, and Chapter 11-200.1, HAR; however, the PUC declined to be the accepting authority for any environmental review and deferred such authority to another undetermined agency that would serve as the accepting authority for the environmental review.

In letters dated November 2, 2021, and March 22, 2022, the State of Hawaiʻi Office of Planning and Sustainable Development (OPSD) responded to PGV's request to designate an approving agency for the environmental review. The OPSD designated the County of Hawaiʻi Planning Department as the approving agency for the Project for any environmental review that is required. The County of Hawaiʻi Planning Department was selected as a permissible approving agency under HRS Section 343-5 because the Proposed Action would occur on Hawaiʻi island and the Planning Department is capable of overseeing the Chapter 343 process, has the greatest expertise or access to information, and has the highest level of participation because it would be issuing ministerial permits~~, such as a Grading and Grubbing Permit, for~~ the Project.

On November 5, 2021, in Order No. 38063 following the OPSD's designation, the PUC lifted the suspension of the docket and stated it would proceed with its review of the ARPPA concurrently with Hawaiʻi County's environmental review. In response to these events, the County of Hawaiʻi Planning Department determined that an EIS was the appropriate level of environmental review for the Project to satisfy the PUC's request for environmental review and to assure a comprehensive understanding of the environmental aspects of the proposed Project. On March 16, 2022, the PUC approved the ARPPA (Decision and Order No. 38276) with conditions that the "HEPA review" be complete prior to the commencement of Project construction.

This EIS has been prepared in accordance with Chapter 343, HRS, and Chapter 11-200.1, HAR, for the Project, which proposes to upgrade equipment and associated infrastructure. Under a recent new interpretation of "state land" by the PUC, the heat extracted from the geothermal fluid beneath the site, a resource to which the State of Hawaiʻi claims title, is "state land," so the Project's use of the geothermal resource triggers environmental review. The property is held in private title, and no state or county funds are proposed to be used for the Project.

1.2 Proposed Action

The Project would involve an upgrade to an existing facility. PGV operates the first **and only** commercial geothermal power plant and associated geothermal wellfield in the State of Hawaiʻi. Current production of electric power at PGV includes production wells, injection wells, a steam plant, a brine plant, and associated infrastructure (**Figure 2**). The Project would replace existing geothermal energy converters with more efficient energy converters using the same geothermal energy source. The increase in power production during Phase 1 would be 8 MW (from 38 MW to 46 MW), or an approximately 21 percent increase. The overall property size would remain 815 acres. Most of the existing infrastructure and buildings would remain for the Project including administration buildings, the control room, maintenance areas, well pads, and the gathering system. As part of the Project, the existing 12 steam and brine energy converters would be replaced with three new energy converters in Phase 1 (and one additional converter in Phase 2 would be added) at a new location on the site (**Figure 3**). The amount of power generated in Phase 1 matches the amount approved in the ARPPA. PGV would need to further amend the agreement prior to implementing Phase 2, which would increase power generation to 60 MW (30 percent increase from the 46 MW produced under Phase 1). **In a cost analysis filed with the PUC, the state's consumer advocate estimated that the typical residential customer could save approximately $22.68 per month under the First and Second Amendments to the ARPPA (Division of Consumer Advocacy 2023).**

The Project would also install new piping and reduce existing steel structures, piping, mechanical components, and associated flange connections (associated with the replacement of the currently operating equipment). The Project would increase the production of renewable energy at the existing facility (within the current site fence line) using new geothermal power-generating units on a smaller land footprint compared to the existing units. **Geothermal energy production plays an important part in transitioning the state from fossil fuels.**

1.3 State Energy Goals and Production

Hawaiʻi's Current Energy Mix

The current energy mix for Hawaiʻi consists of both fossil fuels and various sources of renewable energy. Hawaiian Electric (which provides electricity for 95 percent of residents of the state on Oahu, Maui, Molokai, Lanai, and Hawaiʻi Island) tracks its sales of renewable energy (Hawaiian Electric 2023a). The exact mix of renewables produced in Hawaiʻi is a product of complex and in-flux considerations of fossil fuel prices, renewable energy technologies, renewable energy regulations and policies, consumption patterns, a grid adapting to distributed generation, environmental impacts, perceptions of different energy production by residents, and investor interest. In this context, it is useful to briefly consider a comparison of energy production in the state, the position of geothermal energy relative to the current renewable energy policies and goals, and the role of geothermal energy in the local production and consumption of electricity.

Hawaiʻi's geographic isolation has historically required Hawaiʻi to import fuel resources to meet its energy needs for electricity as well as land, sea, and air transportation. In 2022, approximately 70 percent of Hawaiʻi's energy was met by imported fossil fuels (which is consistent with figures from previous years), making Hawaiʻi the most fossil fuel–dependent state in the nation. Since there are no local sources, the state is dependent on imported fossil fuels for both transportation and electricity generation. This dependence on imported fossil fuels for generating electricity and the isolated island grids contribute to Hawaiʻi having the highest average electricity retail price of any state and nearly triple the United States (U.S.) average rate (Hawaii State Energy Office 2023). With the current dramatic rises in fossil fuel prices, electricity costs for island residents are predicted to increase an additional 20 percent (Hawaiʻi Tribune-Herald 2022).

Liquid fossil fuels are transported across the ocean from Indonesia, Argentina, Brazil, Angola, Congo, and Libya and are offloaded in waters off Oahu before being refined, repackaged, and shipped on barges to other islands (HSEO 2023). Vessels of liquid fossil fuel moving through the Hawaiian Islands regularly pose a risk to the marine environment, and the burning of fossil fuels contributes to the state's greenhouse gas (GHG) emissions, which contribute to the global climate crisis (HSEO 2023). In 2017, GHG emissions from the energy sector accounted for 86 percent of Hawaiʻi's total GHG emissions. Of the 86 percent generated by the energy sector, stationary combustion facilities (e.g., electric power plants, petroleum refineries and fugitive emissions from petroleum refineries, and industrial facilities) generated the second most GHG emissions after transportation at 46 percent (HSEO 2022a).

In addition to petroleum and imported resources, Hawaiʻi utilizes renewable resources to produce electricity throughout the state, including solar power, onshore wind resources, biomass, hydropower, geothermal, and other developing hydro-related technologies.

Hawaiʻi Renewable Energy Goals and Policies

The Hawaiʻi Clean Energy Initiative (HCEI) was established to reduce the state's dependence on imported petroleum for energy production and locally produce more clean energy. The HCEI was launched in 2008 when a Memorandum of Understanding was signed between the state and the U.S. Department of Energy and developed a framework of statutes and regulations to establish renewable energy goals and policy. The original goal was for Hawaiʻi to meet 70 percent of its total energy needs through clean sources by 2030.

The HCEI's renewable energy and energy efficiency targets, which have been codified into law, drive Hawaiʻi's clean energy policy agenda. Other policy actions include regulatory reform to tax policy and clean energy financing. The state exceeded the HCEI original target to achieve a 2015 renewable portfolio standard (RPS) of 15 percent, and in 2018 the state was generating 27 percent of its electricity sales from clean energy sources (HCEI 2018). In May 2015, the state set its goals higher and adopted an RPS of 100 percent by 2045, with interim targets of 30 percent by 2020 (which was met, reaching 35 percent), 40 percent by 2030, and 70 percent by 2040. HCEI identified the following objectives to help meet that goal:

- Define the new infrastructure needed for a clean energy economy;
- Foster and demonstrate innovation in the use of clean energy technologies, creative financing, and public policy to accelerate the transition to clean energy;
- Create economic opportunity by developing and diversifying Hawai‘i’s economy;
- Establish an open-source learning model that supports other island communities with similar goals; and
- Build a workforce with new skills that form the foundation of an energy-independent Hawai‘i (HCEI 2022).

Additionally, Hawaiian Electric has committed to help achieve the state's goals of increasing Hawai‘i’s use of clean energy and reducing dependency on imported oil, with a goal to cut carbon emissions from power generation by 70 percent by 2030 (from 2005 levels) and to achieve net zero or net negative carbon emissions (i.e., if there are any emissions, they will be captured or offset) by 2045. The key elements to meet this goal include the shutting down of the state’s last coal plant on Oahu in 2022, adding rooftop solar systems, retiring at least six fossil-fueled generating units and reducing the use of other fossil fuel units as new renewable resources come online, adding community-based renewable energy, using more grid-scale and customer-owned energy storage, expanding geothermal resources, and creating customer incentives to change patterns of energy use (Hawaiian Electric 2021).

In order to meet statewide decarbonization goals, Hawaiian Electric’s May 2023 Integrated Grid Plan (IGP) identifies that 27.2 percent of Hawai‘i Island’s electricity would come from geothermal by 2045 (Hawaiian Electric 2023a). With one of six types of renewable energy generation sources proposed for Hawai‘i Island identified in the IGP, geothermal contributes to a diverse energy resource portfolio and increases system reliability and mitigates against interruption risks created by limited sources of energy generation. In 2017, PGV provided approximately 31 percent of all energy delivered to the HELCO grid. Following the 2018 Lower Puna eruption and returning to the facility’s current generation capacity and PPA contracted output of 38 MW, geothermal energy produced at the PGV facility would represent approximately 30 percent of all energy delivered to the HELCO grid.

State Renewable Energy Production

~~In 2021, Hawaiian Electric reported that the percentage of renewable energy generated in the state was 38 percent (for a total of 470,612 customers) (Hawaiian Electric 2023a). The island of Kaua‘i is powered by a utility cooperative owned by Kaua‘i energy users (the Kaua‘i Island Utility Cooperative), which achieved 67 percent renewable energy generation in 2020 (HSEO 2022b).~~

~~In 2021, Hawaiian Electric reported the following breakdown of renewable power generation facts:~~

- ~~For its 307,378 customers, Oahu generated **32.8 percent** of its energy through renewable resources;~~
- ~~For its 87,357 customers, Hawai‘i Island generated **60 percent** of its energy through renewable resources; and~~
- ~~For its 73,304 customers on Maui, Molokai, and Lanai, Maui County generated **50.2 percent** of its energy through renewable resources (Hawaiian Electric 2023a).~~

~~The 2021 percentage of 38 percent of electricity sales from renewable resources in the state was an increase from 34.8 percent in 2020 and 28.4 percent in 2019 (Hawaiian Electric 2022).~~ **In 2022, the percentage of generation from renewable energy by island is as follows: 28.2 percent for Oahu; 35.6 percent for Maui County; and 47.9 percent for Hawaii Island (Hawaiian Electric 2023b).** Hawaiian Electric achieved a 32 percent renewable portfolio standard (RPS) in 2022 using a new calculation signed into law last year. The RPS calculation previously reflected the renewable percentage of electricity sold. Under the old formula, the RPS for 2022 would have been 39 percent, up from 38 percent in 2021. The RPS definition was changed under Act 240, which was signed into state law in July 2022. The revised definition showing the percentage of total generation from renewables is a more accurate way to measure progress toward the goal of achieving 100 percent renewable energy by 2045 (Hawaiian Electric 2023**c**).

Hawaiʻi Island Renewable Energy Production

Hawaiʻi Island currently has the highest percent of energy among Hawaiian Electric–powered islands generated by renewable resources in the state.[2] The companies and resources that have capacity to generate power in 202~~1~~**2** appear in **Table 1-1** below and include oil (~~40~~**52** percent) and renewables (~~60~~**48** percent), including sources from geothermal, hydroelectricity, wind, and solar.

Table 1-1 Power Generation Capacity on Hawaiʻi Island in 2021

Source	Source Name	Capacity (Megawatts)
Firm Generation[1]		
Hawaiian Electric Plants (Oil)	Keahole	77.6
	Puna	36.7
	Kanoelehua	21.0
	Waimea	7.5
	Hill	34.7
	Dispersed generation	5.0
Independent Power Producers	Hāmākua Energy (Oil)	60.0
	Puna Geothermal Venture (Geothermal)	38.0
	Total firm capacity[2]	**280.5**
Variable (As-Available) Generation[3]		
Hawaiian Electric Plants	Puueo Hydro	3.4
	Waiau Hydro	1.1
Independent Power Producers	Pakini Nui Wind, Wailuku River Hydro, Hawi Renewable Development, Customer-site renewable	~~159.1~~**164.1**
	Approximate non-firm capacity	~~**163.6**~~**168.6**

Source: Hawaiian Electric 2023**d**~~a~~

1. Firm generation means sources of power generation that are controllable and reliable in that they are not episodic or reliant on environmental variables such as the wind and sun to produce electricity.

2. Retired Units: Shipman (oil) (capacity: 15.2 MW): 0 MW generated in 202~~1~~**2**.

Projects in development **or recently developed** on Hawaiʻi Island include the following: AES Waikoloa Solar (30 MW + 120 megawatt-hour [MWh] storage); Hale Kuawehi Solar (30 MW + 120 MWh storage); Hu

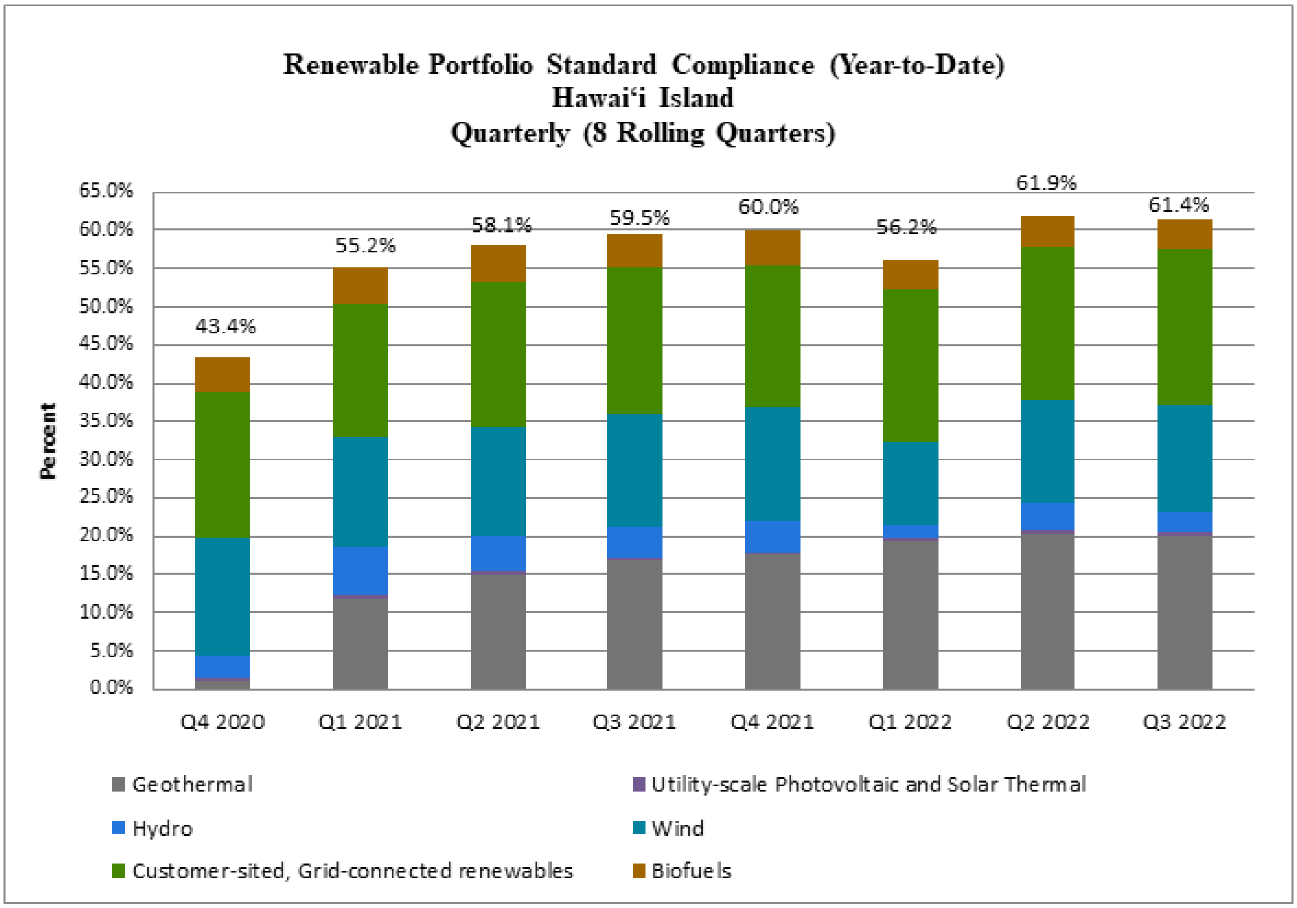
2. Hawaiian Electric does not provide power on Kauaʻi Island; this comparison includes Oahu, Maui County, and Hawaiʻi Island.

Honua (biomass) (21.5 MW); Keahole Battery Energy Storage (12 MW/12 MWh storage only); and shared solar: 0.750 MW (Hawaiian Electric 2023ea).

The amount of power generated on Hawaiʻi Island from renewable energy in 2020 before PGV came back online was approximately 23 percent of the system's renewable energy (i.e., percent of total net generation that is represented by renewable energy rather than being based on sales and does not include customer-sited renewable generation). With the production of energy from geothermal resources at PGV recommencing, Hawaiʻi Island was able to increase this amount to approximately 38 percent in system renewable energy in 2021 and 2022. **In 2022, the total system generation mix for Hawaii Island was as follows: 0.0 percent biomass; 15.7 percent geothermal; 0.3 percent utility-scale photovoltaic and solar thermal; 2.1 percent hydro; 10.6 percent wind; 3.5 percent biofuels; 15.8 percent customer-sited, grid-connected renewables; 52.1 percent oil; and 0.0 percent coal (Hawaiian Electric 2023b).**

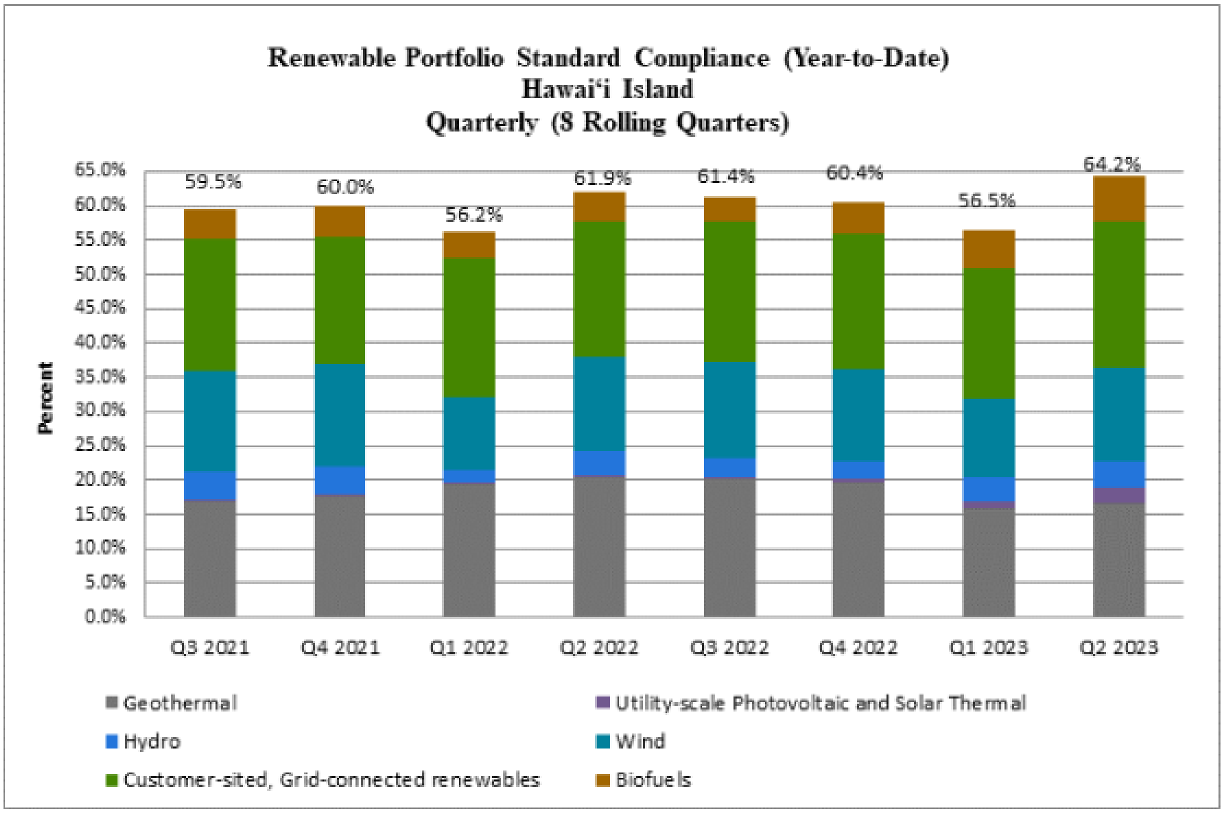
The renewable energy portfolio represents the percent of sales that is represented by renewable energy, which is averaged around 6058 percent in 2021 and 61 percent in 2022 (**Graph 1**). **In response to public comments received on the Draft EIS to include data available following preparation of the Draft EIS, Graph 2 shows that the renewable energy portfolio averaged 60 percent in 2023.**

Graph 1 Hawaiʻi Island Percent System Renewable Energy (Q4 2020 – Q3 2022)



Source: Hawaiian Electric 2023fb

Graph 2 Hawaiʻi Island Percent System Renewable Energy (Q3 2021 – Q2 2023)



Source: Hawaiian Electric 2023f

1.4 Purpose and Need

The purpose of the Project is to continue supplying electrical power produced using renewable geothermal resources in response to Hawaiian Electric's forecasted need for energy on Hawaiʻi Island. According to the PUC, "in addition to providing new energy and firm dispatchable capacity, the 8 MW upgrade increases PGV's ability to provide inertia and useful grid services such as primary frequency response and reactive power to Hawaiian Electric's system." The upgrades in the proposed Project would be useful and complementary to other generators and to those expected to be added in the coming years.

The proposed upgrades, described in further detail below in **Section 2.2**, would occur in two phases to adapt to HELCO's projected increase in energy demand[3]. The Project is consistent with both state and county goals to increase efficiency at an operating power facility to generate more energy for the residents of Hawaiʻi Island in an area already set aside for this purpose, reducing energy costs for residents, and decreasing Hawaiʻi's reliance on imported fossil fuels.

1.5 Alternatives

The Project (the Proposed Action) consists of upgrading certain generating equipment and increasing geothermal energy production at an existing operating facility. The applicant, PGV, is a geothermal power producer with no **current** plans to investigate different alternative energy sources in Hawaiʻi County such as solar, wind, tidal power, or biomass. Neither PGV nor Ormat holds additional properties for geothermal energy development on Hawaiʻi Island (or elsewhere in the state) that allow them to commercially produce

[3] **The amount of power generated in Phase 1 of the proposed project matches the amount approved in the PPA. As stated in Section 1.2, PGV would need to amend the PPA and receive PUC approval prior to implementing Phase 2 of the proposed project.**

energy using geothermal resources on the same timeline as the Project. Further, PGV is not proposing to export the energy generated at the PGV facility from Hawai‘i Island.

1.5.1 46 MW Alternative

Consistent with HAR Section 11-200.1-24(h), one reasonable alternative to the Proposed Action considered in detail in this EIS is construction of only Phase 1 of the Project, referred to herein as the 46 MW Alternative. Under this alternative, PGV would increase power production from 38 to 46 MW and replace all 12 currently operating power-generating units with three upgraded power-generating units. The fourth replacement power-generating unit, as described for Phase 2 of the Proposed Action, would not be constructed; therefore, the Project would have the capacity to generate up to 46 MW of power with the replacement of the three power-generating units. The extent of the Project that would occur under this alternative is shown on **Figure 3** as Phase 1. Under the 46 MW Alternative, the Project would proceed with a modified Noncovered Source Permit (NSP) and the current ARPPA (without requiring another modified ARPPA, compared to the Proposed Action which requires both a modified NSP and ARPPA). However, this alternative would not maximize the energy the facility could produce and would not generate the additional 14 MW that are authorized in the GRP and proposed as Phase 2 of the Proposed Action. Under this alternative, Hawaiian Electric would still need to meet increasing demand for power for the additional 14 MW either through the burning of fossil fuels at existing facilities on Hawai‘i Island or partnering with other renewable energy providers.

1.5.2 No Action Alternative

HAR Section 11-200.1-24(h) also requires that the EIS include a discussion of the No Action Alternative. Under this alternative, Ormat would not upgrade equipment at the PGV facility. Since the proposed location of the upgraded energy-generating units is within the current PGV facility site and within the Kapoho Section of the Kīlauea Lower East Rift Geothermal Resource Subzone, future actions at the site would likely be associated directly or indirectly with energy production, although other land uses in line with existing or potential future uses in the vicinity, including farming, tourism, or housing, would not be precluded. These future actions, which are not currently proposed, would depend on many factors including the market as well as government permitting and would be decided by the landowner (Kapoho Land Trust).

For the purposes of this EIS analysis, the No Action Alternative considers mainly the consequences of the present situation, which is the current operation of the geothermal energy production facility through 2027 under the current PPA (not the ARPPA approved by the PUC in 2022) or an extended term of the PPA under the status quo conditions. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of ~~the~~ **any** PPA **extension and status quo conditions would persist. Upon termination of the existing PPA in 2027 (or following the end of any extended term), w**ithout the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawai‘i Island or partnering with other renewable energy providers. Other renewable energy projects would **be determined by Hawaiian Electric, the competitive procurement process, and market dynamics. These projects** need to be economically feasible, require approval from the PUC, and comply with other local, state, and federal laws and regulations. Until those projects are developed, the residents of Hawai‘i are subject to power shortages when there is unplanned equipment failure and low wind conditions. Residents could experience rolling blackouts under these circumstances without additional fixed power generation (Hawai‘i Tribune-Herald 2023).

To understand the facility's relative renewable energy contribution to Hawai'i Island, prior to the 2018 eruption PGV produced 38 MW of energy, which was approximately 31 percent of all the electricity delivered to the HELCO grid. Under this alternative, the facility would not be upgraded to deliver 46 MW, which PGV estimates would provide up to 37 percent of the electricity delivered to the HELCO grid in Phase 1, which would equate to a loss of approximately six percent renewable energy to the HELCO grid. **Thus, under the**

No Action Alternative, HELCO and the State of Hawai'i would lose ~~of~~ **the benefit of the additional eight MW of renewable energy that would be produced for the grid under Phase 1 of the Proposed Action.** Additionally, under this alternative the lost benefit of not constructing Phase 2 would equate to a loss of approximately 11 percent less renewable energy to the HELCO grid. **Furthermore, if the current PPA is not extended beyond 2027, or is otherwise terminated, under the No Action alternative, HELCO would need to replace approximately 30 percent (i.e., 38 MW or 46 MW depending on the generation of the PGV facility at the time) of renewable energy to the grid from other sources.**

This provides a useful baseline for comparison of impacts with the Proposed Action and is analyzed throughout this Draft EIS, as required by HEPA rules.

1.6 Geothermal Land Use Background and Project Location

Geothermal Resource Subzones: A Brief History

The development of geothermal energy began in Hawaiʻi in 1961 with the drilling of the first exploratory wells. Under direction of the University of Hawaiʻi, the Hawaiʻi Geothermal Project began in 1972, which led to the drilling of the first successful well in 1976 and to the construction of the 3 MW HGP-A operating plant in 1981, which was funded by the National Science Foundation and the U.S. Department of Energy with contributions by the state. The HGP-A plant operated for approximately eight years and demonstrated the technical and economic feasibility of geothermal energy in Hawaiʻi. In an effort to promote use of indigenous resources for energy production, Hawaiʻi's State Legislature enacted the Geothermal Resource Subzone Assessment and Designation Law (Act 296-83), determining that the development and exploration of Hawaiʻi's geothermal resources is of statewide concern and that this interest must be balanced with preserving Hawaiʻi's unique social and natural environment (Yoshihara 1985).

Act 296-83 mandated the creation of "geothermal resource subzones" where geothermal development could take place regardless of the existing land use classification (urban, rural, agricultural, and conservation). The intent was not to overhaul or displace the existing land use system but to add the requirement of a subzone procedure application to geothermal activities. The counties would continue to maintain jurisdiction and authority to approve site-specific activities on agricultural, rural, and urban lands, while the Board of Land Natural Resources would continue to maintain jurisdiction on conservation lands (Yoshihara 1985).

The subzones were defined in HRS Section 205-5.1, and designated subzones included the following: Lihue (Kauaʻi); Koolau and Waianae (Oahu); West Molokai (Molokai); Palawai (Lanai); Honolua, Lahaina, Olowalu, Haleakalā Northwest Rift Zone, Haleakalā Southwest Rift Zone, Haleakalā East Rift Zone (Maui), Kohala, Kawaihae, Hualalai, Mauna Kea Northwest Rift Zone, Mauna Kea East Rift Zone, Mauna Loa Northeast Rift Zone, Mauna Loa Southwest Rift Zone, Kīlauea Southwest Rift Zone, and Kīlauea East Rift Zone (Hawaiʻi) (https://files.hawaii.gov/dbedt/op/gis/maps/geothermal_maps.pdf). However, HRS Section 205-5.1 was repealed by Act 97 (2012). Geothermal resource development is a permitted use in all State Land Use Districts in accordance with HRS Section 205-2.

Project Location

The Project would be located within the existing approximately 815-acre PGV facility site boundary in the Kapoho Section of the Kīlauea Lower East Rift Geothermal Resource Subzone (Project Area), an area that has produced geothermal heat for hundreds of years and is expected to continue producing geothermal heat for ~~hundreds~~ **thousands** of years to come.

The existing facility encompasses approximately 55 acres within the 815-acre boundary. The proposed upgrades would encompass nine acres in Phase 1 and 2.9 acres in Phase 2 (for a total of 11.9 acres) and would be located within the 16.4-acre Project Area shown on **Figure 3**.

It should be noted that the State of Hawai'i owns all mineral rights (including geothermal resources) in the state, including those for the Project, and has issued a Geothermal Resources Mining Lease for the existing PGV facility under which the Project would continue to operate.

1.7 Public Participation

Public participation is a key component of the HEPA process. Opportunities for public input and participation in the HEPA EIS process occur during two stages: (1) during the scoping period, following publication of the Environmental Impact Statement Preparation Notice (EISPN) consistent with HAR Section 11-200.1-23; and (2) during the comment period, following publication of the Draft EIS consistent with HAR Section 11-200.1-25.

1.7.1 EIS Preparation Notice

A notice of the EISPN availability was published in the State of Hawai'i's Environmental Review Program's monthly publication, *The Environmental Notice*, on July 23, 2022. Publication of the EISPN started a 30-day public review and comment period (i.e., a scoping period) to provide an opportunity for agencies, groups, and individuals to provide written comments regarding potential environmental effects from the Project. The EISPN notice is provided in **Appendix B**.

1.7.2 Scoping

In accordance with HAR Section 11-200.1-23, a public scoping meeting was held at the Pāhoa Neighborhood Facility on Wednesday, August 17, 2022, from 5–8 p.m. during the 30-day scoping period. Scoping serves as an opportunity to obtain input from the community, agencies, and other stakeholders regarding the issues and resources they would like to see addressed and analyzed throughout the EIS process, as well as identify reasonable alternatives. The public was invited to provide oral comments at the scoping meeting or written comments during the 30-day scoping period.

Methods to solicit public input during the scoping period for this EIS included notification, publication of project information, and invitations to participate in scoping. The scoping period ran 30 days from the publication of the EISPN in *The Environmental Notice* on July 23 through August 22, 2022. Additionally, news stories were published online in Big Island Video News, online in Big Island Now, and in print and online on the Hawai'i Tribune-Herald announcing the publication of the EISPN and the date and time of the scoping meeting.

Letters were sent with similar information to 63 individual, agency, and organization stakeholders on July 23, 2022 (see **Section 6.0**). Stakeholders consist of agencies with a regulatory role, individuals and organizations interested in geothermal activities, and elected officials whose jurisdiction includes PGV. The direct scoping letter is shown in **Appendix B**.

Additionally, information regarding the EISPN and scoping meeting was made available on PGV's website under the tab created for the EIS: https://punageothermalproject.com/eis/.

The first hour of the scoping meeting was open-house style with posters set up around the Pāhoa Neighborhood Facility and staff available around the posters to answer public questions and receive written comments. Scoping meeting materials are included in **Appendix C**. Oral comments were received from in-person and then online attendees from 6–8 p.m. During the two-hour comment period at the scoping meeting, 28 oral comments were received. The majority of commenters expressed concerns regarding current operations to air quality, geologic hazards, noise, and hazardous materials. Specifically, commenters raised concerns about current operations including existing permits, impacts to the Native Hawaiian community and cultural practices, induced seismicity, volcanic activity, emissions of hydrogen sulfide gas, impacts from hazardous materials including pentane, noise, socioeconomic impacts, and the Emergency Response Plan (ERP). Commenters requested that the EIS consider changes in the landscape following the 2018 eruption. There were requests for the EIS to consider an action alternative that decommissioned the plant prior to the current terms in the PPA with the PUC. Commenters also requested additional monitoring for air quality and seismicity under existing permits.

A total of 29 written submissions were received during the 30-day scoping period. Nearly all submittals were provided by individuals, agencies, and organizations within the state. All submissions were reviewed carefully, and individual comments were identified in each submission. The EIS preparer assigned topic(s) for each substantive comment corresponding to the nature of the comment. In determining whether a comment is substantive, the EIS preparer "shall consider the validity, significance and relevance of the comment to the scope, analysis or process of the EIS" (Section 11-200.2-26[a], HAR). For this EIS, comments were considered substantive if they helped refine the Proposed Action or alternatives, identified specific resource analysis to be conducted in the EIS (e.g., air quality, noise, geologic hazards), and/or recommended technical data, specific impacts, or mitigation measures. Statements considered to not be substantive were general comments with no specific information, such as those that stated preferences for or against the Proposed Action.

In total, the EIS team identified 200 substantive comments and 18 topics in the written submittals. Most of the substantive comments fell under the following topics: air quality; geologic hazards; hazardous materials; water quality; and noise. **Appendix D** includes all scoping comments received and provides responses to the substantive comments.

1.7.3 Draft EIS

The public comment period on the Draft EIS was initiated through publication of the Draft EIS in *The Environmental Notice* **on May 8, 2023**. Additionally, letters with similar information to the public notice were sent to approximately 100 individual, agency, and organization stakeholders and elected officials (**Table 6-1**), including those individuals, agencies, and organizations who submitted written (and oral) comments on the EISPN or during the scoping meeting. Publication of the Draft EIS initiated the 45-day public review period. A voluntary Draft EIS public meeting ~~is scheduled for~~ **was held on** June 1, 2023, to provide information to the public and agencies and to facilitate oral and written comments. **A total of 68 written comment letters were received on the Draft EIS, and a total of 28 oral comments were given at the voluntary public meeting.** ~~Written comments must be received or postmarked within 45 days of publication of the Draft EIS.~~ All substantive oral and written comments on the Draft EIS ~~will be~~**were** considered during the preparation of the Final EIS**, and Appendix D includes all public comments received and provides responses to substantive oral and written comments.**

1.7.4 Final EIS

The Final EIS ~~will~~ take**s** into consideration comments received on the Draft EIS, identif**ies**~~y~~ substantive comments, and provide**s** responses commensurate to the **substantive** comments. The Final EIS ~~may be~~**has been** refined to address substantive comments and to clarify information. Similar to the Draft EIS, availability of the Final EIS will be published in *The Environmental Notice*. The County of Hawai'i's Planning Department, as the accepting authority for this EIS, will conduct its HEPA acceptability determination within 30 days of receiving the Final EIS. The Planning Department's determination will be published in *The Environmental Notice*.

2.0 Project Description

2.1 Existing Operations (No Action Alternative)

Construction and operation of the facility has been previously authorized under a variety of permits issued by the County of Hawaiʻi. The 1987 Puna Geothermal Venture Project EIS, as noted earlier, was submitted to the County of Hawaiʻi (PGV 1987). Ormat is the parent company of PGV and has over 56 years of experience in developing and operating geothermal power facilities and producing geothermal energy and currently owns and operates over 1,000 MW of geothermal energy production, storage, photovoltaic solar, and recovered energy generation around the globe. The description provided below is a summary of the authorized and existing PGV facilities and operations as of May 2022. Where applicable, the 1987 EIS is referenced in the description of authorized operations below.

2.1.1 Existing Operations: Geothermal Wells and Wellfield Facilities

The existing facility currently consists of five well pads (A, B, D, E, and F), of which three have operational wells (pads A, B, and E). Wells are spaced approximately 50 to 100 feet apart **at the surface,** within the well pad and are **directionally** drilled to a depth of approximately 4,000 to 8,000 feet below the surface. The piping subsystem begins downstream of the master shutoff valves at each wellhead and includes production, throttling, and isolation valves and flow rate metering devices and instrumentation required for local or remote monitoring and control of each well. A rock catcher (rock particle separator) is installed immediately downstream of each wellhead. The subsystem includes a moisture separator that flashes the geothermal fluids into steam and brine fractions. A list of past and current wells is included in **Table 2-1**.

Table 2-1 Past and Current Wells at PGV

Well Number	Well Type	Status	Well Pad
KS-1	Plugged or covered	Out of Service	A
KS-1A	~~Injection~~**Plugged or covered**	Out of Service	A
KS-2	Plugged or covered	Out of Service	B
KS-3	Injection	In Service	E
KS-4	Plugged or covered	Out of Service	E
KS-5	Production	Out of Service	E
KS-6	Production	Out of Service	E
KS-7	Plugged or covered	Out of Service	F
KS-8	Plugged or covered	Out of Service	D
KS-9	Production	Out of Service	A
KS-10	Production	Out of Service	A
KS-11	Injection	In Service	A
KS-13	Injection	In Service	A
KS-14	Production	In Service	E
KS-15	Injection	In Service	B
KS-16	Production	Out of Service	A
KS-17	Production	In Service	A
KS-18	Production	In Service	E
KS-19	**Production**~~Injection~~	~~Planned~~**In Service**	E
KS-20	Injection	In Service	A
KS-21	~~Production~~**Injection**	~~Planned~~**Out of Service**	A

Well Number	Well Type	Status	Well Pad
KS-22	**Production**~~Injection~~	~~Planned~~**In Service**	E
MW-4	Monitoring	In Service	B
MW-5	Monitoring	In Service	B

Source: EPA 2021a**; PGV 2023**

Monitoring Wells

Because groundwater monitoring wells MW-1, MW-2, and MW-3 were inundated by lava during the 2018 eruption of the Kīlauea volcano, new groundwater monitoring wells were needed to maintain the number of monitoring wells at the site. Therefore, PGV replaced the inundated groundwater wells with two on-site groundwater monitoring wells, MW-4 and MW-5**, which have a capacity of 1,200 gallons per minute and 250 gallons per minute, respectively. The primary use of water pumped from MW-4 is to ensure sufficient water flow for drilling and well control and MW-5 is used to fill the 500,000-gallon capacity plant water tank, which is used for general PGV facility usage (i.e., equipment cooling and general maintenance for cleaning equipment).** In addition, PGV utilizes one off-site and downgradient monitoring well (Lippe Well at Pohoiki or MW-6).

Production and Injection Wells

Geothermal wells for the current operations are identified as either production or injection depending upon the performance of the well. Each production well has an approximate average flow rate of 90,000 pounds per hour of steam deliverable to the power plant. Injection wells are used to reinject brine and process fluids generated in the operation of the power plant back into the geothermal reservoir. Marginal geothermal production wells (wells that contained less than desired steam flow or steam fraction) can be converted into injection wells as needed.

Currently, PGV is permitted to operate six injection wells. An additional ten production wells could be converted to injection wells pursuant to the Environmental Protection Agency's (EPA's) Underground Injection Control (UIC) Permit (October 19, 2021) (EPA 2021a). As of 2023, ~~three~~ **five** production and ~~four~~ **five** injection wells are in service. An additional eight injection wells were approved as part of the UIC permit renewal on October 19, 2021.

The Project also operates under a state UIC permit issued by the Hawai'i Department of Health (DOH) Safe Drinking Water Branch. The application for renewal of this permit was submitted in March 2020, and the DOH approved the renewed permit renewal process on September 24, 2022.

The geothermal resource required to generate this power is obtained through ~~drilling~~ **the** ~~and~~ operation of production and injection wells. PGV is authorized to drill production and injection wells in accordance with its existing permits. At the time this EIS was prepared, the authorized number of wells varies by permit and are as follows: the DOH's NSP covers 14 operating wells, the DLNR's Plan of Operation covers 28 wells, and the GRP covers 30 wells. Prior to shutting down in 2018, the facility flowed approximately six million gallons of geothermal resource per day to generate 38 MW.

2.1.2 Existing Operations: Gathering Systems

Three gathering systems—steam, condensate, and brine—are used to collect and transport fluids to the appropriate downstream processing units. All three gathering systems consist of independent piping networks that interconnect only where two streams are present. All pipes are engineered for stresses induced by thermal, pressure, dead, and seismic loads. The gathering systems generally follow the shortest route from the source to the destination; however, terrain, visual impacts, and existing road alignments partially dictate the layout. All pipelines are painted dark green or grey, and vegetation is encouraged to grow around the pipes to minimize visual impacts.

In response to a comment received during the Draft EIS requesting information on how pipes are insulated: the pipes at the existing facility are insulated with material to protect employees from high temperature piping that could cause burns in accordance with OSHA requirements. Piping insulation also minimizes heat losses as the geothermal fluids are transported from the production wells throughout the power plant. The insulation materials consist of temperature resistant fiberglass and some ceramic material, and are enclosed with aluminum sheathing.

