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Port Gamble S'Klallam Tribe Strategic Energy Plan

December 2025

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Summary

The Port Gamble S'Klallam Tribe (PGST), originally known as the Strong People, has been established in the Puget Sound Basin and surrounding areas since 2400 BCE. The Tribe has a reputation for grit and resilience, with a vision as a sovereign nation to be self-sufficient, proud, strong, healthy, educated, and respected.[1] Tribal members have for many generations subsisted off the land—hunting, fishing, and living deeply connected to the land and its resources. As outlined in PGST's 2024 Priority Climate Action Plan,[2] the Tribe recognizes the need to take action to reduce the harmful impacts of severe weather and enhance the energy independence and resilience of its community. To further support these goals, PGST applied for and received technical assistance from the U.S. Department of Energy (DOE) Energy Technology Innovation Partnership Project (ETIPP)[3] from 2023 to 2025. Through a community-driven approach that leverages local partner networks and national laboratories, ETIPP supports remote, coastal, and island communities in transforming their energy systems by providing technical assistance tailored to each community's needs. Goals and principles guiding this work were developed by PGST.

The PGST Reservation is connected to the rest of Kitsap County by a single road, Hansville Rd NE, which can result in the reservation becoming cut off from the nearest emergency services if the road is closed for any reason (e.g., vehicle accidents, downed trees). PGST's electricity is supplied through two power lines: One is a transmission line that comes up from Hansville Rd NE; the other is an underwater distribution cable that crosses Port Gamble Bay. PGST's location puts them at the "end of the line" for power restoration, resulting in multiday power outages when storm events disrupt existing power sources. During a power outage, Tribal members wait for power to be restored, and the community can quickly become isolated from outside resources. Because of these challenges, PGST developed an energy vision that centers around enhancing resilience for the community through energy diversification, self-reliance, and capacity building. By engaging Tribal leaders and stakeholders, the following guiding principles for PGST's energy vision were identified:

- **Resilience:** Implement renewable energy generation, battery storage, and other redundancy/resilience measures to sustain critical infrastructure for 7 days in the case of a severe power outage or natural hazard.
- **Capacity building:** Develop internal capacity, infrastructure, and local workforce to support the Tribe's energy transformation and engage with staff, partners, and the community to achieve energy and resilience goals.
- **Energy efficiency:** Empower both Tribal staff and community members to improve energy efficiency in Tribal community buildings and their own homes.
- **Energy system transformation:** Advance toward the goal of transforming energy systems on PGST's Reservation and achieving energy independence by exploring options such as renewable energy generation, battery storage, microgrids, and fleet electrification.

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[1] Port Gamble S'Klallam Tribe https://pgst.nsn.us/

[2] PGST Priority Climate Action Plan https://www.epa.gov/system/files/documents/2024-04/portgamblesklallamtribe-pcap.pdf

[3] Energy Technology Innovation Partnership Project https://www.nrel.gov/state-local-tribal/energy-technology-innovation-partnership-project.html

Where applicable, these guiding principles were aligned with existing initiatives and strategic plans. To support the development of the Strategic Energy Plan, the team conducted the following activities:

- Established a baseline energy use for PGST's campus facilities.
- Conducted initial feasibility studies of renewable resources, including solar photovoltaics (PV), wind energy, marine energy, and bioenergy.
- Performed energy and water efficiency audits in selected PGST buildings, including the Administration, Youth Center, Children and Family Services/Police (CFS/Police), and Early Childhood Education buildings.
- Identified risks and vulnerabilities to critical energy infrastructure.
- Analyzed the potential for other technologies, such as ground source heat pumps and electric vehicle charging.
- The Säzän Group (Säzän), along with team members from Spark Northwest and MZ Solar Consulting, conducted a techno-economic analysis and feasibility study for potential microgrids that could enhance resilience for key PGST facilities.
- Spark Northwest, along with team members from the Pacific Northwest National Laboratory and PGST, developed a workforce development plan, including education and training programs and energy career pathways.

The analyses result in the following key findings:

- **Solar PV—for example, solar panels—on various PGST-owned facilities can offset 11% to 33% of individual building loads.** Of the renewable energy technologies analyzed, solar PV is the most viable for PGST because of the combination of resource availability and local preferences. On PGST-owned facilities such as the Beach Shelter, Clinic, Early Childhood Education, Tribal housing, and Wastewater Treatment Plant buildings, there is the potential to install solar PV systems that could help offset between 11% and 33% of the individual building loads. Open areas such as the Clinic and Casino parking lots also have significant potential for solar PV.
- **Other renewable energy technologies were explored, and some warrant further exploration.** Marine energy and wind energy were found to have limited viability to serve PGST facilities because of a combination of resource availability and cultural significance. The area lacks a significant marine energy resource, and the Tribe wanted to avoid any potential impacts of marine energy devices on local fisheries.[1] The wind energy resource offers potential in limited areas that are less viable because of distance from other infrastructure. Wind energy was also deprioritized because of potential impacts to wildlife, particularly the bald eagle population.[2] Other technologies such bioenergy may be viable in the long term and merit additional investigation.
- **Microgrids are feasible at multiple locations with one selected for implementation.** The microgrid feasibility study resulted in three prioritized microgrid system concepts to strengthen the ability of key PGST facilities to withstand a 7-day outage:

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[1] As marine energy remains an emerging sector with few commercially deployed technologies, the full extent of its environmental impacts is not yet fully understood, though research is actively progressing.