The steam-gathering system transports steam from the well pads to the turbine in the power plant. Steam pipelines begin as a single line from each well pad and join before reaching the power plant and include a moisture separator to remove any entrained water.

The condensate-gathering system collects steam that condenses in the steam-gathering pipelines at the two moisture separators and at low points in the steam-gathering system. The condensate-gathering system transfers the collected condensate, under pressure, to the steam turbine condenser.

The brine-gathering system collects the brine generated at the well pad separator. The brine is transported to a heat exchanger in the power plant and then to the injection wells for reinjection into the geothermal reservoir.

2.1.3 Existing Operations: Power Plant

Electricity is generated in the steam power plant through the use of Ormat energy converters (OECs). PGV currently operates ~~12~~ **10** OECs**, of the existing 12 OECs,** for power production. Geothermal steam powers the steam turbine that converts the energy into mechanical work, which is then used to rotate the generator, creating electricity. Depressurized steam leaves the turbine and enters into a heat exchanger where it vaporizes pentane, a low boiling point hydrocarbon. In the process, the steam condenses and is collected into a **condensate** holding tank at the bottom of the condenser. The vaporized pentane turns a binary turbine before being exhausted into an air cooler to be condensed. The liquid pentane then flows back into the heat exchanger to begin the “closed-loop” system again.

The steam entering the heat exchanger contains non-condensable gases (NCGs) including hydrogen sulfide (H_2S), carbon dioxide (CO_2), nitrogen gas (N_2), and hydrogen gas (H_2). These gases are removed using a steam ejector vacuum system, **cooled,** compressed, and piped into the reinjection system.

The hot geothermal ~~brine~~ **condensate** is pumped to a heat exchanger located in an OEC. In the heat exchanger, the ~~brine vaporizes~~**condensate pre-heats the** pentane. The lower-temperature ~~brine~~ **condensate exiting the heat exchanger** is collected and ~~combined with the condensed steam before being piped~~ **pumped** into the reinjection system. The vaporized pentane turns a binary turbine and is then treated in a similar manner as described above.

Each turbine is equipped with a bypass system so that it can operate even during turbine upset conditions or plant start-up. Steam turbine bypass valves open, and the pentane “closed-loop” would continue to operate.

Integrated Two-Level Units

PGV currently operates two integrated two-level units (ITLUs) for power production. Each ITLU consists of two turbines coupled to a synchronous generator. Geothermal brine is diverted to the unit, where the brine flows through four heat exchangers, two vaporizers, and two preheaters, which heat and vaporize pentane. Before entering the turbine, the vaporized pentane passes through a liquid separator that removes liquid from the vapor.

2.1.4 Existing Operations: Supporting Infrastructure

Additional infrastructure and ancillary facilities at the PGV facility include the maintenance building, an administration building, a control building, a machine shop, a warehouse facility, transformers, and chemical tanks.

Following damage during the 2018 Lower Puna eruption and in order to resume operations, PGV's initial restoration efforts involved the reestablishment of an access road from Highway 132 back to the PGV site. Primary access to PGV was completed in December 2018. Secondary access from the Pohoiki Road was no longer available due to impacts from the 2018 Lower Puna eruption. PGV then coordinated with HELCO to rebuild the substation and transmission lines. During this effort, HELCO and PGV each rebuilt their respective components of the substation (e.g., switches, breakers, meters) and coordinated to connect the components. The rebuilding effort was funded by PGV.

Under current conditions, PGV uses approximately 28,000 gallons of water per day from Hawai'i County water supply for PGV facility general needs, primarily for cooling of the bottoming units' pH adjustment system and kitchen, restrooms, and by personnel. PGV is preparing plans to modify the cooling system which would reduce facility usage of Hawai'i County water supply by approximately 50 percent per day.

2.1.5 Existing Operations: Staffing

Current staff for the existing facility includes approximately 31 employees for operation and maintenance.

2.1.6 Existing Operations: Pentane Recovery, Pollution Abatement, and Hazard Control

The facility's principal pollution recovery and abatement systems and hazard controls for potential geologic hazards are described below. Pentane is a hydrocarbon used as a motive fluid in a closed-loop system in the operations and is recovered as part of the operations. Abatement for H_2S consists of reinjection into the geothermal reservoir. Reinjection is essentially a closed-loop disposal system since the fluids are returned to the same geologic zone from where they originated. This section also describes mitigation for noise and potential geologic hazards.

Pentane Recovery

The Vapor Recovery Maintenance Unit (VRMU) is used to evacuate and recover pentane before venting NCGs from the pentane system (turbines, cooler, heat exchanger, etc.). The VRMU uses a four-step recovery and an activated carbon filtering system. Recovered pentane is returned to the pentane storage vessels.

The Vapor Recovery Unit (VRU) is normally used to remove pentane before venting NCGs from the pentane system (turbines, cooler, heat exchanger, etc.). The VRU uses a two-stage refrigeration cycle to recover the pentane, and then the recovered pentane is returned to the pentane storage vessels. **This system was replaced by a redundant VRMU system.**

Pollution Abatement

The following H_2S abatement systems are summarized from PGV's NSP No. 0008-02-N (PGV 2022a).

Sulfa-Treat System: The Sulfa-Treat system collects and abates fugitive H_2S emissions that result from upset conditions of the steam turbine seals. The system operates on a vacuum to collect the fugitive emissions from the seals and then uses a system of abatement reactors in a series to chemically abate the H_2S emissions. The permit lists two abatement reactor vessels.

Power Plant – NCG System: This system has the potential for fugitive H_2S emissions through leaking seals, flanges, valves, and other points. Sensors with alarms set for 10 parts per million (ppm) are located on each turbine/generator unit. The alarms are activated in the control room and immediately alert personnel of fugitive H_2S emissions so that corrective action can be taken. The permit includes NCG compressor units and pressure relief valves.

Wellfield Pads, Injection Wells, Production Wells, and Associated System: Wells and associated equipment have the potential for fugitive H_2S emissions. Sensors are located strategically throughout the wellfield. H_2S emissions during maintenance operations are abated using a portable H_2S abatement vessel.

Emergency Steam Release Facility (ESRF): This system, including sodium hydroxide, mufflers, silencers, tanks, and associated equipment, is designed to handle emergency situations such as a problem with the electrical transmission line(s) out of the power plant, upset of the geothermal fluid injection system, or if the pressure in the steam line exceeds the safe operating set points. The ESRF is used for upset conditions and to prevent a release of unabated H_2S to the atmosphere. Chemical abatement of H_2S is performed automatically, as a requirement by the DOH permit, to scrub a minimum of 95 percent of the H_2S contained in the steam. This is accomplished by PGV as follows: In the event of a steam header over pressure condition, the steam is released through a series of pressure control valves through the rock mufflers, then to the atmosphere to the SRF area. The chemical abatement system uses a mixture of water and 15 percent caustic soda (NaOH) solution injected into the steam flow at a rate necessary to maintain less than 5 lb/hr H_2S discharge to the atmosphere. The caustic soda and water combine with the H_2S to form sodium sulfide, which remains in the fluid mixture that gravity drains to the holding pond. Liquid from the holding pond is pumped to the reinjection system.

Solid Waste

Solid waste is generated from time to time from scale cleanouts of geothermal piping. PGV is considered an episodical generator. All scale is treated as hazardous waste and is disposed of in accordance with federal requirements. Solid waste generated by employees and operations is collected weekly by a local solid waste contractor, and wastewater is disposed of in a ~~cesspool~~ **large quantity septic system** on-site.

Noise

Noise levels are monitored continuously, and results are posted on PGV's publicly accessible website. The facility adheres to Hawai‘i guidelines on noise.

Several steps are taken to reduce normal operation noise levels. These steps include the following:

- Insulating pipes, valves, and equipment;
- Enclosing equipment in structures, where feasible;
- Installing silencers on pressurized steam outlets; and
- Purchasing quiet fans and motors (PGV 1987).

Additionally, PGV constructed a sound wall around its currently operating OECs and incorporates sound control during well drilling activities including, but not limited to, the following: use of sound control mats, sound barrier curtains, and acoustical absorbers around the drill rig; placement of diesel generators on the ground (rather than on the drilling platform); and adjusting loud work activities, where feasible, to daytime hours including operation of the cementing unit of the drill rig (Ebisu 2015, 2016). Additionally, PGV has replaced high-pitched backup alarms on mobile equipment (e.g., forklifts) with broadband noise backup alarms to make them less audible and noticeable for surrounding residents.

Geologic Hazards

Although volcanic and seismic hazards for the existing facility exist, with risks posed to engineered structures and installations, it should be noted that such hazards are to be expected given the geologic history of the area. The site of the Project was chosen because of its potential for geothermal resources. In 1976, the state drilled the HGP-A well on a location adjacent to where the PGV facility is sited. The HGP-A facility was a pilot project that proved the viability of a geothermal resource on the LERZ of Kīlauea. The HGP-A project generated up to 3 MW of electricity and operated for several years. These risks have been significantly mitigated through procedures in facility siting, design, and operation as described in the 1987 Puna Geothermal Venture Project EIS (PGV 1987).

Risks from volcanic hazards include lava eruptions, lava flows, ash falls, splatter falls, and associated surface disruptions. The existing facility was sited on higher ground to avoid lava flows in the low area, which was demonstrated effective during the 2018 Lower Puna eruption. In 2018, a layer of volcanic cinders was placed to protect the lower well pads and key elements of pipelines from lava flow. Each wellhead in low ground is protected from lava flow by a plan for the timely full closure of the master valves and by burying the cellar and wellhead with cinders (PGV 1987).

Potential seismic hazards are generated by earthquakes and include ground motion, ground ruptures, and subsidence. The strength and duration of motion from the strongest projected earthquake that might impact the Puna area can be largely mitigated by appropriate design. Critical components of the site (e.g., abatement equipment, above-grade pipe supports) were constructed to comply with the most stringent (Seismic Zone 4) seismic building requirements, even though the current vicinity area is officially in a Seismic Zone 3. This planning proved effective during the 2018 Lower Puna eruption, which inundated extensive areas surrounding PGV's facility.

Fluid pipelines are the structures most vulnerable to disruption from geologic hazards. This risk was mitigated by appropriate design of the piping system to allow flexibility and movement. Automatic shutoff of the power plant takes place under extreme conditions, and pipeline damage is repaired in the shortest practical period of time. PGV coordinates closely with Hawaiʻi Volcano Observatory, the **United States Geological Service** ~~Hawaiʻi Institute of Geophysics~~ **(USGS)**, and state and county officials to further reduce risk and ensure timely warnings of impending geologic hazards (PGV 1987).

2.1.7 Existing Operations: Monitoring and Maintenance

An important part of the operation of the facility is regular monitoring and maintenance of both the power plant and the wellfield. Qualified staff are on-site at all times when the plant is operating. Routine maintenance is conducted by workers during the normal daytime work shift. When operating units are out of service, maintenance work continues 24 hours per day, seven days per week, until full power output can be resumed. If all units are operating at approximately full power, the maintenance work is done by one shift per day, five days per week. The information in this section is summarized from the 1987 Puna Geothermal Venture Project EIS (PGV 1987).

Wellfield Monitoring

All wellheads are equipped with temperature and pressure ~~gauges~~ **devices** on the well casing below **and above** the master valves. Flow from each well is measured in the line downstream of each control valve. Flow indication is local, and operation of the flow control valves are capable in automatic or manual modes. The control valves at the steam release facility have air-piston operators that respond automatically to signals from the plant control room or upon sensing overpressure in the steam pipeline. The H_2S abatement system at the steam release bypass will operate automatically when steam is vented.

Wellfield Maintenance

Wellfield maintenance is generally performed without shutting off the flow of steam from any well. When this action cannot be taken or is unsafe, maintenance work for the wellfield would be phased to minimize the number and time that wells are shut down. Remedial drilling of wells is usually needed for proper wellfield maintenance **to improve flow rates during the life of a well** and is anticipated every two to five years for each well.

Power Plant Monitoring

The power plant is designed with an automatic control system. The plant operator performs restart checks and manual valving, monitors the plant during operation, and regularly inspects the equipment. The power-generating units are operated from a single control room, and control systems operate automatically to prevent injuries to plant personnel or equipment. Standby equipment starts automatically to avoid tripping a turbine-generator unit during normal operations. An independent, self-contained control system is associated with each generating unit.

Power Plant Maintenance

Scheduled maintenance is conducted at each generating unit at intervals of one to two years, as needed. Thorough maintenance procedures, such as turbine disassembly/inspection and condenser inspection/repair, are conducted during these planned outages. Scheduled maintenance periods require approximately one to two weeks for each unit and are coordinated with HELCO to ensure the maintenance of a reliable power system. Maintenance crews are engaged 24 hours a day, seven days per week, during this maintenance, and work crews work eight- to 12-hour shifts.

2.1.8 Existing Operations: Emergency Response Plan

PGV has developed an ERP for the PGV facility in compliance with Condition #26 of GRP 87-2 and in conformance with discussions with the County of Hawaiʻi Civil Defense Agency (CDA), the Hawaiʻi DOH, and the staff of the Hawaiʻi State Emergency Response Commission (SERC). Hawaii established a SERC to provide hazardous materials planning, funding, training and education, and oversight of the Local Emergency Planning Committees (HFD 2023). The most recent version of the ERP was updated in ~~2022~~ **2023** and is available **on PGV's homepage** at https://punageothermalproject.com/.

The ERP provides a plan of action to deal with facility emergency situations that may threaten the health, safety, and welfare of the employees and other persons in the vicinity of the facility site. This plan is the basis of all actions by PGV's personnel and management staff in responding to these situations and is updated appropriately when necessary. Site personnel also follow related Site Safety, Environmental, and Operating Procedures. Table 1-1 of the ERP also identifies where GRP requirements can be found within the document.

2.1.9 Existing Operations: Decommissioning

At the end of the PPA term (or any extended term), the facility and the wellfield are anticipated to be shut down, and the structures and equipment would be removed (assuming that the PGV facility cannot be put to another use). Economic and resource conditions would dictate when the facility should be decommissioned. As part of decommissioning, the facility site would be returned to its natural state and the following steps would be taken (consistent with Condition 50 of the GRP):

- Structures and piping would be removed;
- Dry or abandoned wells would be abandoned in accordance with existing permits and plugged with concrete, wellhead equipment and casing would be removed to below grade, well casing capped, and the surface restored;
- Roadways would be abandoned consistent with the lease agreement with the landowner; and
- The site would be regraded to approximate natural contours, and the site would be seeded or planted with vegetation.

2.1.10 Existing Operations: Existing Permits

Table 2-2 includes a list of existing permits for the facility.

Table 2-2 Existing Permits for the Current Facility

Permit Title	Agency
Federal	
Underground Injection Control (UIC) HI596002	Environmental Protection Agency
State	

Permit Title	Agency
Underground Injection Control (UIC) UH-1529	Department of Health, State of Hawaiʻi
Authority to Construct 7 Geothermal Wells (UIC)	Department of Health, State of Hawaiʻi
Noncovered Source Permit No. 0008-02-N	Department of Health, State of Hawaiʻi
Noncovered Source Permit No. 0008-03-N	Department of Health, State of Hawaiʻi
Plan of Operation	Department of Land and Natural Resources, State of Hawaiʻi
County	
Geothermal Resource Permit (GRP 87-2) for up to 60 MW	County of Hawaiʻi Planning Commission
Plan Approval	**County of Hawaiʻi, Planning Department**
Building Permit	County of Hawaiʻi ~~Planning~~ Department **of Public Works**
Grading Permit	County of Hawaiʻi ~~Planning~~ Department **of Public Works**

2.2 Proposed Operations (Proposed Action)

The Project includes two phases: Phase 1 would increase the generating capacity to 46 MW (which is 8 MW more than the current approval) by replacing the 12 existing generating units with three more efficient generating units, and Phase 2 would increase the generating capacity to 60 MW by adding one more generating unit. The current property boundary of 815 acres would remain the same under the Proposed Action.

The following description is based on the schematic plan for the Project. As required by the ARPPA, PGV would provide a complete set of detailed engineering, vendor and manufacturing, and as-built drawings and calculations relating to the design and construction of the facility to HELCO for review after they are submitted to the appropriate government authority. Per the conditions in the ARPPA, construction work is subject to HELCO inspections and monitoring.

2.2.1 Proposed Operations: Power Generation

Phase 1

As described in the ARPPA to achieve the 8 MW increase form 38 MW to 46 MW in Phase 1, the 12 existing OECs (combined power-generating units) currently in use would be replaced with three new 15.3 MW OECs that are designed to more efficiently utilize the energy of geothermal steam and brine. The three new OECs would be identical in construction and would be named OEC 41, 42, and 43. Each new OEC would utilize both steam at approximately 678 kilo-pounds per hour (kph) and brine at 226 kph, producing together 52.5 MW gross power and 46 MW net power. Proposed units are shown on **Figure 3**. Combined, these flow rates would equate to approximately three million gallons of geothermal resource per day (compared to the rate prior to the facility shutting down in 2018 of six million gallons of geothermal resource per day to generate 38 MW).

Each new OEC unit includes a synchronous generator that is driven by an organic Rankine cycle turbine, an air-cooled condenser, a cycle pump, and a control system. The gathering system conveys steam and brine from the existing separator to the facility. The steam and brine pass through the new OEC units and flow through the gathering system to the reinjection system, which collects a mixture of the cooled brine and condensate that passed through the facility and reinjects it into injection wells by the facility's reinjection pumps. The operation of the gathering system as it currently exists will be the same for the new OECs.

Decommission Previous Units

Once the ~~new~~ three **new** OECs and balance of plant (BOP) are constructed and connected, and the new OECs are operational, PGV would disconnect and decommission the existing 12 OECs. It is expected that

PGV would begin removing the 12 OECs from the facility site after the three new OECs are operational. **All of t**he existing 12 OECs will not be operated at the same time as the three new OECs.

Phase 2

During Phase 2, a fourth new 15.3 MW OEC unit would be installed and connected to the infrastructure described in Phase 1 (OEC 44) (**Figure 3**). This would allow for the production of up to 60 MW of power. The combined four OECs would utilize approximately 904 kph of steam and 201 kph of brine, for a total of four million gallons of geothermal resource per day (one million gallons more per day compared to Phase 1), to generate 60 MW.

2.2.2 Proposed Operations: Geothermal Wells and Wellfield Facilities

The Project would either use the existing well pads in their current location or construct ~~new~~ well pads in accordance with approved permits.

Prior to shutting down in 2018, the PGV facility flowed approximately six million gallons of geothermal resource per day to generate 38 MW. The proposed new power-generating equipment for Phase 1 is designed to generate up to 46 MW, utilizing 678 kph of steam and 226 kph of brine. Combined, these flow rates equate to about three million gallons of geothermal resource per day.

For Phase 2, the geothermal resource required to generate 60 MW would be 904 kph of steam and 201 kph of brine. These flow rates would equate to about four million gallons of geothermal resource per day.

2.2.3 Proposed Operations: Gathering System

As part of Phase 1, PGV would utilize the existing gathering system to the extent possible and install new piping where necessary. In Phase 2, it is expected that there would be a 20 percent increase in piping infrastructure (above existing) to connect a fourth new OEC.

2.2.4 Proposed Operations: Supporting Infrastructure

Phase 1

Existing infrastructure associated with the facility that would remain for the Project includes the administration buildings, control room, electrical substation and distribution lines, and maintenance areas. Phase 1 would involve facility upgrades including reducing steel structures, piping, mechanical components, and associated flange connections. There would be a 20 percent increase in BOP, with all supporting components of the facility contributing to overall power generation from the new OECs and power delivery increasing by approximately 20 percent. BOP equipment would include, but not be limited to, a fire suppression system, VRMU, VRU, separator, and pentane storage vessel. Additionally, a satellite control building would be constructed adjacent to the first OEC constructed,

The following supporting electrical equipment for the new OEC units would be installed as described in the ARPPA for Phase 1:

- 13.8-kilovolt (kV) circuit breakers;
- Three step-up transformers;
- Three lightning arresters mounted on the high voltage side of the step-up transformer;
- Three 69 kV circuit breakers (one per transformer);
- Three sets of 69 kV primary and secondary metering devices connected to one metering set of instrument transformers per transformer to monitor each of the three step-up transformers;
- Dial-up telephone line installed close to 69 kV metering cabinet to allow remote metering reading;

- Fiberglass or stainless-steel demarcation cabinet located along the switching station fence; and
- Underground cable and duct line from the switching station to the facility.

As part of the Project, PGV would also comply with specific interconnection relays and relay settings, generation relays and relay settings, and specific features for the switching station, which would be connected to the high voltage circuit breaker.

The 3.8-acre area east of the new OECs has already been graded and is currently used for equipment and aggregate material storage as part of the existing facility. As part of the Project, this area would also be used as a temporary laydown area during construction.

PGV would construct two visual screening walls in Phase 1 that would extend along two sides of the three new OECs (**Figure 3**).

Phase 2

As part of Phase 2, PGV would remove the east-west visual screening wall north of the third OEC in Phase 1. PGV would install and connect a fourth OEC, extend the north-south screening wall, and construct a new east-west screening wall north of the fourth OEC in Phase 2 (**Figure 3**).

2.2.5 Proposed Operations: Staffing

During construction of the Project, approximately 75 temporary employees would be utilized, of which approximately one-third would be local and two-thirds would be from off-island, depending on availability and expertise. Operation of the Project would not be anticipated to increase the permanent staff of 31 employees at the PGV facility.

2.2.6 Proposed Operations: Pentane Recovery, Noise and Pollution Abatement, and Hazard Control

These systems would be the same as those described in **Section 2.1.6**. As a result of new technology, the proposed OECs are much quieter than existing OECs; however, PGV would still purchase and install quiet fans and motors to ensure minimal noise generation. Sound control for well drilling would continue as described in **Section 2.1.6**.

2.2.7 Proposed Operations: Construction Schedule

In compliance with the Guaranteed Project Milestones identified in the ARPPA, PGV would complete construction of the proposed facility and associated infrastructure within 36 months after completion of the environmental review requirements set by the PUC**, and approval of the ARPPA by the PUC**.

2.2.8 Proposed Operations: Monitoring and Maintenance

Monitoring and maintenance under the Proposed Action would be consistent with the activities described for the existing facility (see **Section 2.1.7**). The reduced number of pipes associated with fewer generating units and the smaller footprint associated with the Project would reduce the **requisite** amount of monitoring and maintenance equipment compared to the current facility.

2.2.9 Proposed Operations: Emergency Response Plan

The ERP described for the existing facility in **Section 2.1.8** would continue to be implemented under the Proposed Action.

2.2.10 Proposed Operations: Project Closure

The 1987 Puna Geothermal Venture Project EIS (PGV 1987) stated that the decommissioning process refers to the shutdown of the wellfield and removal of structures and equipment at the end of the PPA term (or any extended term). At that time, the facility was estimated to have an approximately 35-year PPA term, with the actual PPA term dictated by economic and resource conditions. The facility has now been commercially operating for almost 30 years, and the economic and resource conditions make it feasible and desirable to repower the facility to extend its use beyond the 35 years estimated in 1987. The geothermal resource at the Project site has proven to be a long-term available resource, far exceeding the approximate PPA term stated in 1987 (or any extended term). The longevity of safely operating geothermal electricity-generating plants has been demonstrated many times throughout the United States (Office of Energy Efficiency & Renewable Energy 2023).

To continue utilizing the existing facility without replacing certain equipment would require substantial costs to maintain and keep the existing equipment in operation. The proposed operations with three new OECs will require less ongoing maintenance and expenditures. The three new OECS are state-of-the-art and are much more efficient equipment that will result in an increase of 8 MW, while utilizing the same amount of geothermal resource that the 12 OECs utilize today.

As the term of the ARPPA approaches its end in 205~~6~~**2**, PGV will again evaluate whether, based on economic and resource conditions, the power plant and wellfield should be refurbished to further extend the PPA term of the facility or whether the facility should be decommissioned. When decommissioned, the site will then be returned to its natural state. Demolition of the facility would comply with ~~Title 11, Chapter 26, HAR~~**Chapter 5 of the County of Hawaiʻi Construction Administrative Code**. The following steps will be taken during decommissioning (consistent with Condition 50 of the GRP):

- Structures (including wellfields, supporting structures, and OECs) and piping will be removed;
- Dry or abandoned wells will be plugged with concrete, wellhead equipment and casing removed to below grade, well casing capped, and the surface restored;
- Roadways will be abandoned to the extent agreed upon with the landowner; and
- The site will be regraded to approximate contours that match the 2018 Lower Puna eruption lava flow, and the area will be seeded or planted with natural vegetation.

3.0 Existing Environment, Environmental Impacts, and Mitigation Measures

This chapter examines the pertinent features of the physical and natural environment. Existing environmental data have been compiled from past environmental studies, and new studies were completed to address the potential impacts to specific discipline areas where necessary. The existing environment section describes the setting for each discipline area, or resource, in the Project vicinity.

The environmental consequences section for each resource includes an analysis of environmental impacts, including direct and indirect effects from the Project for each alternative. The scope of the Project includes the replacement of the existing OECs. Therefore, the analysis in the EIS focuses on impacts from construction and connection of the four new OECs and the subsequent decommissioning of the 12 OECs in current operation. Other activities at the plant (including, but not limited to, activities in the wellfield) would continue as authorized and are considered ongoing and not within the scope of the analysis in this EIS. The interrelationships and cumulative environmental impacts for each alternative are also discussed. The impact analyses and conclusions are based on the review of existing literature, baseline studies, best available science (defined as peer-reviewed), information provided by professional experts, analyses provided by other agencies, professional judgment, and public input.

The facility is located just off Highway 132 approximately 10 miles east of Pāhoa and 1.5 miles east of Lava Tree State Park. The surrounding area is rural, and adjacent communities include Leilani Estates, Nanawale Estates, Kapoho, and Pāhoa. Properties adjacent to the site are residential, and the nearest residences are located approximately 2,000 feet east of the proposed OECs. Prior to the eruption, additional residences were located south of the facility in Lanipuna Gardens approximately 1,500 feet southwest of the proposed OECs, and 2,000 feet west of the proposed OECs in Pohoiki Bay Estates (just west of Pohoiki Road).

3.1 Geology

This section of the EIS examines the pertinent features of the physical and natural environment in the Project vicinity including the bedrock and surficial geology, as well as seismic and volcanic hazards.

3.1.1 Existing Environment

3.1.1.1 General Geologic Setting

The Proposed Action is located near the eastern tip of Hawaiʻi Island, 41 kilometers (km) from the main vent and crater of Kīlauea Volcano. Hawaiʼi Island is home to five major volcanoes: Kohala, Mauna Kea, Hualalai, Mauna Loa, and Kīlauea. Kīlauea is one of the most active and most comprehensively monitored volcanoes on earth (Houghton et al. 2021). Hawaiʻi Island is the southernmost in a series of aerially exposed shield volcanoes comprising the Hawaiian-Emperor seamount chain, an approximately 6,000-km-long sequence of mantle plume-driven intraplate volcanoes that have been active for over 81 million years (Ma) (Harrison et al. 2020). The linear surficial expression of these seamounts and aerially exposed islands is the result of the north and westward movement of the Pacific plate, which moves at a rate of nine to 10 centimeters per year, over the mantle plume (hotspot) below (Harrison et al. 2020).

The Hawaiian hotspot is currently located below southeastern Hawaiʻi Island. The Hawaiian-Emperor seamount chain is characterized by increasingly younger volcanism to the south. Kīlauea Volcano on Hawaiʻi Island and Loʻihi Volcano on the seafloor southeast of Hawaiʻi Island represent some of the youngest and most recently active volcanic areas in the seamount chain (Sherrod et al. 2021; Wood 2019). Hawaiʻi Island hosts four major rift zones, one on Kohala Volcano, one crossing Hualalai Volcano, one on Mauna Loa Volcano, and one on Kīlauea Volcano. The Project is within the LERZ. The LERZ spans an approximately two-km-wide swath to the west of PGV and narrows to the east, extending over approximately 120 km. Basalt flows less than 500 years old cover 80 percent of the LERZ, and older flows cover the remaining area.

3.1.1.2 Volcanic Eruptions in the Vicinity of the Project

Kīlauea Volcano has produced intermittent eruptions and lava flows large enough to reach the ocean for decades. A generalized model of eruptions since 1983 indicates that mantle-generated magma rises toward the summit of Kīlauea, moves toward, and is erupted along the LERZ (USGS 2020**b**). The LERZ is characterized by a series of northeast trending fractures, pit craters, and volcanic vent alignments extending over **approximately** ~~125~~**50** km east of the Kīlauea caldera. Recent historic eruptions within the LERZ took place in 1955, 1960, and most recently, 2018 (Teplow et al. 2009; Neal et al. 2019). Since 2021, Kīlauea Volcano has produced 111 million cubic meters of lava; however, the eruption and current volcanic activity remains primarily centered around the Kīlauea Volcano crater, 40 km west of the existing PGV facility.

The PGV facility is located within Lava Hazard Zone 1, an area where vents and rift zone eruptions have taken place ~~in~~ **since** his4toric time (Wright et al. 1992). The most recent eruption in the Project vicinity began in 2018 and continued until December 13, 2022. The eruption produced basaltic lava flows and fissure vent eruptions along the LERZ during the first fourteen weeks of surface activity. Ground deformation data including from borehole tiltmeters, real-time Global Navigation Satellite System, and interferometric synthetic aperture radar collected by the Sentinel-1 satellite and European Space Agency provided indicators of magmatic activity leading up to and during the eruption. Tiltmeter data from Puʻu ʻŌʻō began to indicate magmatically driven inflation of the ground surface beginning in mid-March 2018, and these data were essential to the Hawaiian Volcano Observatory's ability to issue a warning of the impending eruption, which began on April 17, 2018 (Neal et al. 2019). The initial eruption was followed by collapse of the Puʻu ʻŌʻō vent on April 30, 2018, and continued into August 2018, covering 35.5 square km in lava flow deposits and resulting in a total erupted volume of approximately 0.8 cubic km (Neal et al. 2019; Liu et al. 2018). Data from the eruption indicate that the summit caldera and LERZ are hydraulically well-connected and that seismic activity during the eruption may have aided the movement of magma along the rift zone until the magmatic system was significantly depleted, apparently disconnecting the magma source from the eruptive area of the rift zone (Neal et al. 2019).

As a result of volcanic activity, the surficial geology within the Project Area consists of basaltic lava flows, cinder cones, and spatter deposits from the 2018 Lower Puna eruption of the LERZ and older historic eruptions (Neal et al. 2019; Trusdell & Moore 2006; Moore & Trusdell 1991). The bedrock geology of Hawaiʻi Island and within the Project vicinity is broadly composed of Pleistocene- and Holocene-age basaltic lavas erupted over the past 2.58 Ma (Sherrod et al. 2021; Trusdell & Moore 2006). Diorite dikes and a dacitic-composition melt were uncovered during drilling at the Project. Injection well KS-13 drilling in 2005 uncovered a 75-meter interval of diorite rock at a depth of 2,415 meters and a pocket of dacitic melt at a depth of 2,488 meters. Repeated drilling through the melt interval indicates the melt interval is eight meters thick, and greenschist facies metamorphic rocks and diorite dikes overlie the melt interval (Teplow et al. 2009).

Basalt flows and intrusions are intersected and cut by the faults, fractures, and fissures of the LERZ, resulting in naturally high fluid permeability in the Project Area (**Figure 4**). These structural features form grabens, surficial and subsurface cracks, and fissures (Trusdell & Moore 2006; Moore & Trusdell 1991; Sherrod et al. 2021). Most faults and fissure vents in the LERZ are oriented east-west, and most faults have a normal sense of displacement, although thrust faults do exist on the island (USGS 2020**b**; Trusdell & Moore 2006; Moore & Trusdell 1991). In the LERZ, faulting and fracturing is primarily driven by volcanic flank subsidence and magmatic intrusion (Lautze et al. 2017).

3.1.1.3 Earthquakes in the Vicinity of the Project

Earthquakes are common in Hawaiʻi and often associated with magmatic and volcanic activity. Kīlauea Volcano and its associated LERZ are one of the most seismically active areas in the world. Potential hazards within the rift zone include eruptions, lava flows, volcanic gas emissions, earthquakes, surface deformation associated with fault movement or lava tube collapse. Repeated episodes of crustal inflation and deflation associated with magma movement and storage have been recorded in the LERZ (Patrick et al. 2019; Thornber et al. 2003). These events are associated with seismic activity and rockfalls in the region (Neal et al. 2019). In the first two weeks of May 2018, deflation and subsidence in the Kīlauea caldera area led to more than 800 recorded earthquakes and several rockfalls. However, most seismic events in the area are small in magnitude, cannot be felt by people, and do not result in surface deformation. While some have suggested that injection of geothermal fluids from PGV operations results in increased seismicity in nearby areas, data from the seismic network installed in 1993, which operated for three months prior to PGV's operations beginning, do not support this claim. Rather, structural disruptions in the LERZ affect geologic stress conditions and patterns of magma movement in the subsurface that may result in seismic swarms. **Seismic events associated with geothermal operations are typically considered "microseismic", which means these events are small magnitude and not strong enough to cause deformation or be felt by humans at the ground surface. The seismic monitoring array previously installed at PGV was destroyed in 2018. PGV installed a new, continuous recording, eight-station monitoring array in 2022.** Seismic data indicate that the PGV area experiences background seismicity rates of approximately eight earthquake events per day, with magnitudes ranging from -1.0 to 2.0, and larger magnitude events occurred at variable rates of four to 10 events per year from 1987 to 1992 (USGS 2020**a**). Additionally, the USGS confirmed that there have been no significant changes due to human activity in patterns or trends of deformation or seismicity in the LERZ in the last 35 to 50 years (before and during geothermal operations) (USGS 2020**a**).

3.1.1.4 Geothermal Power Production and Geologic Events

Other geothermal project sites, but not PGV, employ enhanced geothermal systems (EGS) as part of their operations. EGS use fluid pressurization, hydrofracturing, or chemical stimulation techniques ("reservoir stimulation") to intentionally re-open existing fractures or create and develop new fracture pathways (and increase permeability). Reservoir stimulation activities at EGS sites results in induced seismicity as fractures open in the subsurface. EGS are developed at sites where permeability and fluid flow pathways are limited. Reservoir stimulation increases potential fluid flow rates and volumes and the rate of heat transfer from the rock to the geothermal fluids, with the goal of developing a more efficient power production system. Induced seismicity protocols issued by the Department of Energy are specific to the context of EGS projects (USEPA 2021b; DOE 2012). In contrast, PGV does not seek to increase subsurface permeability or create new fractures in the rock, and the facility is not an EGS operation. Additionally, PGV does not use hydraulic fracturing ("fracking"), which is common in the oil and gas industry, to increase subsurface permeability. Fracking projects are typically short duration utilizing high pressure fluids, which may contain sand or other additives, to create new cracks, open older or smaller existing cracks, and increase permeability in reservoir rock. Fracking is typically carried out on oil and natural gas project sites rather than commercial geothermal power projects.

Fluid injection activities can lead to induced seismic response and is typically associated with subsurface pressure buildup. This pressure buildup can activate faults, resulting in seismic events. These seismic events are typically associated with three conditions: 1) the presence of a fault which is in a near-failure state of stress; 2) pathways exist which allow injected fluid to reach the fault; and 3) the fluid provides enough pressure over a long enough period of time to allow movement to occur along the fault (USEPA 2015). The chances of triggering induced seismicity increases with increased fluid injection volume and increased injection rate. Induced seismicity is more common in rock formations with limited permeability or where large volumes of fluid are injected (USEPA 2021b).

While some have suggested that the transition of water to steam (during well quenching when water is added to reduce pressure in wells) may trigger explosive eruptions of volcanic material or steam at the surface, it should be noted that the volume change of water undergoing a phase change to steam in geothermal wells and in the subsurface is limited by physical laws related to temperature and pressure conditions at depth. Similarly, as stated by the EPA, the amount of pressure needed to physically inject, fracture, and transport solid rock in the subsurface is extremely unlikely to be achieved given the permitted injection pressures at PGV's wells and also very unlikely to occur in a short time period (such as those experienced between injection on May 9 and the opening of Fissure 17 on May 12) (EPA 2021b). The more geologically sound conclusion is that a dacite (i.e., volcanic rock) source exists beneath both the PGV well field and Fissure 17 to the east (EPA 2021b).

3.1.1.5 Geologic Process for Geothermal Power Production

At PGV, power is generated using geothermal fluid, which is recirculated through the naturally high permeability, high temperature reservoir rock. Hot geothermal fluid is brought to the surface at production wells and transported to the power plant through insulated surface piping. After passing through the power plant, the fluid flows through surface piping to the injection wells, where it is injected back into the reservoir rock below. Once injected, the fluid flows through pre-existing fractures in the rock and is brought back to the surface through production wells in the recirculation system. Because the reservoir rock at PGV has naturally high permeability, PGV does not seek to increase subsurface permeability or open new fractures in the rock. Thus, fluid flow rates and system pressures are designed and operated to minimize the likelihood of new fracture formation and the induced seismicity typically associated with EGS or hydraulic fracturing projects. The injection rates and pressures utilized at the PGV facility do not create a sustained increase in reservoir pressure, and the fluids injected are part of a recirculating system where the overall fluid volume within the system does not increase with time. These conditions result in limited pressure increases at injection well locations, and the minimal pressure changes associated with fluid injection are insufficient to cause induced seismic events (USEPA 2021b).

For the geothermal wells (injection and production wells) at PGV, EPA's Safe Drinking Water Act regulations for Class V wells do not require consideration of seismicity in contrast to UIC regulations for Class I wells for the injection of hazardous waste or Class VI wells for geologic sequestration of carbon dioxide (USEPA 2021b). Operating procedures and permit provisions at PGV ensure that no sustained buildup of pressure takes place. These permit provisions include:

- Part II.D.2, limits fluid injection pressure to a level below that required to fracture the reservoir rock formation;
- Part II.E.2, requires continuous monitoring of injection pressure and notification to EPA if the Permit level is exceeded;
- Part II.E.6.b, requires that each injection well be equipped with a pressure relief valve to reduce injection pressure, should the actual pressure ever approach the injection pressure limit; and
- Part II.D.1.b, requires PGV to shut in any well causing a pressure buildup and seek EPA approval before injection resumes.

Although injection wells at PGV are not operated as Class II disposal wells, operating procedures at the site follow key recommendations from the report Minimizing and Managing Potential Impacts of Injection-induced Seismicity from Class II Disposal Wells: Practical Approaches (USEPA 2015). The design, operation, and monitoring related to fluid management at PGV are intended to minimize the likelihood of induced seismicity occurring at PGV.

3.1.1.6 Seismic Activity in the Vicinity of the Project

One study of seismic activity in the Project Area indicates that "no significant change in the background seismicity rate was observed during the 5 days after Well KS-9/10 was brought to full production levels. (A single seismometer left running at the Puna Research Center from August 1994 to June 1995 also measured no significant change in background seismicity)" (Cooper and Dustman 1995). Another study in the Project Area found that, "there was a few percent increase over background in the number of earthquakes weaker than magnitude 0.5 over a linear trend" (Lewis Kenedi et al. 2010). Work by Lewis Kenedi et al. (2010) speculates that the observed increase in seismicity may be attributed to reinjection of geothermal fluids at PGV, but their study does not conclude that fluid injection or production are the cause of the increase.

Where induced seismicity does occur, whether at EGS projects or associated with hydraulic fracturing activities, most seismic events are small magnitude, not felt at the surface, do not result in surface shaking or damage to infrastructure, and are extremely unlikely to cause major movement along faults or endanger an underground source of drinking water (USEPA 2021b).

Historic, large-magnitude earthquakes recorded on the island include the Kau earthquake, a magnitude (M) 7.9 event recorded in 1868; the M 7.~~2~~**7** Kalapana event in 1975; the M 6.6 Kaoiki earthquake of 1983; and others (Lipman et al. 1985; USGS 1997; **Neal et al. 2019**). On May 4, 2018, approximately five meters of fault slip occurred during an M 6.9 earthquake associated with the LERZ eruption. Located 6 km below the surface of Kīlauea's south flank, this was the largest earthquake recorded on the island in 43 years. The event likely occurred on the basal decollement fault between the pre-existing seafloor and the volcanic pile (Neal et al. 2019). Seismic data and kinematic modeling indicate that the event took place on a shallowly dipping thrust plane located offshore of the island (Liu et al. 2018).

Seismic monitoring on Hawai‘i Island began in the early 1900s, and the island now hosts one of the densest seismic monitoring networks in the U.S. (Lautze et al. 2017). **As described in Section 3.1.1.3, the former seismic array was destroyed by the 2018 Lower Puna eruption, after which PGV installed new seismometers.** Seismic monitoring within the Puna geothermal field includes an array of eight three-component borehole seismometers installed at depths of 24 to 210 meters. **Continuously recorded seismic data are collected locally at each seismometer location, which include solar powered data transmission capability. Event-detected time segments are transmitted to a server in near real-time for processing and preliminary event cataloging. The preliminary event catalog maintains a record of the origin time, location, depth, and magnitude of detected events. A secondary seismic data catalog is compiled periodically and created by processing the station's non-transmitted (non-event) data into a catalog system for data management. Additionally, USGS maintains two seismic monitoring stations near the existing PGV facility site, KLUD, approximately 2.8 miles southwest of PGV, and KIND, approximately 4.2 miles west-southwest of PGV.** The PGV lease block typically experiences six to 12 seismic events per day, typically ranging from M -1 to 2. Seismic activity in the PGV lease block has remained relatively constant since before the start of power production and fluid injection in 1993 (Teplow et al. 2009). Power plant and fluid injection activities appear to influence local seismic activity, although the majority of seismic events are small magnitude (<M 0.5) and do not result in shaking felt at the surface or in visible ground disturbance (Lewis Kenedi et al. 2010).