[2] Conversations with PGST leadership revealed that populations of bald eagles resided on trust and new lands. Since wind energy can impact avian populations in a variety of ways, including habitat loss and physical impact, PGST opted to not potentially disrupt existing populations with a wind energy project.

  - Concept 1: Clinic Building Critical Loads Solar and Storage Microgrid
  - Concept 2: Early Learning Center/Clinic Building Solar and Storage
  - Concept 3: Higher Education/Longhouse/Elder's Solar and Storage Microgrid.

Based on stakeholder interest and its financial benefit, lowest operating cost, and lowest project complexity, Concept 1 was selected for near-term implementation. PGST has obtained a Washington Department of Commerce Clean Energy Grant to pursue this project, and the remaining microgrid options may be considered for implementation in the future.

- **Efficiency measures can provide estimated cost savings of $15,818 annually.** The on-site energy and water audit of selected PGST buildings identified efficiency measures with estimated annual cost savings of $15,818 from avoided electricity and propane costs. The estimated cost to implement all identified measures is $156,480, which yields a simple payback period of 9.9 years and a savings-to-investment ratio (SIR) of 1.3. Incentives by Puget Sound Energy (PSE) could reduce the simple payback even further. These audits highlight there are likely additional efficiency opportunities to be pursued at PGST administrative buildings and potentially on other buildings on the reservation. Key next steps for PGST include conducting energy audits at all PGST campus buildings, working with PSE to identify additional incentive and rebate opportunities, and developing a process for periodically reviewing energy and water consumption in its buildings.
- **Resilience strategies are needed to harden critical energy infrastructure against potential threats.** Critical infrastructure was identified through conversations with PGST staff and Tribal Council members and is defined as assets and systems that provide functions necessary for the Tribe's way of life. This includes critical buildings, backup generators, water/sewer infrastructure, and PSE infrastructure. A variety of hazards put the infrastructure at risk; in particular, earthquakes, coastal flooding, sea level rise, and severe weather and windstorms could have implications for resilience improvement efforts and potential renewable energy siting efforts. There are strategies PGST can use to mitigate the risks to its infrastructure.

Understanding the opportunities for various technologies and interventions at its campus facilities is only the first step for PGST to achieve its energy vision. With this information, the Tribe can take targeted steps to advance toward each of its goals and eventually grow its program to reach beyond the campus buildings. The strategic plan presented in this report outlines a few short-, medium-, and long-term steps PGST can take to achieve its goals. Engaging Tribal residents and developing the local workforce will also be key in PGST's success, ensuring all stakeholders can play a role in executing the Tribe's energy vision.

Acknowledgments

This research was supported by the Energy Technology Innovation Partnership Project (ETIPP) program, which receives funding and support from several offices within the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). The National Laboratory of the Rockies (NLR), formerly known as the National Renewable Energy Laboratory (NREL), manages the ETIPP program. Sean Esterly and Trent Dillon at NLR oversaw this project.

We extend our appreciation to Säzän Group for its partnership in assessing microgrid technologies for the Port Gamble S'Klallam Tribe (PGST) and its support in integrating its separate project outcomes into this related project. The Säzän team was led by Tom Bowen.

We would like to acknowledge Spark Northwest for its role as a community partner, facilitating meaningful relationships with the PGST community and engaging in discussions to ensure the project scope and ongoing efforts aligned with the Tribe's needs, resulting in context-sensitive and well-vetted recommendations. The Spark Northwest team was led by Eriq Acosta and supported by Mia Devine, Lindsey Bear, and Haya Muñoz.

Finally, special thanks to our partners at PGST including project manager Tamara Gage and the PGST steering committee, including Mike Rorem, Sam Phillips, Joe Sparr, Benjamin Harrison, Kelly Sullivan, and Matt Ives (Tribal Council Member). We are grateful to the many Tribal staff and members who provided feedback, data, access to Tribal facilities, and other resources essential to success. PGST's unflagging engagement and support were crucial to this partnership project.

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This report was funded by the U.S. Department of Energy's Energy Technology Innovation Partnership Project (ETIPP). ETIPP is a community-led technical support program for coastal, remote, and island communities to access unique solutions and increase energy resilience. By uniting federal agencies, national laboratories, regional organizations, and community stakeholders, ETIPP provides tailored technical support to help communities achieve affordable, reliable solutions to their energy system challenges. This collaborative model leverages the combined expertise and resources of its partners to deliver comprehensive, practical solutions that align with local needs.

Acronyms and Abbreviations

AC	Alternating Current
AFDC	Alternative Fuels Data Center
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
BEV	battery electric vehicle
BESS	battery energy storage system
BSE	Building Science Education
CFS	Children and Family Services
DC	direct current
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
E2C	Energy to Communities
EERE	Energy Efficiency and Renewable Energy
EIA	Energy Information Agency
ESPC	energy savings performance contracts
ETIPP	Energy Technology Innovation Partnership Project
EV	electric vehicle
EVI	electric vehicle infrastructure
FEMA	Federal Emergency Management Agency
GHX	ground heat exchanger
GSHP	ground source heat pumps
GW	gigawatt
HVAC	heating, ventilation, and air conditioning
ICE	internal combustion engine
IGSHPA	International Ground Source Heat Pump Associate
lbs/ft2	pounds per square foot
kW	kilowatt
kWDC	kilowatts direct current
kWh	kilowatt-hour
kWh/m2/day	kilowatt-hours per square meter per day
m	meter
MMBtu	million British thermal units
mpg	miles per gallon
mpge	miles per gallon equivalent
m/s	meters per second

MW	megawatt
MWDC	megawatts direct current
NEVI	national electric vehicle infrastructure
NOAA	National Oceanographic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
NLR	National Laboratory of the Rockies
NSRDB	National Solar Radiation Database
NWIC	Northwest Indian College
O&M	operations and maintenance
OBF	on-bill financing
OBR	on-bill repayment
OSHA	Occupational Safety and Health Administration
ORNL	Oak Ridge National Laboratory
PACE	property-assessed clean energy
PGST	Port Gamble S’Klallam Tribe
PHEV	plug-in hybrid electric vehicle
PNNL	Pacific Northwest National Laboratory
PSE	Puget Sound Energy
PV	photovoltaic
REAP	Rural Energy for America Program
SIR	savings-to-investment ratio
SUV	sport utility vehicle
TERO	Tribal Employment Rights Office
TMY	typical meteorological year
USDA	U.S. Department of Agriculture
WAHP	water-to-air heat pump
WBDG	Whole Building Design Guide
WWHP	water-to-water heat pump

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1.0 Introduction

The Port Gamble S'Klallam Tribe (PGST), originally known as the Strong People, has been established in the Puget Sound Basin and surrounding areas since 2400 BCE. The Tribe has a reputation for grit and resilience, with a vision as a sovereign nation to be self-sufficient, proud, strong, healthy, educated, and respected.[1] Tribal members have for many generations subsisted off the land—hunting, fishing, and living deeply connected to the land and its resources. As outlined in PGST's 2024 Priority Climate Action Plan,[2] the Tribe recognizes the need to take action to reduce the harmful impacts of severe weather and enhance the energy independence and resilience of its community. To further support these goals, PGST applied for and received technical assistance from the U.S. Department of Energy (DOE) Energy Technology Innovation Partnership Program (ETIPP)[3] from 2023 to 2025. Through a community-driven approach that leverages local partner networks and national laboratories, ETIPP supports remote, coastal, and island communities in transforming their energy systems by providing technical assistance tailored to each community's needs. The PGST ETIPP project is led by Pacific Northwest National Laboratory (PNNL)[4] with support from regional nonprofit partner Spark Northwest[5] and administrative support from the National Laboratory of the Rockies (NLR).[6]

The project had four key focus areas:

1. Provide education and outreach to build capacity within the Tribal Council, staff, and community members to understand and address energy topics.
2. Understand resilience needs and identify resilience improvements for critical infrastructure.
3. Conduct strategic energy planning for Tribal government buildings, including establishing an energy baseline and identifying energy efficiency and renewable energy opportunities.
4. Create a framework for energy transition workforce planning and development.

This report documents the results and recommendations from the technical assistance efforts of the ETIPP project and serves as a Strategic Energy Plan (Figure 1) that can be used to support and guide PGST's energy-related decision making as it strives to achieve its energy goals.

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[1] Port Gamble S'Klallam Tribe https://pgst.nsn.us/

[2] PGST Priority Climate Action Plan https://www.epa.gov/system/files/documents/2024-04/portgamblesklallamtribe-pcap.pdf

[3] Energy Technology Innovation Partnership Project https://www.nrel.gov/state-local-tribal/etipp-technical-assistance.html