Lewis Kenedi et al. (2010) analyzed borehole seismometer data from over 4,000 microearthquakes to assess fault and fracture orientation and develop a localized seismic velocity model for the PGV area. The majority of microseismic events recorded took place at depths of 1.5 to 3.5 km below the geothermal plant, consistent with injection depths. Most events occurred along northeast trending fractures, while a subset of events took place on fractures oriented orthogonal to the general northeast-southwest trend of the LERZ. Deeper events located at 3.5 to 5.5 km were noted throughout the study area but were most evident toward the summit of Kīlauea and to the southeast of the rift zone. The events located southeast of the LERZ are consistent with the northeast-striking normal fault in the area.

Although seismic and volcanic activity is common in Hawai‘i, the USGS notes that subsidence has progressed at a minimal rate, with approximately one centimeter per year recorded since measurements began in 1958, and there is no evidence that the geothermal activities at PGV have resulted in additional subsidence above background levels (USGS 2012). Additionally, the USGS did not find evidence that the 2018 Lower Puna eruption of Kīlauea Volcano was triggered or influenced by human activities. The eruption was caused by injection of magma down rift from Pu‘u ‘Ō‘ō and the summit of Kīlauea, and the event fits a pattern of activity that has occurred many times previously on the LERZ (USGS 2020**a**; EPA 2021a). These events are within the normal behavior for Kīlauea Volcano. The 2018 Lower Puna eruption occurred within Lava Hazard Zone 1, and the erupted lava flowed through that zone into Lava Hazard Zone 2. The high volume and eruption rate are commensurate with previous LERZ eruptions, and the 2018 fissures were in the same area that has hosted past eruptions (USGS 2020**a**). In summary, consistent with EPA UIC response to comment for th**e existing PGV facility** ~~is Project~~ as well as the 2020 USGS Open-File Report: 2020-1017, there is no evidence to support claims that human activity triggered or influenced the 2018 Lower Puna eruption (USGS 2020**a**; EPA 2021a). **Furthermore, geothermal wells are unlikely to become conduits though which fluid magma could reach the surface and result in surface lava flows. Volcanic eruptions from fissures, including the fissures of the ERZ, are sometimes fed by magma dike propagation. At the existing PGV facility site, geothermal exploration and development targets high temperature zones related to the presence of magma which was previously emplaced and cooled to below the temperature at which it becomes solid rock. PGV's geothermal wells do**

not intersect fluid magma; rather, they intersect solid rock containing residual heat from when magma was originally emplaced in the subsurface.

Volcanic and tectonic risks to PGV have been mitigated by siting, design, and engineering standards as described in this EIS.

3.1.2 Environmental Impacts

3.1.2.1 Proposed Action

As part of the Proposed Action, PGV would replace the 12 existing OECs with three new OECs in Phase 1 and a fourth OEC in Phase 2. Since Phase 1 is expected to use the same amount of geothermal fluid, the environmental consequences are not expected to change from current conditions. Replacement of the fourth OEC in Phase 2 would result in a relatively small increase of approximately 20 percent in use of geothermal fluids, and the environmental consequences of this increase are not expected to change significantly from current conditions as a result of Phase 2 activities. The support equipment required for Phase 2 would increase by approximately 20 percent. No additional impacts to seismic and volcanic activity at the Project Area are expected because of activities planned for Phase 1 or Phase 2.

Volcanic and tectonic risks to PGV would continue to be mitigated by siting, design, and engineering standards as described in this EIS.

3.1.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would still need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. As described above, no impacts to seismic or volcanic activity at the Project Area are expected to result from implementation of the 46 MW Alternative.

3.1.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment, and geology would continue to be influenced by volcanic flank subsidence, magmatic intrusion, and seismic activity that has historically occurred on the LERZ. Future actions at the site would likely occur as described under **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**.

3.2 Hydrology

3.2.1 Existing Environment

The Project is located in the southeastern portion of Hawaiʻi Island within the LERZ of Kīlauea Volcano. The region's hydrology is influenced by high rates of rainfall (110 to 125 inches per year) and highly permeable basaltic lava flows, allowing high rates of recharge to groundwater and the general absence of surface water features. Groundwater hydrology is further influenced by the density contrast between fresh and saline groundwater, the presence of geothermal activity, and structure of the LERZ. Aspects of hydrology within the vicinity of the Project are described in the following subsections.

3.2.1.1 Surface Water Features

Despite having high rates of precipitation, surface water features within the vicinity of the Project are limited. The nearest mapped riverine feature is an unnamed intermittent stream coinciding with Keonepoko Nui, located approximately five miles to the northwest of the Project (**Figure 5**). Mapped waterbodies near the Project, excluding the Pacific Ocean, included Green Lake in the Kapoho Crater (approximately 3.7 miles northeast), the Waiʻōpae tidepools (approximately 4.5 miles east), and three unnamed ponds located approximately four miles to the east. These water bodies are classified as perennial in the National Hydrography Dataset (NHD) (EPA 2022). Lava flows from the 2018 Lower Puna eruption inundated the Green Lake and the Waiʻōpae tidepools; therefore, these features are no longer present.

No wetland features are mapped within the Project facility site. Wetland features mapped in the vicinity of the Project Area included freshwater forested/shrub wetlands identified in the Puulena Crater and adjacent to the Kapoho Crater (approximately 0.9 miles south of the Project) (**Figure 6**) and estuary and marine wetlands identified at the coastline and within Kapoho Bay (approximately 3.5 to five miles south and east of the Project) (USFWS 2022a). Lava flows from the 2018 Lower Puna eruption covered or filled the wetland near the Kapoho Crater, Kapoho Bay, and approximately five miles of coastline; therefore, these features are no longer present.

3.2.1.2 Springs

Springs near the Project are not identified in the NHD (EPA 2022), but coastal springs have been identified (**Figure 7**) and described elsewhere (Janik et al. ~~1995~~**1994**; Evans et al. 2015). Historically, one inland spring was present within the LERZ; Blue Grotto spring was located northeast of Green Lake but was covered by lava eruptions in 1995 and 1961 (Staub 1994). Coastal springs have brackish water and are referred to as anchialine pools, which have thermal origins and are recognized as important habitats in the near-shore environment (Foote 2005). USGS conceptualization of coastal spring water chemistry indicates a mixture of thermally altered seawater and dilute**d** shallow groundwater (Janik et al. ~~1995~~**1994**; Evans et al. 2015). Elevated temperatures in these coastal springs are from conductive heat flow as opposed to the discharge of geothermal fluids. Water quality of anchialine pools is described further in **Section 3.2.1.6**.

3.2.1.3 Groundwater

Groundwater in the vicinity of the Project, and excluding the geothermal reservoir, is regionally present in an unconfined aquifer and locally present in perched aquifers. A generalized cross section of the hydrogeology is shown on **Figure 8**. The unconfined aquifer is present as a lens of freshwater atop underlying saline water (e.g., basal groundwater). In areas with relatively homogenous aquifer materials, the thickness of the freshwater lens depends on the density difference between fresh and saline groundwater and the water table elevation above sea level, described by the Ghyben-Herzberg principle. The structure of lava flows manifests as aquifer anisotropy and freshwater distributions that deviate from the Ghyben-Herzberg assumptions. Furthermore, dikes and faults of the LERZ compartmentalize the aquifer and limit the horizontal flow of groundwater, resulting in freshwater zones that are thicker than predicted by Ghyben-Herzberg assumptions. At the interface between fresh and saline groundwater is a transition zone with mixed groundwater, at which fresh groundwater mixes with saline groundwater and discharges at the coastline or subsea.

Perched aquifers are locally present above the regional aquifer and have formed where ash or tuff layers restrict the downward flow of groundwater, resulting in locally saturated conditions. As stated in the 1987 EIS, perched aquifers are virtually unknown in the Puna area and are of only minor significance as a source of usable groundwater (PGV 1987). East of the Puna area in the vicinity of Kapoho Crater, an ash layer and perched groundwater conditions are associated with the historical Green Lake, and a drinking water well has been reported in the perched aquifer at the Kapoho Crater.

Underlying fresh and saline groundwater in the unconfined aquifer is a relatively impermeable caprock at approximately 2,500 feet below mean sea level. The caprock separates the unconfined aquifer from the geothermal reservoir utilized by PGV (**Section 3.2.1.5**). A generalized hydrogeological model of PGV is shown on **Figure 9**. While generally hydraulically isolated from the unconfined aquifer, natural leakage from the geothermal reservoir into the unconfined aquifer does occur in the vicinity of the Project, which affects water quality. The portion of the groundwater aquifer that serves as water supply in the area is at least 2,000 feet above the caprock (EPA 2021a).

Groundwater flow in the unconfined aquifer generally follows topographic gradients toward the Pacific Ocean. Groundwater flow paths out of the LERZ are expected to follow the same trend but may be hindered due to structural features. The hydraulic conductivity between the LERZ and coastal springs was estimated at one to six kilometers per day (Imada 1984; Takasaki 1993; Gingerich 1995). Groundwater velocities, which are a function of hydraulic conductivity, hydraulic gradient, and porosity, were estimated to be three to 30 meters per day (Sorey and Colvard 1994). Using the environmental tracer tritium, a naturally and anthropogenically produced radioactive isotope of hydrogen, the time between infiltrating to groundwater and subsequently discharging to coastal springs was estimated at 18 to 25 years (Scholl et al. 1996).

3.2.1.4 Wells

The Hawai‘iI Groundwater & Geothermal Resources Center digitized all water well files from the Hawai‘i Department of Land and Natural Resources (DLNR) until November 2012 (HGGRC 2022). Wells installed after November 2012 are not included in this database. A total of 42 wells are identified within five miles of the Project (**Figure 10**). Details on the replacement of groundwater monitoring wells as a result of lava inundation from the 2018 Lower Puna eruption are included in **Section 2.1.1**. This database shows that all wells within one mile of the Project are identifiable as related to geothermal exploration or monitoring. Excluding those geothermal wells, the nearest well is Malama Ki, located 1.7 miles south of the Project. Public and community water supply wells in the vicinity of the Project include Pahoa Deepwells #1 and #2 (approximately 3.5 miles east), Hawaiian Shores 1 and 2 (approximately 3.8 miles northwest), Kapoho Well (approximately 4.1 miles northeast), and Vacationland #1, #2, #3, #4, 1A, 2A, 3A, and 4A (approximately 5 miles east).

3.2.1.5 Geothermal Reservoir and Caprock

The geothermal reservoir utilized by PGV is located within the LERZ at a depth exceeding 4,000 feet below the ground surface. Heat flow from magmatic activity results in high fluid temperatures and convective flow within the reservoir. A caprock composed of basalt separates the geothermal reservoir from the overlying groundwater aquifer. The caprock is located at the depth range of approximately 2,750 and 4,000 feet below the ground surface (EPA 2021a). Geologically, the caprock is a transitional zone between subaerial basalts of the unconfined aquifer and submarine basalts of the geothermal reservoir below. A generalized cross section of the geothermal reservoir is provided on **Figure 9**. The caprock is largely impermeable but is locally permeable due to fractures and faults. Naturally occurring leakage through the caprock impacts groundwater quality in the vicinity of the Project. As a result of its water chemistry, depth, and temperature, the geothermal reservoir is not a source of drinking water (**Section 3.2.1.6**).

Since 1991, PGV has extracted geothermal fluids from the geothermal reservoir via production wells. Production wells target highly permeable fracture zones within the geothermal reservoir at depths between 4,500 and 6,500 feet below the ground surface. Steam and brine are produced at temperatures of 600 degrees Fahrenheit (°F), equal to 315 degrees Celsius (°C), and pressures of 1,430 pounds per square inch. Following energy harvesting in the power plant, cooled geothermal fluids are reinjected into the geothermal reservoir via injection wells. Injection depths are between 4,200 and 8,000 feet below the ground surface, with the majority of injection depths below 6,500 feet below the ground surface. The locations of injection relative to production are adjusted to optimize reservoir usage and to avoid short-circuiting between injection and production wells. Meteoric water is conceptualized to enter the reservoir vertically through permeable fractures in the caprock and horizontally from the intrusive dike complex located below the main geothermal reservoir. Seawater also enters the reservoir laterally through the intrusive dike complex. As previously stated, geothermal fluids naturally leak through the caprock via permeable fractures.

3.2.1.6 Water Quality

Surface Water

Surface water quality data is available for the historically present Green Lake within Kapoho Crater (Staub 1994). In 1991, the lake had chloride concentrations of 31 milligrams per liter (mg/L) and a temperature of 26°C. Based on hydrogeology and water quality, Green Lake was part of a perched aquifer and therefore not hydraulically connected to the basal aquifer or geothermal system.

Springs

Evans et al. (2015) sampled 10 coastal or near-shore springs within approximately five miles of the Project. The dominant cation of these wells was sodium, and the dominant anion was chloride. Total dissolved solid (TDS) measurements of these springs exceeded 5,000 mg/L and were up to 10,600 mg/L. Temperatures of these springs were between 26.6 and 35.7°C. Four springs had arsenic concentrations exceeding the drinking water standard (0.01 mg/L). An additional five samples did not detect arsenic.

Dissolved hydrocarbons and volatile organic compounds (VOCs) were analyzed for at several coastal springs by Evans et al. (2015). Hydrocarbon analytes included hexane (C_6H_{14}) and lighter hydrocarbons, which included pentane (C_5H_{12}) and isomers of butane. Pentane is utilized in the binary power plant at PGV and is present in injectate and therefore has been recognized as a potential tracer of contamination from PGV injection operations. No pentane or any other hydrocarbons were detected in sampled springs. VOC analyses included 38 chemicals including isopropanol (C_3H_8O), which is utilized by PGV in corrosion-inhibiting additives. PGV usage of isopropanol began in September 2013, and isopropanol has been measured in injectate and produced geothermal fluids (Evans et al. 2015). Isopropanol and other VOCs were not detected in coastal springs. Furthermore, Evans et al. (2015) note that isopropanol was unlikely to be detected in the springs at the time of sampling due to the springs' distance from PGV.

Groundwater

The groundwater aquifer in the immediate vicinity of the Project does not include potable water since the caprock separating the reservoir and aquifer is locally permeable, resulting in naturally occurring leakage of geothermal fluids into the shallow aquifer (PGV 1987). Water quality data in the vicinity of the Project is available from PGV and USGS monitoring programs and water quality reports associated with private wells and community water supplies. Groundwater quality in the area is known to be temporally variable due to factors including rapid infiltration of rainfall, a thin freshwater lens, and convective instabilities near the rift zone, which result in variable mixing between dilute and saline fluids (Evans et al. 2015; Thomas 1987; Ingebritsen and Scholl 1993).

Water quality from non-geothermal supply wells within approximately five miles of the Project were compiled by Evans et al. (2015). The dominant cation of these wells was sodium, and the dominant anion was bicarbonate. These supply wells had TDS concentrations between 135 and 854 mg/L. Most supply wells had TDS values below 200 mg/L. The Kapoho Shaft well had a TDS of 854 mg/L, but it is noted that this well is no longer used as a supply well. Excluding Kapoho Shaft, supply well water quality samples met primary and secondary maximum concentration limits (MCLs) for inorganic constituents. Water temperature from these wells varied from 19.4 to 25.6°C.

The Department of Water Supply publishes annual water quality consumer confidence reports for public water supplies in the vicinity of the Project, including Pāhoa and Kalapana. The Hawaiian Beaches Water Company publishes a consumer confidence report for its water supply.

As of 2021, water sources for Pāhoa Water System are Pāhoa Battery Well Nos. A and B and Keonepoko Nui Well Nos. 1 and 2 (Department of Water Supply 2021). The water quality met EPA drinking water quality guidelines, while three contaminants were detected but at concentrations below MCLs. Contaminants included chromium, fluoride, and total trihalomethanes (TTHMs). Chromium and fluoride in water supply sources are typically from the erosion of natural deposits. TTHMs are typically a byproduct of drinking water disinfection.

As of 2021, water sources for Kalapana Water System are Keauohana Well Nos. 1 and 2 (Department of Water Supply 2021). The water quality met EPA drinking water quality guidelines, while five contaminants were detected but at concentrations below MCLs. Contaminants included beta/photon emitters, fluoride, nitrate, haloacetic acids, and TTHMs. The beta/photon emitters are typically from the decay of natural and humanmade products. Nitrate is typically from runoff from fertilizer use, leaching from septic tanks, sewage, and the erosion of natural deposits. Haloacetic acids are typically a byproduct of drinking water disinfection.

As of 2022, water sources for the Hawaiian Beaches community are “one of two wells at the top of the subdivision which are approximately 400 feet deep” (Hawaiian Beaches Water Company 2022). Based on location, these wells are presumably the Hawaiian Shores 1 and 2 wells. The water quality met EPA drinking water quality guidelines, while three contaminants were detected but at concentrations below MCLs or action levels. Contaminants included nitrite, copper, and TTHMs. Nitrite is typically from runoff from fertilizer use, leaching from septic tanks, sewage, and the erosion of natural deposits. Copper is typically from the corrosion of household plumbing systems and the erosion of natural deposits.

Historical monitoring wells associated with PGV’s Hydrologic Monitoring Program (HMP) include MW-1, MW-2, MW-3 (**Figure 11**), and occasionally additional wells that serve as backup monitoring locations in the event that the primary monitoring wells cannot be sampled due to technical issues.

In samples collected from 2014 (Evans et al. 2015), MW-1, MW-2, and MW-3 had sodium as the dominant cation. MW-1 and MW-3 had sulfate as the dominant anion, and MW-2 had chloride as the dominant anion. Samples from these three monitoring wells had TDS concentrations of 511 to 1,560 mg/L. These concentrations exceed the secondary drinking water MCL standard of 500 mg/L. MW-2 had a chloride concentration of 750 mg/L, which exceeds the secondary MCL of 250 mg/L.

Evans et al. (2015) analyzed for dissolved hydrocarbons in area supply wells, HMP wells, produced brine and steam, and injectate. At four groundwater monitoring sites, hydrocarbons heavier than methane were detected. At these sites, pentane was generally non-detectable at less than 0.01 micromoles per kilogram (μmol/kg) via the dissolved organic carbon (DIC) method or greater than 0.001 μmol/kg via the serum method. Pentane was detected in Keonepoko Nui #2 at 0.008 μmol/kg via DIC and MW-2 at 0.001 μmol/kg via serum. Evans et al. (2015) note that excess pentane relative to butane is an indicator of fluids associated with geothermal injectate. None of the groundwater monitoring locations show this trend, and the low levels of hydrocarbons that were measured were attributed to contamination during sampling or natural occurrences due to the breakdown of organic matter.

Evans et al. (2015) also analyzed for VOCs in area supply wells, HMP wells, produced brine and steam, and injectate. VOCs were detected in Keonepoko Nui #1, Keonepoko Nui #2, and MW-2 but at concentrations near the detection limits, which may be spurious. Isopropanol was detected in produced brine and steam and injectate but not in any area supply wells or HMP wells.

Due to the 2018 Lower Puna eruption lava flow events, MW-1, MW-2, and MW-3 are no longer accessible, and the HMP was modified to include on-site wells MW-4 and MW-5 and off-site well MW-6 (**Figure 11**).

The most recent water quality results from MW-4, MW-5, and MW-6 are from ~~August~~ **June** 202~~2~~**3**. The temperature of water pumped for sampling (not downhole temperatures) was between ~~54.7~~**57.4** and **61.4**~~57~~°C. All three sites had sodium as the dominant cation and chloride as the dominant anion. TDS was between **3,510**~~3,240~~ and **4,590**~~3,980~~ mg/L. Parameters exceeding primary or secondary MCLs included chloride, ~~lead~~**iron**, manganese, sulfate, and TDS. Samples were analyzed for VOCs, including isopropanol, and no VOCs were detected. Samples were also analyzed for pentane, which was not detected in any sample. Groundwater monitoring results at MW-4, MW-5, and MW-6 have shown temporal variability in temperature, pH, and major ions. The cause for variability in water quality has not yet been determined but may be a natural progression as the groundwater chemistry stabilizes following the 2018 Lower Puna eruption lava flows, which undoubtedly perturbed the local hydrogeological system. PGV is continuing to closely monitor the evolution of water chemistry at these monitoring wells.

Once annually, injection wells are tested and surveyed to verify mechanical integrity of the injection well casing and the hangdown liner. Pressure and temperature surveys are used to confirm that all the injected fluid is exiting at the permitted injection zone with no inter-formational flows behind the casing. Annual surveys are compared with surveys from previous years to identify changing or abnormal conditions. Test results are sent for external review. Well conditions are then summarized and reported to the DLNR, DOH, and EPA. Continuous monitoring is performed by purging the annular space between the injection casing and the hangdown liner. Purge pressure and flow rate are monitored for any change indicative of a casing leak. Pressurizing the annular space is also used to maintain fluid levels below 2,000 feet below the ground surface, so if any leak occurs in this zone, it is nitrogen that leaks and not geothermal fluid. Liners are also tested by depressing fluid levels to 3,000 feet below the ground surface and measuring leak off rate, running a pressure temperature tool during shut-in testing, and running a camera or caliper survey to further identify potential issues.

In the event that the continuous monitoring system indicates that a well fails to meet the integrity criteria, action would be taken to confirm the findings, shut in the well, and repair the leak. If the injection well is shut-in, injectate is redirected to a properly operating injection well, as the system is designed for redundancy in injection well capacity. If several injection wells were shut-in for maintenance, decreasing injection capacity below production rates, production rates would be decreased by the operator.

The installation of additional production or injection wells, which have already been authorized under the 1987 EIS for the existing PGV facility site, would require drilling through the LERZ aquifer to reach the geothermal reservoir. The well bores would be drilled using non-toxic, temperature-stable drilling mud composed of a bentonite clay-water or polymer-water mix for all wells. To prevent corrosion, increase mud weight, and prevent mud loss, variable concentrations of additives would be added to the drilling mud. Some of the additives may be hazardous substances; however, these additives would be used in low concentrations that would not render the drilling mud toxic or hazardous. During any drilling activity at the Project, all fluids produced from the wells related to the previously authorized drilling task are stored in lined ponds, also referred to as drilling sumps. The fluids, as well as rainwater that accumulates in the drilling sumps, are disposed of via the injection wells. This environmentally sound disposal strategy essentially amounts to returning the produced fluids to the location where they were generated. Drilling fluids contain a mixture of drilling water (sourced from wells MW-4, MW-5, and county water), produced formation water, and drilling mud additives.

To prevent contamination of the LERZ or basal aquifer, wells would be constructed with testing protocols following DLNR requirements (Subtitle 7, Chapter 183, S13-183-76, Well Testing). Each well would be completed with three casing strings cemented to the surface. Following each casing string placement and cementing, and prior to drilling out the shoe, the casing would be pressure tested to ensure casing integrity. After drilling out the shoe, a formation integrity test (FIT) is performed below the casing strings and liners. The FIT procedure tests the formation up to a predetermined pressure that is lower than a pressure that could cause fracturing. If leakage occurs, the shoe will be cemented and retested until the FIT is passed. During subsequent operations, injection pressure is limited to the same FIT pressure to ensure injectate will not go up behind the casing to a shallower depth where the basal aquifer could be impacted.

Upon completion of each well, an injection test may be performed to give an initial indication of reservoir permeability. These tests involve pumping cool fresh water into the well and monitoring pressure and running temperature logs. Temperature logs can be used to identify leaks in the casing.

Geothermal Fluids

Geothermal fluid chemistry was reported by Evans et al. (2015) with samples including brine and steam from the KS-5 production well and injectate from the Pad A well. The dominant cation of produced and injected fluids was sodium, and the dominant anion was chloride. The TDS of produced brine was

16,300 mg/L, and the TDS of injected brine was 14,100 mg/L. The produced steam had relatively low TDS at 29 mg/L.

The gas compositions in produced and injected fluids were also measured by Evans et al. (2015). Gases accounting for at least one percent by volume included hydrogen, hydrogen sulfide, carbon dioxide, and nitrogen. Oxygen and argon were both detected at less than one percent. Pentane was detected in produced steam at 0.005 percent via gas chromatograph equipped with a thermal conductivity detector. Pentane was detected in injected fluid at 0.031 percent via thermal conductivity detector. Pentane content analyzed via flame ionization detector was comparable to thermal conductivity detector results.

Dissolved hydrocarbons were also analyzed for in produced steam and injected fluid. Pentane was present at 0.03 μmol/kg in produced steam and 0.14 μmol/kg in injectate. Furthermore, pentane was elevated relative to butane, which is an indicator of a pentane source as opposed to naturally occurring organic matter. Pentane has been monitored since 2000 in the non-condensable gas line at PGV. Concentrations were initially 0.632 percent but have since been much lower at around 0.02 to 0.04 percent, with no indication of increasing trends.

VOCs were analyzed in produced steam and brine, injectate, and monitoring wells. Isopropanol was present in brine, steam, and injectate at concentrations of 3.8, 60.8, and 496 micrograms per liter (μg/L), respectively. Isopropanol is an ingredient of ChemTreat GG442, which is used by PGV to control corrosion in pipelines at the plant. ChemTreat GG442 contains one to five percent isopropanol. The 496 μg/L in injectate is consistent with PGV utilization of ChemTreat GG442 at 52 gallons per five million gallons of injectate. The decrease in isopropanol concentrations between injection and production indicates that the chemical is degraded and/or diluted within the geothermal reservoir. Furthermore, higher concentrations of isopropanol in the steam relative to the brine indicates that isopropanol readily exsolves into the gas phase.

Five other VOCs were detected in geothermal fluids but at concentrations near the detection limit and therefore may not be actual detections; these VOCs are not expected to be associated with the geothermal system. Evans et al. (2015) notes one exception being isopropyl acetate, which was detected in injectate. The isopropyl acetate may be an impurity in ChemTreat GG442 or be a reaction byproduct involving isopropanol.

The plant storage tank is the source for all process water at the plant; water is used for steam turbine seal water, in the water softener system, as cooling water in the SULFATREAT heat exchanger, and as raw/quench water. Historically, process water has been sourced from wells MW-1 and MW-3 and county water. However, with the destruction of these wells following the 2018 Lower Puna eruption lava flow event, the process water source now includes wells MW-4 and MW-5. These wells are completed in the basal aquifer, and water quality is monitored twice per year.

In addition to the plant storage tank, the Project includes another water storage facility, the ESRF. The ESRF is used in the event of certain plant upsets and includes a hydrogen sulfide gas abatement process. Fluid from this system, which may include geothermal fluids, plant supply water, and sodium hydroxide, are transferred to an ESRF fiber-reinforced, gunite-lined pond. Additionally, this pond collects various supplemental plant water, such as water softener rinsate, SULFATREAT vacuum pump seal waters, SULFATREAT condensate drain water, periodic SULFATREAT cooling water, rainwater, and triple rinse water from the approved additives. Water in the ESRF pond may evaporate and may eventually be injected back into the geothermal reservoir.

Preventative maintenance of the plant, wells, pipelines, and associated infrastructure requires the usage of chemical additives. The purpose of these chemical additives is to adjust solution chemistry to minimize damage to the system caused by corrosion and scaling. These chemical additives include inorganic and organic salts classified as corrosion inhibitors, oxygen scavengers, anti-scalants, pH adjusters, hydrogen sulfide abators (SULFATREAT), and microbiocides. These chemicals are utilized as required and then ultimately injected into the geothermal reservoir along with brines and NCGs. Barrier oil, a synthetic lubricant that seals reinjection pumps, could be injected into the geothermal reservoir if a reinjection pump seal leaked.

Once injected into the geothermal reservoir, these system maintenance chemicals are diluted via mixing in the reservoir and are subject to degradation due to high temperatures and may become attenuated or adsorbed to rock surfaces within the reservoir. The presence of these chemicals in the geothermal reservoir do not adversely affect water quality, as the geothermal reservoir does not contain potable water. Leakage of geothermal fluids from the geothermal reservoir into the overlying basal aquifer could result in these chemicals being present in the basal aquifer; however, these chemicals would be further diluted in the basal aquifer. Historically, these chemicals have not been detected in monitoring wells.

3.2.2 Environmental Impacts

3.2.2.1 Proposed Action

Surface Water

There are no surface water features within the Project Area, and the nearest mapped surface water feature that was not destroyed from the 2018 Lower Puna eruption lava flows is at Keonepoko Nui, located approximately five miles to the northwest (**Figure 5**). Precipitation is known to rapidly infiltrate into the ground or evaporate and not form riverine features. Local unmapped surface water features could be impacted during construction activities; however, it is unlikely surface waters would be impacted by sedimentation or erosion from the Proposed Action, as grading slopes for grading of the new OEC construction area would be directed toward the existing reserve pit to prevent movement of stormwater runoff. Stormwater runoff from the undisturbed areas around the construction area would be directed into adjacent ditches and back onto undisturbed ground, consistent with best management practices (BMPs) for stormwater. BMPs implemented on-site may include, but are not limited to, berms, filters, channels, or grading to create diversions.

Should it be determined that a National Pollutant Discharge Elimination System permit be required for construction activities under the Project, which would be triggered if discharges to Waters of the US or Waters of the State have the potential to occur, a Stormwater Pollution Prevention Plan would be developed and implemented for the Project. It is unlikely that surface waters would be impacted by construction activities under the Project due to the measures that would be implemented under the Stormwater Pollution Prevention Plan, as well as the requirements under the Grading Permit including compliance with Chapter 10 of the Hawaiʻi County Code (Erosion and Sediment Control) that would be implemented for spill or discharge contingency planning. The potential impacts to surface water quality from the Proposed Action would be minimized by the implementation of these environmental protection measures and implementation of the existing environmental protection measures under the current authorization (PGV 1987) for geothermal drilling and development activities at the PGV facility site; therefore, impacts to surface water quality would be negligible.

Decommissioning activities have the potential to locally impact surface water in the same manner that construction activities may impact surface water. BMPs will be utilized during decommissioning of the 12 existing OECs to minimize runoff and transport of sediment as analyzed under the PGV 1987 EIS.

Springs

There are no springs within the Project Area, and the nearest mapped springs are brackish coastal springs located 3.5 to five miles southeast of the Project (**Figure 7**). These coastal springs, which contain geothermally heated water, have somewhat inconclusive origins but contain a mixture of saline and fresh water and have elevated temperatures due to thermal influences. The thermal influence may be conductively heated seawater (i.e., not mixed with geothermal fluid) or geothermal fluid that naturally leaks into the basal aquifer. As warm water discharging to the coastal springs has an unknown origin, decreased temperature of the geothermal reservoir following injection of cooler fluids would have an unknown impact on the coastal springs; however, the thermal mass of the aquifer system five miles from PGV is unlikely to be significantly altered by changes to temperature in the geothermal reservoir because the geothermal resource being produced would not change in Phase 1 and increase by approximately 20 percent in

Phase 2. Significant cooling to the geothermal reservoir could impact groundwater temperatures over a large area; however, a substantial change in reservoir temperature is unlikely.

Groundwater in the basal aquifer and LERZ aquifer flows toward the coast with a component of this relatively dilute groundwater discharging to the coastal springs. Therefore, any contamination to the basal aquifer or LERZ aquifer may result in contamination of coastal springs. Sampling and analysis by Evans et al. (2015) found no evidence of contamination at the coastal springs that could be associated with two decades of operations at PGV. However, they also note that constituents like pentane, which were not detected in the springs, are not geochemically stable and are subject to degradation along the flow path to these springs; furthermore, contamination of the basal aquifer or LERZ aquifer would be detected close to the Project in monitoring wells long before any such contaminated water flows to the coastline (Evans et al. 2015), which is estimated to take 18 to 25 years (Scholl et al. 1996). If contamination is detected in monitoring wells, further assessments of contamination and mitigation of the contamination could be implemented prior to a plume of contamination reaching coastal springs. Therefore, no impacts are expected to near-shore environment or near-shore marine life from temperature change or contamination from the Project.

Groundwater

Groundwater resources in the vicinity of the Project include fresh to saline water in the basal aquifer and the LERZ, which are underlain by a transition to groundwater with the composition of seawater, followed by the geothermal reservoir below the caprock. Groundwater in the vicinity of the Project is generally non-potable due to elevated salinity, as geothermal fluids naturally leak into the groundwater reservoir. The Proposed Action includes construction activities at the site **that would be concurrent with** well drilling and testing, and the production and injection of geothermal fluids associated with **existing and authorized** plant operations. These activities have the potential to contaminate groundwater in the basal and LERZ aquifers.

Construction

Construction activities would include ground disturbance and the grading and clearing of land as necessary to construct new equipment, deconstruct old equipment, and transport equipment, supplies, and workers. Construction activities would utilize BMPs to minimize the chance of groundwater becoming contaminated by hydrocarbon or chemical spills. This would include the proper storage and containment of chemicals and site grading to capture spills in surficial basins. Impacts to groundwater are not anticipated as a result of the Proposed Action during construction.

Operations

During operations, geothermal fluids are continuously produced from the geothermal reservoir, utilized by the plant, and reinjected into dedicated injection wells. The fluids injected into the geothermal reservoir do not migrate to the basal groundwater layer because injection pressures are too low to allow upward migration; rather, injected fluids flow toward the production wells used to produce the geothermal fluids and generate electricity (EPA 2021a). Conditions of PGV's UIC permit issued by the EPA include injection pressure limits that are based on formation testing to reduce the potential for the creation of fractures and well construction requirements to ensure that injected fluids do not migrate to and endanger underground sources of drinking water. As part of the UIC, there are continuous monitoring and systematic testing requirements to ensure that each injection well has mechanical integrity and groundwater is monitored for any potential indicators that suggest impacts to water quality from injection activities. PGV would retain the existing authorization to drill up to 30 wells for geothermal power production, as authorized by its Amended Geothermal Resource Permit (GRP 2), some of which would be necessary to be developed in tandem with the Proposed Action; however, the requirements under the existing PGV UIC permit for injection well activities would continue under the Project across all operations at the PGV facility site. Impacts to groundwater resources during operations associated with injection wells would be greatly minimized with continued implementation of the existing injection well monitoring programs to monitor well integrity. Under the Proposed Action, impacts to groundwater would not increase above existing conditions, which include impacts for all authorized wells under the 1987 EIS.

EPA UIC permit conditions for construction and operation of any existing or proposed wells would prevent conditions that were experienced during the 1991 incident at KS-8 (when uncontrolled geothermal fluids were released for a period of approximately 31 hours). It is important to note that no such incident has occurred during well drilling and development at the PGV facility site since that incident. As described above, the proposed Project would continue to comply with regulations and permit requirements when constructing future wells.

Permit conditions and facility procedures also ensure that if magma is encountered, similar to what occurred in 2005 during the drilling of well KS-13, appropriate steps would be taken to ensure that impacts are minimized. In 2005, no magma was flowing, and no fissure resulted from the inadvertent encounter with magma.

Per the GRP, the EPA's UIC permit, and the Hawaiʻi State Safe Drinking Water Branch UIC permit, PGV also conducts hydrological monitoring (according to a monitoring program reviewed by the state and EPA) semiannually to ensure the existing facility does not contaminate groundwater and sends reports of this monitoring to the State Safe Drinking Water Branch, the EPA, and the Planning Department. As stated in the GRP, if pollution of the aquifer is demonstrated to occur from Project operation or maintenance activities, as determined by the Planning Director in consultation with the Department of Water Supply and DLNR, PGV would need to act to abate these impacts and eliminate the source of pollution. The existing monitoring requirements would continue under the Proposed Action.

In addition to geothermal fluids, the facility uses supplemental water and chemical additives. In comparison to the geothermal fluid flow, which averages approximately 99 percent of the total flow, the supplemental water and chemical additives are minimal. As with current operations, under the Proposed Action, supplemental water would be stored in the plant storage tank located on-site. The groundwater monitoring program would continue biannually as required, with water quality samples collected and reviewed for changes in water quality and indicators of geothermal injectate such as propanol and isopropanol. If water quality in the monitoring wells indicated the presence of geothermal injectate, plant operations and well integrity would be reviewed to determine the cause. Furthermore, any contamination to the basal aquifer originating from PGV activities would be assessed and mitigated if the contamination presented potential to impact public health or environmental resources. Impacts to groundwater resources from chemicals injected into the geothermal reservoir would be greatly minimized with continued implementation of the well monitoring program.

Decommissioning

As the term of the ARPPA approaches its end in 2056, PGV will again evaluate whether, based on economic and resource conditions, the current power plant and wellfield should be refurbished to further extend the PPA term of the facility or whether the facility should be decommissioned. When decommissioned, the land that the PGV facility is sited on will then be returned to its natural state (or as close to it as practicable) as analyzed and permitted under the 1987 EIS.

Regarding groundwater resources, dry or abandoned wells would be plugged with concrete, wellhead equipment and casing removed to below grade, well casing capped, and the surface restored. Well plugging would prevent cross-formational flow in the event that well casing was degraded following decommissioning. PGV's UIC permit includes a plugging and abandonment plan, which is consistent with BLNR requirements. Abandonment would include connecting to the blowout prevention equipment, killing the well if needed using plant water, removing the hangdown liner, setting plugs, salvaging surface equipment, cutting off casing, and reclaiming the location. Plugging activities would be recorded using EPA Plugging and Abandonment Plan form 7520-14.

3.2.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. The impacts to water quality from this alternative would be the same as those described above for Phase 1 of the Proposed Action.

3.2.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment, including generating power and utilizing geothermal fluid at rates comparable to historical records. Additional production or injection wells may be drilled to best utilize the geothermal resource, pursuant to PGV's existing UIC permit through the EPA. Future actions at the site would likely occur as described under **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Under this alternative, hydrology would continue to be influenced by geothermal processes that have historically occurred on the LERZ.

3.3 Air Quality and Climate Change

3.3.1 Existing Environment

Information in **Section 3.3** is from the air quality and greenhouse gas technical report prepared for the Project, which is included as **Appendix E** (Ramboll 2023). Hydrogen sulfide is addressed in hazardous materials (**Section 3.10**) and public health and safety (**Section 3.11**).

3.3.1.1 General Discussion of Air Quality Pollutants

Criteria Air Pollutants

Criteria air pollutants are defined as pollutants for which the federal and state governments have established ambient air quality standards, or criteria, for outdoor concentrations to protect public health. The federal and state standards have been set, with an adequate margin of safety, at levels above which concentrations could be harmful to human health and welfare. These standards are designed to protect the most sensitive people from illness or discomfort. Pollutants of concern include ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), and particulate matter (PM_{10} and $PM_{2.5}$). There are no large sources of lead (Pb) emissions associated with the construction or operation of the Project; as a result, Pb emissions were not evaluated.

Ozone

O_3 is a colorless gas that is formed in the atmosphere when VOCs, sometimes referred to as reactive organic gases, and oxides of nitrogen (NO_X) react in the presence of ultraviolet sunlight. O_3 is not a primary pollutant; it is a secondary pollutant formed by complex interactions of two pollutants directly emitted into the atmosphere. The primary sources of VOCs and NO_X, the precursors of O_3, are automobile exhaust and industrial sources. Meteorology and terrain play major roles in O_3 formation, and ideal conditions occur during summer and early autumn on days with low wind speeds or stagnant air, warm temperatures, and cloudless skies. Short-term exposures (lasting for a few hours) to O_3 can result in breathing pattern changes, reduction of breathing capacity, increased susceptibility to infections, inflammation of the lung tissue, and some immunological issues.

Nitrogen Dioxide

Most nitrogen dioxide (NO_2), like O_3, is not directly emitted into the atmosphere but is formed by an atmospheric chemical reaction between nitric oxide (NO) and atmospheric oxygen. NO and NO_2 are collectively referred to as NO_X and are major contributors to O_3 formation. The primary sources of NO, the precursor to NO_2, include automobile exhaust and industrial sources. High concentrations of NO_2 can cause breathing difficulties and result in a brownish-red cast to the atmosphere, causing reduced visibility. There is some indication of a relationship between NO_2 and chronic pulmonary fibrosis, and some increase in bronchitis in children (two and three years old) has also been observed at concentrations below 0.3 ppm by volume.

Carbon Monoxide

Carbon monoxide (CO) is a colorless and odorless gas formed by the incomplete combustion of fossil fuels. CO is emitted almost exclusively from motor vehicles, power plants, refineries, industrial boilers, ships, aircraft, and trains. In urban areas, automobile exhaust accounts for the majority of CO emissions. CO is a non-reactive air pollutant that dissipates relatively quickly; therefore, ambient CO concentrations generally follow the spatial and temporal distributions of vehicular traffic. CO concentrations are influenced by local meteorological conditions, primarily wind speed, topography, and atmospheric stability. CO from motor vehicle exhaust can become locally concentrated when surface-based temperature inversions are combined with calm atmospheric conditions, a typical situation at dusk in urban areas between November and February. The highest levels of CO typically occur during the colder months of the year when inversion conditions, where a layer of warm air sits atop cool air, are more frequent and can trap pollutants close to the ground. In terms of health, CO competes with oxygen, often replacing it in the blood, thus reducing the blood's ability to transport oxygen to vital organs. The results of excess CO exposure can be dizziness, fatigue, and impairment of central nervous system functions.

Sulfur Dioxide

Sulfur dioxide (SO_2) is a colorless, pungent gas formed primarily by the combustion of sulfur-containing fossil fuels. The main sources of SO_2 are coal and oil used in power plants and industries; as such, the highest levels of SO_2 are generally found near large industrial complexes. In recent years, SO_2 concentrations have been reduced by the increasingly stringent controls placed on stationary source emissions of SO_2 and limits placed on the sulfur content of fuels. SO_2 is an irritant gas that attacks the throat and lungs and can cause acute respiratory symptoms and diminished ventilator function in children. SO_2 can also yellow plant leaves and erode iron and steel.

Particulate Matter

Particulate matter pollution consists of very small liquid and solid particles floating in the air, which can include smoke, soot, dust, salts, acids, and metals. Particulate matter can form when gases emitted from industries and motor vehicles undergo chemical reactions in the atmosphere. $PM_{2.5}$ and PM_{10} represent fractions of particulate matter. Fine particulate matter, or $PM_{2.5}$, is roughly 1/28 the diameter of a human hair. $PM_{2.5}$ results from fuel combustion (e.g., motor vehicles, power generation, and industrial facilities), residential fireplaces, and woodstoves. In addition, $PM_{2.5}$ can be formed in the atmosphere from gases such as SO_X, NO_X, and VOCs. Inhalable or coarse particulate matter, or PM_{10}, is about one-seventh the thickness of a human hair. Major sources of PM_{10} include the following: crushing or grinding operations; dust stirred up by vehicles traveling on roads; wood-burning stoves and fireplaces; dust from construction, landfills, and agriculture; wildfires and brush/waste burning; industrial sources; windblown dust from open lands; and atmospheric chemical and photochemical reactions. $PM_{2.5}$ and PM_{10} pose a greater health risk than larger-sized particles. When inhaled, these tiny particles can penetrate the human respiratory system's natural defenses and damage the respiratory tract. $PM_{2.5}$ and PM_{10} can increase the number and severity of asthma attacks, cause or aggravate bronchitis and other lung diseases, and reduce the body's ability to fight infections. Very small particles of substances such as lead, sulfates, and nitrates can cause lung damage directly or be absorbed into the bloodstream, causing damage elsewhere in the body. Additionally, these substances can transport absorbed gases, such as chlorides or ammonium, into the lungs, also causing injury. Whereas PM_{10} tends to collect in the upper portion of the respiratory system, $PM_{2.5}$ is so tiny that it can penetrate deeper into the lungs and damage lung tissues. Suspended particulates also damage and discolor surfaces on which they settle, as well as produce haze and reduce regional visibility.

Greenhouse Gases

There is a general scientific consensus that global climate change is occurring, caused in whole or in part by increased emissions of GHGs that keep Earth's surface warm by trapping heat in the earth's atmosphere, in much the same way that glass traps heat in a greenhouse. The earth's climate is changing because human activities, primarily the combustion of fossil fuels, are altering the chemical composition of the atmosphere through the buildup of GHGs.

GHGs allow the sun's radiation to penetrate the atmosphere and warm the earth's surface but do not let the infrared radiation emitted from Earth escape back into outer space. As a result, global temperatures are predicted to increase over the century. In particular, if climate change remains unabated, surface temperatures in Hawai‘i are expected to increase anywhere from 5 to 7.5°F by the end of the century. Not only would higher temperatures directly affect the health of individuals through greater risk of dehydration, heat stroke, and respiratory distress, the higher temperatures may increase ozone formation, thereby worsening air quality. Higher temperatures along with reduced water supplies could reduce the quantity and quality of agricultural products. In addition, there could be an increase in wildfires and a shift in distribution of natural vegetation throughout the state. Global warming could also increase sea levels and coastal storms resulting in greater risk of flooding and warmer ocean water temperatures, impacting sea life.

Emissions of carbon dioxide (CO_2) are the leading cause of global warming, with other pollutants such as methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6) also contributing. The magnitude of each GHG's impact on global warming differs because each GHG has a different global warming potential, which indicates, on a pound-for-pound basis, how much the pollutant will contribute to global warming relative to how much warming would be caused by the same mass of CO_2. CH_4 and N_2O, for example, are substantially more potent than CO_2, with global warming potentials of 27.9 and 273, respectively.

National and State Ambient Air Quality Standards

As required by the Clean Air Act Amendments of 1970, the EPA has established National Ambient Air Quality Standards (NAAQS) for the following air pollutants: CO; ozone; nitrogen dioxide (NO_2); particulates (PM_{10} and $PM_{2.5}$); oxides of sulfur (SO_X); and lead (Pb). The DOH has also established standards for these pollutants for Hawai‘i. The federal and state governments have both adopted health-based standards for pollutants. Per the Clean Air Act, the EPA periodically (every five years) reviews the science upon which the NAAQS are based and undertakes a process for revising the standards if it is deemed necessary.

Table 3-1 lists the federal and Hawai‘i standards. The federal primary standards are intended to protect the public health with an adequate margin of safety. The federal secondary standards are intended to protect the nation's welfare and account for air pollutant impacts on soil, water, visibility, vegetation, and other aspects of the general welfare. Areas that violate these standards are designated nonattainment areas. Areas that once violated the standards but now meet the standards are classified as maintenance areas. Classification of each area under the federal standards is done by the EPA based on state recommendations and after an extensive review of monitored data.

Hawai‘i County, Hawai‘i, where the Project is located, has not been classified as a nonattainment area for any criteria pollutants under NAAQS.

Table 3-1 National and State Air Quality Standards

Pollutant	Averaging Time	NAAQS		Hawai‘i Air Quality Standards
		Primary	Secondary	
Ozone (O_3)	1-hour	-	-	
	8-hour	0.070 ppm	0.070 ppm	0.080 ppm
Carbon Monoxide (CO)	1-hour	35 ppm	-	9 ppm
	8-hour	9 ppm	-	4.4 ppm
Nitrogen Dioxide (NO_2)	1-hour	0.100 ppm	-	-
	Annual	0.053 ppm	0.053 ppm	0.04 ppm
Sulfur Dioxide (SO_2)	1-hour	0.075 ppm	-	-
	3-hour	-	0.5 ppm	0.5 ppm
	24-hour	0.14 ppm	-	0.14 ppm
	Annual	0.03 ppm	-	0.03 ppm
Inhalable Particulate Matter (PM_{10})	24-hour	150 µg/m^3	150 µg/m^3	150 µg/m^3
	Annual	-	-	50 µg/m^3
Fine Particulate Matter ($PM_{2.5}$)	24-hour	35 µg/m^3	35 µg/m^3	-
	Annual	12 µg/m^3	15 µg/m^3	-
Lead (Pb)	30-day			-
	Calendar Quarter	1.5 µg/m^3	1.5 µg/m^3	-
	Rolling 3-Month Average	0.15 µg/m^3	1.5 µg/m^3	1.5 µg/m^3

3.3.1.2 Air Quality Setting: Ambient Air Monitoring Data

The Hawai‘i DOH Clean Air Branch operates AQ monitoring sites that measure ground-level concentrations of criteria pollutants. The monitoring data shown in **Tables 3-2** through **3-4** were sourced from the Hawai‘i DOH website. **Tables 3-2** through **3-4** present the data that were available for 2020–2022 for the three monitoring sites on Hawai‘i Island that are closest to the PGV plant: Leilani, KS Hawai‘i, and Mountain View. No exceedances of NAAQS or Hawai‘i AQS were observed during the three-year period reviewed.

Table 3-2 Ambient Air Quality Monitoring Data, Leilani Site

AQS Site Leilani							
Pollutant (ppb)	Averaging Time	Form	2020	2021	2022	HI AQS	NAAQS
Hydrogen Sulfide (H_2S)	1-Hour	Annual Average	10	2.3	0.94	25	N/A
Sulfur Dioxide (SO_2)	1-Hour	9[9th]h Percentile	2.0	2.0	2.0	N/A	75
		3-Year Average	2.0				

Table 3-3 Ambient Air Quality Monitoring Data, KS Hawai‘i Site

AQS Site KS							
Pollutant (µg/m^3)	Averaging Time	Form	2020	2021	2022	HI AQS	NAAQS

Fine Particulate ($PM_{2.5}$)	24-Hour	9^{8t}h Percentile	6.2	5.7	6.9	N/A	35
		3-Year Average	6.3				
Fine Particulate ($PM_{2.5}$)	Annual	Annual Average	3.1	3.0	3.1	N/A	12
		3-Year Average	3.1				

Table 3-4 Ambient Air Quality Monitoring Data, Mountain View Site

AQS Site Mountain View							
Pollutant	**Averaging Time**	**Form**	**2020**	**2021**	**2022**	**HI AQS**	**NAAQS**
Fine Particulate ($PM_{2.5}$) (μg/m^3)	24-Hour	9^{8t}h Percentile	4.7	4.9	6.9	N/A	35
		3-Year Average	5.5				
Fine Particulate ($PM_{2.5}$) (μg/m^3)	Annual	Annual Average	2.6	2.5	2.9	N/A	12
		3-Year Average	2.6				
Sulfur Dioxide (SO_2) (ppb)	1-Hour	9^{9t}h Percentile	3.0	8.0	10	N/A	75
		3-Year Average	7.0				

3.3.2 Environmental Impacts

3.3.2.1 Proposed Action

Construction activities from the Project would temporarily generate emissions. The construction schedule includes two phases: Phase 1 involves the removal of existing equipment and upgrades that will reduce steel structures, piping, mechanical components, and associated flange connections. It includes the installation of three new OECs and supporting electrical equipment. Phase 2 includes an expected 20 percent increase in BOP and one additional OEC unit. The existing infrastructure associated with the facility, including office buildings, control room, electrical substation, distribution lines, and maintenance areas, would remain unchanged with the Project. The existing property boundary would also remain the same after Project completion, and most of the existing 815-acre property would not be altered.

Construction Emissions

The analysis estimated criteria air pollutants and GHG emissions from construction activities in Phase 1 and Phase 2.

Methodologies for Construction Emissions

The methodologies used to calculate construction emissions are included in **Appendix E** and include emissions from off-road equipment, on-road vehicles (including those operated by site construction workers), and fugitive dust. Fugitive dust emissions are typically generated during construction phases of projects and contribute to both $PM_{2.5}$ and PM_{10} emissions. Fugitive dust is generated by various activities during construction such as material handling, bulldozing, scraping, and grading. Because movement of soil off-site is out of scope for this Project, fugitive dust emissions from material handling are assumed to be minimal due to no significant material movement. On-road fugitive dust is also associated with vehicles traveling on paved and unpaved roads. Airborne, visible fugitive dust during construction would be controlled at the Project site in accordance with the Air Pollution Control standards stated in HAR § 11-60.1-33. Methods of control would include the use of water or appropriate chemicals to control fugitive dust; application of asphalt, water, or appropriate chemicals on roads and material stockpiles; installation of hoods, fans, and fabric filters where appropriate; covering all moving, open-bodied trucks that may result in fugitive dust; and the maintenance of clean roadways.

In addition to power plant emissions, mobile operational emissions occur as a result of work trips for the existing 31 employees and periodic truck trips for maintenance activities. Operation of the post-Project PGV power plant would not require additional employees; thus, the mobile operational emission sources represent a continuation of existing travel patterns and activities that currently occur at the Project site. Any existing infrastructure associated with the facility is also expected to remain the same with the Project. Therefore, under the Proposed Action, there would not be an increase in operational emissions compared to the No Action Alternative.

Summarized Construction Emissions

The uncontrolled criteria air pollutant and GHG emissions from on- and off-road construction sources for both construction phases are presented in **Appendix E**. The controlled emissions are shown in **Table 3-5**. The construction equipment required for the Project is typical of equipment used for routine development projects. Short-term emissions from construction equipment would be inconsequential compared to regional emissions or the US inventory for GHG emissions, factoring in the substantially greater number of unrelated on-road vehicles and associated emissions that constitute the majority of baseline vehicle emissions in the Project Area. Therefore, construction emission impacts are anticipated to be less than significant.

Table 3-5 Controlled Construction Emissions by Construction Year and Phase

Year	**Criteria Air Pollutant Emissions (tpy)**						**GHG Emissions (MT/yr)**
	ROG	**NO_X**	**CO**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
2023	0.0085	0.11	0.070	2.9E-04	0.71	0.22	96
2024	0.047	0.52	0.36	0.0014	2.9	0.90	470
2025	0.036	0.42	0.28	0.0012	2.7	0.83	388
2026	0.014	0.15	0.095	4.9E-04	0.60	0.19	164
Phase 1 Total	0.059	0.67	0.45	0.0018	3.6	1.1	588
Phase 2 Total	0.046	0.54	0.36	0.0016	3.3	1.0	530
Total Construction Emissions	0.11	1.2	0.81	0.0034	6.9	2.1	1,118

Note: Controlled emissions assume 74 percent control efficiency for fugitive dust from construction equipment.

Operational Emissions

The upgraded OECs would utilize existing geothermal wells, and PGV may drill additional injection and/or production wells, as needed, in accordance with its state and federal UIC permits; mobile emissions for current and future drilling are covered in the DOH's Noncovered Source Permits for the Project. The existing infrastructure, including administration buildings, control rooms, and maintenance areas, is expected to remain unchanged with the installation of the new OECs, so no operational emission increases from land uses are anticipated. Finally, the total number of employees would not increase with the proposed OEC upgrades, so no increase in mobile source operational emissions from worker trips is anticipated as a result of the Project.

Existing Emissions Sources

Emission sources from existing, normal operation of the geothermal power plant come from three sources: the VRMU, VRU, and SULFATREAT system. Both the VRMU and VRU produce n-pentane emissions from vaporizing of the motive fluid within the geothermal combined cycle units (GCCUs), while the SULFATREAT system leads to H_2S emissions. All operational emission sources outlined would remain unchanged with the Proposed Action. Each source is described in more detail below:

- The VRMU is used to evacuate and recover pentane before venting NCGs from the pentane system. The VRMU consists of a four-step recovery and carbon filtering system.
- The VRU is normally used to remove pentane before venting NCGs from the pentane system. The VRU uses a two-stage refrigeration cycle to recover the pentane and return it to the pentane storage tanks.
- The SULFATREAT system captures fugitive H_2S emissions from the turbine seals. The system uses negative pressure to capture the fugitive emissions, which then pass through a series of two reactors for chemical abatement. The abatement reactor configuration changes occasionally but maintains a consistent control efficiency.

In addition to the above-mentioned sources, operational emissions for the site also include mobile source emissions that occur as the result of worker trips. The PGV plant currently has 31 employees. Mobile source operational emissions were estimated based on the existing workforce of 31 personnel, assuming a five-day workweek, two trips per day, and a 10-mile trip length, as specified by PGV. Operational on-road fugitive dust emissions from worker and maintenance truck trips are estimated in **Appendix E**. Operational emissions are presented in **Table 3-6**.

Summary of Project Operational GHG Emissions

No GHG emissions are emitted during normal PGV plant operations. Electricity generated on-site is used to power the compressors, pumps, and cooling fans.

The criteria air pollutant and GHG emissions from controlled operational sources are presented in **Table 3-6**.

Table 3-6 Operational Emissions Summary

Source	Criteria Air Pollutant Emissions (tpy)								GHG Emissions (MT/yr)
	ROG	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	n-Pentane	H_2S	CO_2e
Worker Commute	0.037	0.027	0.63	4.53E-04	0.0076	1.75E-03	-	-	62
Maintenance Truck Trips	1.26E-05	9.55E-05	1.20E-04	1.61E-07	8.21E-06	4.92E-06	-	-	0.04
Power Plant	-	-	-	-	-	-	1.72	0.03	-
Total Operational Emissions	**0.04**	**0.03**	**0.63**	**4.54E-04**	**0.01**	**1.75E-03**	**1.72**	**0.03**	**62**

Based on the GHG analysis conducted for the Project and included in the ARPPA, approval and completion of the Project would result in a significant reduction in lifecycle GHG emissions relative to the baseline without the Project upgrade. As part of the ARPPA, the GHG emissions that would result if the Project were not built (i.e., avoided GHG emissions) have been calculated to be at least 223 kg CO_2e/MWh.

Summary

Air pollutants in the vicinity of the Project Area are currently below NAAQS and Hawaiʻi standards. The modeled air pollutant concentrations together with the applicable background standards do not exceed applicable NAAQS or Hawai'i standards (HAR Chapter 11-60.1). Impacts to air quality from construction emissions would be short-term and last approximately 18 months, and impacts from operational emissions would be the same as current operations.

The Project would continue to comply with federal and state standards as well as monitoring and reporting requirements in applicable permits including the facility's Noncovered Source Permits and the GRP. PGV would continue to implement best available control technology for air quality for the Project and control fugitive dust in accordance with the Air Pollution Control standards stated in HAR Chapter 11-60.1-33. Acceptable methods of control include the following: use of water or appropriate chemicals to control fugitive dust; application of asphalt, water, or appropriate chemicals on roads and material stockpiles; installation of hoods, fans, and fabric filters where appropriate; covering all moving, open-bodied trucks that may result in fugitive dust; and the maintenance of clean roadways.

Per the EPA Greenhouse Gas Equivalence Calculator, the Proposed Action would produce approximately the same amount of GHG emissions annually (62 tpy of CO_2e) as that produced by 215 households annually during construction (approximately 18 months) and 12 households annually during operations (EPA 2023). The GHG emissions resulting from the Proposed Action during construction and operations would represent approximately 0.4 and 0.2 percent, respectively, of the gross GHG emissions for the County of Hawaiʻi (2.8 million metric tons) (County of Hawaiʻi 2022a). Additionally, an air emissions analysis for projected GHG emissions for PGV power generation up to 46 MW was conducted as part of the ARPPA approved by the PUC. The results of the analysis concluded that with successful geothermal power generation up to 46 MW, which would occur under Phase 1 of the Proposed Action, there would be a net GHG remissions reduction of 811,500 metric tons of CO_2e over Project operations and 798,584 metric tons of CO_2e over the life of Phase 1 of the Project (i.e., power generation of up to 46 MW). Cumulative GHG emissions have been linked with accelerated global climate change, and the Project's negligible impacts from emissions would be offset by the generation of renewable geothermal energy and replacing current electricity generated by burning fossil fuels.

3.3.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. The impacts to air quality and climate change from this alternative would be the same as those described above for Phase 1 of the Proposed Action.

3.3.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. Future actions at the site would likely occur as described in **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Under this alternative, impacts to air quality would be consistent with the operational emissions described for the Proposed Action through the end of PGV's operations. Impacts to air quality from Project construction would not occur under this alternative. However, under this alternative when geothermal production at PGV ends, secondary impacts to air quality on Hawaiʻi Island would increase as a result of energy production by the burning of fossil fuels and/or development of new power production projects brought online (the ratio of renewable to nonrenewable production in 2027 is unknown and would depend on multiple factors). As stated above, if the Project is not built GHG emissions from the No Action Alternative could be at least 223 kg CO_2e/MWh greater than the Proposed Project.

3.4 Noise

3.4.1 Existing Environment

PGV is operating with a noise permit issued by the State DOH Noise and Radiation Branch. PGV is classified as a Class C facility, which allows the facility to operate at a maximum level of 70 dBA, measured 24 hours a day at the property boundary. Noise is monitored by use of noise microphone devices installed at the property boundaries at three locations:

- **Southeast Fenceline Monitoring Site A1** – This site was chosen due to a cluster of homes that are topographically downgradient from the existing operations.
- **Southwest Fenceline Monitoring Site B1** – This site was chosen due to the proximity of the Nanawale Estates subdivision. This location was destroyed by the 2018 Lower Puna eruption but was rebuilt.
- **West Fenceline Monitoring Site C1** – This site was chosen due to the proximity of homes at the Leilani Estates subdivision.

An alarm system is installed in the facility's control room for early detection to allow prompt action if required. The noise alarm setpoint for early warning detection is set at 65 dBA. The measurements obtained at the monitoring stations have all been within the parameters of health, workplace, and other standards relating to short- or long-term exposure to noise levels.

In the original GRP approved by the County of Hawaiʻi on October 3, 1989, PGV agreed to "not exceed a general noise level of 55 dBA during the daytime [7 a.m. to 7 p.m.] and 45 dBA at night [7 p.m. to 7 a.m.] measured at the nearest residence." This general noise level could be exceeded by up to 10 dBA but not for more than 10 percent of the time within any 20-minute period. There was also an exception for periods of venting and drilling. **To clarify, in response to comments received on the Draft EIS, there is no current nighttime drilling ban in effect for the Project.** These standards applied only until noise regulations were adopted by the state or county. Then the DOH revised its noise regulation effective September 23, 1996. The new regulations identify Class C zoning districts, which include the PGV power plant, as all areas equivalent to lands zoned for agriculture, country, industrial, or similar uses. The maximum permissible sound level for Class C property is 70 dBA, regardless of the time of day.

The GRP was ~~updated~~ **amended** on February 6, 2001, and include**s**~~d in~~ Condition 22 regarding noise levels at the Project facility site, which states the following:

> The permittee (PGV) shall report average noise levels for each hour and report a daily and monthly average. Except as allowed below:
>
> a. the average for any month shall not exceed 54 dBA;
>
> b. the average for any day shall not exceed 57 dBA;
>
> c. the average for any hour shall not exceed 62 dBA; and
>
> d. the average for any five-minute period shall not exceed 68 dBA.

The allowable noise levels may be exceeded at each monitoring station by no more than 3 dBA for the following periods: five months per year for the monthly average; five days per month for the daily average; and five hours per month for the hourly average.

During specified steam pipeline cleanout periods, construction, and testing of wells, best available control technology shall be applied, and the allowed noise levels may be exceeded by not more than 5 dBA. During specified periods of drilling, the permittee shall comply with the DOH's noise rules and permit requirements.

Averaging shall be done in a manner consistent with the reporting of noise data by the permittee in the January to June 2000 period. The monthly average shall be the arithmetic mean of the daily averages. The daily average shall be the arithmetic mean of the hourly averages.

In conformance with GRP Condition 22, a data acquisition and storage computer located in the PGV plant operations center polls each data logger once every five minutes at the three noise monitoring stations. PGV provides the results of monitoring in monthly reports to the County of Hawaiʻi Planning Department. Additionally, the five-minute averaged data are checked for noise levels in excess of 68 dBA, and the computer generates an alarm at the facility if an exceedance is detected. PGV's operations department investigates every noise alarm, documents its possible source, and logs it in the control room logbook. If the DOH is contacted by the public regarding a noise complaint for the facility, PGV is contacted to reveal the possible source and reports to the DOH. As stated in Section 9.3 of the ERP, PGV notifies the CDA, County of Hawaiʻi Planning Department, and DOH Noise and Radiation Branch in the event that any upset of PGV's operations leads to an exceedance of the appropriate ambient noise levels, and actions are taken at the site to stop the source of the noise (PGV 2022b). The facility also employs the best available control technology consistent with GRP Condition 20 to minimize noise from the facility and its activities.

3.4.1.1 Baseline Background Noise Levels

Information in this section is from the noise technical analysis prepared for the Project, which is included as **Appendix F** (Ebisu 2023).

Baseline background noise levels without the plant in operation were obtained in June 2019 following the 2018 Lower Puna eruption. These baseline background noise levels with the PGV plant not in operation were obtained at the locations identified in Ebisu (2019) and were used to characterize the residual baseline background noise levels in the entire area surrounding the PGV plant during conditions with only the natural sounds of birds, insects, foliage, and coqui frogs being present. These residual background noise levels were very low and typically below 40 dBA, except during the nighttime when insects and coqui frogs raise the nighttime A-Weighted and high-frequency background noise levels. Low- and middle-frequency background noise levels are not affected by the sounds of coqui frogs and insects. Table 1 in **Appendix F** presents the results of these residual background noise levels in the form of A-Weighted sound levels at locations that were not affected by the 2018 Lower Puna eruption and where shown on Figure 2 of **Appendix F**. Measured baseline A-Weighted and Octave Band spectrums of daytime and nighttime background noise levels at these locations with the existing plant not in operation are shown in Figures 3 through 7 of **Appendix F.** Where nighttime measurements included the high-frequency sounds of coqui frogs and insects, the A-Weighted and Octave Band contributions were eliminated (or parsed), as shown in the figures, to provide estimates of the lowest potential baseline background noise levels without the influence of insects and coqui frogs. According to the data presented in **Appendix F**, daytime baseline background noise levels ranged between 32.2 dBA at Receptor Site 10A to 52.8 dBA at Receptor Site PGV-A. Measured parsed nighttime background noise levels ranged between 31.2 dBA at Receptor Site 10A to 33.0 dBA at Receptor Site M1.

Residual background noise levels during the operation of the existing 30 MW plant in December 2010 and during June 2011 with both the 30 MW and 8 MW plants in operation were also obtained, and the data with both plants operating were used to characterize current background noise levels with the existing power-generating plants in operation. These measurements are shown in Tables 2 and 3 in **Appendix F** and include measurements at community locations that were affected by the 2018 Lower Puna eruption so as to include a broader database of existing community background noise levels. Residual background noise levels as represented by the Lmin (minimum sound level) and L90 (sound levels exceeded 90 percent of the time) values in the tables are indicative of probable power plant noise levels, particularly where indicated in the tables that the plant was possibly audible at those locations. The Lmax (maximum sound level), Leq (average sound level), and L10 (sound level exceeded 10 percent of the time) values in the tables are probably more attributable to other non-plant noise sources, particularly when the plant was not audible.

At existing residences east of the PGV facility, noise-shielding effects behind and/or downslope of Puʻu Honuaʻula have resulted in generally lower plant noise levels along the east plant boundary than along the south plant boundary, with existing background noise levels between 40 to 50 dBA. Low-frequency noise from the 30 MW plant is audible along the east plant boundary at these residences, but mid- and high-frequency plant noise is not. Residual background noise levels at locations east of the plant are shown in Table 1 and on Figures 6 and 7 in **Appendix F**. Background noise measurements obtained in May 2021 with the 30 MW plant operating at approximately 17.5 MW output ranged from 34 to 47 dBA at Sites M1, M, and N, with low-frequency plant noise audible at these locations.

At former residences near the south boundary of the PGV plant (Sites 1 and 2), background noise levels were controlled by the PGV plant and ranged between 45 to 55 dBA, with low-frequency noise from the 30 MW plant and mid- and high-frequency noise from the 8 MW plant being the dominant plant noise sources, particularly during adverse meteorological conditions (northerly winds and with temperature inversion).

At former and existing residences of Leilani Estates to the west that tend to be upslope of the PGV plant, noise-shielding effects from terrain features generally do not exist except at certain locations where localized depressions in ground features occur. Due to the generally greater distances between residences of Leilani Estates and the existing PGV plant, existing PGV plant noise levels are less than 45 dBA. Because residual background noise levels are less than 40 dBA during the quieter periods, PGV plant noise may also be faintly audible at Leilani Estates. Similar background noise conditions are believed to exist in areas north of the PGV plant that are upslope of the plant. In areas south of the PGV plant, similar background noise conditions may occur primarily during meteorological conditions (downwind sound propagation and thermal inversion), which tend to increase PGV plant noise levels to worst-case plant noise levels.

Prior to the 2018 Lower Puna eruption, residences along the south plant boundary experienced the highest plant noise levels, which did not exceed 57 dBA. Overall, existing PGV plant noise levels (which includes operation of the power plant and drilling activities in the wellfield) following the 2018 Lower Puna eruption at current neighboring residences are well below the not-to-exceed 57 dBA limit of the Hawaiʻi County GRP. The ideal long-term goal of not exceeding 55 dBA during the daytime at residences outside the station is also being achieved following full operation of the existing plant at 38 MW. The presence of coqui frog and insect noise during the nighttime has complicated the identification and verification of a nighttime noise limit for plant noise sources, but a level less than 45 to 50 dBA may be possible.

3.4.2 Environmental Impacts

3.4.2.1 Proposed Action

Information in **Section 3.4.2** is from the noise technical analysis prepared for the Project, which is included as **Appendix F** (Ebisu 2023). The analysis in this section is focused on the proposed activities including installation and operation of the OECs.

Predictions of Noise Impacts

The Proposed Action would ultimately replace the existing 30 MW and 8 MW power plants with a group of four approximately 15.3 MW OECs over two phases, which are co-located west of the 30 MW plant and on the 2018 Lower Puna eruption lava flow where shown on Figure 1 in **Appendix F**. Phase 1 of the Project would consist of the installation of the three southernmost OECs for PGV to generate up to 46 MW, and Phase 2 of the Project would include installation of one additional OEC that would further increase power generation capabilities up to 60 MW (see Figures 7 and 8 in **Appendix F**). The equipment planned to be used at PGV is similar to facilities recently constructed and in operation on the U.S. mainland (e.g., McGinness Hills Phase III Geothermal Plant), except the total number of cooling fans required at PGV will be much lower. Past noise measurements obtained on the mainland by the Saxelby Acoustics consulting firm, after downward adjustments for the lower number of PGV cooling fans, were used to predict the anticipated plant noise levels at the PGV station. As indicated in Figures 1 and 9 in **Appendix F**, the proposed 60 MW PGV plant configuration will consist of four power-generating OECs, with each OEC including a single turbine/generator unit, four 400 horsepower feedwater pumps, and 22 cooling fans. The turbine/generator unit, feedwater pumps, and cooling fans will be the primary noise sources of the Proposed

Action, which will be similar to, but quieter than, the primary noise sources at the existing 38 MW power plant.

Within each new OEC, point noise sources were located and modeled on the Project site as shown on Figure 1 in **Appendix F**. Identical point noise sources were grouped within each new OEC, with each OEC arranged and modeled as shown on Figure 8 of **Appendix F**. Third Octave Band sound power levels of the turbine/generator unit, feedwater pumps, and cooling fans used in the analysis and their assumed elevations are listed in Table 4 in **Appendix F**. Figure 9 of **Appendix F** depicts the planned arrangement of the four OECs to form the Phase 1 (45 MW) and Phase 2 (60 MW) versions of the repower plant.

Predictions of the total noise level from the entire 60 MW plant were then made at various community locations (shown on Figure 2 and in Table 5 of **Appendix F**). All plant noise predictions are shown without the beneficial effects of attenuation from terrain obstruction features and are, therefore, considered to represent worst-case predictions. As indicated in Table 5 of **Appendix F**, the predictions at community locations and at the PGV on-site monitoring stations, PGV-A, PGV-B, and PGV-C, were compared to show the differences in plant noise levels between the existing 38 MW and planned 60 MW plants for unobstructed line-of-sight conditions without shielding effects from local terrain features. The values shown in Table 5 of **Appendix F** for unobstructed line-of-sight conditions should reflect worst-case conditions, with only distance and molecular absorption effects controlling the power plant's noise levels from the plant to the receptor locations.

As indicated in Table 5 of **Appendix F**, predicted noise levels from the 60 MW plant should not exceed 44 dBA at the existing noise receptors to the east or 35 dBA at the existing noise-sensitive receptors to the west. Existing terrain-shielding features to the east should normally provide approximately 17 to 19 dBA of noise-shielding effects toward the receptors to the east, except during adverse meteorological conditions of westerly winds and/or adverse thermal ducting effects that tend to occur during the early morning hours prior to sunrise. Reductions in power plant noise levels at community locations to the east are predicted to be between 12 to 14 dBA from the Project and between 0 to 2 dBA at Leilani Estates to the west. Increased sound attenuation due to distance effects resulting from the relocation of the power plant noise sources toward the west within the PGV property is the primary cause of the larger noise level reductions expected east of the plant. Reduced buffer distances to the east combined with the reduced plant equipment noise levels are the case of the near-zero reduction in plant noise levels expected toward Leilani Estates to the west.

Comparisons of the predicted audio frequency content of the noise levels from the 60 MW plant with those of the existing 38 MW plant are shown on Figures 10 through 15 of **Appendix F** and key community locations west and east of the PGV facility. It should be noted that the background noise contributions from coqui frogs are limited to frequencies between 1,250 Hz to 3,150 Hz, and the background noise contributions from insects tend to be concentrated around 5,000 Hz. The dominating influence of coqui frogs and insects on the nighttime A-Weighted and high-frequency background noise levels is shown on Figures 3 through 6 in **Appendix F**. Eliminating, or parsing, these high-frequency components results in dramatic reductions of the A-Weighted nighttime background noise levels. The contributions of PGV plant noise in the surrounding communities will primarily be associated with low- and mid-frequency noise components as shown on Figures 10 through 15 in **Appendix F**, which is a condition similar to the existing plant noise. Risks of exceedances of the residual background noise levels by the Proposed Action, inclusive of both Phase 1 and Phase 2, are anticipated to be similar to existing conditions at Leilani Estates and lower in the communities to the east. These conclusions were based on similarities of the audio frequency content of the existing PGV Facility at Leilani Estates (see Figures 10 through 13 in **Appendix F**) and the 10+ dBA reduction in noise levels to the east combined with the Proposed Action (see Figures 14 and 15 in **Appendix F**).

Compliance with the Geothermal Resource Permit and Long-Term Goals

The not-to-exceed 57 dBA limit of the GRP was not and is currently not being exceeded at residences outside the PGV generating station during the operation of the 38 MW power plant (i.e., the No Action Alternative). A fixed noise monitoring station (Site A) had been located near the PGV south boundary where risk of exceeding the 57 dBA limit was the highest prior to the 2018 Lower Puna eruption. As indicated in Table 5 in **Appendix F**, at former Sites 1 and 2 near the south boundary, risks of exceeding 57 dBA will be greatly diminished with the implementation of the Proposed Action.

Table 5 in **Appendix F** also indicates a potential noise level of 57.2 dBA at the former west gate of the PGV facility in the vicinity of Site 12 where shown on Figure 2 of **Appendix F**. Risks of exceeding the 57 dBA limit will increase at that location with the implementation of the Proposed Action. While noise mitigation measures should not be required along the west PGV facility boundary, an examination of the effectiveness of a sound-attenuating wall located approximately 92 feet west of the 60 MW plant was performed to determine the possible benefits at the existing receptors at Leilani Estates.

Table 6 in **Appendix F** presents the results of the calculation of plant noise attenuation at Receptor Sites 4A and 6 in Leilani Estates, which are located approximately 5,000 and 6,000 feet, respectively, from the proposed repower plant. Predicted worst-case plant noise levels at Receptor Sites 6 and 4A are 31.7 dBA and 34.8 dBA, respectively, and well below the 57 dBA limit. Figures 10 and 11 in **Appendix F** compare existing and proposed plant noise levels, which indicate little to no change in plant noise levels. Figures 3 and 4 of **Appendix F** indicate residual background noise levels at both locations, which could possibly be less than the existing and worst-case plant noise levels if the added noise contributions from coqui frogs and insects are eliminated. Because of all these considerations plus the need to construct very tall and solid noise barriers to achieve 7 to 11 dBA of plant noise reduction at these two locations, constructing a sound attenuation wall to provide noise shielding and attenuation at Leilani Estates was not considered to be reasonable. If the lands in the vicinity of the former west gate of the PGV facility become developed with noise-sensitive uses in the future, the use of a sound-attenuating wall west of the Project should be reconsidered.

At existing community locations to the east (Receptor Sites M, M1, and N), which are at shorter distances (2,600 to 3,500 feet) from the Proposed Action, predicted worst-case plant noise levels are also well below 57 dBA (see Table 5 in **Appendix F**). The noise-shielding effects from the higher-elevation terrain features of Pu‘u Honua‘ula and lands east of the existing 30 MW plant have not been included in Table 5 but are estimated at being greater than 10 dBA when thermal ducting and westerly winds do not occur. Figures 14 and 15 in **Appendix F** indicate that low-frequency plant noise (which can be audible under existing conditions) should dimmish following transition to the Proposed Action. The final consideration was that the effectiveness of a sound-attenuating wall on the east of the Project could be reduced by the same unfavorable meteorological conditions that reduce the shielding effects from the natural elevated terrain features east of the plant. For these reasons, constructing a sound attenuation wall to provide noise shielding and attenuation at the existing communities to the east was not considered to be reasonable.

Summary

It was determined that the Proposed Action of replacing the existing 38 MW power plant with an initial 46 MW plant and ultimately a 60 MW plant should not result in significant adverse noise impacts on the neighboring land uses. Plant equipment noise data provided by PGV and based on similar equipment used at other Ormat facilities indicate the proposed plant equipment ~~are~~ **is** sufficiently quieter than the existing plant equipment so as to not increase future background noise levels in the surrounding communities. Existing power plant noise levels in the surrounding communities are very low and well below the 57 dBA not-to-exceed limit imposed on the PGV facility, and the proposed 46 MW and 60 MW phased facility should not change these background noise conditions.

Replacement of the existing power plant equipment with new, quieter equipment will allow for much higher power plant output without increasing the background noise levels in the surrounding communities. The noise mitigation measures have been directed at using sufficiently quieter equipment so that the addition of external noise mitigation measures, such as sound-attenuating walls, will not be necessary. Also, PGV would continue monitoring and reporting to the Planning Department and would also continue to coordinate with the CDA and other agencies to advise them of the anticipated duration of the upset and high noise level situations.

3.4.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. The noise impacts from this alternative would be the same as those described above for Phase 1 of the Proposed Action.

3.4.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be replaced and upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. Future actions at the site would likely occur as described in **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Under this alternative, impacts to noise from biological factors and meteorological conditions as described in the existing environment would continue.

3.5 Biological Resources

3.5.1 Existing Environment

The Project is located in the Puna District in an area considered the windward lowlands of Hawaiʻi Island. Elevation in the Project Area ranges from 615 to 640 feet above sea level, and rainfall exceeds 120 inches per year (Giambelluca et al. 2013).

The entire Project Area consists of approximately 815 acres. Within the Project Area, only approximately three acres remain vegetated in the southern portion of the Project site. The Project site is surrounded by the 2018 Lower Puna eruption lava flow, a kīpuka (area of land surrounded by younger lava flows) of remnant vegetation, and the existing PGV facility. The three acres that are vegetated in the Project site are part of an approximately nine-acre kīpuka that extends outside the Project Area and presents as a forested ridge of spatter cones created during the 1955 lava flow of Kīlauea Volcano and was surrounded by the 2018 Lower Puna eruption lava flow. A biological survey was completed in 2022 of the nine-acre kīpuka (Geometrician 2022), herein referred to as the survey area (**Figure 12**).

Regional Vegetation Types and Influences

The vegetation of the LERZ is directly impacted by the regularly shifting geology. With eruptions occurring at various points up and down the LERZ, most new lava surfaces only attain an age of a few hundred to a thousand years before once again being covered with lava. The vegetation of the LERZ is a mosaic of old, new, and medium-aged surfaces. It varies from bare lava to sparse forest covered with pale lichens and small ʻōhiʻa trees (*Metrosideros polymorpha*) to tall, diverse forests of trees, ferns, vines, and herbs.

In younger lava flows below 800 feet in elevation, the natural vegetation is Lowland Wet ʻŌhiʻa/Uluhe Fern Forest (Gagne and Cuddihy 1990). In wet forests on Puna lava flows younger than 100 years, ʻōhiʻa trees are abundant but generally small (15 to 40 feet high; 2 to 10 inches in diameter at breast height) and sparsely to moderately distributed among patches of native uluhe (*Dicranopteris linearis*) fern. A variety of ferns (e.g., amaʻu [*Sadleria cyatheoides*]) and fern allies and sedges such as ʻuki (*Machaerina mariscoides* ssp. *meyenii*) may also be fairly abundant. In general, very few native understory plants are present, but eventually certain species proliferate, including lama (*Diospyros sandwicensis*), kopiko (*Psychotria hawaiiensis*), kolea (*Myrsine lessertiana*), maile (*Alyxia oliviformis*), ʻieʻie (*Freycinetia arborea*), and hapuʻu (*Cibotium menziesii* and *C. chamissoi*).

Under natural conditions, younger-aged lava flows provide nurseries for more uncommon plants that establish in small numbers but eventually may become prominent elements. Endangered plants are usually not present in lowland Puna, but several individuals of an endangered subshrub, haʻiwale (*Cyrtandra nanawaleensis*) have been found in a variety of locations. Several studies have revealed somewhat confusing associations between substrate age and species diversity that are well summarized in Dupuis (2012), which revealed that forests between 200 and 750 years in age were the primary sites for both high-diversity forests and rare plants. Many of these lava flows are dominated by ʻaʻa, the clinkery form of lava.

The alteration of natural vegetation directly through agriculture, settlement, and timber harvest, as well as indirectly through the introduction of non-native animals, plants, and pests, dramatically alters natural patterns (Cuddihy and Stone 1990). Even when evidence of direct human disturbance is not obvious, wildfire and cattle grazing have decreased native plant diversity and increased the prevalence of weed species in Puna's younger substrates. GIS maps of Hawaiʻi Island created by overlaying the geographic ranges of plant species reveal that the upper-elevation parts of the LERZ are largely native-dominated, and the LERZ where the property is located is mostly non- native-dominated (Price et al 2007). Major invasive plants here include the extremely rapid-growing albizia tree (*Falcataria moluccana*), strawberry guava (*Psidium cattleianum*), broomsedge (*Andropogon virginicus*), Asian melastome (*Melastoma* spp.), and a host of other plants in the melastome family.

Vegetation History on the Property

The two low joined spatter cones located in the biological survey area were created in the 1955 eruption and have slowly sprouted vegetation. Aerial imagery from 1955 shows a light-colored surface devoid of sizable trees but likely containing lichens and seedlings. By the time of a 1975 photograph, forest had developed over the central portion of what is now the kīpuka, although the rim and interior of the cones' craters were still somewhat barren. Satellite imagery in 1985 shows little detail but an overall greenish hue, indicating that the entire kīpuka was vegetated. By 2007, imagery shows the southwestern half was covered with a thick layer of albizia, while the northeastern half was much sparser and appeared to be at least partially composed of ʻōhiʻa. Satellite imagery from 2016, following impacts of Tropical Storm Iselle in 2014, reveals many downed trees on the southwestern side. By 2017 these had largely grown back, and albizia was encroaching well into the northeastern half, including the entire northern fringe. In May 2019, nine months after the 2018 Lower Puna eruption lava flow had ceased, the margins of the kīpuka consisted of burned and downed trees. The partial defoliation of unburned trees damaged by volcanic gases, which impacted albizia more than ʻōhiʻa, is still visible in that image. Today, although the skeletons of burned trees still surround and penetrate the kīpuka, the vegetation is green and vigorous. Due to the geologically recent substrate (1955 and 2018), no true soil is present, but the crumbly spatter cone surface and the abundant leaf litter have created a moist covering of decomposing organic material over mineral-rich decomposing rock that supports prolific vegetation.