[4] PNNL ETIPP Communities https://www.pnnl.gov/projects/ETIPP/communities

[5] Spark Northwest https://sparknorthwest.org/

[6] ETIPP Communities https://www.nrel.gov/state-local-tribal/communities.html

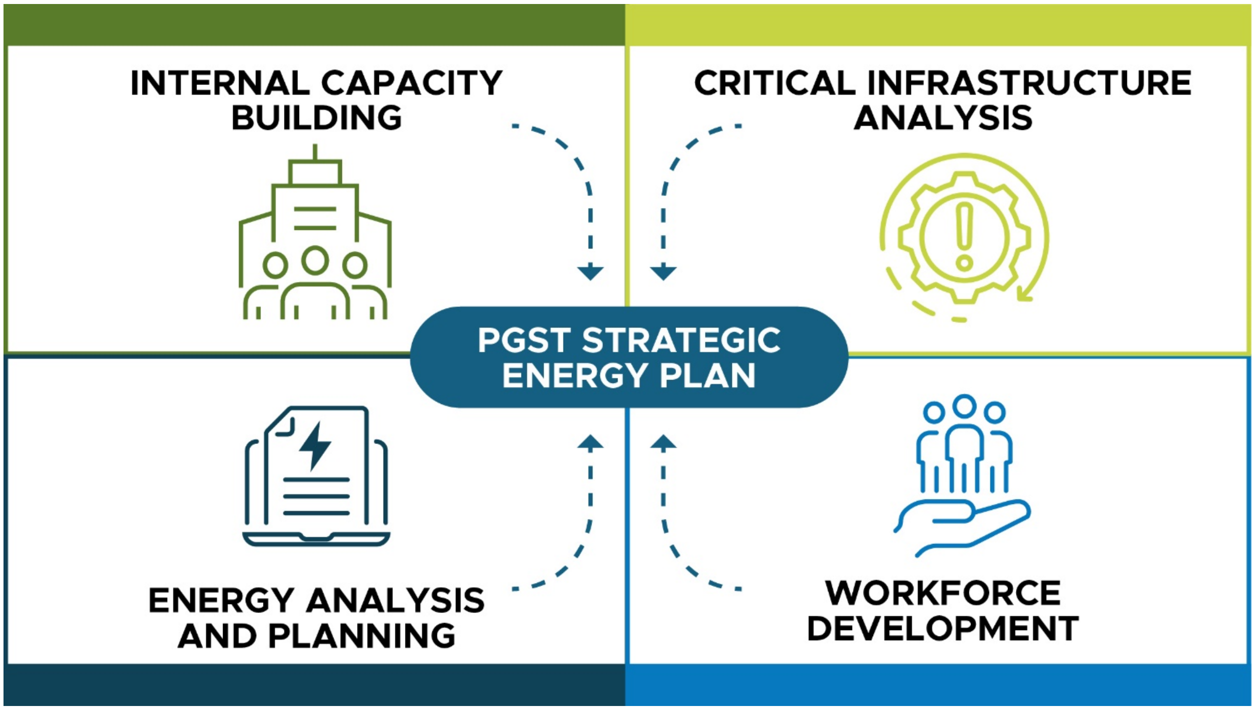

Figure 1. Short-term action priority timeline for the Port Gamble S'Kallam Tribe

1.1 Project Approach to Technical Assistance

This project involved collaboration between PNNL (technical assistance), Spark Northwest (regional partner), and NLR (administrative support). All laboratory partners, including representatives from PGST, met biweekly for discussion and updates on the technical assistance process. To understand PGST's energy goals, Spark Northwest created an online Mentimeter survey to encourage active participation in topics such as priority projects, energy-related concerns, visions of success, interest in renewable technologies, and community values.

1.1.1 Scoping

The technical assistance began with a collaborative scoping process to identify the objectives of the project. The scope development began with discussions to understand the Tribe's cultural values and beliefs before engaging in conversations around energy goals and energy vision. After initial results were reviewed, two additional surveys were created to gather more detail about specific technologies and opportunities for the Tribe. One survey was created to assess the Tribe's interest in wind energy, the potential challenges it might see bringing wind energy to the community, and what approach the Tribe prefers for education on new technologies. The second survey was created to assess the Tribe's interest in solar energy, rank the types of solar technologies, describe its definition of energy resilience, identify challenges to bringing solar energy to the reservation, and understand the Tribe's preparedness and capacity for renewables. These surveys provided valuable insights that would shape the Tribe's energy goals and energy vision.

1.1.2 Site Visits

Figure 2. Left: Health Clinic site chosen for microgrid implementation; right: Beach structures assessed for solar PV potential. Photos by Kristen Jones, PNNL.

In addition to the biweekly meetings, the project team met with the Tribe at the PGST campus for three site visits. The first visit occurred in November 2023 and focused on relationship building and introduction to the ETIPP program and potential outcomes. Other outcomes of that site visit included familiarization with energy terminology and renewable energy technologies; discussions around resilience, considerations for siting energy projects, and expectations (Figure 2). In addition, as part of the Commerce + Storage prize, engineers from the Säzän Group (Säzän) analyzed the Tribe’s buildings and energy infrastructure. The third site visit took place in April 2024 with the goal of conducting energy audits of four priority buildings: Administration, Youth Center, Community Family Services/Police, and Early Childhood Education. This site visit included a building engineer from PNNL to conduct the energy audits and two representatives from Puget Sound Energy (PSE).

2.0 Port Gamble S’Klallam Tribe’s Energy Landscape

The PGST Reservation is located on the northern tip of the Kitsap Peninsula in Washington State and is home to about 1,400 Tribal members. The PGST Reservation is connected to the rest of Kitsap County by a single road, Hansville Rd NE, which can result in the reservation being cut off from the nearest emergency services if the road is closed for any reason (e.g., vehicle accidents, downed trees). PGST’s electricity is supplied through two power lines: One is a transmission line that comes up from Hansville Rd; the other is an underwater distribution cable that crosses Port Gamble Bay. PGST’s location puts it at the “end of the line” for power restoration, resulting in multiday power outages when storm events disrupt existing power sources. During a power outage, Tribal members wait for power to be restored, and the community can quickly become isolated from outside resources. Because of these challenges, PGST developed an energy vision that centers around enhancing resilience for the community through energy diversification, self-reliance, and capacity building.

2.1 Energy Vision

By engaging Tribal leaders and stakeholders, the following guiding principles for PGST’s energy vision were identified:

- **Resilience:** Implement renewable energy generation, battery storage, and other redundancy/resilience measures to sustain critical infrastructure for seven days in the case of a severe power outage or natural hazard.
- **Capacity building:** Develop internal capacity, infrastructure, and local workforce to support the Tribe’s energy system design and implementation and to engage with staff, partners, and the community to achieve energy and resilience goals.
- **Energy efficiency:** Empower both Tribal staff and community members to improve energy efficiency in Tribal community buildings or their own homes.
- **Energy system transformation:** Advance toward the goal of transforming energy systems on PGST’s Reservation and achieving energy independence by exploring options such as renewable energy generation, battery storage, microgrids, and fleet electrification.

Where applicable, these guiding principles were aligned with existing initiatives and strategic plans. The principles can be translated into actionable goals, metrics, and targets as shown in Table 1 and can be used by the Tribe to direct future energy transition and resilience efforts.

Table 1. PGST Energy Goals, Metrics, and Targets

Goal	Metric	Target
Enhance resilience of Tribal government buildings and critical infrastructure	Days of operations maintained during outage	7 days
Provide redundancy and flexibility of energy resources in an emergency	Portable energy resource provided	One (1) solar trailer
Local renewable energy workforce	Renewable energy industry training program offered	Develop a pathway to offering a training program locally
	Renewable energy positions hired by PGST	One (1) position in 2025 (renewable energy manager), 1–5 positions in the next 5–10 years as infrastructure (solar photovoltaics [PV], microgrid, battery storage, EV) grows (e.g., solar installer/technician, electrician, engineer, sustainability manager)
Improve energy efficiency in Tribally owned buildings	Number of buildings audited	Conduct energy audits at all Tribally owned buildings
	Number of efficiency projects implemented	Apply energy efficiency measures from Energy Audit Report to 1–2 selected buildings in 2025 (budget dependent)
Increase energy independence and reduce carbon footprint through fleet electrification	Percent of PGST vehicle fleet electrified	25% of PGST vehicle fleet electrified by 2035
	Electric vehicle (EV) charger installation	Install one (1) or more EV chargers for community use

2.2 Energy Baseline

Estimating the potential impact of renewable energy deployment requires an understanding of current energy use. An energy baseline establishes a starting point to model growth and future electricity needs. It also helps determine seasonal variations in electricity consumption, enabling a comparison with the energy generation potential of various types of renewable energy technologies.

This energy baseline focuses on the PGST Administrative Campus, which comprises facilities for governmental administration, community services, client services, police, and courts. (PSE provided monthly electricity consumption for all PGST Administrative Campus meters between January 2022 and September 2023.) The PGST campus is not connected to natural gas infrastructure; however, PGST receives regular propane deliveries. Several buildings use propane for space and water heating purposes (Admin, Children and Family Services [CFS]/Police, Early Childhood Education), cooking (Elder's Center) or backup generation (CFS/Police, Food Bank). The campus water pump is also powered by a propane generator.

The facilities considered in this energy baseline, their associated electricity meter, and their 2022 electricity consumption are included in Table 2. The clinic has a 25.4-kilowatts direct current (kW_{DC}) solar photovoltaic (PV) array, which generates approximately 25,000 kilowatt-hours (kWh) annually, or about 11% of the building's annual electricity needs. This array is described further in Section 3.1.3.

Table 2. 2022 Electricity Consumption at PGST Tribal Government Facilities

Meter Number	Meter Name	2022 Electricity Consumption (megawatt-hours [MWh])
P159381367	Tribal Center/Admin/gym/kitchen	217
P150795473	Clinic	206
P158622203	Early Childhood Education	163
X162347032	Elder's Center	76
X162347031	Fitness Center	55
X144384087	CFS/Police	51
P159381976	Campus Water Pump	50
P159381368	Youth Building	49
X159358493	Food Bank	44
X156028433	Education/Longhouse	44
X152786631	Housing	39
P159382320	Main Lift Station	37
X162346257	Library	30
X158653138	Natural Resources	17
P144385871	Streetlights Baseball Field Rd	14
X159358495	Baseball Concession	2
P159381976	Campus Water Pump	50
P159381368	Youth Building	49

The three largest electricity users are the Tribal Center/Admin/gym/kitchen, the Clinic, and Early Childhood Education buildings. In addition, electricity consumption varies seasonally, with the highest consumption in the winter months (Figure 3). The three largest electricity users also have the highest seasonal variability in energy usage.