Botanical Resources

Vegetation within the survey area is dominated by albizia forest and includes a remnant of ʻōhiʻa. Impacts to vegetation from eruption including fire, heat, and gases destroyed or damaged ʻōhiʻa and especially albizia in the survey area. The albizia is vigorously recovering and is the dominant species, while ʻōhiʻa appears to be rebounding slowly in the survey area. ʻŌhiʻa is only dominant on the upper rims of the cinder cones. A layer of understory trees is present, especially on the lava flow margins, consisting of Asian melastome, gunpowder tree (*Trema orientalis*), and lesser numbers of various other trees including cecropia (*Cecropia obtusifolia*) and strawberry guava. Just a few amaʻu and hapuʻu tree ferns have survived. The dominant species on the forest floor almost everywhere is non-native sword fern (*Nephrolepis multiflora*), but the native fern uluhe covers the bottom of the crater. Other prominent species at the lowest layer include broomsedge, Napier grass (*Cenchrus purpureus*), bamboo orchid (*Arundina bambusifolia*), maunaloa (*Canavalia cathartica*), and pilau maile (*Paederia foetida*), which are all non-native.

All plant species identified during the survey are listed in **Appendix G**. Of the 48 species identified, four were indigenous (native to the Hawaiian Islands and elsewhere) and three were endemic (found only in the Hawaiian Islands). No plants introduced by Polynesians were observed. All native plants observed within the survey area are common throughout the Hawaiian Islands, and no rare or unusual plant species were present. Some plant individuals were not able to be confirmed for species presence during the biological survey because the example plants were sterile, juvenile, and/or in poor condition. It is highly unlikely that any of these unidentified plants would be a rare species.

No threatened or endangered plant species as listed by the U.S. Fish and Wildlife Service (2022) were identified within the survey area. No uniquely valuable plant habitat is present. The survey area is not suitable habitat for the endangered subshrub haʻiwale, which generally requires more intact ʻōhiʻa forest with a native understory. No federally designated or proposed critical habitat is present on or within 10 miles of the Project Area (USFWS 2022b).

Wildlife

Although only two bird species were detected during the survey, northern cardinal (*Cardinalis cardinalis*) and warbling white-eye (*Zosterops japonicus*) habitat exists in the survey area for additional bird species, nearly all of them likely to be non-native. Based on other surveys in similar habitats in Puna, the typical non-native birds likely to be found foraging in or within the vicinity of the Project Area include the following: common myna (*Acridotheres tristis*); northern cardinal (*Cardinalis cardinalis*); house finch (*Carpodacus mexicanus*); yellow-fronted canary (*Crithagra mozambica*); chicken (*Gallus gallus domesticus*); zebra dove (*Geopelia striata*); red-billed Leiothrix (*Leiothrix lutea*); melodious laughing-thrush (*Leucodioptron canorum*); spotted dove (*Streptopelia chinensis*); and warbling white-eye.

The only native bird almost certain to be occasionally present is the Hawaiian hawk (*Buteo solitarius*), which was formerly listed as endangered under the Endangered Species Act of 1973 and is currently listed by the State of Hawaiʻi. The Hawaiian hawk occurs throughout Hawaiʻi Island from sea level to 8,500 feet above sea level and is frequently observed in a variety of habitats in the Puna District and all forested areas of Hawaiʻi Island. These hawks generally prefer ʻōhiʻa forest habitat but are known from both native and non-native forests and even range into farmland and towns to forage. Hawks nest in tall trees within their large territories from early March through the end of September. Nesting usually occurs in native ʻōhiʻa trees but can occur in non-native species including eucalyptus, ironwood, mango, coconut palm, and macadamia trees as well. The forest within the Project Area lacks tall, mature ʻōhiʻa or any other trees that would make highly suitable nests. Furthermore, high noise levels are present due to the proximity of drilling, heavy equipment, and other industrial activity currently occurring at the PGV site, which discourages nesting.

Throughout Hawaiʻi Island, several threatened or endangered seabirds may overfly, roost, nest, or utilize resources in the Pahoa area, including the endangered Hawaiian petrel (*Pterodroma sandwichensis*), the endangered band-rumped storm petrel (*Oceanodroma castro*), and the threatened Newell's shearwater (*Puffinus auricularis newelli*). Although they may fly over various locations in Puna on their way to and from mountain nesting areas and the open ocean, very little suitable nesting habitat for any of these seabird species is present in the lowland areas of the LERZ. Research at larger, isolated volcanic cones at slightly higher elevations has indicated habitat potential at some of them (Reynolds and Ritchotte 1997). It is unlikely that any habitat is present within the Project Area. The primary cause of mortality for these seabirds in Hawaiʻi is predation by non-native mammalian species at the nesting colonies. Collision with humanmade structures is another significant cause. Nocturnally flying seabirds, especially fledglings on their way to sea in the summer and fall, can become disoriented by exterior lighting. Disoriented seabirds may collide with humanmade structures, leading to fatalities or injuries causing them to become easy targets of predatory mammals.

The threatened Hawaiian goose or nēnē (*Branta sandwicensis*) has become very common on many Hawaiian islands and can be found at elevations ranging from sea level to sub-alpine areas above 7,000 feet above sea level. Historically, flocks moved between high-elevation feeding habitats and lowland nesting areas. Nēnē nests consist of a shallow scrape lined with plant material and down. Breeding pairs usually return to the previous year's nest site, typically in dense vegetation. Nēnē have an extended breeding season, and nesting may occur in all months except May, June, and July. Nēnē can be abundant in shoreline areas of Puna where large ponds exist. The dense albizia forest, lack of water bodies, and absence of short grass make the property unsuitable habitat for nēnē foraging or nesting. No potential habitat for nēnē or individual nēnē were identified within the biological survey area.

Potential habitat for endangered Hawaiian hoary bats (*Lasiurus cinereus semotus*), the only native Hawaiian land mammal, occurs on the margins of the biological survey area for feeding, and the interior of the kīpuka may include roosting habitat. Hawaiian hoary bats have been found throughout Hawaiʻi Island. Individuals may forage for flying insects within the Project Area on a seasonal basis and may also roost in trees and large shrubs in the kīpuka.

No bats were observed in the pedestrian biological surveys, which took place in full daylight and did not involve the use of acoustical detection equipment. For the purposes of this EIS, it is assumed that Hawaiian hoary bats are present at least some of the time, as they have been frequently seen and detected by ultrasound and radar in young ʻōhiʻa forests as well as non-native forests, particularly on the edges of clearing. Hawaiian hoary bats rear their young during the summer pupping season.

No feral mammals were detected, but it is possible that pigs (*Sus scrofa*), small Indian mongoose (*Herpestes a. auropunctatus*), mice (*Mus* spp.), rats (*Rattus* spp.), cats (*Felis catus*), and dogs (*Canis f. familiaris*) could occasionally be present within or in the vicinity of the Project Area.

There are no native terrestrial reptiles or amphibians in Hawaiʻi. Although no terrestrial species were located, it is reasonable to expect that various species of skink (Family: Scincidae), geckoes (Family: Gekkonidae), and anoles (Genus: *Anolis*) could be present in the Project Area. The highly invasive coqui frog (*Eleutherodactylus coqui*) is also known within the vicinity and likely occurs in the Project Area, including potentially within the survey area. None of these alien mammals, reptiles, or amphibian species is protected, and all are deleterious to native flora and fauna.

The biological survey did not include identification methods for invertebrates, but in general, rare, threatened, or endangered invertebrates on Hawaiʻi Island tend to be associated with high-elevation, diverse rainforests (e.g., various *Drosophila*), coastal dry shrubland (e.g., various *Hylaeus*), the summit of Mauna Kea (*Nysius wekiuicola*), extremely dry, disturbed ʻaʻa flows (*Manduca blackburnii*), or aquatic settings (various *Megalagrion*). Neither intensely invaded albizia forests nor young lowland ʻōhiʻa forests located in the Project Area provide habitat for any threatened or endangered invertebrates, and it is unlikely that any rare, threatened, or endangered invertebrates would be present.

3.5.2 Environmental Impacts

The proposed Project could result in approximately 11.9 acres of new surface disturbance from grading the Project Area within the existing 815-acre PGV property. The Project Area does not include the approximately 8.4 acres of previously disturbed land that has been graded for permitted activities, including a laydown area, access roads, a power transmission line, and aggregate storage adjacent to the existing power substation. Project-related surface disturbance would include up to approximately 11.9 acres from the installation of the OECs and ancillary facilities in the Project Area, 9.0 acres in Phase 1, and an additional 2.9 acres in Phase 2 (**Figure 3**); the exact location of these facilities would be determined as part of the final design.

Impacts to biological resources in the Project Area would occur until the Project ends and the land is reclaimed and all equipment is removed. Until that time, the Project would result in impacts to the 2018 Lower Puna eruption lava flow and the vegetated kīpuka in the Project Area.

3.5.2.1 Proposed Action

Botanical Resources

The low elevation, lack of diversity, and heavy presence of invasive species in the Project Area result in limited native vegetation and no habitat for threatened or endangered plant species. The Project could impact up to approximately 11.9 additional acres within a 16.4-acre Project Area located on the existing

815-acre property; only 2.4 acres of disturbance would occur to the vegetation in the kīpuka. The remaining disturbance would occur on the portion of the Project Area impacted by the 2018 Lower Puna eruption lava flow. Therefore, the Project is not expected to result in impacts to any uniquely valuable plant habitat or federally listed plant species or their habitat.

The recently discovered Rapid ʻŌhiʻa Death is a disease caused by two fungal pathogens (*Ceratocystis lukuohia* and *C. huliohia*) that impacts ʻōhiʻa trees (Hawaiʻi DLNR 2017). This disease has killed hundreds of thousands of ʻōhiʻa trees across more than 34,000 acres of Hawai'i Island, first discovered in Lower Puna. The fungus enters ʻōhiʻa plants through a wound, which can occur from cutting, pruning, sawing, breakage, strong winds, root abrasion, weed-whacking, lawn mowing, rubbing by ungulates, and root trampling. The Project Area contains numerous ʻōhiʻa trees. Projects that cut or relocate ʻōhiʻa trees can spread the disease, and certain mitigation measures are recommended, although it is important to recognize that treatment protocols are evolving. PGV would implement the following measures in consultation with the Hawaiʻi DLNR, Division of Forestry and Wildlife:

- Prior to any forest clearing in any areas with ʻōhiʻa, any isolated ʻōhiʻa trees on the clearing boundary should be identified. Any such trees that are not planned for removal on the edges should be protected from disturbance entirely or cut and chipped or buried to ensure that they do not present a ready target for Rapid ʻŌhiʻa Death infection that could spread to other trees;
- Treat any unavoidable scars on ʻōhiʻa trees that result from clearing to prevent infestation of the fungus; and
- Stack all removed ʻōhiʻa trees and dispose of them by burying or chipping; do not remove from the Project site. Decontaminate boots and work tools before and after working in an area with ʻōhiʻa trees.

As part of the Project, PGV would continue to comply with the following botanically related conditions of the GRP:

- **Condition 32:** PGV would continue to use native plants for landscaping in the Project Area;
- **Condition 34:** PGV would provide a revegetation/site reclamation plan to the Planning Director in coordination with the DNLR Forestry Division; and
- **Condition 50:** Upon termination of operations or abandonment of any portion of the site, PGV would grade the land to blend with the surrounding area and revegetate the area.

To minimize the introduction and spread of pests, PGV would ensure equipment, materials, and personnel brought to the facility are cleaned of excess soil and debris. On-site housekeeping would continue to minimize any trash that would attract pests to the Project Area.

Wildlife

The majority of the OEC portion of the Project Area (approximately 11.9 acres) is vegetated only with colonizing species following the 2018 Lower Puna eruption. The 3.8 acres of the laydown area have already been disturbed as part of approved activities. The habitat in the kīpuka within the Project Area (approximately 2.4 acres) provides limited habitat for native wildlife species.

Overall, the Project would temporarily directly impact up to 11.9 acres of potential wildlife habitat during Project construction, including the area of the OECs, screening wall, and 50-foot buffer, which would remain impacted for the duration of the Project. Short-term impacts to wildlife would occur during demolition of the existing OECs and ancillary facilities and construction of the new OECs and ancillary facilities and would occur as a result of grading and Project installation. Short-term impacts to wildlife from the Project would include noise and human presence during construction. Long-term impacts from the Project would include loss of habitat from vegetation removal, operation of the OECs and ancillary equipment, and include noise, use of lights, and human presence during maintenance operations.

Hawaiian Hawks

Although the forest within the Project Area has limited highly suitable nesting sites, it is possible that Hawaiian hawks forage in the Project Area and could nest on or near the PGV facility site in the tall trees in the center of the kīpuka. To prevent impacts to nesting Hawaiian hawks from the Project, PGV would implement the following mitigation measures:

- If work must be conducted during the Hawaiian hawk breeding season (March 1 through September 30), PGV would have a biologist familiar with the species conduct a nest search of the Project footprint and surrounding areas immediately prior to the start of construction activities. Pre-disturbance surveys for Hawaiian hawks are only valid for 14 days. If disturbance for the specific location does not occur within 14 days of the survey, an additional survey would be required;
- PGV would ensure no clearing of vegetation or construction activities would occur within 1,600 feet of any active Hawaiian hawk nest during the breeding season until the young have fledged; and
- Regardless of the time of year, PGV would ensure that trees containing a hawk nest should not be cut, as nests may be re-used during consecutive breeding seasons.

Hawaiian Petrel, Band-rumped Storm Petrel, and Newell's Shearwater

Potential impacts to the endangered Hawaiian petrel, the endangered band-rumped storm petrel, and the threatened Newell's shearwater from the Project could occur if nocturnally flying seabirds become disoriented by exterior lighting. Disoriented seabirds may collide with humanmade structures, leading to fatalities or injuries causing them to become easy targets of predatory mammals. Although there is low potential for these species to travel over the Project Area to breeding grounds and no breeding habitat is present in the Project Area or vicinity, PGV would continue to fully shield all outdoor lights so that the bulb can only be seen from below bulb height and only be used when necessary. PGV currently complies with Condition 31 of the GRP, which states that all lights, at a minimum level consistent with the safety of operations, are shielded or directed away from surrounding residential or populated areas and do not interfere with important biological resources in the area.

Additionally, PGV would implement this additional mitigation measure to prevent impacts to endangered seabirds (and protect dark skies) from the Project during night operations:

- To avoid potential seabird downing through interaction with outdoor lighting, PGV would avoid unshielded equipment lighting after dark between the months of April and October. All permanent lighting would be kept to the minimum necessary levels, with shielded lights so as to lower the ambient glare, in conformance with the Hawai'i County Outdoor Lighting Ordinance (Hawai'i County Code Chapter 9, Article 14). Furthermore, where possible, exterior lighting would consist of blue-deficient lighting such as filtered LED lights or amber LED lights, with a Correlated Color Temperature of 2,700 Kelvin.

Nēnē

The dense albizia forest, lack of water bodies, and absence of short grass in the Project Area do not provide suitable nesting or foraging nēnē habitat. Although no nēnē have been detected on the property and are not expected to, PGV would implement the following mitigation measures to prevent impacts to nēnē:

- PGV would ensure employees do not approach, feed, or disturb Hawaiian geese;
- If Hawaiian geese are observed loafing or foraging within the Project Area during the breeding season (September through April), have a biologist familiar with the nesting behavior of nēnē survey for nests in and around the Project Area prior to the resumption of any work. Repeat surveys after any subsequent delay of work of three or more days (during which the birds may attempt to nest);

- PGV would cease all work immediately and contact the United States Fish and Wildlife Service (USFWS) for further guidance if a nest is discovered within a radius of 150 feet of proposed work or if a previously undiscovered nest is found within said radius after work begins; and
- In areas where Hawaiian geese are known to be present, post and implement reduced speed limits, and inform project personnel and contractors about the presence of endangered species on-site.

Hawaiian Hoary Bats

Hawaiian hoary bats may utilize the margins of the property for feeding and may even utilize the interior for roosting. The Project could impact habitat during vegetation clearing and could impact nearby roosting individuals during Project operations. In order to minimize impacts to Hawaiian hoary bats, PGV would implement the following mitigation measures:

- PGV would not disturb, remove, or trim woody plants greater than 15 feet in height during the bat birthing and pup-rearing season (June 1 through September 15); and
- PGV would not use barbed wire for fencing.

Since **Section 3.2** identified that no impacts are expected to near-shore environment or near-shore marine life from temperature change or contamination from the Project, no impacts to near-shore marine species (including ʻōpaeʻula [*Halocaridina rubra*]) are anticipated from the Project.

Summary

The short-term impacts to wildlife from Project construction and operation are consistent with the current use at the Project site, and long-term impacts would be minimized with the implementation of the mitigation measures listed above.

3.5.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. The impacts to biological resources from this alternative would be the same as those described above for Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**.

3.5.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. Future actions at the site would likely occur as described under **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**.

Under this alternative, impacts to biological resources would be consistent with the existing environment described above through the end of Project operations. Impacts to biological resources from Project construction would not occur under this alternative. However, under this alternative when geothermal production at PGV ends, impacts to biological resources could occur from subsequent use of the site and secondary impacts from climate change from the burning of fossil fuels and/or development of new power production projects on Hawaiʻi Island.

3.6 Socioeconomics and Environmental Justice

3.6.1 Existing Environment

The Project is located in Census Tract 15001021101 (211.01), which includes the area bounded to the west by Pāhoa Kalapana Road, to the north by Highway 132, and to the southeast by the Pacific Ocean. The Project Area does not occur within a Census Designated Place (CDP); however, impacts to Leilani Estates and the adjacent Nanawale Estates Pāhoa CDPs may occur and are discussed where data are available. Data from Hawaiʻi County and the State of Hawaiʻi are included as reference populations.

The details below represent the best available information for the existing social and economic condition of the area of analysis using publicly available data. However, due to the uncertainties related to the ongoing COVID-19-related economic impacts and changes in regional economic and social conditions, the data below may be inexact.

3.6.1.1 Population and Demographics

The State of Hawaiʻi experienced growth from 2010 to 2016; however, population growth slowed from 2017 to 2019 and decreased in 2020 (**Table 3-7**). Estimates suggest that the population of Hawaiʻi will continue to decrease, largely driven by migration to the mainland U.S. because of the economic impact of the COVID-19 pandemic. Since 2010, Hawaiʻi County has experienced a period of sustained growth, increasing by approximately 12 percent, making it Hawaiʻi's second fastest-growing county after Kauaʻi County.

During the period from 2010 to 2020, the populations of Census Tract 211.01 and the Leilani Estates, Nanawale Estates, and Pāhoa CDPs fluctuated but ultimately increased in population. Most notably, populations decreased for these locations following the 2018 Lower Puna eruption but have since made modest recoveries.

Table 3-7 Population

Year	Leilani Estates CDP	Nanawale Estates CDP	Pāhoa CDP	Census Tract 211.01	Hawaiʻi County	Hawaiʻi
2010	1,563	1,377	890	2,829	180,362	1,333,591
2011	1,634	1,500	983	3,012	182,997	1,346,554
2012	1,653	1,384	865	3,133	185,399	1,362,730
2013	1,749	1,316	879	3,111	187,044	1,376,298
2014	1,729	1,661	862	3,062	189,382	1,392,704
2015	1,557	1,714	826	3,117	191,482	1,406,299
2016	1,629	1,590	731	3,101	193,680	1,413,673
2017	1,655	1,766	772	3,196	196,325	1,421,658
2018	1,708	1,995	896	3,359	197,658	1,422,029
2019	1,576	1,707	805	3,054	199,459	1,422,094
2020	1,784	1,385	1,234	3,328	201,350	1,420,074
Percent Change 2010 to 2020	14%	1%	39%	18%	12%	6%

Sources: USCB 2019a, USCB 2020a

Census Tract 211.01 and the Leilani Estates CDP are considerably less racially diverse than both the State of Hawaiʻi and Hawaiʻi County, with approximately 59.7 percent and 59.9 percent of the population identifying as white, respectively, as compared to Hawaiʻi's 21.6 percent and Hawaiʻi County's 32.2 percent. Similarly, both Asians and Native Hawaiian and other Pacific Islanders make up a smaller portion of the population in Census Tract 211.01 and the Leilani Estates CDP than in Hawaiʻi and Hawaiʻi County (**Table 3-8**). The Nanawale Estates and Pahoa CDPs are more similar to Hawaiʻi and Hawaiʻi County in that they have large proportions of Asian, Native Hawaiian and other Pacific Islander, and multi-racial populations (**Table 3-8**).

Table 3-8 Race and Ethnicity

Race or Ethnicity	Leilani Estates CDP	Nanawale Estates CDP	Pāhoa CDP	Census Tract 211.01	Reference Populations	
					Hawai‘i County	Hawai‘i
White Alone (Not Hispanic/Latino)	59.9%	33.0%	16.0%	59.7%	32.2%	21.6%
Hispanic or Latino	9.7%	12.3%	9.4%	7.8%	11.1%	9.5%
Non-White (Not Hispanic/Latino)	30.5%	54.7%	74.6%	32.4%	56.7%	68.9%
Black or African American Alone	1.6%	1.6%	0.1%	1.0%	0.6%	1.5%
American Indian and Alaska Native Alone	0.6%[2]	1.6%[2]	0.1%	0.8%[2]	0.3%	0.2%
Asian Alone	3.2%	13.7%	33.7%	8.1%	19.1%	36.5%
Native Hawaiian and Other Pacific Islander Alone	6.8%	16.3%	18.4%	7.3%	13.1%	10.2%
Some Other Race Alone	0.6%	0.6%	0.6%	0.8%	0.5%	0.4%
Two or More Races	17.6%	20.8%	21.6%	14.6%	23.1%	20.1%
Total Minority[1] Population	40.1%	67.0%[2]	84.0%[2]	40.3%	67.8%	78.4%

Source: USCB 2020b
1. Minority as defined in Executive Order 12898 *Federal Actions to Address Environmental Justice Minority Populations and Low-Income Populations*. Minority populations include all individuals who identify as non-white or Hispanic/Latino.
2. Population meets criteria for environmental justice population.

Minority environmental justice populations are present when the population of minority individuals exceeds 50 percent or more than 10 percent of the reference population (i.e., Hawai‘i and/or Hawai‘i County). Minority environmental justice populations have been identified in the Nanawale Estates and Pahoa CDPs, as presented in **Table 3-8**.

American Indian environmental justice populations are present when the population of individuals exceeds 50 percent or is more than the reference population (i.e., Hawai‘i and/or Hawai’i County). Hawai‘i and Hawai’i County have low American Indian and Alaska Native populations (2.4 percent and 4.1 percent, respectively); as a result, all geographies within the area of analysis have American Indian environmental justice populations (**Table 3-9**).

Table 3-9 American Indian and Alaska Native Alone or in Combination with Any Other Race

Race	Leilani Estates CDP	Nanawale Estates CDP	Pāhoa CDP	Census Tract 211.01	Reference Populations	
					Hawai‘i County	Hawai‘i
American Indian and Alaska Native	6.8%[1]	10.8%[1]	4.2%[1]	7.1%[1]	4.1%	2.4%

Source: USCB 2020c
1. Population meets criteria for environmental justice population.

3.6.1.2 Economy and Employment

Hawai‘i County’s primary economic driver is tourism, with approximately 16.0 percent of jobs in the arts, entertainment, and recreation, and accommodation and food services industry and 11.3 percent of jobs in retail trade. Other industries with substantial employment in Hawai‘i County include educational services and health care and social assistance, as well as professional, scientific, and management, and administrative and waste management services, with 20.9 percent and 10.9 percent of jobs, respectively (**Table 3-10**). Within the Project vicinity, educational services and health care and social assistance jobs comprise between 21.6 and 40.7 percent of all employment. Other important industries in the area of analysis include construction and retail trade. Within the Pāhoa CDP and the Puna region as a whole, agricultural jobs are an important form of employment, with significant banana, papaya, macadamia nut, and flower production (County of Hawaiʻi 2005).

Table 3-10 2020 Industry Employment

Industry	Leilani Estates CDP	Nanawale Estates CDP	Pāhoa CDP	Census Tract 211.01	Reference Populations	
					Hawaiʻi County	Hawaiʻi
Agriculture, forestry, fishing and hunting, and mining:	2.8%	8.5%	19.8%	7.8%	4.8%	1.4%
Construction	15.6%	8.0%	3.9%	11.0%	7.6%	7.3%
Manufacturing	3.0%	1.7%	0.0%	6.0%	2.2%	2.9%
Wholesale trade	3.9%	2.5%	0.0%	2.0%	2.2%	2.2%
Retail trade	20.2%	5.5%	3.5%	13.3%	12.3%	11.3%
Transportation and warehousing, and utilities	5.2%	2.7%	2.2%	5.7%	4.2%	6.2%
Information	2.0%	0.5%	0.0%	2.1%	1.6%	1.5%
Finance and insurance, and real estate and rental and leasing	2.0%	5.2%	0.0%	3.4%	5.6%	6.6%
Professional, scientific, and management, and administrative and waste management services	9.7%	13.8%	3.9%	7.8%	10.9%	10.3%
Educational services, and health care and social assistance	19.4%	29.1%	40.7%	21.6%	20.9%	21.3%
Arts, entertainment, and recreation, and accommodation and food services	7.8%	9.8%	15.5%	6.6%	16.4%	16.0%
Other services, except public administration	3.0%	2.0%	7.3%	7.2%	4.7%	4.3%
Public administration	5.5%	0.5%	3.2%	5.4%	6.6%	8.8%

Source: USCB 2020d

As of September 2022, Hawaiʻi County had an unemployment level of approximately 3.5 percent, or 3,350 people unemployed. Unemployment in Hawaiʻi has recovered since a peak in April 2020 at 21.9 percent due to the COVID-19 pandemic and was 3.3 percent or 14,950 people as of September 2022. Unemployment in Hawaiʻi County also peaked in April 2020 at 21.9 percent (DBEDT 2022).

3.6.1.3 Income

Within Hawaiʻi County, the industries with the highest average wages include data processing, hosting, and related services ($703,758), other information services ($473,564), and electronic markets, agents, and brokers ($131,841) (DBEDT 2021).

Estimates for 2020 indicate that both median household income and per capita personal income in Census Tract 211.01 lag behind the state average by approximately 61 percent and 13 percent, respectively (**Table 3-11**). Additionally, the poverty rate for the Leilani Estates, Nanawale Estates, and Pāhoa CDPs and Census Tract 211.01 is considerably higher than the reference population of Hawaiʻi and Hawai'i County. This would constitute a low-income environmental justice population within the Project vicinity.

Table 3-11 Median Household Income, Per Capita Income, and Poverty Rate of Individuals

Category	Location					
	Leilani Estates CDP	Nanawale Estates CDP	Pāhoa CDP	Census Tract 211.01	Hawaiʻi County	Hawaiʻi
Household Median Income (dollars)	$27,708	$42,563	$31,734	$27,670	$65,401	$83,173
Per Capita Income (2020 dollars)	$23,250	$22,913	$19,947	$25,719	$31,863	$37,013
Percent Below Poverty Level	35.1%	21.9%	29.7%	31.3%	14.0%	9.3%

Sources: USCB 2019c, USCB 2019d, USCB 2019e

In 2021, the average annual wage was $51,495 in Hawaiʻi County and $59,641 in Hawaiʻi (DBEDT 2021).

3.6.1.4 Housing

Workers typically choose a residence location based on a combination of job proximity, housing availability, and access to public and private services. The Kīlauea Voluntary Housing Buyout Program was initiated in April 2021 and used federal funds to purchase properties impacted by the 2018 Lower Puna eruption. Eligible properties must have been impacted by the disaster, whether by inundation, isolation, damage by fires caused by lava, or secondary effects of volcanic activity, such as heating or gases. Acquired residences will be removed and properties will be managed as open space with the possibility of limited agricultural use. Large portions of the Project vicinity, including the eastern portion of the Leilani Estates CDP, were impacted by the 2018 Lower Puna eruption and are eligible for the buyout. A total of 612 homes, including 294 primary residences, were destroyed during the eruption (County of Hawaiʻi 2022b). As a result, housing opportunities in the vicinity of the Project are limited. Housing vacancy rates as of 2020 are provided in **Table 3-12**.

Data from the 2020 Census indicate that Census Tract 211.01 has an estimated 415 vacant units out of 1,958 units for a total vacancy of 21 percent. Vacancy within the Leilani Estates CDP is estimated at 13 percent, with approximately 113 vacant units. These vacancy estimates likely include vacant properties that are eligible for the buyout program due to property damage or isolation; therefore, vacancy within the Project vicinity is likely lower than estimated. Housing near the Project is also available within the Nanawale Estates CDP and the Pāhoa CDP, with vacancy rates of 17 percent and 25 percent, respectively. These areas were not directly affected by the 2018 Lower Puna eruption (USCB 2020d).

Short-term lodging opportunities within the Project vicinity are limited. There are no hotels in the Project vicinity. The establishment of new short-term vacation rentals is prohibited within much of the area surrounding the Project; however, exceptions for existing establishments apply, and there are several private residences available for rent, primarily in the south near the Kehena Black Sand Beach (Planning Department 2022). Multiple large hotels are available in the Hilo area including the Grand Nanniloa Hotel (379 rooms), SCP Hilo Hotel (128 rooms), and Hilo Hawaiian Hotel (286 rooms).

Table 3-12 Housing Vacancy Rates within the Area of Analysis (2020 Estimates)

Location	Total Housing Units	Occupied Housing Units	Vacant Housing Units	Vacancy Rate (percent)	Vacancy Rate by Type (Percent)	
					Homeowner Units	Rental Units
Leilani Estates CDP	887	774	113	13%	0.0%	6.6%
Nanawale Estates CDP	691	573	118	17%	0.0%	4.7%
Pāhoa CDP	359	268	91	25%	6.6%	18.2%
Census Tract 211.01	1,958	1,543	415	21%	0.0%	5.6%
Hawaiʻi County	87,824	69,453	18,371	21%	2.6%	9.6%

Location	Total Housing Units	Occupied Housing Units	Vacant Housing Units	Vacancy Rate (percent)	Vacancy Rate by Type (Percent)	
					Homeowner Units	Rental Units
Hawaiʻi	542,674	459,424	83,250	15%	1.4%	9.4%

Source: USCB 2020c

3.6.1.5 Community Development

A Geothermal Relocation Fund was created in 1996 and was subsequently expanded in 2008 to the Geothermal Relocation and Community Benefits Fund. The fund can be used for two primary purposes: to purchase property from owners/occupants near the PGV plant and for infrastructure and service improvements in Lower Puna. The Hawaiʻi County Planning Department administers the fund. This fund collects geothermal royalties for the "utilization of geothermal resources" (Kohala Center 2012). Examples of community benefits supported by the fund include the purchase of two 33-passenger buses for the region, Pahoa Pool and community center upgrades, and road upgrades (Planning Department 2010).

3.6.2 Environmental Impacts

3.6.2.1 Proposed Action

Population and Demographics

The construction phase of the Project**, under both Phase 1 and Phase 2 of the Proposed Action,** is expected to require a temporary workforce of approximately 75 contractors. **No additional permanent jobs beyond those already existing would result from the Project; o**~~O~~perations employment is not expected to increase beyond the current workforce of 31 employees. Selection of contractors would be based on job requirements. It is estimated that approximately one-third of the workforce needed is available locally on-island (25 employees). Approximately two-thirds of the workforce would be from contractors located off-island (50 employees). Workers from off-island would consist of employees from elsewhere in Hawaiʻi and from the mainland and may include current Ormat contractors working on other projects.

Because of the nature of construction activities, it is likely that the workers during the construction phase would include mostly younger workers who would relocate to the island temporarily and would not bring their families. On-island workers that are not from the Hilo or Puna area and off-island workers would be expected to return home after the completion of Project construction, and as a result, demographics, including total population and racial and ethnic diversity, of the area would not be anticipated to change dramatically from existing conditions.

Furthermore, based on the state's consumer advocate estimate that the typical residential customer could save between $22.68 per month under the First and Second Amendments to the ARPPA (Division of Consumer Advocacy 2023), this would be considered a beneficial impact to local low-income communities.

Economy and Employment

Direct jobs are positions that are created directly by PGV. Indirect jobs are created as a result of PGV spending on goods and services, and induced jobs are created by the spending of PGV employees in the region. As stated above, 75 direct jobs would be created during the construction phase of the Proposed Action, of which approximately 25 are expected to be locals and 50 are expected to be non-locals. Direct positions include welders, heavy equipment operators, drillers, and construction workers. The Project may also create a small number of indirect and induced jobs, including positions in employment services, support transportation, restaurants, and/or hospitals. Employers would likely hire local workers for indirect and induced jobs.

Approximately 25 direct employees would be hired locally, representing approximately 0.7 percent of unemployed people in Hawaiʻi County. Additionally, the Project would have a small effect on unemployment within the state of Hawaiʻi and on the mainland. Overall, the effect of the Project on employment in the area of analysis would be beneficial, and impacts are expected to be minor and short-term.

Income

For construction of the Project, PGV would hire positions such as welders, heavy equipment operators, drillers, and construction workers. The average annual wages for positions within the construction industry in Hawaiʻi and Hawaiʻi County are presented in **Table 3-13**.

Table 3-13 Average Annual Wages for Select Construction Industry Jobs (2021)

Industry	Average Annual Wages (Hawaiʻi County)	Average Annual Wages (Hawaiʻi)
Total Annual Average Wage for All Industries	$51,495	$59,641
23 – Construction	$67,150	$80,273
236 – Construction of buildings	$67,953	$82,680
2362 – Nonresidential building construction	$83,592	$95,989
237 – Heavy and civil engineering construction	$81,647	$99,428
2371 – Utility system construction	$69,344	$90,005
2379 – Other heavy construction	N/A	$113,122
238 – Specialty trade contractors	$61,748	$74,950
2381 – Building foundation and exterior contractors	$56,580	$69,301
2382 – Building equipment contractors	$69,044	$80,284

Source: DBEDT 2021

Although actual wages are unknown, estimates suggest that the average annual wages for construction workers at the Project would exceed the average annual wages in Hawaiʻi County and Hawaiʻi. However, due to the small number of locally hired employees and the short-term nature of the construction phase, the Project is unlikely to significantly improve the median income, per capita income, and poverty rates within the Project vicinity. Overall, impacts as a result of income would be minor, short-term, and regional.

For operations at the Project, PGV would retain the current operations workforce of 31 employees, as stated above. Operations jobs at PGV fall under the power generation and supply industry, within which average wages are the 10th highest for all industries in Hawaiʻi County, with an average salary of $118,862 for 2021. Power generation and supply salaries were the 12th highest for the State of Hawaiʻi at $114,664 annually (DBEDT 2021). If operations at the PGV facility site were to be extended, these well-paying jobs would in turn be extended and continue to contribute to the local economy.

Housing

Workers from on-island that do not currently reside in the Pāhoa or Hilo area would likely stay in hotels in Hilo and return home on the weekends. Workers from off-island would likely stay in hotels in Hilo or rent houses in Hilo, Pāhoa, or the surrounding communities for the duration of the Project's construction. As shown in **Table 3-12**, vacant rental units are available in neighborhoods in the Project vicinity. Impacts to the available housing stock are anticipated to be minor, short-term, and regional.

3.6.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. The impacts to socioeconomics and environmental justice from this alternative would be the same as those described above for the Proposed Action.

3.6.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. Future actions at the site would likely occur as described in **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Under this alternative, the economic benefits of employment at the facility and the Geothermal Relocation and Community Benefits Fund would end after decommissioning activities are completed if the facility were to be decommissioned in 2027, without an extension, after the current PPA expires. Secondary impacts to minority environmental justice populations from this alternative could result from subsequent development of the site, increased burning of fossil fuels, and/or development of new power production projects.

3.7 Historic Resources

Information in this section is summarized from the Archaeological Field Inspection conducted for the Project, included as **Appendix H** (Escott 2023a).

3.7.1 Existing Environment

3.7.1.1 Traditional Accounts (Moʻolelo) of Puna and Kapoho

The Project is located in Kapoho Ahupuaʻa, Puna District. Puna District is located on the eastern tip of Hawaiʻi Island and extends from the ocean to the eastern edge of Kīlauea-iki Crater (Halemaʻumaʻu) at 4,000 feet above mean sea level and Kūlani cone at 5,518 feet above mean sea level. The division of Hawaiʻi Island into six moku-o-loko (districts) and smaller ahupuaʻa was formalized during the early 16th century under the rule of Umi-a-Līloa. The divisions are part of a sociopolitical agricultural land management system influenced by natural environmental factors, agricultural zones, family relationships, and traditional Hawaiian cultural values.

Kapoho Ahupuaʻa is located from the ocean just below Cape Kumukahi at the eastern tip of Hawaiʻi Island to 680 feet above mean sea level. Kapoho translates literally as “the depression,” which references the large Kapoho Crater two kilometers west of the coastline; the Kapoho Ahupuaʻa crater is the result of a cone formed between 400 and 700 years ago. Puʻu Honuaʻula, translated literally as “red place of refuge,” is a second large cone formed between 200 and 400 years ago and is located at the Project facility site.

Many of the traditional moʻolelo (legendary accounts) passed down orally refer to the specific moku-o-loko, ahupuaʻa, puʻu (cones), and other natural geological features where the stories take place. There are also numerous moʻolelo and ʻōlelo noʻeau (proverbs and sayings) that tell of Puna’s natural beauty, its gods (akua and aumakua) and places, and its inhabitants’ practices.

Puna translates to “well-spring,” and the Puna District is closely associated with Kāne, god of the verdant forests of Puna and the Hawaiian god of sunlight, also known as Kāne-i-ka-nohi-o-ka-i (Kāne-in-the-eyeball-of the sun). Kāne is foremost among the great gods and is associated with procreation, regeneration, the dawn, sunlight, lightning, refreshing spring water, irrigated agriculture, and fishponds. Kāne and Lono were the deities most commonly addressed by those who offered prayers for the restoration of anyone to health.

When Hawaiians who had been ill recovered, they frequently vowed to make a “journey of health.” This meant that they came to the place now known as Hilo Bay. There they bathed by the beautiful little Coconut Island, fished up by the demi-god Maui, and swam around a stone known as Moku-ola (the-island-of-life). They walked along the seashore day after day until they were below Kīlauea Volcano and went up to the pit of Pele, offered sacrifices, then followed an overland path back to Hilo. It was an ill omen if for any reason they went back by the same path, as they must make the "journey of health" with the face forward. Hopoe (the dancing stone), Kapoho (the green lake), and Kumu-kahi were among the places that must be visited.

One ʻōlelo noʻeau says, "Puna, kaʻāina i ka haupo o Kāne," the land [held] in the bosom of Kāne. Another says of Puna, "Ke one lauʻena a Kāne": the rich, fertile land of Kāne. Puna is known through traditional oral accounts and proverbs for its groves of pū hala (pandanus trees) with their fragrant clusters of hua hala (pandanus fruit born on the female trees) and the hīnano (blossoms of the male pandanus).

The traditional oral accounts of early Puna recognize the presence of a volcanic god of fire, called ʻAi-lāʻau (the devourer of forests), that lived within Kīlauea before the arrival of Pele to the island. While ʻAi-lāʻau lived within Kīlauea, he also inhabited the LERZ craters for a time before returning to his main residence within Kīlauea. It was there he resided when Pele first arrived, who landed on the island along the shore of Puna and proceeded inland to meet ʻAi-lāʻau and to find a new home with him. ʻAi-lāʻau was filled with fear upon seeing Pele arrive, ran away, became lost, and vanished. Pele made her new home within Kīlauea.

In the 19th century, Frenchman Jules Remy recorded a story told to him by an aliʻi of Kona called Kanuha, anticipated to have taken place during the 17th century. According to the story, an aliʻi from Puna named Keliʻikuku was boasting of Puna to a prophet of Pele from Kauaʻi named Kāne-a-ka-lau. Keliʻikuku boasted of Puna's charms, abundance, and rich sandy plains where everything grows luxuriantly. Pele, hearing Keliʻikuku's boasting, covered the fertile plains and forests of Puna with burning lava.

3.7.1.2 Testimony Before the Commission to Quiet Land Titles

Article IV of the Board of Commissioners to Quiet Land Titles was passed in December 1845 and began the legal process of private land ownership. The Māhele (1848–1850) established a board of five commissioners to oversee land claims and to issue patents and leases for valid claims. Many scholars believe that Kauikeaouli (Kamehameha III) established laws intended to protect Hawaiian sovereignty and crown lands from foreigners who had already begun claiming ownership of land they were granted permission to use for homes and business interests. Among other things, the foreigners were demanding private ownership of land to secure their island investments, particularly agricultural and ranching ventures.

As legal statutes defining the Māhele continued to be enacted from 1845 to 1850, the lands of the kingdom of Hawaiʻi were divided among the king (crown lands), the aliʻi and konohiki, and the government. Once lands were thus divided and private ownership was instituted, the makaʻāinana (commoners), if they had been made aware of the procedures, were able to claim the plots on which they had been cultivating and living as stipulated in the Kuleana Act (1850). However, these claims could not include any previously cultivated or presently fallow land, ʻokipuʻu (forest clearing created to allow sunlight to reach the forest floor), stream fisheries, or many other resources traditionally necessary for survival. The right of claimants to land was based on the testimony of at least two witnesses who could corroborate the claimant's long-standing occupation and use of the lot(s) in question. The claimant was then awarded land parcels, also known as kuleana parcels, for which they received a Land Commission Award. The Kapoho ahupuaʻa was given to Charles Kanaina during the Māhele of 1848 by King Kamehameha III. His land claim was subsequently confirmed through Land Commission Award 8559-B. No kuleana parcels in Kapoho ahupuaʻa were awarded by the Land Commission.

3.7.1.3 Historic Accounts of Pre-Contact Era Puna

Historical accounts pertaining to lands in the vicinity of the PGV facility site are scarce but provide some information on traditional residence patterns, land use, and subsistence. Situated along the windward coast of Hawaiʻi Island, Puna is a verdant and abundant district with good rainfall and rich soils; however, it is also subject to volcanic eruptions and has been covered by new lava in many places over the last 1,000 years. Much of the district's coastal areas have thin soils, and there are no good deep-water harbors. The ocean along the Puna coast is often rough and windblown. As a result of these two factors, settlement patterns in Puna tend to be dispersed and without major population centers in contrast to north and south Kona and Hilo and Hāmākua. Villages in Puna tend to be spread out over larger areas and often are inland, sometimes away from the coast, where the soil is better for agriculture.

3.7.1.4 Historic Accounts of Contact Era Puna

William Ellis passed through Puna in 1823 while traveling along the coastal trail from Kīlauea to Waiākea Ahupuaʻa in Hilo. Ellis' journey took him along the coast near past Kapoho Crater and Green Lake. His journal includes descriptions of the villages and landscape he passed through. It also includes descriptions of gardens, the availability and quality of drinking water, population estimates, and moʻolelo, which are the most detailed and complete from the contact era accounts of Puna.

3.7.1.5 Changing Residential and Land Use Patterns

The modern history of land use in Kapoho Ahupuaʻa is tied to the development of commercial agriculture and the construction of transportation routes. The potential to use Kapoho's rich arable land for commercial prospects was recognized in the late 1800s and early 1900s when it was purchased for commercial sugarcane and coffee growing, as well as for cattle pasture. In 1881, large tracts of land in north and south Puna were purchased at auction by Samuel Damon, William H. Shipman, and E. Elderts from trustees of the deceased William C. Lunalilo Estate. Shipman bought out the two partners within three years of purchasing the land. William H. Shipman operated a cattle ranch in Kapoho Ahupuaʻa and was the owner of the Waiākea Stock Ranch. Shipman was also co-owner of the Shipman Meat Market, later the Hilo Meat Company. He also established the ʻOlaʻa Sugar Company in the Puna District in 1899 and leased large portions of his land in Puna to the newly formed company.

During the modern era, lands surrounding the PGV facility site were used primarily for private residences and small privately owned farms.

3.7.1.6 Previous Archaeological Investigation

There are very few previous archaeological studies within Kapoho Ahupuaʻa. Many of the heiau identified in Puna were abandoned and in disrepair at the time they were recorded in the early 1900s, and there were no heiau identified in Kapoho Ahupuaʻa.

Four archaeological studies were conducted within the Project Area, and an additional archaeological reconnaissance survey of Kapoho Well Site 1 and Kapoho Well Site 2 within the currently existing PGV facility site was conducted. There were no archaeological remains identified within the PGV property boundary. Additional details regarding previous archaeological investigations are included in **Appendix H** and the 1987 EIS (PGV 1987).

3.7.1.7 Current Survey Area

Consistent with Chapter 6E-42, HRS, and Condition 28 of the GRP, a pedestrian archaeological survey of the proposed areas of surface disturbance not previously surveyed was conducted for the Project (**Appendix H**). There were no archaeological features, feature remains, or artifacts identified within the pedestrian survey area, nor were there any on the 2018 Lower Puna eruption lava flow. The field inspection pedestrian survey concluded that there are no archaeological sites or features within the Project Area.

3.7.2 Environmental Impacts

3.7.2.1 Proposed Action

The Proposed Action would result in up to 11.9 acres of surface disturbance; however, no archaeological sites or features ~~were~~**are** located in the Project Area, and none are known in the immediate vicinity based on the results of the pedestrian archaeological survey (**Appendix H**). As part of the application for previous grading permits associated with the existing PGV facility site, PGV has complied with the Chapter 6E (Historic Preservation Review) process to demonstrate that no subsequent work has affected historic properties. PGV would continue to comply with Chapter 6E under the Proposed Action. Additionally, PGV would continue to comply with Condition 29 of the GRP, which states that if construction activities expose any cultural remains, the permittee must immediately cease work, the Planning Department and DLNR State Historic Preservation Division would be contacted, and monitoring by a qualified archaeologist would be conducted during Project activities. As a result, the Project is not anticipated to impact historic resources.

3.7.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. The impacts to historic resources from this alternative would be the same as those described above for the Proposed Action.

3.7.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described above. Future actions at the site would likely occur as described in **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Impacts beyond existing conditions to historic resources would not occur under the No Action Alternative.

3.8 Cultural Practices

Information in this section is from **the 1987 FEIS and from** the Cultural Impact Assessment (CIA) and *Ka Paʻakai O Ka ʻĀina* Analysis conducted for the Project, which is included as **Appendix I** (Escott 2023b).

Cultural Impact Assessment

Act 50, enacted by the Legislature of the State of Hawaiʻi (2000) with House Bill 2895, relating to EISs, proposes that:

> . . . there is a need to clarify that the preparation of environmental assessments or environmental impact statements should identify and address effects on Hawaiʻi's culture, and traditional and customary rights . . . (H.B. No. 2895).

Act 50 requires state agencies and other developers to assess the effects of proposed land use or shoreline developments on the "cultural practices of the community and State" as part of the HRS Chapter 343 environmental review process (2001). This CIA involves evaluating the probability of impacts on identified cultural resources, including values, rights, beliefs, objects, records, properties, and stories occurring within the Project Area and vicinity (H.B. 2895, Act 50, 2000). The CIA was prepared in accordance with the methodology and content protocol provided in the Guidelines for Assessing Cultural Impacts (Environmental Council 1997).

Ka Paʻakai O Ka ʻĀina Consideration

The September 11, 2000, Hawaiʻi Supreme Court decision in *Ka Paʻakai O Ka ʻĀina v. Land Use Commission* ruled that state agencies are required to assess, preserve, and protect traditional Hawaiian practices associated with lands over which state agencies have power of permit. The decision provides an analytical framework for addressing the preservation and protection of native Hawaiian customary and traditional practices. The framework includes determining the following:

> (1) the identity and scope of "valued cultural, historical, or natural resources" in the petition area, including the extent to which traditional and customary native Hawaiian rights are exercised in the petition area; (2) the extent to which those resources—including traditional and customary native Hawaiian rights—will be affected or impaired by the proposed action; and (3) the feasible action,

> if any, to be taken by the LUC [state agency] to reasonably protect native Hawaiian rights if they are found to exist (*Ka Pa‘akai O Ka ‘Āina v. Land Use Commission*, 94 Hawai‘i 31, 7 P.3d 1068 [2000]).

3.8.1 Existing Environment

Historical and Cultural Contexts

Many archaeologists believe that Hawai‘i Island was first settled around AD 1000 by people sailing from the Marquesas (**Appendix I**). An article published in the *Journal of Archaeological Science* reviewing radiocarbon dates recovered at archaeological sites on Hawai‘i Island suggests that, by relying on only carbon samples from short-lived plant remains, the most reliable dates point to initial Polynesian colonization of Hawai‘i Island occurring between AD 1220 and 1261.

The recent studies that included Hawai‘i Island short-lived radiocarbon dating samples assess those recovered exclusively from sites in North Kohala, South Kohala, and Hāmākua (Rieth et al. 2011) or from South Point (Ka Lae) in Ka‘ū. Many of the former region sites are rock shelters, and the latter are sand dune sites. Sixteen radiocarbon samples from North Kohala, South Kohala, and Hāmākua returned conventional radiocarbon ages from 400 to 781 years before present. The early date is consistent with ranges of AD 1040–1090 and AD 1120–1280 from Ka Lae in South Point, Ka‘ū. All of the samples were recovered from sites in arid environments that have not been disturbed by modern development or human activity. There are no radiocarbon dating samples from Hilo or Puna where there has been a lot of development-associated disturbance and where environmental conditions for radiocarbon sample preservation is less favorable.

The Project Area is located in Kapoho Ahupua‘a, Puna District. There are numerous mo‘olelo and ‘ōlelo no‘eau (proverbs and sayings) that tell of Puna’s natural beauty, its gods (akua and aumakua) and places, and its inhabitants’ practices. A detailed list and descriptions of akua and aumakua associated with Puna can be found in Uyeoka et al. (2014). An in-depth ethnographic study for the Hawai‘i Geothermal Project documenting traditional accounts and beliefs can be found in Matsuoka et al. (1996).

Three mo‘olelo of Pele were included in the CIA (Appendix I).

Ke One Lau‘ena A Kāne, The Great Sands of Kāne

Traditional mo‘olelo describe early Ka‘ū and Puna as beautiful lands without lava beds (Uyeoka et al. 2014:86). It was said that there was only earthen soil from one end to the other. The mo‘olelo tell of the existence of a very long sandy stretch called Keonelauenaakāne (“Kāne’s great sand stretch”) in the Puna District that was covered by lava and transformed the area into a land of lava rock **during a fight between Pele and** ~~.The~~**two** mo‘o **named** Wakakeakaikawai, and Puna‘aikoa‘e~~ were destroyed by Pelehonuamea of the eternal fires~~. According to this legend, the fight between these mo‘o and ~~Pelehonuamea~~ **Pele** began in Punalu‘u in Ka‘ū, continued in Puna, and ended in Waiākea in Hilo. Through the course of the battle, a long stretch of sand extending from Waiākea, Hilo, to Pānau in Puna called Keonelauenaakāne was covered with lava. Because ~~Waka~~ **Wakakeakaikawai** ran through Puna, with Pelehonuamea in pursuit, most of the land in Puna became covered with rough and smooth lava and remains so to this day. The famous stretch of sand disappeared, and currently, only traces of it can be seen in small pockets scattered from Waiākea to Puna.

Pelehonuamea and Keli‘ikuku

The stor~~e~~**y** of Pele’s introduction and presence in Puna **and throughout the Hawaiian Islands** is described in the historic resources section above. Pele was known to become impatient with the misdeeds of others and would often:

> send a flood of lava in her anger and burn everything up. Earthquakes came when Pele stamped the floor of the fire-pit in anger. Flames thrusting themselves through cracks in a

> breaking lava crust were the fire-spears of Pele's household of au-makuas or ghost-gods. Pele's voice was explosive when angry. Therefore it was called "pu."

There are numerous traditional accounts of Pele punishing arrogant and impudent chiefs, including chief Kahawali, chief Kumu-kahi, chief Papalauahi, Kapapala, and Kealohalani. Pele punished them by sending out rivers of lava that often chased the offenders to the sea where they or their families and lands were covered and destroyed. Pele would also reward those who treated her with generosity and proper respect. According to accounts, offerings made to appease Pele include fruits, flowers, lei, pigs, chickens, fish, and men.

Pōhaku-o-Hanalei and Pōhaku-o-Lēkia

Pōhaku-o-Hanalei and Pōhaku-o-Lēkia are pōhaku (stones) that reside within the ahupuaʻa of Kapoho in Puna. These pōhaku are situated on either side of the lake called Wai a Pele, known as Green Lake today. When Pele and her immediate family came from Tahiti, certain rock kupua accompanied her to the islands of Hawaiʻi, namely Pōhakuolēkia (who lived in Kapoho, Puna).

Historic Accounts

Historic accounts of Puna are described in the historic resources section above.

Interviews

Invitations to consult were sent to individuals and organizations whose jurisdiction includes knowledge of the area. Consultation was sought from the following: Shane Palacat-Nelsen**, Kamakana Ferreira, Kalena Blakemore, and Lauren Morawski**, Office of Hawaiian Affairs (OHA); Jordan Kea Calpito, DLNR State Historic Preservation Division Burial Sites Specialist; and Desmon~~d~~ Haumea, Hawaiʻi Island Burial Council (HIBC) Puna Representative. OHA was also sent a copy of the CIA for comment on April 12, 2023.

HIBC Puna Representative Desmon~~d~~ Haumea, a long-time traditional Hawaiian cultural practitioner, responded by phone call that he was familiar with the Project Area lands and PGV. He noted that there are many Hawaiians who both oppose and support the production of electricity by PGV. Opposition is likely because of the traditional Hawaiian beliefs and practices surrounding Pele and the natural environment in general. He noted that those who support it likely do so because of beliefs that geothermal electricity generation is a more environmentally friendly and sustainable means of producing electricity compared to generating electricity by burning fossil fuels. While Mr. Haumea is familiar with cultural beliefs and practices surrounding Pele, he is not aware of any cultural practices associated with the Project Area lands.

Area resident and Hawaiian Luana Jones responded to the public notice (Appendix B to the CIA) by letter dated August 31, 2022. Ms. Jones' letter stated her opposition to the Project noting that it goes against the traditional Hawaiian cultural belief of the interdependence of all living things and the natural environment and the practice of responsibly nurturing the land. Her main concern is that the ground temperatures are too hot and will cause blowouts and release of toxic fluids and gases, thereby poisoning the surrounding environment and communities.

Area resident and Hawaiian Luella Nohea Crutcher responded to the public notice (Appendix B to the CIA) by letter dated September 2, 2022. Ms. Crutcher's letter states her opposition to the Project, as it goes against the traditional Hawaiian belief of respecting the elements of the natural environment and the traditional Hawaiian practices of preserving, protecting, and being one with the elements of the natural environment. Hawaiians show respect and give thanks for all that nature gifts through their traditional practices. Ms. Crutcher stated that it is disrespectful and a desecration to take from Pele by drilling into the earth. In addition, the drilling causes pollution to the air, land, and ocean. She stated that the taking of heat from Pele and polluting the environment are not supported by and do not respect traditional Hawaiian cultural beliefs and practices.

Hawaiian traditional cultural practitioner Palikapu Dedman testified at the public community meeting held at the Pāhoa Neighborhood Facility in Pāhoa on August 17, 2022. Mr. Dedman began by asking what happens to Hawaiians when foreigners impose their beliefs on Hawaiians and alter the traditional beliefs of Hawaiians. He continued by stating traditional Hawaiian beliefs are in danger and there should be more respect for Hawaiians, including traditional beliefs about Pele. Hawaiians hold these traditional beliefs, and there are federal laws and the state constitution that protect their rights to traditional beliefs and practices. Mr. Dedman stated that everybody should respect Hawaiian traditional beliefs.

In addition to the consultation, historical and cultural source materials were extensively researched during preparation of the CIA. The scholars referenced in **Appendix I** have contributed, and continue to contribute, to our knowledge and understanding of Hawaiʻi, past and present. The Native Hawaiian Ethnographic Study for the Hawaiʻi Geothermal Project (Matsuoka et al. 1996) was also researched to determine the cultural sensitivity and traditional Hawaiian cultural beliefs and practices of the Project Area and surrounding lands of Kapoho Ahupuaʻa. The works of these and other authors were consulted and incorporated into the CIA where appropriate. Land use document research was supplied by the Waihona ʻAina 2007 database.

Past and Current Consultation and Testimonies

The 1987 EIS and 1996 Native Hawaiian Ethnographic Study for the Hawaiʻi Geothermal Project include extensive discussions of Native Hawaiian religious beliefs and practices, with an emphasis of traditions and beliefs pertaining to Pele. These discussions include a summary of archival research, interviews, and testimonies presented to the Board of Land and Natural Resources in 1985 and 1986 and obtained through interviews in 1996. The information about cultural practices and traditions documented in the 1987 EIS remains relevant today and is echoed in public comments received during the comment period for the Draft EIS for this Project. Collectively, past and present testimonies and comments indicate:

1. **According to traditional Hawaiian beliefs held in the past and present, especially by Pele practitioners who actively worship her, Pele is a revered and living akua (deity) and may be aumakua (family or personal deity) and/or kupuna (ancestor).**
2. **Pele traveled to Hawaiʻi from Kahiki with many of her relatives, including her favorite sister Hiʻiaka.**
3. **Puna, and the other areas of volcanism (including Halemaumau) are the physical body and home of Pele, and that the islands abound with places she has traveled and left evidence of her being and the moʻolelo that tell her story.**
4. **Physical manifestations (kino) of Pele include magma, lava, heat, water, steam, smoke, and vapor associated with volcanism.**
5. **There are a variety of religious beliefs held by Native Hawaiians, and their religious concerns deserve respect and care should be taken not to harm religious practice. To some, taking geothermal heat without permission is disrespectful and a desecration; to others, geothermal heat is a makana (gift) from Pele.**

Identified Cultural Practices

Based on the research conducted for the Proposed Action, and the comments and responses received during consultation and as part of the EIS process, no ongoing traditional Hawaiian cultural practices currently occur within the Project Area. The body of research stretching back to the preparation of the 1987 EIS does not identify any past cultural practices conducted in the Project Area, except as conducted on behalf of PGV. These included cultural protocols such as blessings and requesting permission conducted by the late Kahu Minnie Kaʻawaloa and by Kahu Piʻilani Kaʻawaloa. For a variety of reasons since 2018, PGV has not requested that Kahu Pi`ilani Ka`awaloa participate in such cultural practice protocols at the PGV facility. These protocols were performed ahead of major projects at the site.

PGV also conducts annual cultural education of its staff, including a chant entitled "Ku Makou" which speaks to the migration of Pele from Tahiti to Hawaiʻi.

Summary

T~~Based on t~~he results of consultation, **past testimonies,** ethnographic research, and previous archaeological studies **referenced above provide information regarding cultural practices as discussed in Act 50 and valued cultural, historical, and natural resources in the Project Area including the extent to which traditional and customary native Hawaiian rights are exercised in the Project Area as discussed in *Ka Pa'akai O Ka 'Āina v. Land Use Commission.***

Based on these results, there are no **discrete** cultural, historical, **or** natural resources ~~, or past or ongoing cultural practices located specifically in the Project Area~~located specifically in the Project Area. **Although no discrete resources have been identified, Native Hawaiian traditions and beliefs, and especially the traditions of Pele practitioners, state that Pele is present throughout Hawai'i and especially in volcanic areas of Puna, which includes the Project Area. Kinolau (manifestations) of Pele include magma, lava, heat, water, steam, smoke, and vapor associated with volcanism, as well as ferns, certain shrubs and trees, and certain volcanic landforms or features, such as significant pu'u.**

Cultural practices, including the exercise of traditional and customary native Hawaiian rights, conducted in the Project Area, until disrupted in 2018, were limited to traditional Hawaiian protocols such as blessings conducted by Hawaiian cultural practitioners on behalf of PGV. No other traditional Hawaiian cultural practices are known for the Project Area. Cultural education for employees and coordination with local cultural practitioners have also been conducted at the PGV facility. Consultation for this Project identified general traditional Hawaiian beliefs recognizing the interdependence of people and the natural environment and traditional values to protect and nurture the natural environment. There are traditional practices that protect and increase the environment's health and bounty associated with those beliefs. These beliefs and practices would include not increasing pollution.

~~Consultation identified general traditional Hawaiian beliefs recognizing the interdependence of people and the natural environment and traditional values to protect and nurture the natural environment. There are traditional practices that protect and increase the environment's health and bounty. These beliefs and practices would include not increasing pollution. In addition, there are traditional beliefs that volcanic activity is of and from Pele. In general, traditional beliefs and practices surrounding Pele include reverence and respect and offerings made to Pele.~~

3.8.2 Environmental Impacts

3.8.2.1 Proposed Action

No discrete valued cultural, historic, or natural resources are identified within the Project Area; however, under the Proposed Action, the same geothermal energy source that is currently in use at PGV would continue to be used. Some members of the public and some native Hawaiian cultural practitioners believe that volcanic activity is simultaneously a form of Pele and something created by her. Traditional beliefs and practices surrounding Pele include reverence, respect, and offerings made to her. Testimony received during the comment period for the Draft EIS indicates that some Pele practitioners believe that the extraction of heat and steam from the Project Area, especially if done in a culturally insensitive manner and without permission, is disrespectful to Pele and risks alienating her from those who believe in her. At the same time, other testimony received during the comment period states that some traditional native Hawaiian cultural practitioners consider geothermal resources to be a makana or gift from Pele, and that using this gift can be culturally appropriate. Based on the research conducted for the Project, and the comments and responses from the above-listed individuals, it is acknowledged that given the nature of certain native Hawaiian traditional and customary beliefs, any operation of the PGV facility would be considered by some people and/or practitioners to negatively impact to their relationship with Pele. For those who consider geothermal resources to be makana from Pele, the Proposed Action, if conducted in a culturally appropriate manner, would not negatively impact that relationship.

As stated in the CIA (**Appendix I**), ~~all the research suggests that,~~ in general, there are traditional Hawaiian beliefs recognizing the interdependence of people and the natural environment and that ~~there are important traditional values to~~ protect**ing** and nurtur**ing**~~e~~ the natural environment **are important traditional values**. There are traditional practices **based on these beliefs** that protect and increase the environment's health and bounty~~. These beliefs and practices would include not increasing pollution. In addition, there are traditional beliefs that volcanic activity is of and from Pele. In general, traditional beliefs and practices surrounding Pele include reverence, respect , and offerings made to Pele~~As discussed above, the Proposed Action is anticipated to decrease **impacts to** air ~~pollution~~ **quality** ~~resulting from~~**by** replacing existing facility equipment with new and more efficient equipment **(see Section 3.3.2.3)**. **To the extent that the existing PGV facility proceeds to operate as currently authorized and helps to reduce air pollution by lessening dependence on electricity generated by burning fossil fuels, the replacement of the 12 existing OECs with the four new OECs proposed under the Proposed Action could be considered consistent with the general spirit of traditional Hawaiian cultural beliefs and practices regarding protection and care of the environment**. **BMPs including controlling and preventing the release of hazardous materials would ensure that these traditional cultural values, beliefs, and practices are not adversely affected.**

Because there are no ongoing traditional Hawaiian cultural practices within the Project Area, other than those that would be conducted on behalf of PGV, the proposed action will have no impacts to traditional Hawaiian cultural practices.

In summary, it is acknowledged that certain native Hawaiian cultural practitioners would consider that the use of geothermal resources within the Project Area would adversely impact to their relationship with Pele; however, there are other traditional Hawaiian cultural practitioners who would not consider the Proposed Action to cause such an impact. PGV respects these beliefs and will continue to provide cultural education protocols for PGV employees. As discussed above, the Proposed Action is anticipated to decrease air pollution by replacing certain existing facility equipment with new and more efficient equipment, which is consistent with general traditional native Hawaiian cultural values concerning care of the environment. For these reasons, the Proposed Action is not anticipated to significantly adversely result in unavoidable adverse long-term impacts to traditional and customary native Hawaiian rights related to traditional cultural resources, beliefs, and practices protected by law, as it would not prevent, hinder, or restrict such practices and beliefs from continuing.

~~Based on the results or consultation, ethnographic research, and previous archaeological studies, there are no cultural, historical, natural resources, or past or ongoing cultural practices located specifically in the Project Area. The Project Area is not an area identified in ethnographic, historical, or archaeological documents as having had or having cultural, historical, natural resources, or past or ongoing cultural practices. Add text to talk about impacts to Pele.~~

~~To the extent that the existing PGV facility site proceeds to operate as currently authorized but reduces pollution from depending on electricity generated from fossil fuels, the replacement of the 12 existing OECs with the four new OECs proposed under the Proposed Action would not cause significant adverse impacts to the general spirit of traditional Hawaiian cultural beliefs and practices. Best management practices controlling and preventing the release of hazardous materials would ensure traditional cultural values, beliefs, and practices are not adversely affected. and the preventative measures listed above, it is reasonable to conclude that Hawaiian rights related to traditional cultural resources, beliefs, and practices, protected by law, would not be significantly adversely impacted, prevented or hindered, or otherwise affected by the Proposed Action.~~

3.8.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawai'i Island or partnering with other renewable energy providers as described in

Section 1.5. ~~The i~~**I**mpacts to cultural practices from this alternative would be the same as those described above for the Proposed Action.

3.8.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described above. Future actions at the site would likely occur as described in **Section 1.5.** Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Impacts **to cultural practices or resources** beyond existing conditions ~~to cultural practices or resources~~ would not occur under the No Action Alternative.

3.8.2.4 *Ka Paʻakai* Analysis

The Hawaiʻi Supreme Court's *Ka Paʻakai* decision provides an analytical framework to effectuate the State's obligation to protect native Hawaiian customary and traditional practices while reasonably accommodating competing private interests. Within that framework, an agency must make specific findings and conclusions about: (1) the identity and scope of "valued cultural, historical, or natural resources" in the petition area, including the extent to which traditional and customary native Hawaiian rights are exercised in the petition area; (2) the extent to which those resources—including traditional and customary native Hawaiian rights—will be affected or impaired by the proposed action; and (3) the feasible action, if any, to be taken to reasonably protect native Hawaiian rights if they are found to exist. For the purpose of the current EIS, as the Accepting Agency, the County of Hawaiʻi Planning Department is the agency that approves the EIS and oversees the implementation of the GRP.

With respect to the first part of the analysis, Section 3.8.1 identifies cultural resources and practices, with a discussion of beliefs surrounding geothermal use generally, as well as what resources and practices are located within the PGV site. As discussed above, no past or ongoing traditional Hawaiian cultural practices are known to have occurred within the Project Area, other than those conducted on behalf of PGV. These protocols have been performed ahead of major projects at the site, such as the drilling of new wells. PGV also conducts annual cultural education of its staff, including a chant entitled "Ku Makou" which speaks to the migration of Pele from Tahiti to Hawaiʻi.

Under the second part of the analysis, impacts to the identified resources and practices are considered. Sections 3.8.2.1 through 3.8.2.3 acknowledge that some people and/or native Hawaiian cultural practitioners consider any operation of the PGV facility to adversely impact their relationship to Pele, whom they believe is physically present in all aspects of volcanic activity, including geothermal resources. Other people and/or native Hawaiian cultural practitioners, however, do not feel this way and instead believe that geothermal energy is a gift from Pele. Because there are no identified cultural practices in the Project Area, aside from those requested on behalf of PGV, the Proposed Action would have no impacts to cultural practices. Traditional and customary native Hawaiian rights related to traditional cultural resources, beliefs, and practices that occur outside of the Project Area will not by prevented, hindered, restricted, or otherwise affected by the Proposed Action.

Under the third part of the analysis, the agency must identify the feasible action to be taken, if any, to protect traditional and customary resources and practices. PGV will continue to provide cultural education protocols for PGV employees and continue to coordinate with native Hawaiian organizations and cultural practitioners.

3.9 Aesthetics

3.9.1 Existing Environment

The 1987 EIS assessed the impacts to the aesthetic setting from development of the originally proposed power plant and well pads, as well as from construction equipment, which included analysis of line-of-sight visibility, potential for proposed facilities to appear in profile above distant skylines, and effects from vapor plumes (PGV 1987). The appearance and visibility of the PGV facility (now considered a part of the existing environment) was shown in simulated views from the following eight locations along nearby roads or within subdivisions or public parks: from the west of the power plant along Pāhoa-Pohoiki Road (Point 1), from the north along Kapoho Road (Points 2 and 3), from the southwest in the Leilani Estates subdivision (Points 4, 5, and 6), from the south in the Lanipuna Gardens subdivision (Point 7), and from the east along Highway 137 (Point 8). An analysis of these simulations indicated limited visibility of the PGV site facility, generally due to its low profile and the screening effects of vegetation and topography within the Project site and its vicinity. The 1987 EIS concluded that "most, if not all" of the impacts would be temporary, with views of the power plant insignificant once planned landscaping matures and provides screening. Design considerations, including additional landscaping, painting of structures and pipelines, and site lighting treatment, were prescribed as mitigation through various county and state permit requirements. **The existing PGV facility currently operates in compliance with Conditions 30 and 31 of the GRP to ensure that no lighting interference occurs with the observatories at Mauna Kea in accordance with Chapter 14 Article 9 of Hawai'i County Code, and to ensure that lighting is at a minimum level consistent with safety operations and is shielded and directed away from surrounding residential and populated areas and important biological resources.** These measures were presented as further reducing visual effects or visibility of the existing operations.

The existing aesthetic environment within and in the vicinity of the Project Area was substantially altered by the 2018 Lower Puna eruption. While the landscape of the broader Puna District remains geologically characterized by volcanic uplands, puʻus, and craters, the majority of the vegetation within and surrounding the site described in the 1987 EIS—the low bushes and grasses, agricultural plantings, and forested areas including tree-lined and canopied roads—was destroyed in the aftermath of the 2018 Lower Puna eruption. The blackened areas clearly visible in aerial views of the Project site vicinity indicate defoliation (**Figure 13**). Once cooled, the eruption's lava flow altered the topography in some areas, including much of the land adjacent to the Project site, where ground levels are now, to varying degrees, at higher elevations than they were prior to 2018. Additionally, many sources with aesthetic impact concerns (i.e., houses, roads, and public parks) in the area were destroyed, including the segments of Pāhoa-Pohoiki Road, Kapoho Road, and Highway 137, as well as portions of the Leilani Estates subdivision and Lanipuna Gardens subdivision where views assessed in the 1987 EIS were located.

To evaluate aesthetic impacts under the Proposed Action, views were collected from five viewpoints (VPs) (**Figure 13**), which replicate, to the extent possible given current conditions, a subset of the previously assessed views in the 1987 EIS:

- VP 1 provides a view to the north-northeast from a point along the path of Pāhoa-Pohoiki Road, which was destroyed during the 2018 Lower Puna eruption but will be rebuilt (**Figure 14a**). VP 1 is approximately 0.3 miles to the southeast of the 1987 EIS Point 1 to account for the highest current elevation on the lava flow.
- VP 2 provides a view to the south from Kapoho Road at the original Point 2 (**Figure 15a**).
- VP 3 provides a view to the northeast from within Leilani Estates, approximating the position of the original Point 4 (**Figure 16a**). Homes that were spared from the 2018 Lower Puna eruption are nearby, and views from this location represent future residential views should homes be rebuilt.
- VP 4, along the edge of Leilani Estates, provides a view to the north from a position near the intersection of Leilani Avenue and Pāhoa-Pohoiki Road, which will potentially be rebuilt (**Figure 17a**). The original Point 6 was located about one-third of a mile to the southeast.

- VP 5 provides a view to the north-northwest from a point near the intersection of Hinalo Street and Lauone Street within Lanipuna Gardens (**Figure 18a**). The original Point 7 was 0.2 miles to the west-southwest; VP 5 affords a better view toward the Proposed Action.
- Views from these VPs were photographed by drone because most are currently inaccessible due to inundation from the 2018 Lower Puna eruption lava flow, though ~~they are~~**it is** assumed **that they will**~~to~~ eventually be publicly accessible and are therefore considered representative of public views. Drone pilots approximated ground-level views to the extent possible, given safety considerations. The resulting images afford a more expansive view of existing conditions, indicating the manner in which the existing PGV **facility** site ~~facility~~, generally at a higher elevation than its surroundings, appears island-like in the landscape (VP 1). This effect is accentuated by the mature vegetation that remains in the Project Area. Built features, including the existing power plant and ancillary facilities, appear in stark contrast to the charred lands within the path of the 2018 Lower Puna eruption lava flow. Forested areas adjacent to the Project Area partially screen or otherwise absorb existing industrial-appearing components. Vertical elements associated with current operations (lattice communications towers and monopole transmission structures) extend into the skyline above the forested puʻu in the right half of the view and above the ocean horizon in the left half of the view, which is visible just over five miles away, beyond areas defoliated by the lava flow.

In the view from the north (VP 2), the vegetation that remains on higher elevations emphasizes the contrast between the Project Area at the far end of the view and its surroundings. The road built to maintain access to the existing PGV site facility is a linear feature extending through the middle of the view. A variety of forms are visible in the landscape, from small structures to the aforementioned vertical poles and towers that appear even more irregular, as a whole, in views from Kapoho Road. All are subordinate to the crumpled, darkened texture of the land, the view's dominant feature to which the raised and forested Proposed Action area serves as backdrop.

Views from the southwest and south (VP 3 and VP 4) serve to further visually delineate between lands burned by the 2018 Lower Puna eruption lava flow and lands that were untouched. The existing PGV **facility** site ~~facility~~ including transmission facilities is visible extending horizontally across the majority of these views. However, they also appear wholly enclosed within the elevated, vegetated areas. Components that extend above the skyline or tree line are readily observed. Lower components appear absorbed into the forested backdrop to varying degrees.

The view from the south-southeast (VP 5) depicts nearly a third of a mile of lava flow between viewer and the existing PGV facility, the effects of which are influenced by the cloudy conditions during site photography. The lava flow bed appears darker than in other views, which draws the eye toward the existing power plant features. Craters in the left half of the view and the vegetated highlands in the right create a focal effect in the center of the view in which existing power plant facilities and lattice towers are made more clearly visible despite their distance from VP 5 and the relatively small portion of the overall view that they occupy. Such effects could be expected throughout the broader landscape, where existing structures would be viewed beyond or between irregular landforms and therefore have viewer attention drawn to them.

The County of Hawaiʻi General Plan (County of Hawaii 2005) includes a Natural Beauty chapter that describes the inland areas of Puna as "lava land," saying that the region "is significant in that it represents the force of nature in altering the landscape feature into a cone and desolate field of lava," and volcanic regions are identified as "major areas of natural beauty" (p. 7-3). The current conditions at the existing PGV facility site and in the vicinity are an exhibit of such landscape alteration. The same chapter includes policies and standards related to establishment of "view plane regulations to preserve and enhance views of scenic or prominent landscapes from specific locations, and coastal aesthetic values" (Section 7.3 – Policies) and designation of "sites and vistas of extraordinary natural beauty that shall be protected" (Section 7.4 – Standards).

3.9.2 Environmental Impacts

Natural beauty sites in the Puna District identified in the latest draft update to the General Plan (County of Hawaiʻi 2019) include shoreline views, views of Mauna Kea and Mauna Loa, lava flows, and locations along

Pāhoa-Kapoho Road, none of which affords views of the Proposed Action. The five VPs developed for analysis as described above were analyzed to determine potential impacts under the Proposed Action. As described in **Section 2**, the Proposed Action includes two phases of development, each of which would result in alteration of views toward the Project Area. Phase 1 would involve removal of the 12 existing OECs from two locations within the existing PGV facility site and replacement with three new OECs in the Project Area (**Figure 3**). Phase 2 would involve installation of a fourth new OEC. Each of the new OECs would include a turbine-driven generator, air-cooled condenser, cycle pump, and control system. The entirety of the Proposed Action would occur within the existing property boundary. The Project would either use the existing well pads in their current location or construct new well pads that were previously approved under the 1987 EIS; no~~w~~ new wells are proposed under the Proposed Action. The three Phase 1 OECs would utilize the existing gathering system and install new piping, and installation of the fourth OEC under Phase 2 would require a 20 percent increase in piping infrastructure. Additional supporting infrastructure, including electrical equipment and various mechanical and structural upgrades, would be included for both phases. A visual screening wall would be constructed around the new OECs during both phases of the Proposed Action (**Figure 3**).

The top portions of the OECs and the wall are the proposed components that would be most prominent in views toward the PGV facility site and are the proposed changes likely to be detectable by viewers. Impacts during construction would be temporary. Operational effects related to vapor plumes from the OECs are not anticipated to be markedly different than evaluated for the existing PGV facility site in the 1987 EIS.

3.9.2.1 Proposed Action

The addition of the four new OECs under Phase 1 and Phase 2 would be visible to varying degrees from viewpoints located to the north, west, and south of the Project Area. In unobstructed views, the OECs and visual screening wall would appear as a mostly rectilinear feature, larger in scale than existing site components and partially appearing above the existing skyline in some cases. However, with the mitigation described below, the presence of the Proposed Action in these views would not have an adverse effect on visual quality, nor would it substantially affect the visual character of the existing aesthetic landscape. It would appear either set within or as an expansion of an industrial facility already in view. In accordance with Condition 33 of the existing GRP, all exterior surfaces would be of a rough texture, with no reflective material, and painted in colors so as to blend in with the surrounding environment. The color of the OECs under the Proposed Action would be consistent with the color of the current OECs, which help them to appear absorbed into vegetated backgrounds and reduce contrast with natural surroundings. **Furthermore, PGV would continue to comply with Conditions 30 and 31 of the GRP, as detailed in Section 3.9.1.**

The view from VP 1 showing Phase 1 (**Figure 14a**) and Phase 2 (**Figure 14b**) depicts conditions under which the Proposed Action would be most visible and result in the greatest degree of contrast with the existing PGV facility site's current surroundings. The elevation of the ground-level area in the view from VP 1 is generally the same as that of the existing PGV facility site. While the elevated view in the figures exaggerates somewhat the extent of the Proposed Action that would be visible in some ground-level views, the wall and top of the four new OECs would nonetheless be prominently visible in views from the west, where other portions of the existing PGV facility site would be partly screened or not visible at all. The greatest contrast in VP 1 would be the horizontal, rectilinear form associated with the Proposed Action extending northward from the portion of the PGV facility site that is developed with the existing power plant. The Proposed Action's presence would enhance the visual contrast in existing views from the current power plant facilities, most of which are vertical and narrow. The wall and OECs would appear to occupy a relatively substantial portion of horizontal space in the view. Forestlands that would have screened views from this location before 2018 were burned by the Lower Puna eruption lava flow. As seen in direct, unobstructed views from VP 1, the scale, solid color, and smooth texture of the wall would enhance its visual presence in a landscape that, while disturbed by the lava flow, is now possessed of the natural beauty described in the County of Hawai'i General Plan's discussion of "lava land" (County of Hawai'i 2019). In accordance with Condition 32 of the existing GRP, PGV would develop a detailed landscaping and siting plan to show elevational views of all proposed structures under the Proposed Action and provide landscaping improvement plans. Per Condition 32.c., to the extent possible, the structures associated with the Proposed Action would be landscaped and sited to reflect the existing agricultural character of the area and would utilize native plantings.

In views north of the Project Area along Kapoho Road (VP 2), Phase 1 of the Proposed Action would be visible along the horizon approximately one-third of a mile away, appearing atop the lava flow but below existing transmission structures and lines (**Figure 15a**). The green color of the OECs and wall would contrast with the darkened terrain surrounding the Project Area but relate to the vegetation visible to the left (east) and right (west) of the area proposed for development. During Phase 2 (**Figure 15b**), the new structures would appear slightly closer to the viewer. From this distance, the relatively low profile of the Proposed Action would limit its presence in views, and it would appear consistent in character with the energy-related infrastructure visible throughout the foreground. Implementation of wall treatment mitigation (such as the landscaping requirements under Condition 32 of the existing GRP) would further reduce these effects by appearing to break up the bulk of the Project as seen from this VP and better incorporate it into a view with a predominantly varied and textured foreground.

As in the view from VP 1, the view from VP 3 with Phase 1 (**Figure 16a**) and Phase 2 (**Figure 16b**) installed demonstrate the extent to which the Proposed Action would appear to expand the existing footprint of development at the existing PGV facility site. While consistent in character with existing facilities (though the removal of the current OECs would be observable in this view), there would be no comparable features in the view to which the new visual screening wall and new OECs could relate in terms of apparent scale, form, or texture. The northern extent of the wall and OECs would encroach on the skyline in some views, accentuating the more straight-lined character of the Proposed Action and its contrast with its surroundings. The attention drawn to the Proposed Action would be reduced with implementation of wall treatment mitigation that would reduce the monolithic appearance of the Project from VP 3.

The view to the north from VP 4 with Phase 1 (**Figure 17a**) installed shows removal of the existing 12 OECs, which would reduce the density and industrial character of the existing power plant facilities and the partial visibility of the proposed four new OECs. Looking across the existing site minimizes the Proposed Action's presence. The rounded form of the OEC air-cooled condensers add variation to the new form and facilitate its absorption into its surroundings. Effects as seen from VP 4 would be minimal, as new features would appear beyond and of a similar character to existing conditions. As Phase 2 would extend the footprint of the Proposed Action to the north, there would be no detectable difference from here once constructed (**Figure 17b**).

In the view from VP 5, the Proposed Action would be partially visible about a half mile away. With Phase 1 constructed (**Figure 18a**), the Proposed Action would be highly noticeable in the center of the view, though its individual components would be difficult to discern from this distance. With Phase 2 (**Figure 18b**), the portion of the view's focal point occupied by power plant facilities would appear to expand slightly to the north. The presence of trees along the far horizon, along with nearer lattice towers and monopole transmission structures, would offset any encroachment into the skyline from this location. The Proposed Action would, while noticeable, appear set into the landscape, visually buffered by natural features along the backdrop and existing industrial-appearing features nearer the viewpoint. While the Proposed Action features would be clearly observable in this view, the expansion of the existing PGV facility site development footprint within the Project boundary would be less obvious. Overall, impacts from the Proposed Action would not conflict with the existing characteristic landscape. The proposed visual screening wall that would be installed around the Project and the associated vegetation that would be planted and established around the wall would not overtake the view of the existing PGV facility, and visual impacts would be minimal.

3.9.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawai'i Island or partner with other renewable energy providers as described in

Section 1.5. The impacts to aesthetics from this alternative would be the same as those described above for the Proposed Action.

3.9.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. At the end of current operations, PGV would restore and revegetate the site consistent with permitting requirements and conditions. Future actions at the site would likely occur as described in **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Under this alternative, there would be no change to aesthetics from existing conditions.