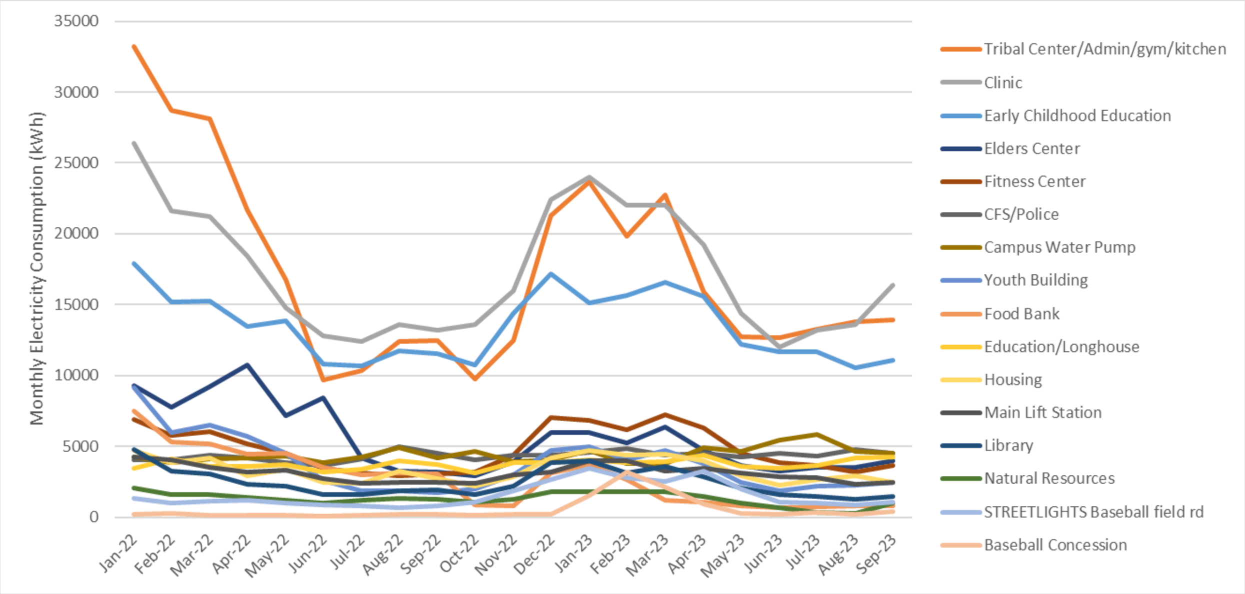

Figure 3. Monthly electricity consumption for selected PGST administrative campus meters (Jan 2022–Sep 2023).

3.0 Renewable Resource Assessments

The project team assessed the energy generation potential for several types of renewable energy technology. At the time of this study, PGST was primarily interested in solar PV, but additional exploratory analysis was conducted for wind, marine, and biomass energy (bioenergy). Based on feedback provided by PGST on the results of each assessment, it was determined that solar PV is the most viable technology for the Tribe at this time, with wind and biomass energy applications being open for further consideration in the future. Marine energy was determined to not be viable on PGST lands.

This section presents the results of all renewable energy assessments based on their applicability to PGST:

- Viable technologies: solar PV assessment
- Technologies for future consideration: wind and biomass energy assessments
- Technologies considered but not recommended: marine energy assessment.

3.1 Viable Renewable Energy Technologies

3.1.1 Solar Resource Assessment

Solar power, also known as solar energy, is a renewable source of electricity generated by harnessing the radiant energy emitted by the sun. Solar power is primarily generated using PV solar panels, which convert sunlight into electricity. These panels comprise semiconductor materials that release electrons when exposed to sunlight, generating a direct current (DC) that can be converted into alternating current (AC) for use in homes, businesses, and industries. Solar power allows communities to generate their own electricity, reducing reliance on fossil fuels and utility providers, while lowering the greenhouse gas emissions associated with electricity generation. Solar PV systems are designed to generate power for 20–30 years. At the end of the system's life, options include refurbishing the system by repairing and replacing individual components, repowering the system by replacing the entire PV array and/or inverters, or decommissioning the system by removing the PV array, racks, foundations, and enclosures and restoring the site to its original state.

Solar PV is installed at a range of scales to meet various needs, from powering individual buildings to powering entire communities. Residential rooftop PV capacity typically ranges between 5 and 20 kilowatts (kW), sized to provide power for an individual building. Community-scale PV can be installed on rooftops, carports, or the ground and can range widely in capacity—from 20 kW to more than 2 megawatts (MW), providing power to dozens or hundreds of buildings. Utility-scale projects have arrays that are either single-axis tracking (i.e., the array follows the sun as it travels across the sky to maximize energy production) or fixed-axis and tend to have capacities ranging from 1 MW to more than 1 gigawatt (GW) for the largest projects.

Capital costs for installing solar PV typically range around $3,000/kW for residential rooftop solar, $2,000/kW for community-scale fixed-tilt ground-mount solar, and $1,000/kW for utility-scale single-axis tracking ground-mounted solar (Feldman et al. 2021). These cost benchmarks are based on national averages and can be significantly higher in remote or rural areas.

Operations and maintenance (O&M) for solar PV is relatively simple, especially for fixed-axis systems, because they have no moving parts. O&M tasks include periodic cleaning of the modules, vegetation management, system inspection, and corrective maintenance. On PGST land, regular rainfall may be sufficient to keep panels clean—at least during the winter months. Relying solely on solar PV for electricity production can be challenging because of the resource's inherent intermittency and variability. Integrating other generation technologies, such as small-scale wind and energy storage, can help smooth out these fluctuations in electricity generation.