3.10 Hazardous Materials and Solid Waste

3.10.1 Existing Environment

Hazardous materials currently utilized or present at the facility include lubrication and fuel oil, pentane, sodium hydroxide, and H_2S. Lubrication and fuel oil are utilized for operating equipment. Pentane is a hydrocarbon used as a working fluid in geothermal energy operations. Sodium hydroxide (NaOH; caustic soda) is used in the steam release facility to remove the H_2S. Finally, H_2S, which is emitted as a gas as a result of volcanic activity, is managed and abated as part of operations at the facility. **Table 3-14** includes a summary of hazardous fuel storage at the facility.

Table 3-14 On-site Hazardous Fuel Storage Locations

Material	Quantity	Capacity (nominal capacity) in gallons	Notes
Pentane	2	10,000	To support geothermal energy conversion activities
Pentane	1	10,000	Located at Pad D
Diesel	1	<100	For emergency water pump in the wellfield
Diesel	1	500	For diesel-driven emergency firewater pump at power plant
Diesel	1	1,500	For standby generator at power plant
Diesel	1	1,000	For vehicle use
Diesel	1	13,000	To fill day tanks for engines used for drilling rig
Diesel	4	40	Day storage tanks, one for each of three Waukesha engines (drilling rig) and one shared between the two Caterpillar engines (drilling rig)
Diesel	1	3,000	Day storage tank, for top drive engine for drilling rig
Diesel	4	500	Day storage tanks, one for each of the engines listed as Stack #S-DR4 through #S-DR7
Unleaded gasoline	1	1,000	For vehicle use

These materials must be and are stored, transported, and/or disposed of in accordance with applicable federal, state, and local regulations (i.e., in steel vessels or tanks that are surrounded by berms). Typical of most industrial operations, the storage or use of these materials may result in minor, incidental spills of diesel fuel or gasoline. Other incidental spills could be associated with equipment failures, such as ruptured hoses.

Pentane is a clear colorless liquid with a petroleum-like odor. Pentane's primary hazardous characteristic is its extreme flammability as a liquid and vapor, but it is not considered acutely toxic by oral or inhalation routes. It is used on-site operationally as a heat transfer fluid because of its low boiling point. During the energy generation process, depressurized steam leaves the turbine and enters into a heat exchanger where it vaporizes pentane. In the process, the steam condenses and is collected into a holding tank at the bottom of the condenser. The vaporized pentane turns a binary turbine before being exhausted into an air cooler to be condensed. The liquid pentane then flows back into the heat exchanger to begin the "closed-loop" system again.

Sodium hydroxide is a corrosive material that is toxic if ingested and can cause skin and eye irritation upon contact. It is soluble in water and used in households as a cleaning agent. In addition to the hazardous fuels noted in the table above, sodium hydroxide will be delivered to the site as a 50 percent solution and stored in two tanks, one with a 50 percent solution as delivered and the other tank with a 15 percent solution, diluted for use in the abatement system. Consistent with the Project's NSP, sodium hydroxide is used to abate H_2S emissions.

Broadly, risk mitigation and assessment are conducted in a hierarchical fashion: When confronted with a hazard, the best option is to eliminate the hazard. If a hazard cannot be eliminated, then administrative controls or engineering controls may be implemented. The hierarchy continues down to the least-desirable mitigation measures, such as personal protective equipment for individual workers.

For the existing geothermal plant, PGV has implemented engineering and administrative measures that mitigate the risks associated with incidental equipment failures and other emergencies associated with hazardous materials in accordance with applicable federal regulations (e.g., Occupational Safety and Health Administration and EPA) and Hawai'i regulations (e.g., DOH). For example, all existing pipes are engineered to withstand the stresses induced by thermal, pressure, dead, and seismic loads. Secondary containment structures such as dikes or berms are constructed around the sodium hydroxide storage tanks, gasoline, diesel, and bulk treatment chemical day tanks. These tanks are segregated by distance from any incompatible materials. To prevent accidental releases of hazardous materials stored at the facility, PGV stores and handles hazardous materials in accordance with manufacturers' recommendations and applicable regulations. The Safety Data Sheets for chemicals used at the facility are kept in the Control Building and accessible to staff. **There are strict State and Federal required operating procedures relating to the handling of hazardous materials.** Measures like this are intended to stop releases before they occur.

Additionally, applicable Department of Transportation regulations (Title 49 CFR, Section 171-178) are incorporated into the procedures for delivery of any hazardous materials used on-site.

Additionally, PGV maintains an ERP that includes emergency preparedness by ensuring that facility staff and visitors are aware of the hazardous materials on-site and understand the protocols and operations that must be invoked in the unlikely event of a release. The ERP includes mandates for training in regard to H_2S and other aspects of on-site operations.

The current recovery of pentane, H_2S abatement, and solid waste management are described in **Section 2.1.6**. The VRMU and VRU for pentane, as well as H_2S abatement, are described in **Section 2.1.6**. With these systems in place, injection fluids are designed to be contained. The ERP includes procedures for a variety of scenarios that could impact hazardous substances and materials at the facility. For example, if injection fluids were to escape containment, PGV would implement these procedures. The ERP includes steps to notify emergency response organizations (including the CDA and DOH, local fire and police departments, the DLNR, and the public) and evaluate any potentially hazardous situations. As part of PGV's UIC permit with the EPA (Part III.D.1 and 2), if this situation were to occur, the EPA may also require an assessment of any endangerment and, if necessary, a remedial response.

As described in the NSP and the ERP, monitoring for H_2S occurs continuously at the site. Detectors for pentane, fire, and gas are located throughout the facility and monitored continuously as described in the

ERP. Pentane is used in sufficient quantities on-site that the facility is regulated under the EPA's Risk Management Program rule. In compliance with this rule, PGV has prepared an approved Risk Management Plan for pentane at the facility including a hazard assessment and worst-case scenario analysis.

The ERP includes details regarding spill control and containment for spills or leaks of chemicals, including hydrocarbons, which could occur related to transfer or storage of pentane, caustic soda, treatment chemicals, diesel fuel, or unleaded gasoline. Caustic soda is considered hazardous because of its corrosivity but is otherwise not toxic, and the quantity stored on-site will not be able to move off-site under any upset condition. As described in the ERP, although geothermal brine spills may occur, the brine from the wells at the facility does not contain levels of constituents that necessitate its classification as hazardous waste. Brine chemistry will be evaluated analytically each year to monitor any changes in brine characteristics.

Although these systems are in place for controlling releases, fugitive emissions of pentane are a regular part of Project operations. The NSP sets a limit of fugitive emissions for the Project at 10,000 ppm from any seal, flange, valve, or any other fugitive emission point. If an exceedance occurs, PGV is required to take immediate corrective action. Additionally, the NSP sets a limit of 300 pounds per day of total pentane emissions (from fugitive sources and the VRU and/or the VRMU) calculated as a quarterly average. Regarding purging to the atmosphere, the NSP states that no major maintenance or overhaul resulting in the purging to the atmosphere of the turbine/generator modules shall be allowed without the operation of a VRU and/or the VRMU with a minimum recovery efficiency of 95 percent. During normal power plant operations, all purging of NCGs to the atmosphere or the release of pentane from the turbine/generator modules to the atmosphere are directed through the VRU and/or the VRMU. The VRU and VRMU are maintained in accordance with the manufacturer's operational specifications (e.g., temperature, pressure, etc.).

As stated in the ERP Section 9.0: Upset Conditions, upsets can occur during the life of the Project, whether caused by natural or humanmade events. The ERP includes a table of specific routine and upset conditions that could occur at the facility for H_2S, sodium hydroxide, diesel fuel, lubrication oil, pentane, and brine. PGV immediately notifies the CDA when any facility emergency situation occurs or is indicated that could threaten the health, safety, or welfare of persons in the vicinity of the facility site. In addition, PGV has a responsibility to notify the CDA (and other appropriate governmental agencies) when the routine and upset conditions occur. Finally, PGV has the responsibility under its permits and other regulatory authorities to notify various regulatory agencies related to the operation of the Project ~~and when~~**if** certain upset conditions occur at the site. Even though the NSP requires that the facility not cause or contribute to an exceedance of the H_2S ambient level of 25 parts per billion (ppb) on a one-hour average (or 10 ppb on a 24-hour rolling average) at or beyond the project boundary, as an extra precaution PGV notifies the CDA ~~when~~ **if** H_2S is detected at 5 ppb.

The NSP also requires that in the event of an operational upset, equipment failure, or malfunction that may allow an increase in the emissions of H_2S, particulate matter, or pentane, PGV shall apply appropriate measures to control and minimize any air emissions and take immediate steps to correct the condition. The ERP includes response actions to control any spills that occur at the facility.

Spills of geothermal brine may also occur during facility operations. However, the geothermal brine expected from the wells that feed the facility does not contain levels of constituents that necessitate its classification as hazardous waste. Brine chemistry is evaluated analytically each year during hydrological monitoring (see **Section 3.2**) for changes in brine characteristics.

Non-hazardous solid waste generated from operations and employees is collected regularly, and wastewater disposal is managed in a large quantity septic system per state and federal regulations. All chemicals used at the facility are non-toxic, and no per- and polyfluoroalkyl substances are used on-site.

3.10.2 Environmental Impacts

3.10.2.1 Proposed Action

The Proposed Action would result in the continued use of hazardous materials in accordance with all applicable laws and waste management practices for geothermal production, with the potential to affect air, water, soil, and biological resources from an accidental release of hazardous materials and/or solid and hazardous waste during transportation to the facility or during storage and use on-site. Decommissioning and construction phases of the Project could result in possible environmental impacts beyond existing conditions; however, all required handling requirements and BMPs would be observed during construction and decommissioning of the site. However, once the Project is complete and the new facilities initiate power generation, the impacts would not differ greatly from existing conditions.

The Project includes the decommissioning of existing infrastructure and the construction and development of new facilities. The twelve OECs in current use would be replaced by three new OECs during Phase I, followed by a fourth unit during Phase II. Operation of the new OECs requires BOP equipment as well a new pentane storage vessel (10,000- to 15,000-gallon capacity) in the Project Area to replace the current vessel (10,000-gallon capacity) at the facility. The old OECs would be decommissioned after commencement of operation of the new OEC units. The old OECs would not be operated at the same time as the new OEC units.

The Proposed Action includes major changes to the power-generating units and associated infrastructure, but some existing infrastructure would not change. Administrative buildings, the control room, the electrical substation, distribution lines, and maintenance areas would remain the same under the Proposed Action. Consequently, there are no impacts associated with hazardous materials beyond those that already exist in these areas. Because the four new OECs will be sited in an area of the property that is not currently utilized, the use of hazardous materials in that area will be new and have the potential to cause impacts. However, all use and handling of materials will be in compliance with applicable laws and the ERP.

The decommissioning and construction of facilities would require an influx of personnel and significant construction activity. The potential construction of well pads and the expected construction and placement of the OECs themselves would require an additional 75 temporary workers on-site. Two-thirds of this labor would be expected to be sourced off-island, depending on qualifications and expertise. The increase in site workers in tandem with construction activity that is otherwise not present could increase the potential for incidental spills associated with fueling equipment, equipment maintenance, and equipment malfunctions. However, all site workers would be trained according to the ERP. The existing conditions, risk mitigation measures, and response protocols would remain in place. It is important to note that the ERP states that it will be updated as necessary by PGV; changes required in response to the high-volume influx of site workers would be made as necessary in order to ensure that adequate protections remain in place.

If ~~new~~**additional approved** wells and well pads are required, drilling operations would be conducted and associated hazardous substances would be managed in compliance with the ERP. The ERP maintains emergency preparedness and response protocols for drilling operations by mandating safety training for hazards involved, including H_2S. For example, unannounced, monthly drills would be conducted in order to ensure an effective and timely response. In addition, the training mandate included in the ERP pre-emptively addresses releases by increasing site worker awareness of the potential risks associated with hazardous substances. These strategies mitigate risk associated with hazardous materials.

Throughout the construction phases and beyond, proper handling, storage, and disposal of all hazardous materials and solid waste would be conducted in accordance with the ERP and state and federal regulations, including Resource Conservation and Recovery Act requirements (40 CFR 261-265). Additionally, all hazardous materials in transport to or from the site as a result of construction or decommissioning activities and regular plant operations would be conducted in accordance with all state and federal regulations, including Title 49 of the CFR.

PGV would ensure that no soil, groundwater, or surface water contamination occurs that would result in any adverse effects on the environment or site worker health and safety. Were a release to occur, response actions would follow the protocol outlined in the ERP, with the response tailored to all relevant release characteristics, including the size of the release, the location of the release, and the nature of the release. Reporting and on-site cleanup actions would adhere to the direction required by agencies involved with compliance at the site.

Small quantities of solid waste would be generated during Phase I and Phase II of the Project as they are under existing conditions. Solid waste would be collected as normal and disposed of in accordance with state and federal guidelines.

Once the new OECs are constructed and operating, the environmental impacts under the Proposed Action would be very similar to the environmental impacts under the status quo, and the risks associated with hazardous materials at the facility would be the same. Spills or leaks of chemicals, including hydrocarbons, could occur related to the transfer or storage of pentane, caustic soda, treatment chemicals, diesel, or gasoline. Of these, only a catastrophic spill of pentane could result in an off-site emergency situation. If such an event were to occur, the procedures outlined in the ERP would be invoked. Spills of geothermal brine could also occur during plant operation; however, the brine from the wells would not be expected to contain constituents that necessitate its classification as hazardous waste. Brine chemistry would be monitored regularly in order to maintain an understanding of its characteristics.

3.10.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. The potential impacts from hazardous waste and solid materials from this alternative would be the same as those described above for the Proposed Action.

3.10.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. At the end of current operations, PGV would reclaim and revegetate the site consistent with permitting requirements and conditions. Future actions at the site would likely occur as described in **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Potential impacts from hazardous materials during construction of the Project would not occur under this alternative; however, potential impacts from hazardous materials could occur from continued operation of the PGV facility and any subsequent site development.

3.11 Public Health and Safety

Health is defined by the World Health Organization as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. During public consultation for the PGV Repower Project, concerns pertaining to public health and safety were raised by community members. Many of the concerns were based on individual experiences or anecdotes.

3.11.1 Existing Environment

The three main concerns that were expressed by the public with respect to health and safety during the public scoping period were as follows:

- Commenters were concerned with odors and health problems associated with the release of H_2S from the PGV plant;
- Commenters were concerned with excessive noise from the PGV plant; and
- Commenters were concerned with potential exposure to hazardous materials such as pentane from the PGV plant.

Concerns associated with increased geological instability as a result of the Project, and concerns about whether or not the facility's ERP ~~was~~ **is** adequate to protect the health and safety of nearby residents, were also noted during public consultation. Further discussion on these topics is provided in **Sections 3.2**, **3.3**, and **3.10.**

All chemicals (from both anthropogenic and natural sources) have the potential to cause adverse health effects. However, the level of the effect depends on the receptor being exposed (e.g., person or animal), the route and duration of exposure (e.g., inhalation), and the hazard (i.e., inherent toxicity) of the chemical. If all three components are present (**Graph ~~2~~3**), the possibility of a risk to health exists.

Graph 3. Risk Venn Diagram

~~**Graph 2**. Risk Venn Diagram~~

By focusing on the interactions among receptors (people living near the PGV facility site) and exposures (inhalation of H_2S, exposure to excessive noise, proximity to pentane), statements about the risks associated with public health and safety are made below.

Hydrogen Sulfide (H_2S)

When sulfur gases are released from magma and encounter groundwater as they rise, the sulfur can react with water and form H_2S (USGS 2023a). H_2S is emitted during volcanic eruptions along with other gas molecules including water vapor, carbon dioxide, sulfur dioxide, carbon monoxide, hydrogen chloride, and hydrogen fluoride (USGS 2023b). H_2S is a flammable, colorless gas that smells like rotten eggs. It occurs naturally in crude petroleum, natural gas, volcanic gases, and hot springs. The steam that is used in PGV operations contains H_2S, and as such, there is potential for fugitive H_2S emissions from the plant. While volcanic eruptions can lead to loss of vegetated areas due to lava flows, the loss of vegetation is not anticipated to influence air flow or H_2S dispersion patterns. If air flow or H_2S dispersion patterns were to be impacted in areas void of vegetation or difference in elevation following a lava flow event, PGV's air quality monitoring program currently in place would detect reportable levels and/or increases of H_2S at the monitoring sites identified under **Section 3.3**.

Studies in humans exposed to H_2S suggest that the respiratory tract and nervous system are the most sensitive targets. Exposure to low concentrations (less than 10 ppm) of H_2S can cause irritation to the eyes, nose, or throat (National Research Council 2010). It may also cause difficulty in breathing for some asthmatics. Respiratory distress has been observed in people exposed to very high concentrations (greater than 40 ppm) of H_2S for more than 25 minutes. Acute exposure to greater than 500 ppm H_2S can result in respiratory failure. Brief exposures (several minutes to an hour) to very high concentrations of H_2S can cause loss of consciousness; however, the exact exposure concentrations in such cases were not known. In most cases, the person appears to regain consciousness without any other effects. Short exposures (30 minutes) to low concentrations (e.g., 2 ppm) of H_2S may cause headaches, poor memory, tiredness, and balance problems (ATSDR 2016). Hazard information on H_2S by itself is inadequate for characterizing the level of the effect on human health. The route and duration of exposure must also be taken into account. Exposures from fugitive H_2S emissions are heavily influenced by plume characteristics, average and peak durations of concentrations, atmospheric conditions, topography, humidity, and other meteorological and geographic factors (Adler et al. 2013).

The NSP establishes maximum allowable 1-hour and 24-hour rolling average H_2S concentrations of 25 ppb and 10 ppb, respectively, at the facility based on measurements from the air quality monitoring stations. These limits apply to normal day-to-day operations. This is consistent with the Occupational Safety and Health Administration exposure limit for H_2S, which states, “Exposures must not exceed 20 ppm (ceiling) with the following exception: if no other measurable exposure occurs during the 8-hour work shift, exposures may exceed 20 ppm, but not more than 50 ppm (peak), for a single time period up to 10 minutes” (OSHA 2023).

PGV conducts H_2S monitoring and reporting as required by the NSP (a state air pollution control permit) for its current operations. PGV maintains three air monitoring stations at the facility site property:

- **Southeast Fenceline Monitoring Site A1:** This site was chosen due to a cluster of homes that are topographically downgradient from the existing operations.
- **Southwest Fenceline Monitoring Site B1:** This site was chosen due to the proximity of the Nanawale Estates subdivision. This location was destroyed by the 2018 Lower Puna eruption but was rebuilt.
- **West Fenceline Monitoring Site C1:** This site was chosen due to the proximity of homes at the Leilani Estates subdivision.

These stations record H_2S concentrations, wind speed and direction, and precipitation levels, and the location of the monitoring sites is shown on **Figure 2**. PGV publishes these real-time data on its website. These data are reviewed, validated, and submitted by PGV in monthly reports to the Hawai‘i DOH and semiannual reports to the Planning Department consistent with permit requirements.

The nearest homes to Monitoring Site A1 are approximately 2,700 feet west of the new OECs and approximately 50 feet from the PGV lease boundary. The nearest home in Nanawale Estates subdivision is approximately 1,500 feet northwest from Monitoring Site B1 and approximately 2,000 northwest of the new OECs. The nearest homes in the Leilani Estates subdivision are approximately 2,500 feet west of Monitoring Site C1 and approximately 5,000 feet from the new OECs.

During normal operations at PGV, naturally occurring H_2S is controlled in an essentially closed-loop system whereby more than 99 percent of the H_2S contained in the geothermal fluids is dissolved in the cooling tower blowdown and reinjected back into the reservoir. Abatement systems are employed if the injection system malfunctions (see **Section 3.10**). The remaining one percent of H_2S that is not dissolved in the cooling tower blowdown is injected into the cooling water return line. The total emissions from all sources at the facility is not to exceed four lb/hr under all normal operations (PGV 1987). Periodic maintenance and quality control checks that are performed on the analyzer system may result in elevated H_2S values. Therefore, an elevated H_2S concentration indicated by the monitors may not necessarily be the result of a release.

When assessing the potential human health risks associated with inhalation exposure to H_2S, the frequency, duration, and magnitude of the exceedance all play important roles. Infrequent exceedances of a short-term (one-hour) exposure limit may be less likely to result in respiratory events than exceedances that occur over prolonged periods of time (hours to days at a time). Moreover, the receptor location with the greatest number of exceedances is likely to better represent reasonable worst-case conditions than the receptor location where the maximum concentration is predicted to occur but where fewer exceedances are anticipated. Based on a review of the historical monitoring data directly from the PGV website, out of the 500 measurements recorded between December 16, 2021, and December 16, 2022, at Monitoring Site A1, 499 of the values (greater than 99 percent) were below 25 ppb. There was one exceedance of the 25 ppb limit, with an H_2S concentration of 904.9 ppb, recorded on December 16, 2021, at 8:05 p.m. This concentration persisted for less than one hour, and at 9:05 p.m. the concentration was recorded to be -0.71 (negative readings can occur as a result of acceptable fluctuations [up to ± 3.1 ppb] in values due to manual calibrations of monitoring equipment). The maximum H_2S concentration was 3.3 ppb at Monitoring Site B1 and 3.1 ppb at Monitoring Site C1 between December 16, 2021, and December 16, 2022. These concentrations are well below the 25 ppb threshold set by the DOH. The World Health Organization recommends that to avoid substantial complaints about odor annoyance, H_2S concentrations should not be allowed to exceed 5 ppb on average over any 30-minute period. Monitoring data suggest that H_2S concentrations within the fence line are well below 5 ppb the majority of the time. Thus, under normal operating conditions, residents in nearby communities are not expected to experience an H_2S odor. The DOH originally established three air monitoring stations beyond PGV's property. Two of those were later removed **by DOH** ~~for budget reasons~~ when they had shown no elevated levels of H_2S. The DOH monitoring station at Leilani Estates showed ambient hourly average H_2S concentrations of approximately 0.1 ppb (see **Section 3.3**). These concentrations are also well below the 25 ppb threshold set by the DOH and below the odor annoyance threshold suggested by the World Health Organization.

Much of the public concern regarding H_2S, pertains to high levels of exposure that could **theoretically** arise during upset conditions or in emergency scenarios and less so during normal operations. In 2021, an air dispersion modeling analysis was completed to evaluate H_2S concentrations during uncontrolled flow events and other power plant upset conditions (PGV 2022b, Appendix H). The analyses were conducted to update modeling results for the 12 "worst-case" upset scenarios evaluated in the prior 1992 PGV Facility ERP. The 1992 PGV Facility ERP identified 12 emergency scenarios under which geothermal fluid emissions could occur during uncontrolled flow events at a well pad or during power plant upset conditions. These scenarios provide a conservative representation of emergency H_2S emissions from the facility. Ambient concentrations were estimated using the AERMOD modeling system in conjunction with information about the site, the emission sources, representative meteorological data, and nearby receptors. A hazard analysis was conducted to compare modeled H_2S concentrations against the toxicity criteria described below.

The Centers for Disease Control and Prevention's Agency for Toxic Substances and Disease Registry (ATSDR) has defined Minimal Risk Levels (MRLs) for H_2S, intended to serve as a screening tool (not action levels) for public health officials in assessing exposure. The MRLs are set below levels that may cause adverse health effects in the most sensitive populations. The Acute MRL for an exposure period of one to 14 days is 70 ppb.

The National Academy of Science's Acute Exposure Guideline Levels (AEGLs), adopted by the EPA, represent threshold exposure limits for the general public and are applicable to emergency exposure periods from 10 minutes to eight hours. Three levels have been developed for each of the five exposure periods (10 and 30 minutes and one, four, and eight hours), representing varying degrees of severity of toxic effects:

- **AEGL-1:** The airborne concentration below which could result in mild and progressively increasing but transient and non-disabling odor, taste, and sensory irritation or certain asymptomatic, nonsensory effects in the general population, including susceptible individuals. In contrast, concentrations above the AEGL-1 (but below the AEGL-2) could cause noticeable discomfort or irritation in the general population and susceptible individuals, but the effects are not disabling and are transient and reversible once exposure stops.

- **AEGL-2:** The concentration above which it is predicted the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or impaired ability to escape.
- **AEGL-3:** Concentrations greater than AEGL-3 could cause life-threatening health effects or death in the general population, including susceptible individuals.

The AEGL values are summarized in **Table 3-15**. Although the AEGLs represent threshold levels for the general public, including susceptible subpopulations, such as infants, children, the elderly, persons with asthma, and those with other illnesses, it is recognized that individuals, subject to idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL. The level of distinct odor awareness for H_2S is 10 ppb. The level of distinct odor awareness represents the concentration above which it is predicted that more than half the exposed population will experience at least a distinct odor intensity and about 10 percent of the population will experience a strong odor intensity. This level is below that at which adverse health effects would be experienced. Thus, the derived AEGL-1 values are considered to have warning properties due to odor perception (National Research Council 2010).

The air dispersion modeling analyses evaluated H_2S concentrations for the following averaging periods: 10-minute, 30-minute, 1-hour, 4-hour, 8-hour, and 24-hour. The maximum modeled H_2S concentrations for all 12 emergency scenarios ranged from 4 ppb to 6,118 ppb. A maximum predicted concentration of 6,118 ppb occurred at the facility fence line during the 1-hour averaging period. It is reasonable to assume that residents would not be exposed to this concentration since it is predicted to occur at the fence line. Based on the air dispersion modeling, H_2S concentrations decrease the further one moves from the fence line; however, contour plots show that as far as 1.5 miles beyond the fence line concentrations in residential areas may still exceed the acute MRL of 70 ppb and the 1-hour AEGL-1 of 510 ppb. As such, residents in the surrounding communities may experience transient, non-disabling irritation and discomfort assuming the upset condition continues unabated for an hour. However, this scenario can be quickly controlled by closing valves to shut in the well, so it is unlikely that exposures to this scenario would last as long as an hour. The results of the air dispersion modeling analyses indicate that the AEGL-1 and acute MRL were exceeded for nine out of the twelve modeled upset conditions. The AEGL-2 and AEGL-3 thresholds were not exceeded in any upset scenario. PGV has an ERP in place to protect the health and safety of the public should an upset condition or an emergency scenario occur (refer to the ERP section for more details).

In 2012, Hawaiʻi Island Mayor William Kenoi asked Peter S. Adler, Ph.D., to organize an independent "joint fact finding" study group that would examine the type and extent of health impacts from Hawaiʻi Island geothermal operations. The study group gathered exposure information on H_2S from historical geothermal project activities on Hawaiʻi Island. The only reliable exposure information that the study group was able to collect came from the 1991 well blowout at PGV. Using USGS data from the PGV well blowout, Goddard & Goddard Engineering **(1991)** determined that H_2S exposures about one-half mile from the blowout location were high enough (approximately 1,680 ppb) to be associated with adverse health effects. The full extent and severity of those effects have not been documented. Some of the health concerns that were expressed during public consultation for the Project stemmed from the findings of this study group. However, it is important to discern that the adverse health effects suggested by the study group were based on historical geothermal plant operations in the 1980s (Hawaiʻi Geothermal Project's initial test plant) and on one emergency incident at PGV in 1991. Since the 1991 incident, the Study Group was not able to determine with certainty whether there have been adverse health effects associated with ongoing geothermal operations.

As discussed in **Section 3.10**, the potential for pentane and H_2S emissions is acknowledged as part of facility operations. Permits for the facility (GRP, NSP, and UIC) permits all include requirements for monitoring, controlling, and reporting exceedances. PGV continues to comply with these requirements as part of facility operations. Exceedances that resulted in permit violations for H_2S have occurred only twice in the operational history of the facility.

In 2001, Dr. Marvin Legator published a study that showed that Puna residents had significantly higher adverse health effects normally associated with industrial H_2S than three reference communities **(Legator et al. 2001).** The DOH criticized the methodology for this study because it partially relied on volunteers rather than a complete randomized sample. In 1997, the U.S. Department of Health and Human Services' ATSDR responded to a request from the DOH and performed a health consultation to assess the threat to public health posed by releases of H_2S from PGV. The health consultation relied on the monitoring station data at Lava Tree State Park, 1.5 miles away from PGV. The ATSDR concluded that the concentrations of H_2S in residential areas near PGV did not pose a public health hazard **(ATSDR 1997)**.

Table 3-15 Summary of Relevant H_2S Exposure Limits and Guidelines

Criterion	Averaging Period	Threshold (ppb)
PGV Permit Requirement	1-hour	25
	24-hour	10
ATSDR Acute MRL	1–14 days	70
AEGL-1	10-minute	750
	30-minute	600
	1-hour	510
	4-hour	360
	8-hour	330
AEGL-2	10-minute	41,000
	30-minute	32,000
	1-hour	27,000
	4-hour	20,000
	8-hour	17,000
AEGL-3	10-minute	76,000
	30-minute	59,000
	1-hour	50,000
	4-hour	37,000
	8-hour	31,000

Two studies investigated the potential effects of long-term (chronic) exposure to ambient low-level H_2S on cognitive and respiratory function in an urban population in Rotorua, New Zealand. This city sits on an active geothermal field, with vents emitting H_2S located in and around the city. The population is probably the largest in the world with long-term exposure to levels of ambient H_2S as high as found in Rotorua. The median H_2S concentration for residences in Rotorua was 20.3 ppb and for workplaces, 26.4 ppb. The range for both residences and workplaces was 0 to 64 ppb. The first study involved 1,637 participants aged 18 to 65 years and assessed aspects of cognitive function such as attention, processing speed, memory, psychomotor speed, fine motor skills, and mood. The study found no association between chronic ambient H_2S exposure and cognitive function and no evidence of harmful effects in any cognitive function (Reed et al. 2014). The second study involved 1,639 participants aged 18 to 65 years and assessed lung function, asthma, and chronic obstructive pulmonary disease. This study also found no significant associations between H_2S exposure and lung function, asthma, or chronic obstructive pulmonary disease. There was no evidence of any adverse association between the ambient H_2S levels found in Rotorua and any of the respiratory parameters examined (Bates et al. 2015). The results of these studies provide some reassurance that adverse cognitive and respiratory effects are not expected from chronic exposure to H_2S, at least up to the levels found in Rotorua, which are substantially higher than the H_2S concentrations reported at the three PGV monitoring sites in the past year (based on a one-year public historical data review as of March 28, 2023; maximum concentration at Site A1 = 6.5 ppb, Site B1 = 0.6 ppb, and Site C1 = 3.2 ppb).

Noise

Noise refers to any sound that may produce adverse physiological or psychological effects or interfere with individual or group activities. Noise is associated with both auditory and non-auditory effects. Exposure to noise levels of relatively high degrees can lead to direct hearing loss or hearing impairment. The non-auditory effects include annoyance and disruption of basic activities such as sleep, rest, communication, and concentration (WHO 1999).

Sleep is a biological necessity, and disturbed sleep is associated with a number of health problems. The effects of sleep disturbance have been shown to include but are not limited to increased fatigue, irritability, and decreased concentration and performance. Ongoing disturbed sleep has been reported to be linked to a wide variety of health effects including but not limited to cardiovascular effects, mental health, and accidents.

Comments received during the public consultation indicate that there is periodic excessive noise and continuous low-level noise from PGV, which has created annoyance and irritation for those who live close to the plant. Residents living in close proximity to the plant have mentioned that since the 2018 Lower Puna eruption, which wiped out most of the vegetation surrounding the plant, there is less noise attenuation and that noise levels are greater, both during the day and at night. Sounds in the atmosphere are attenuated with increasing distance from a sound source. Attenuation depends not only on distance but also on relative humidity, temperature, and wind, as well as on the temperature gradients, wind gradients, and turbulence in the atmosphere. Attenuation also varies with the source height, receiver height, topography, the porosity of the ground between source and receiver, and to a minor extent, on vegetation (Burgess 1980). The attenuation of noise from the plant is discussed above in **Section 3.4**.

Noise-related annoyance is described as “a feeling of displeasure evoked by a noise” (Aslund et al. 2013). Although annoyance is considered to be the least severe potential impact of community noise exposure, it has been hypothesized that sufficiently high levels of noise-related annoyance could lead to negative emotional responses (e.g., anger, disappointment, depression, or anxiety) and psychosocial symptoms (e.g., tiredness, stomach discomfort, and stress). Therefore, regulations exist in many jurisdictions around the world to limit community noise exposure in order to curtail community levels of annoyance. However, it is important to emphasize that the existence of these guidelines has not eliminated community noise annoyance, and noise-related annoyance remains prevalent in many communities (Aslund et al. 2013). There have been more than 50 years of social and socio-acoustic research that either directly or indirectly studied the impact of noise on community annoyance. These studies have consistently shown that an increase in noise level is associated with an increase in the percentage of the community indicating that they are highly annoyed.

The most prominent noise sources within the Project vicinity include the existing PGV facility operations, traffic noise, and environmental noise sources, such as wind, birds, and insects. PGV currently conducts continuous noise monitoring at the three air quality monitoring sites discussed above, A1, B1, and C1.

The noise monitoring results are posted on PGV’s publicly accessible website. The facility adheres to Hawaiʻi guidelines on noise for a Class C property. The maximum permissible sound level for a Class C property is 70 dBA, regardless of the time of day.

Data from PGV’s continuous noise monitoring indicate that noise levels are generally lowest at Monitoring Site B1 and highest at Monitoring Site A1. Noise levels fluctuate throughout the day, with the majority of nighttime exceedances occurring from coqui frogs and daytime exceedances often occurring from the presence of wild pigs at the facility. A data acquisition and storage computer located in the PGV plant operations center polls each data logger once every five minutes. The five-minute averaged data are checked for noise levels in excess of 68 dBA, and the computer generates an alarm if an exceedance is detected. As stated in the ERP, PGV notifies the CDA, County of Hawaiʻi Planning Department, and DOH Noise and Radiation Branch in the event that any upset of PGV's operations leads to an exceedance of the appropriate ambient noise levels, and actions are taken at the site to stop the source of the noise. Additionally, PGV's operations department investigates every noise alarm, documents its possible source, and logs it in the control room logbook. If the DOH is contacted by the public regarding a noise complaint for the facility, PGV is contacted to reveal the possible source and reports to the DOH.

The DOH maximum permissible noise level in residential zones (Class A) is 55 dBA during the daytime (7 a.m. to 10 p.m.) and 45 dBA during the nighttime (10 p.m. to 7 a.m.). The statute indicates that noise levels shall not exceed the maximum permissible sound levels for more than 10 percent of the time within any 20-minute period. As such, PGV must ensure that noise emanating from the premises is not higher than permissible noise levels in residential areas. Consideration should also be given to the fact that some residential dwellings may not have windows to attenuate the intruding noise. As described in **Section 3.4**, noise from the PGV plant does not exceed the 57 dBA limit of the GRP.

For a more detailed assessment of noise and the impacts of the plant on the existing noise conditions in the surrounding area, see **Section 3.4**.

Hazardous Materials

Comments received during the public consultation indicated that there is concern about public health and safety related to potential exposure to hazardous materials such as pentane and caustic soda. Commenters were concerned with the following:

- Fugitive emissions of pentane;
- The risk of an explosion of the pentane storage tank and whether an adequate ERP is in place for emergency situations involving pentane;
- Pentane contamination of the groundwater aquifer; and
- Potential exposure to caustic soda.

Pentane is a clear, colorless liquid with a petroleum-like odor. It is used on-site operationally as a heat transfer motive fluid. During the energy generation process, depressurized steam leaves the turbine and enters into a heat exchanger where it vaporizes pentane. In the process, the steam condenses and is collected into a holding tank at the bottom of the condenser. The vaporized pentane turns a binary turbine before being exhausted into an air cooler to be condensed. The liquid pentane then flows back into the heat exchanger to begin the "closed-loop" system again (i.e., pentane is a working fluid and stays in the system and is not injected into the ground). Detectors for pentane, fire, and gas are located throughout the facility and monitored continuously as described in the ERP.

The VRMU and the VRU for pentane are described in **Section 3.10**. With these systems in place, injection fluids are designed to be contained. As stated in the ERP, if injection fluids were to escape containment, PGV would implement the ERP. The ERP includes steps to notify emergency response organizations (including the CDA and DOH, local fire and police departments, the DLNR, and the public) and evaluate any potentially hazardous situations. As part of PGV's UIC permit with the EPA (Part III.D.1 and 2), if this situation were to occur, the EPA may also require an assessment of any endangerment and, if necessary, a remedial response. The Project is also in compliance with the EPA's Risk Management Program for pentane. The NSP also sets limits on pentane fugitive emissions (see **Section 3.10**).

With respect to public concerns regarding groundwater contamination, the USGS analyzed groundwater samples from shallow wells and coastal springs near the PGV site for a variety of chemical species that have been injected into the wells over time, including pentane (see **Section 3.2**). Pentane was detected in one monitoring well near the power plant at a concentration that was too low to determine its source (i.e., it may be naturally present). No other indicators of potential geothermal contamination were noted in the findings of the report.

Caustic soda is employed by PGV to neutralize the effects of H_2S during emergency procedures. Caustic soda is considered hazardous to human health due to its highly corrosive properties. In the event of an upset condition where caustic soda is used on-site, PGV would implement the ERP and take all actions necessary to ensure that public health and safety are protected.

Natural Hazards

Natural hazards that occur in Hawaii include flooding, tsunamis, storms, and sea level rise. The site is not located within a Federal Emergency Management Agency (FEMA) flood zone according to FEMA's Flood Insurance Rate Map. The entire Project facility site is located in FIRM Panel 1551661435F (09/29/2017). The proposed site is outside the tsunami evacuation zone and the sea level rise exposure area, as it is located 3.2 miles away from the nearest coastline. As stated in Section 8.0: Natural Hazards of the ERP, the site could be impacted by natural disasters, including lava flows, magma intrusion, lava intrusion, earthquakes, severe weather systems (tropical storms and hurricanes), lightning, and brush fire (PGV 2022b). The ERP identifies potential impacts to the facility as well as response actions for each hazard by incorporating warning systems, control options, steps for securing and shutting down the facility, personnel evacuation, and notification of appropriate state and county agencies consistent with Condition 24(e) of the GRP. The decision for the facility to remain online during natural disasters (e.g., tropical storms) to provide energy needed for Hawai'i Island is made in coordination with the CDA and HELCO; operation during natural disasters is consistent with the measures outlined in the ERP.

In addition to identifying possible emergency situations, the ERP also clarifies that the CDA has the responsibility for notifying and evacuating the public during emergency conditions, should they arise, at the facility (PGV 2022b). Current evacuation from the facility is along Highway 132 toward Pāhoa. The County of Hawaiʻi's recovery efforts regarding road restoration are summarized in **Section 3.12**.

During an unplanned natural disaster (similar to the 2018 Lower Puna eruption), the state can declare a state of emergency and take operational control of the facility. PGV's regular coordination with state and county officials in these circumstances ensures these transitions are as smooth as possible.

3.11.2 Environmental Impacts

3.11.2.1 Proposed Action

The proposed Project is expected to increase the production of renewable energy at the existing PGV facility site (within the current site fence line) via replacement of the existing 12 OECs with four new, more efficient OECs using quieter equipment on a smaller land footprint compared to the existing operations. The overall property size and most of the existing infrastructure and buildings would remain the same for the Project. Emissions of H_2S and noise are not expected to change as a result of the Project. Continuous monitoring of H_2S and noise will remain in place. Pentane recovery and hazard control systems will also remain the same. Should uncontrolled upset conditions arise during the decommissioning of the old power-generating units and installation of the new units, the ERP will be used to mitigate risks to public health and safety.

Under normal plant operations with the new OECs, emissions of H_2S are not expected to be above the human health thresholds. If H_2S emissions are below the DOH limits of 25 ppb for 1-hour exposure, unacceptable risks to human health are not anticipated. Existing H_2S abatement systems will remain in place to abate fugitive H_2S emissions, which could result from upset conditions. Sensors with alarms are located strategically on each turbine/generator unit and throughout the wellfield. The alarms immediately alert personnel of fugitive H_2S emissions so that corrective action can be taken.

Under normal plant operations, noise emissions are not expected to be above the Class C guidelines set for the PGV property. As a result of new technology, the new OECs are much quieter than existing OECs. Therefore, the noise from the PGV plant during normal operation with the new OECs may be less than the noise from the old OECs. As described in **Section 3.4**, noise data indicate that the proposed equipment will be quieter than the existing plant equipment and would not change background noise conditions. Therefore, noise from the Proposed Action is not expected to result in a significant adverse noise impact on neighboring land uses.

The proposed Project is not anticipated to be adversely affected by flood hazards, tsunamis, sea level rise, and/or coastal hazards. The Project Area is located inland and not near coastal areas or areas that may be adversely affected by the impacts of sea level rise from climate change. PGV would also continue to implement the preparedness actions, response actions and procedures, and reporting requirements identified in the ERP and other permits.

3.11.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawai'i Island or partnering with other renewable energy providers as described in **Section 1.5**. Potential impacts to public health and safety from this alternative would be the same as those described above for the Proposed Action.

3.11.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. Future actions at the site would likely occur as described under **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawai'i Island or partnering with other renewable energy providers as described in **Section 1.5**. Potential impacts to public health and safety during construction and operation of the Project would not occur under this alternative; however, potential impacts to public health and safety from ongoing natural hazards would continue to occur. Secondary impacts to public health and safety would occur from the burning of fossil fuels and/or development of new power production projects.

3.12 Transportation and Access

3.12.1 Existing Environment

Access to the facility from Pāhoa is east along Highway 132. Highway 132 is an important two-lane artery in east Puna. The speed limit along Highway 132 in the Project Area is 35 miles per hour. The 2018 Lower Puna eruption destroyed the portion of Highway 132 to the area known as Four Corners (intersection of Highway 132 and Highway 137) east of the facility, heading toward Kapoho. PGV restored the portion of Highway 132 near the existing operations in 2020 to regain access to the facility and also provide access to residents who had lost access to their properties with the lava flow.

As part of the Kīlauea Eruption Recovery effort, the County of Hawai'i proposes to utilize FEMA funds to restore infrastructure including roads and waterlines along Pohoiki Road and Highway 137. Hawai'i County expects construction for the projects to begin in the fourth quarter of 2023 following completion of an Environmental Assessment (EA) (County of Hawai'i 2022c). The proposed sequence of the road construction would be as follows:

- **Phase 1:** Lighthouse Road and Highway 137 to Kapoho Beach Road and is expected to begin construction at the end of 2023;

- **Phase 2:** Upper/Lower Pohoiki Road and Leilani Avenue to be built concurrent with Phase 1 (and is the segment that passes closest to the Project Area);
- **Phase 3:** Highway 137 from Kapoho Beach Road to Pohoiki Road after Phase 1 is complete; and
- **Phase 4:** Lower Highway 137, to start after Phase 2 is complete.

In August 2023, FEMA published a Draft EA for the County of Hawaiʻi Department of Public Works to realign and reconstruct approximately 9.1 miles of County roads that were inundated with lava from the 2018 Kīlauea volcano eruption in the easternmost portion of the island to bring them back to their pre-disaster function, and for County of Hawaiʻi Department of Water Supply (DWS) to install water lines along approximately 7.8 miles of the same County roads (FEMA 2023). The phases outlined in the EA indicate the schedule is consistent with the information above with the following sequencing of construction:

- **Start construction of Lighthouse Road and Highway 137 from Four Corners to Kapoho Beach Road in quarter 4 of 2023, and finish in quarter 3 of 2024;**
- **Start construction of Pohoiki Road and Leilani Avenue in quarter 3 of 2023 and finish in quarter 1 of 2025;**
- **Start construction of Highway 137 from Kapoho Beach Road to Pohoiki Road in quarter 3 of 2024 and finish in quarter 3 2025; and**
- **Start construction of Highway 137 near MacKenzie State Recreation Area in quarter 1 of 2025 and finish in quarter 3 of 2025 (FEMA 2023).**

As of 2021 annual average daily traffic data (the most recently available data), Highway 132 serves approximately 5,000 vehicles per day (HDOT 2021). Annual average daily traffic represents a typical traffic volume number on any day of the year for a specific road segment.

3.12.2 Environmental Impacts

3.12.2.1 Proposed Action

The current workforce of 31 employees at the PGV facility site would not change long-term. The construction phase of the Proposed Action is expected to require a temporary workforce of approximately 75 contractors. PGV anticipates completion of construction of the Proposed Action and associated infrastructure within ~~18~~**36** months after Project approval. Therefore, temporary increase in personnel accessing the Project would have minimal short-term impacts to traffic on Highway 132 and adjacent roads and intersections. No long-term impacts to transportation or access are expected, as the workforce and operational traffic would not change from current conditions. Additionally, PGV would continue to comply with Condition 40 of the GRP, which requires that large vehicle deliveries to the PGV facility site be limited to daylight hours (7 a.m. to 7 p.m.).

3.12.2.2 46 MW Alternative

The 46 MW Alternative is identical to Phase 1 of the Proposed Action. Under this alternative the additional 14 MW generated during Phase 2 of the Proposed Action would not be produced. It is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawaiʻi Island or partnering with other renewable energy providers as described in **Section 1.5**. Potential impacts to transportation from this alternative would be the same as those described above for the Proposed Action.

3.12.2.3 No Action Alternative

Under the No Action Alternative, equipment would not be upgraded at the PGV facility. The Project would continue to operate as described in the existing environment. Future actions at the site would likely occur as described under **Section 1.5**. Under this alternative, PGV would continue to generate up to 38 MW using the existing 12 OECs through 2027. Should the PPA be extended past 2027 under the current authorization, PGV would be permitted to continue generating up to 38 MW beyond 2027 until the end of the PPA extension. Without the up to 38 MW of power generated through 2027 (or an extended PPA term) PGV is currently authorized for and without authorization for the additional power that would be generated under the Proposed Action (i.e., up to 46 MW under Phase 1 and up to 60 MW under Phase 2), it is assumed Hawaiian Electric would need to meet the increasing demand for power through the burning of fossil fuels at its existing facilities on Hawai‘i Island or partnering with other renewable energy providers as described in **Section 1.5**. Impacts beyond existing conditions to transportation and access would not occur under the No Action Alternative.

3.13 Cumulative Effects

According to HAR Section **11-**200.1-2, “cumulative impact” is the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes the other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The Proposed Action, when considered in conjunction with past, present, and reasonably foreseeable future actions to the environment, may result in cumulative impacts, as described below.

3.13.1 Past, Present, and Reasonably Foreseeable Future Actions and Projects

This section includes a description of past projects or activities (i.e., already occurred or completed), present projects or activities (i.e., approved or application has been received), and reasonably foreseeable future projects (i.e., conceptual) **that should be considered when analyzing the incremental impact of the Proposed Action that may contribute to cumulative impacts**. Projects and activities were identified by reviewing the County of Hawai‘i’s websites and the library of EAs and EISs located on the OPSD-ERP's website. The area of analysis for cumulative impacts considered an area approximately five miles around the Project Area.

The most significant past impact to the Project Area and vicinity is from the 2018 Lower Puna eruption. Since the Project Area and vicinity are located in Lava Hazard Zone 1, the area has (and is expected to continue to) experience impacts from volcanic activity. Most recently, the 2018 Lower Puna eruption had a major impact on the area surrounding the Project, which resulted in changes in topography, loss of homes, and major impacts ($236.5 million) to public infrastructure including local roadways, waterlines, a charter school, utility poles, and an electrical substation (County of Hawai‘i 2022d). The County of Hawai‘i’s Disaster Recovery team continues to work with FEMA and the Hawai‘i Emergency Management Agency on the Kīlauea recovery road and waterline projects. The sequence of proposed road segments that have been selected for restorage are described in the Transportation and Access section (**Section 3.12**). The DWS and Department of Parks and Recreation have also applied for public assistance through FEMA to replace lost infrastructure (County of Hawai‘i 2022d). Additionally, the Department of Environmental Management is also proposing infrastructure improvement projects for the Puna District (OPSD-ERP 2022).

Past and present actions or projects that are located in the vicinity of the Project Area include overall growth and residential development of the adjacent rural communities of Leilani Estates, Nanawale Estates, Pāhoa, and Kapoho since the approval of the subdivisions in the 1950s and 1960s. Growth in these areas continued up until the 2018 Lower Puna eruption when some residents decided to relocate away from the area following the eruption. The growing conditions in Puna support diversified agriculture, and the lowland areas around Kapoho are ideal for cultivating papaya (County of Hawai‘i 2008). The area is used by a variety of recreational activities and was heavily visited by tourists and media during the 2018 Lower Puna eruption. Other recreational opportunities include the Lava Tree State Monument (which encompasses approximately 17.1 acres), which is located near the junction of Kapoho-Pāhoa Road and Pohoiki Road near the PGV facility site. Fishing is popular along the coast, and there is ocean access at Pohoiki Black Sand Beach (part of the Isaac Kepo‘okalani Hale Beach Park) south of the Project Area and existing PGV facility site; however, the 2018 Lower Puna eruption inundated the Pohoiki boat launch ramp with lava.

Reasonably foreseeable future actions in the vicinity of the Project Area include the rebuilding of infrastructure and communities, development of Revitalize Puna’s Strategic Placemaking Implementation Plan, ongoing growth and development of the regional village center in Pāhoa, tourism, recreational activities, and agricultural development. Natural disasters (e.g., tropical storms, hurricanes, volcanic eruptions, etc.) could also continue to impact the vicinity around the Project Area.

3.13.2 Cumulative Effects from the Project and Other Related Actions

The effects of past and present projects and activities (described above) on the cumulative analysis area are evident on the landscape. The most dominant past activity that has affected the area is volcanic activity. Previous lava flows have impacted the natural and built environment in the area, and the recovery efforts that have occurred and are planned to occur are designed to rebuild and improve resiliency of the area. Population growth and associated development have impacted water quality since the majority of houses in the area are cesspool and household aerobic treatment units (OPSD-ERP 2022). Other natural disasters have also impacted both the natural and built environment in the area, resulting in loss of vegetation, downed power lines, and damage to property.

As described in the resource sections above, the Project is expected to have very minimal short-term impacts to the natural and human environment during construction of the proposed four new OECs and decommissioning of the existing 12 OECs. These impacts would no longer occur after construction of Phase 1 and Phase 2 is completed. Long-term adverse impacts from the Project are expected to be less than those experienced by the current PGV facility site operations, as analyzed in the 1987 EIS, as the proposed new OECs are more efficient and quieter than the existing OECs. The proposed OECs have less rotating equipment and would require fewer piping connections. This would collectively result in less noise pollution compared to the existing 12 OECs and would reduce the potential for emissions of the geothermal resource or motive fluid emissions. Since the proposed OECs would have less of an impact on the environment than current equipment, the Project is not expected to result in adverse cumulative effects to the natural and built environment in combination with past, present, and reasonably foreseeable future actions and projects.

4.0 Consistency with Government Plans and Policies and Relevant EAs and EISs Considered

Per the requirements in HAR § 11-200.1-24(j), a summary of the regulations and land use policies that the Proposed Action is in conformance with is provided below.

4.1 Land Use Laws

The purpose of the Hawai'i State Land Use Law, HRS 205, is to establish a framework of land use management and regulation in which all lands in the state are classified into one of four state land use districts: Urban, Rural, Agricultural, or Conservation. The proposed Project is located in the State Land Use Agricultural District and within the Kapoho Section of the Kīlauea Lower East Rift Geothermal Resource Subzone and is therefore consistent with Hawai'i Land Use Law (Chapter 206, HRS). Subzones were designated as areas of significant geothermal potential where geothermal exploration and production are encouraged (see **Section 1.6**). Note that HRS Section 205-5.1 creating such geothermal subzones was repealed by Act 97 (2012). Activities in the Project Area are consistent with the district and geothermal resource subzone uses.

4.2 Hawai'i State Plan and Hawai'i State Functional Plans

The Hawai'i State Planning Act (Chapter 226 HRS, as amended) establishes a set of themes, goals, objectives, and policies that are meant to guide the state's long-run growth and development activities. The Project supports and furthers the state's primary economic objective, to develop and diversify Hawai'i's economic base. A major goal of the state is to increase energy self-sufficiency. A second energy goal is to achieve dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people. The Project supports the state's major energy objective and policy of increasing energy self-sufficiency. By upgrading equipment and capacity of the facility, the Project would supply a large percentage of Hawai'i Island's renewable firm capacity and energy and would be another important step for self-sufficiency for the state. The Proposed Action would also assist in meeting HELCO's forecast for an increase in Hawai'i Island's energy needs.

The Statewide Planning System identified in Chapter 226, HRS, requires State Functional Plans, which implement state and county actions. The Department of Business, Economic Development & Tourism (DBEDT) originally developed the Energy Functional Plan in 1984 and updated it in 1991. The Project is consistent with the DBEDT's 1991 Energy Functional Plan. One of five areas of concern addressed in the plan is alternate energy resource development. The objective is to promote alternate and renewable energy technologies through commercialization in order to shift demand from petroleum to indigenous renewable resources. In response to the state's dependence on imported petroleum, contribution of greenhouse gases from fossil fuel combustion, and possible disruption in oil supplies, the Energy Functional Plan states the following:

> A reduction of our dependence on oil and fossil fuels can be achieved by a balanced combination of demand reduction through the development of conservation and energy efficiency resources and the displacement of fossil fuels with new energy sources through alternate and renewable energy resource development.

Objective B in the Energy Functional Plan: "Displace oil and fossil fuels consumption through the application of appropriate alternate and renewable energy resources and technologies."

The existing facility and Project are consistent with Action B(1): "Assist with the Development of Geothermal First to Serve the Island of Hawai'i, and then for Export if Economically, Environmentally and Socially Acceptable and Feasible."

4.3 Hawai'i Energy Policy

As described in **Section 1.3**, the HCEI was established to reduce the state's dependence on imported petroleum for energy production and locally produce more clean energy. In 2015, Hawai'i set a renewable energy goal of 100 percent by 2045, with interim targets of 30 percent by 2020, 40 percent by 2030, and 70 percent by 2040 (HCEI 2022). Additionally, Hawaiian Electric has committed to increasing Hawai‘i's use of clean energy and reducing dependency on imported oil, with a goal to cut carbon emissions from power generation by 70 percent by 2030 and by 2045 to achieve net zero or net negative carbon emissions (Hawaiian Electric 2021).

4.4 County of Hawai‘i General Plan and Zoning

The General Plan for the County of Hawai‘i is a policy document expressing the broad goals and policies for the long-range development of Hawai‘i Island (County of Hawai‘i 2005). The plan was adopted by ordinance in 1989 and revised in 2005. The General Plan itself is organized into 13 functional elements. In general, the Project would be consistent with the goals, policies and objectives, standards, and principles for several functional areas. The Project is consistent with the following relevant energy goals and policies of the county.

Energy Goals:

- Strive toward self-sufficiency.
- Establish the Big Island as a demonstration community for the development and use of natural energy resources.

Policies:

- Encourage the development of alternate energy resources.
- Strive to assure a sufficient supply of energy to support present and future demands.
- Strive to diversify the energy supply and minimize the environmental impacts associated with energy usage.
- Continue to encourage the development of geothermal resources to meet the energy needs of the County of Hawai‘i.

The Project is consistent with the energy goals and policies in the General Plan by continuing to provide renewable geothermal energy and helping the county achieve self-sufficiency.

County Zoning

The County of Hawai‘i zoning for the Project Area is “A-10a” or Agricultural District (minimum building site of 10 acres). ~~The Project Area is located within a geothermal resource subzone, and the Project is consistent with the activities allowed in these subzones, which include exploration, development, or production of electrical energy from geothermal resources.~~**However, state law prevails (HRS Section 205-2) and geothermal resource development is a permitted use in all State Land Use Districts.**

4.5 Required Permits and Approvals

Consistent with HAR § 11-200.1-24(k), this section includes a list of necessary approvals required for action from governmental agencies, boards, or commissions or other similar groups having jurisdiction. The status of each identified approval is also described.

Table 4-1 summarizes the status of permits for the existing facility, existing permits which need to be amended for the Project, and new permits that are required for the Project. The amount of energy proposed for Phase 1 (46 MW) is covered under the ARPPA approved by the PUC, but PGV and any future off-taker would be required to amend the agreement to generate 60 MW of power prior to implementing Phase 2. Additionally, under Phase 2 of the Proposed Action, PGV would need to either modify its NSP or obtain a new NSP.

Table 4-1 Existing and Required Permits for the Facility

Permit Title	Agency	Existing, To Be Amended for Proposed Project, or New Permit Needed for Proposed Project
Federal		
Underground Injection Control (UIC) HI596002	Environmental Protection Agency	Existing, courtesy notification for the Project
State		
Underground Injection Control (UIC) UH-1529	Department of Health, State of Hawai‘i	Existing, renewal in progress, courtesy notification for the Project
Authority to Construct 7 Geothermal Wells (UIC)	Department of Health, State of Hawai‘i	Existing
Noncovered Source Permit No. 0008-02-N	Department of Health, State of Hawai‘i	Existing, renewal approved on October 19, 2022, modification issued January 23, 2023, amendment needed for the Project
Noncovered Source Permit No. 0008-03-N	Department of Health, State of Hawai‘i	Existing
Noncovered Source Permit	Department of Health, State of Hawai‘i	Need new for Phase 2
Plan of Operation	Department of Land and Natural Resources, State of Hawai‘i	Existing, courtesy notification for the Project
County		
Geothermal Resource Permit (GRP 87-2)	Hawai‘i County Planning Commission, for up to 60 MW	Notification for the Project
Plan Approval	**Hawai‘i County Planning Department**	**Amended**
Building Permit	Hawai‘i County ~~Planning~~ Department **of Public Works**	Need new
Grading Permit	Hawai‘i County ~~Planning~~ Department **of Public Works**	Need new

4.6 Relevant EAs and EISs Considered

Consistent with HAR § 11-200.1-24(d)(7), the relevant Chapter 343, HRS, document considered in the preparation of this document is the EIS prepared by PGV in 1987.

5.0 Findings and Reasons

5.1 Potentially Unavoidable Adverse Environmental Impacts

The Project would be constructed within the current PGV facility site boundaries, would have a smaller footprint of disturbance than the current units, and would increase power production from 38 to 46 MW in Phase 1 (replacing all 12 currently operating power-generating units with three upgraded power-generating units) and further increase production to 60 MW in Phase 2 (adding one additional upgraded power-generating unit). There would be no unavoidable adverse environmental impacts ~~as,~~ under the Project **as** the footprint of disturbance would decrease and the new equipment would utilize more modern technology (with fewer piping connections) compared to current operations. Therefore, as discussed in the sections above, the Project would result in fewer environmental impacts compared to current operations. PGV would continue to apply best available technology and required mitigation measures for the life of the Project. As the term of the ARPPA approaches its end in 2056, PGV will again evaluate whether, based on economic and resource conditions, the facility should be refurbished to further extend the PPA term of the facility or whether it should be decommissioned. When decommissioned, the site will then be returned to as close to its natural state as practicable while considering lease requirements. Air emissions and noise associated with the facility would cease at the end of PGV facility site operations The following sections describe the unavoidable adverse short-term and long-term impacts that could occur as a result of the Project.

5.1.1 Unavoidable Adverse Short-Term Impacts

A minor increase in air emissions could occur during the construction phase of the Proposed Action while installing the four new OECs; however, at the completion of construction and transition into operations, air emissions would be the same as or less than existing conditions. Similarly, minor increases in noise may occur during construction of the Project but are anticipated to be less than existing conditions once the four new OECs are operational given the lower noise generation of the upgraded technology. A temporary increase in traffic to and from the Project site would also occur during construction. All potential adverse impacts described herein would be temporary.

5.1.2 Unavoidable Adverse Long-Term Impacts

No unavoidable adverse long-term impacts from the Project are anticipated. **As discussed in Section 3.8.2.1, based on comments provided on the Draft EIS, it is acknowledged that given the nature of certain Hawaiian traditional and customary beliefs and impacts resulting from those beliefs, any operation of the PGV facility will be considered to be an impact to some people and/or practitioners. As discussed above, the Proposed Action is anticipated to decrease air pollution resulting from replacing existing facility equipment with new and more efficient equipment. Because there are no specific practices conducted on the Project site, and together with the continued cultural education of PGV employees, the Proposed Action is not anticipated to result in unavoidable adverse long-term impacts to traditional and customary native Hawaiian rights related to traditional cultural resources, beliefs, and practices, as it would not prevent, hinder, or restrict such practices and beliefs from continuing.**

5.2 Irreversible and Irretrievable Commitment of Resources

The Project would continue to require the commitment of land, geothermal fluids, building materials, labor, and private capital for construction of Phase 1 and Phase 2 and subsequent operations. Some of these are considered irreversible and irretrievable commitments of resources. The Project would continue to use the land at the facility site and geothermal resources for the life of the Project, and the Project includes a temporary commitment of building materials, labor, and private capital for construction of the Project. Construction of the Project, including decommissioning of the existing 12 OECs and replacement by the proposed four new OECs, would result in consumption of petroleum-derived fossil fuels, which also represents an irretrievable commitment of resources. Such commitments under the Proposed Action would not result in an increase in irreversible and irretrievable commitments of resources beyond existing conditions. The State of Hawaiʻi considers geothermal energy a renewable energy resource. The renewable characteristic of the geothermal resource includes the following processes: the geothermal heat from the geothermal production wells are used to generate electricity; after generating electricity, the cooled geothermal resource is then directed back into the earth via the geothermal injection wells; finally, the cooled fluids eventually migrate to the geothermal production zones, where the renewable process starts again.

5.3 Unresolved Issues

No unresolved issues are anticipated under the Proposed Action.

5.4 Significance Criteria

Based on the preceding analysis in this document, the proposed protection measures, and mitigation measures identified, the Project is not anticipated to have significant **adverse** environmental impacts. This determination is based upon the 13 significance criteria outlined in Chapter 343, HRS, as amended, and Title 11, Chapter 200.1-13, HAR, discussed below.

1. *Irrevocably commit a natural, cultural, or historic resource.* No valuable natural or cultural resources would be committed or lost as a result of the Proposed Project.

2. *Curtail the range of beneficial uses of the environment.* The Proposed Project expands the beneficial uses of the environment by generating renewable energy**, providing an alternative energy source to Hawai'i Island** and is consistent with use in the geothermal resource subzone in the Agricultural district zoning.

3. *Conflict with the state's environmental policies or long-term environmental goals established by law*. The state's long-term environmental policies are set forth in Chapter 344, HRS. The broad goals of this policy are to conserve natural resources and enhance the quality of life. The impact from the proposed Project is consist with these goals since it would reduce the amount of energy generated from fossil fuels and increase the amount of renewable energy. Therefore, the Project is consistent with all elements of the state's long-term environmental policies and environmental goals.

4. *Have a substantial adverse effect on the economic, social welfare, or cultural practices of the community or state.* The proposed Project would have a beneficial effect on the economic and social welfare during construction by providing short-term employment and long-term stability, as well as a reduction in the dependency on imported fossil fuels, reductions in GHG emissions, reductions in noise and air pollution, and expansion of renewable energy generation on Hawai'i Island. No adverse effects to **specific** cultural **resources or** practices are expected since the Project Area was impacted by the 2018 Lower Puna eruption and inundated with lava, and no current cultural practices at the site have been identified through consultation. **However, this EIS acknowledges that given the nature of certain Hawaiian traditional and customary beliefs about Pele, some people and/or cultural practitioners consider any operation of the PGV facility to be an impact, while others do not. PGV would resume practice of cultural protocols and together with the continued cultural education of PGV employees, the Proposed Action is not anticipated to result in unavoidable adverse long-term impacts to traditional and customary native Hawaiian rights related to traditional cultural resources, beliefs, and practices, as it would not prevent, hinder, or restrict such practices and beliefs from continuing.**

5. *Have a substantial adverse effect on public health.* The proposed Project's temporary impacts related to noise, air quality, or water quality during construction would be minimized through compliance with federal, state, and county requirements, environmental protection measures, and BMPs. Public health and safety during operation of the proposed Project would be ensured through compliance with federal, state, and county permits and conditions, Additionally, the proposed Project would result in long-term improvements to air quality, reduction of noise impacts, and increased stability of renewable energy production.

6. *Involve adverse secondary impacts, such as population changes or effects on public facilities.* No adverse secondary effects are expected from the Project.

7. *Involve a substantial degradation of environmental quality.* The impact from construction of the proposed Project is minor and would not contribute to environmental degradation. BMPs and appropriate erosion control measures would be utilized during construction. No long-term adverse impacts are expected from the proposed Project since it would provide more efficient renewable energy for the island without much additional surface disturbance.

8. *Is individually limited but cumulatively has substantial adverse effect upon the environment or involves a commitment for larger actions.* The proposed Project is not related to other activities in the region in such a way as to produce adverse cumulative effects or involve a commitment for larger actions. It is consistent with ongoing operations and is consistent with the geothermal subzone it is located within.

9. *Have a substantial adverse effect on a rare, threatened, or endangered species or its habitat.* The Project site does not contain any critical habitat for rare, threatened, or endangered species. The proposed Project avoids potential impacts to these species if they travel through or near the Project site or are found at the Project site, as discussed in **Section 3.5**. Therefore, the proposed Project is not expected to have a substantial adverse effect on rare, threatened, or endangered species or their habitat.

10. *Have a substantial adverse effect on air or water quality or ambient noise levels.* No adverse effects on air quality, water quality, or noise would occur **beyond existing conditions**. A reduction in noise levels would occur as a result of the proposed Project **due to the implementation of new equipment that is more efficient and operates at a less noisy volume** and would continue to be consistent with their zoning and current use. The ongoing monitoring and permit compliance would ensure that no impacts to water quality or the near-shore environment occur from the proposed Project.

11. *Have a substantial adverse effect on or is likely to suffer damage by being located in an environmentally sensitive area such as a floodplain, tsunami zone, sea level rise exposure area, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.* Although the **Project** property is located in an area with volcanic and seismic risk, the entirety of Hawai'i Island shares this risk, and**, due to the nature of the Project generating energy from geothermal resources, the Project needs to be sited near the geothermal resources. T**~~t~~he proposed Project would help Hawai'i Island and the State of Hawai'i meet their energy goals. The proposed Project has been designed to continuously operate the facility in a safe manner.

12. *Have substantial adverse effect on scenic vistas and viewplanes, during day or night, identified in county or state plans or studies. No scenic vistas and viewplanes identified in the Hawai'i County General Plan will be adversely affected by the Proposed Project.* Scenic effects would be avoided with the visual screening wall and planting of vegetation.

13. *Require substantial energy consumption or emit substantial greenhouse gases.* The Project generates energy and does not require substantial energy consumption and would reduce GHGs **emitted** on Hawai'i Island.

6.0 Public Notification and Comment

6.1 EIS Scoping Consultation

Sections 1.7.1 and **1.7.2** describe the public notification through the publication of the EISPN and the scoping process to obtain public input. Public notification began with publication of the EISPN in the state bulletin and notification of the public scoping meeting in local newspapers and the news. A copy of the scoping notification letter is included in **Appendix A**. Letters providing notification of the EISPN publication and scoping dates were mailed directly to approximately 63 agencies and organizations with jurisdiction, expertise, or elected officials. Those that were notified of the scoping period through direct mail or email are listed in **Table 6-1** and those that provided comments during the scoping period are listed in **Table 6-2**.

In accordance with HAR Section 11-200.1-26, responses to substantive, written scoping comments are published in the Draft EIS. Reproduction of the complete written comments received during scoping for this Draft EIS, and responses to those comments, are provided in **Appendix B**. **Section 1.7.2** provides a summary of oral comments received during the two-hour simultaneous live and virtual event; the oral comments received were recorded and are available as an audio file.

6.2 Notice of Availability for Draft and Final Environmental Impact Statement

The public notification process for theeis Draft EIS is summarized in **Section 1.7.3 and for the Final EIS is summarized in Section 1.7.4**. Entities that were notified of the Draft **and Final** EIS availability through direct mail or email are listed in **Table 6-1**. Individuals who provided public scoping comments, and provided their contact information, were notified of the Draft **and Final** EIS availability by direct mail or email and are listed in **Table 6-2**. Individuals who requested to be added to the Draft **and Final** EIS notification list at the public scoping meeting **and voluntary public comment meeting** were also notified by direct mail or email are listed in **Table 6-3**. The OPSD-ERP informed the public of the Draft **and Final** EIS availability through publication in its bulletin, *The Environmental Notice* (HRS Chapter 3433[c]).

Printed versions of theeis Draft **EIS and this Final** EIS have been **were** provided to the following relevant public libraries to facilitate public review, in fulfillment of HEPA requirements: Hawaiʻi State Library Documents Center and Pāhoa Public Library. The Draft **and Final** EIS**s** is**are** also available online through the OPSD-ERP website, **https://planning.hawaii.gov/erp/ea-and-eis-new-rules/**https://files.hawaii.gov/dbedt/erp/Doc_Library/2022-07-23-HA-EISPN-Puna-Geothermal-Venture-Repower-Project.pdf, and on the PGV's EIS website at https://punageothermalproject.com/eis/.

Table 6-1 EIS Scoping and Notification of Availability for the Draft EIS

Name/Affiliation	Provided Notice of Scoping	Written Scoping Comment Received	Provided Draft EIS Notice of Availability	**Written Draft EIS Comment Received**	**Provided Final EIS Notice of Availability**
Elected Officials					
Josh Green, Governor of Hawaiʻi	Y	N	Y	**N**	**Y**
Mazie Hirono, Senator	Y	N	Y	**N**	**Y**
Brian Schatz, Senator	Y	N	Y	**N**	**Y**
Jill Tokuda, U.S. Representative, Hawaiʻi 2nd Congressional District	Y	N	Y	**N**	**Y**
Joy San Buenaventura, Hawaiʻi State Senator, District 2	Y	N	Y	**N**	**Y**
Greggor Ilagan, Hawaiʻi State Representative, District 4	Y	N	Y	**N**	**Y**
Ashley Lehualani Kierkiewicz, Hawaiʻi County Council, District 4	Y	N	Y	**N**	**Y**

Name/Affiliation		Provided Notice of Scoping	Written Scoping Comment Received	Provided Draft EIS Notice of Availability	**Written Draft EIS Comment Received**	**Provided Final EIS Notice of Availability**
Mitch Roth, Mayor, County of Hawai‘i		Y	N	Y	**N**	**Y**
Federal Agencies						
Environmental Protection Agency, Region 9		Y	N	Y	**N**	**Y**
United States Geologic Survey, Hawaiian Volcano Observatory		Y	N	Y	**N**	**Y**
United States Fish and Wildlife Service		Y	N	Y	**N**	**Y**
U.S. Department of Energy		Y	N	Y	**N**	**Y**
Department of Defense		Y	N	Y	**N**	**Y**
State of Hawai‘i Agencies						
Public Utilities Commission	State of Hawai‘i	Y	N	Y	**N**	**Y**
Hawai‘i State Energy Office	State of Hawai‘i	Y	N	Y	**Y**	**Y**
Department of Agriculture	State of Hawai‘i	Y	N	Y	**N**	**Y**
Department of Business, Economic Development & Tourism	State of Hawai‘i	Y	N	Y	**N**	**Y**
Department of Business, Economic Development & Tourism, Hawai‘i State Energy Office	State of Hawai‘i	Y	N	Y	**N**	**Y**
Department of Education	State of Hawai‘i	Y	N	Y	**Y**	**Y**
Department of Hawaiian Home Lands	State of Hawai‘i	Y	N	Y	**N**	**Y**
Office of Hawaiian Affairs	State of Hawai‘i	Y	N	Y	**N**	**Y**
Department of Health, Clear Air Branch	State of Hawai‘i	Y	Y	Y	**N**	**Y**
Department of Health, Environmental Management Division	State of Hawai‘i	Y	N	Y	**N**	**Y**
Department of Health, Wastewater Branch	**State of Hawai’i**	-	-	-	**Y**	**Y**
Department of Land and Natural Resources	State of Hawai‘i	Y	Y	Y	**N**	**Y**
Department of Land and Natural Resources, State Historic Preservation Division	State of Hawai‘i	Y	N	Y	**N**	**Y**
Department of Transportation	State of Hawai‘i	Y	Y	Y	**Y**	**Y**
HI-EMA	State of Hawai‘i	-	-	Y	**N**	**Y**
University of Hawai‘i Offices/Centers						
Office of Capital Improvement	University of Hawai‘i	Y	N	Y	**N**	**Y**

Name/Affiliation		Provided Notice of Scoping	Written Scoping Comment Received	Provided Draft EIS Notice of Availability	Written Draft EIS Comment Received	Provided Final EIS Notice of Availability
Water Resources Research Center	University of Hawaiʻi	Y	N	Y	N	Y
Environmental Center	University of Hawaiʻi	Y	N	Y	N	Y
County of Hawaiʻi Agencies						
Department of Environmental Management		Y	N	Y	N	Y
Fire Department		Y	N	Y	N	Y
Department of Parks and Recreation		Y	N	Y	N	Y
Planning Department		Y	N	Y	N	Y
Police Department		Y	Y	Y	Y	Y
Department of Public Works		Y	N	Y	N	Y
Department of Research and Development		Y	N	Y	N	Y
Department of Water Supply		Y	Y	Y	Y	Y
Civil Defense Agency		Y	N	Y	N	Y
Organizations						
Hawaiian Electric Light Company		Y	N	Y	N	Y
Kamehameha Schools		Y	N	Y	N	Y
Nanawale Community Association		Y	N	Y	N	Y
Leilani Community Association		Y	N	Y	N	Y
Main Street Pāhoa		Y	N	Y	N	Y
Pele Defense Fund		-	-	-	Y	Y
Pōhaku Pelemaka		Y	N	Y	N	Y
Men of Paʻa		Y	N	Y	N	Y
Nā Maka Hāloa O Waipiʻo		Y	N	Y	N	Y
ʻO Makuʻu Ke Kahua		Y	Y	Y	N	Y
Hoʻoulu Lāhui		Y	N	Y	N	Y
Japanese Chamber of Commerce & Industry of Hawaiʻi		Y	N	Y	N	Y
Hawaiʻi Island Chamber of Commerce		Y	N	Y	N	Y
Hawaiʻi Island Economic Development Board		Y	N	Y	N	Y
Hawaiʻi Leeward Planning Conference		Y	N	Y	N	Y

Name/Affiliation	Provided Notice of Scoping	Written Scoping Comment Received	Provided Draft EIS Notice of Availability	**Written Draft EIS Comment Received**	**Provided Final EIS Notice of Availability**
Native Hawaiian Chamber of Commerce	Y	N	Y	**N**	**Y**
Ohana Ho'opakele	**-**	**-**	**-**	**Y**	**Y**
Sustainable Energy Hawaiʻi	Y	N	Y	**N**	**Y**
Earth Justice Warriors	Y	N	Y	**N**	**Y**
Puna Pono Alliance	Y	Y	Y	**N**	**Y**
Malama O Puna	Y	N	Y	**Y**	**Y**
Hawaiʻi Groundwater and Geothermal Resource Center	Y	N	Y	**N**	**Y**
Parker Ranch	Y	N	Y	**N**	**Y**
Ulupono Initiative LLC	Y	N	Y	**N**	**Y**
Blue Planet Foundation	Y	N	Y	**N**	**Y**
Sierra Club of Hawaiʻi	Y	N	Y	**Y**	**Y**
Kākoʻo Haleakalā	**-**	**-**	**-**	**Y**	**Y**

Table 6-2 List of Additional Oral and Written Commenters Who Submitted Scoping Comments and Comments on the Draft EIS

Individuals	Scoping Comment Received (Oral/Written)	**Public Comment Received (Oral/Written)**
Jon Olsen	Oral	**-**
Palikapu Dedman	Oral	**Oral, Written**
Rocky Jensen	Oral	**-**
Bryan Christ	Oral	**-**
Cory Harden	Oral	**Oral, Written**
Sara Steiner	Oral, Written	**Oral, Written**
Larry Wood	Oral	**Written**
Dante Orpilla	Oral	**-**
Robert Petricci, Puna Pono Alliance	Oral, Written	**Oral**
Loke Madrigal	Oral	**-**
Enoka-Shayne Bingovc	Oral	**-**
Shelly Mahi	Oral	**-**
Mike Ament	Oral	**-**

Individuals	Scoping Comment Received (Oral/Written)	**Public Comment Received (Oral/Written)**
Ben Cole	Oral	**Oral, Written**
Alayna Newton	Oral	**-**
Russ Henrie	Oral	**-**
Keoni Payton	Oral	**-**
Leomana A**. Turalde**	Oral	**Oral**
Jaeric M**edeiros-Garcia**	Oral	**Oral**
Jr. Tupae	Oral	**-**
Paul Kuykendall	Oral	**Oral, Written**
Suzanne Wakelin	Oral	**Written**
Tara Rojas	Oral	**-**
Kiara Lorenzo	Oral	**-**
Brian Ley	Oral	**-**
Kalena Holani	Oral	**-**
Shannon Rudolph	Oral	**-**
Alfred Keaka Hiona Medeiros	Oral	**-**
Steve Sparks, Mg Products, Inc.	Written	**-**
‘O Maku‘u Ke Kahua	Written	**-**
Clean Air Branch, Department of Health	Written	**-**
David Kisor	Written	**Written**
Captain Scott Amaral, Police Department	Written	**Written**
Highways Division, Department of Transportation	Written	**-**
April Spencer	Written	**-**
Chuck Barker	Written	**-**
Kohana / Nolan K. Iopa	Written	**-**
County of Hawai‘i Department of Water Supply	Written	**Written**
Lisa Roach, Savio Realty, Ltd.	Written	**-**
Peter Sternlicht	Written	**-**
Christopher Biltoft	Written	**Written**

Individuals	Scoping Comment Received (Oral/Written)	Public Comment Received (Oral/Written)
Noel Morin	Written	-
Alice Kim	Written	-
Selah Levine	Written	Oral, Written
Paul Kuykendall and Suzanne Wakelin	Written	Oral, Written
Ken Hayashida, KAI Hawaii, Inc.	Written	-
Land Division, Department of Land and Natural Resources	Written	-
Division of Forestry and Wildlife, Department of Land and Natural Resources	Written	-
Heather Irwin, Keone Kalawe, and Keikialoha Kekipi	Written	-
Nick Heinrich	Written	-
Garth Yamanaka, Government Affairs Committee	Written	-
Donald Thomas	Written	-
Eileen O'Hara, Malama O Puna	Written	Written
Shelley Maka'ala	-	Oral
Galen Alpine	-	Written
Amelia Kajiyama	-	Written
George Douvris	-	Written
State of Hawaii Department of Health Wastewater Branch	-	Written
Falk Amelung	-	Written
Nick Conti	-	Written
Desmon Haumea	-	Written
Dendra Best	-	Written
Jasmine Steiner	-	Written
Cindy Conda	-	Written
Rob Kindel	-	Written
Michael Reimer	-	Written
Mary-Frances Sullivan	-	Written
James Lehner	-	Written
Russell Ruderman	-	Written

Individuals	Scoping Comment Received (Oral/Written)	Public Comment Received (Oral/Written)
Kalia Katherine Avery	-	Written
Pua Case	-	Written
Torie Hoopii, Kāko'o Haleakalā from Maui	-	Written
Momi Wheeler	-	Written
Julie-Mae Stitz	-	Written
Emil Svrcina	-	Written
Kapulei Flores	-	Written
Rocky Ishibashi	-	Written
Katherine Marchese	-	Oral, Written
Dephlia (Dea) Rackley	-	Written
Cameron Black (Hawaii State Energy Office)	-	Written
Dephlia (Dea) Rackley	-	Written
Vikki Pfendler	-	Written
Hannah Hartmann	-	Oral, Written
Emma Stierhoff	-	Written
Keith Okamoto, Department of Water Supply	-	Written
Amalia Collins	-	Written
Edward Ige, Department of Education	-	Written
Patricia Wagatsuma Stewart	-	Written
Jim Albertini	-	Written
Claire McGuire	-	Written
Jenna Burns	-	Written
Ohana Ho'opakele, Thomas E. Luebben	-	Written
Sharon Kim	-	Written
Thomas Luebben, Pele Defense Fund	-	Written
Jon Olson	-	Oral
Deanna Wentworth	-	Oral
Rocky Kalani	-	Oral

Individuals	Scoping Comment Received (Oral/Written)	Public Comment Received (Oral/Written)
Emily Naeole	-	Oral
Sativa	-	Oral
Deborah Ward	-	Oral
Linda Penn	-	Oral
Yeshuah Kauhane	-	Oral
Rod Kindel	-	Oral
Luana Jones	-	Oral
Nohea Crutcher	-	Oral
Kathy Heller	-	Oral
Geoff Shaw	-	Oral

Table 6-3 Individuals Who Requested to be Added to the ~~Draft~~ EIS Notification List at the Scoping and Voluntary Public Comment Meetings

Individuals	Requested EIS Notification	Meeting
Brian Ley	Draft EIS	Scoping
Rob Hart	Draft EIS	Scoping
Keone Kalawe	Draft EIS	Scoping
Cynthia Henrie	Draft EIS	Scoping
Paulette Hale	Draft EIS	Scoping
Cory Harden	Draft EIS, Final EIS	Scoping, Public Comment
Ruby Rozell	Draft EIS	Scoping
Keikialoha Kekipi	Draft EIS	Scoping
Ingrid Webb	Draft EIS	Scoping
Michael Ament	Draft EIS	Scoping
Tallchief Comet	Draft EIS	Scoping
Leomana Turalde	Draft EIS	Scoping
Jaerick Medeiros-Garcia	Draft EIS	Scoping
Aerial Douvris	Draft EIS	Scoping
John Douvris	Draft EIS	Scoping
Hannah Hartmann	Final EIS	Public Comment
Sanae Hartmann	Final EIS	Public Comment
Kazuma Martin	Final EIS	Public Comment
Palikapu Dedman	Final EIS	Public Comment
Deanna Wentworth	Final EIS	Public Comment
Bill Wentworth	Final EIS	Public Comment
Brian Ogawa	Final EIS	Public Comment
Jon Olson	Final EIS	Public Comment

Individuals	Requested EIS Notification	Meeting
Rocky Ishibashi	Final EIS	Public Comment
Dea Rackley	Final EIS	Public Comment
Benjamin Cole	Final EIS	Public Comment
Jason Cluto	Final EIS	Public Comment
Jeff Tompkins	Final EIS	Public Comment
Shawn Naone	Final EIS	Public Comment
Shelley S. Ha'i	Final EIS	Public Comment
Katherine Marchese	Final EIS	Public Comment
Jenn Zelko	Final EIS	Public Comment
Ashley Miyashiro	Final EIS	Public Comment
Luella Crutcher	Final EIS	Public Comment
Larry Morris	Final EIS	Public Comment
Sara Steiner	Final EIS	Public Comment
David Sanchez	Final EIS	Public Comment
Kristen Okinaka	Final EIS	Public Comment
Ed Reiners	Final EIS	Public Comment
Megan Moseley	Final EIS	Public Comment
Eileen O'Hara	Final EIS	Public Comment
Selah Levine	Final EIS	Public Comment
Steve Sparks	Final EIS	Public Comment
Michael Manuel	Final EIS	Public Comment
Amalia Collins	Final EIS	Public Comment
Yeshuah Kauhane	Final EIS	Public Comment
Robert Petrucci	Final EIS	Public Comment
Luana Jones	Final EIS	Public Comment
Kathy Heller	Final EIS	Public Comment
Ashley Kierkiewicz	Final EIS	Public Comment

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