In siting solar PV, considerations vary depending on the mount type (i.e., rooftop/carport or ground-mounted). In general, an ideal site will have a south-facing orientation (in the northern hemisphere), proximity to existing roads and electrical infrastructure, and minimal shading from buildings, trees, or other obstacles. For rooftop/carport solar, there are additional factors to consider, including the size, shape, slope, condition, and age of the roof. It is typically advisable to consider roofs with a projected lifespan of at least 15 years and the capacity to bear an additional load of 2–4 pounds per square foot (lbs/ft^2). Rooftop solar PV typically necessitates around 100 ft^2 per kW$_{DC}$ of suitable rooftop space, which is defined as facing west, southwest, south, southeast, or east; not being excessively tilted (<60°); not experiencing excessive shade; and having an uninterrupted footprint of at least 100 ft^2. Considerations for ground-mounted solar include factors such as slope, soil type, and ground cover. The ground should be as level as possible, and the choice of mounting options may vary depending on the soil type. It is also important to consider ground cover beneath the array to prevent vegetation from growing over the panels. Ground-mounted PV typically requires 5–7 contiguous acres per megawatt direct current (MW$_{DC}$) for the entire footprint.

Many resources exist for communities interested in deploying PV. DOE has compiled a list of tools that can be used to estimate the amount of solar that could be installed on a given rooftop.[1] For communities interested in deploying solar, the DOE Solar Power in Your Community[2] guidebook is a good place to start, as is the Energy Transitions Playbook.[3]

3.1.2 Overview of the Solar Resource on Port Gamble S'Klallam Tribe Land

Port Gamble has a global horizontal irradiance resource that averages 3.3 kilowatt-hours per square meter per day (kWh/m^2/day). Solar estimates come from NLR's National Solar Radiation Database (NSRDB), which contains decades of solar radiation data covering the United States and some international locations.[4] This resource is seasonal; there is more solar energy available during the summer and less during the winter when cloud cover is more frequent and days become shorter (Figure 4).

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[1] DOE Solar Potential https://www.energy.gov/eere/solar/solar-rooftop-potential

[2] DOE Solar Guidebook https://www.energy.gov/sites/default/files/2023-03/Solar_Power_in_Your_Community_Guidebook_March2023.pdf

[3] DOE Energy Transitions Guidebook https://www.eere.energy.gov/etiplaybook/

[4] National Solar Radiation Database https://www.nrel.gov/docs/fy22osti/70627.pdf

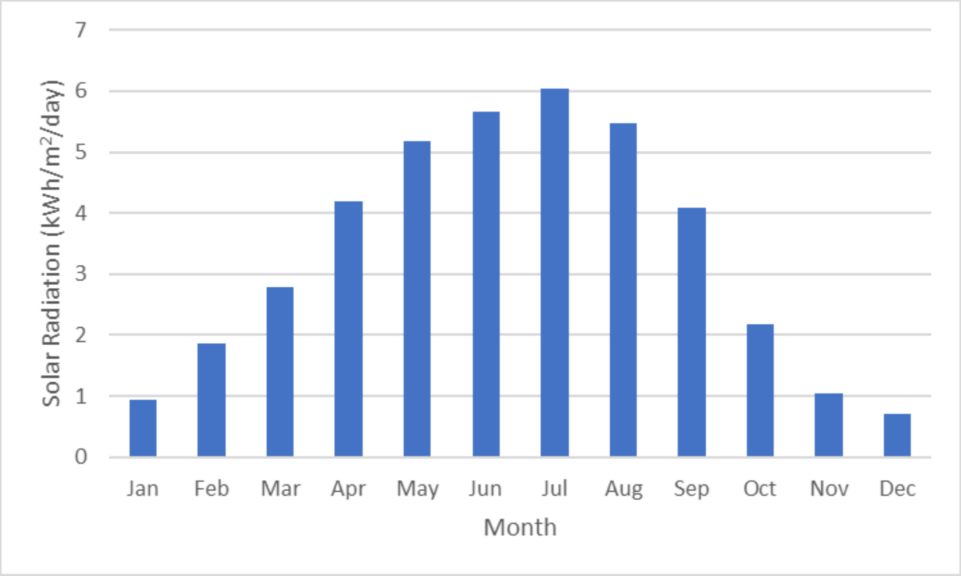

Figure 4. Monthly variation of solar radiation available in Port Gamble (NSRDB)

The NSRDB distills many years of radiation data into a single typical meteorological year (TMY), which is a year of hourly data that represents median weather conditions over many years by selecting the most typical January across the dataset, the most typical February, and so forth. The PVWatts® calculator[1] uses these data to estimate the energy production of user-defined solar PV systems (Dobos 2014). The PVWatts calculator was used to validate the electricity production of an existing solar PV array on the Clinic.

3.1.3 Existing Solar on Port Gamble S'Klallam Tribe Clinic

PGST has an existing 25.4 kW_{DC} solar PV array on the campus clinic building, in operation since 2021. Because PGST does not undertake regular cleaning of the array, it was interested in validating solar PV output from the array with modeled data to better understand if the array was impacted by panel soiling losses.

As such, actual power production data from that array from SolarEdge (July 2023–December 2024) were compared to modeled power production from TMY weather year using PVWatts. TMY data were used because irradiation data for 2023–2024 are not currently accessible through the NSRDB.

Figure 5 indicates good agreement between the modeled and measured data. In some cases, the measured output is smaller than expected (e.g., July 2023, August 2024) or larger than expected (e.g., November 2023, March 2024). This is because solar radiation varies month-to-month and year-to-year, and this analysis uses TMY data rather than actual 2023–2024 data. Because the measured output is relatively close to the modeled data, this analysis confirms the PV array is operating as expected.

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[1] PVWatts Calculator https://pvwatts.nrel.gov/

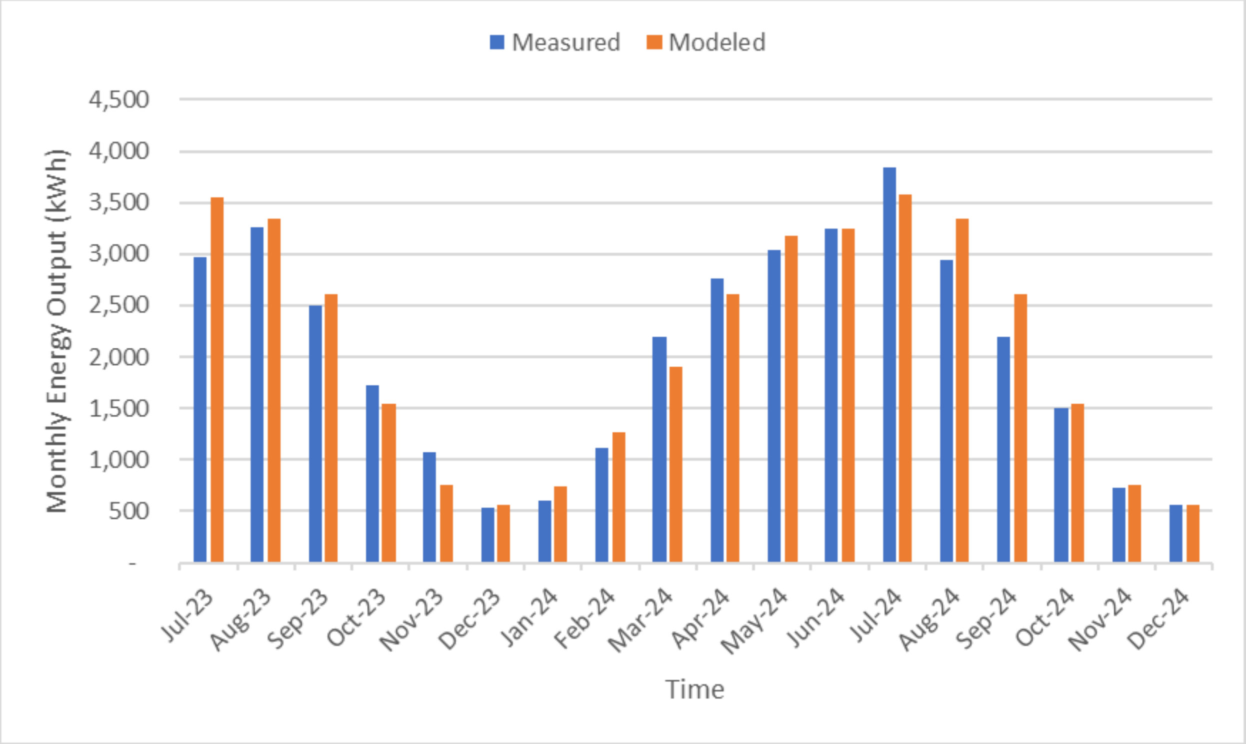

Figure 5. Measured and modeled monthly power output for the PGST Clinic solar PV array

3.1.4 Solar Photovoltaic Assessments

Several locations of interest for deploying solar PV were identified through conversations with Tribal staff. These locations include the Wastewater Treatment Plant drain field, the Clinic parking lot, the Casino parking lot, housing, the Fitness Center, CFS/Police, the Hatchery, and a beach shelter. Solar PV technical suitability was assessed for each location using Aurora Solar design software. Sites with a total solar resource fraction[1] greater than 85% were considered technically feasible.

In addition, Säzän evaluated solar PV on other rooftops as part of its microgrid assessment, further described in Section 4.0. Säzän assessed additional solar PV on the rooftop of the Clinic, Early Childhood Education, and Longhouse.

Table 3 provides an overview of the technical potential for solar PV at each location, the potential annual electricity generation, the percent of the building's consumption the system could offset, and an estimate for system cost. Additional details for each site assessed by PNNL are provided in the following sections. Additional details for the sites assessed by Säzän can be found in its microgrid report.

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[1] The ratio of solar insolation available accounting for shading, orientation, and tilt, compared to the total amount of insolation at the optimum orientation and tilt but without shading, expressed as a percentage.

Table 3. Summary of Solar PV Technical Potential by Location

Location	Solar PV Technical Potential (kW_{DC})	Potential Annual Electricity Generation (kWh/year)	Building 2022 Electricity Consumption Offset (%)
Beach shelter	3.5	3,700	N/A
Casino parking lot	1,676	1,600,000	N/A
CFS/Police	Not recommended because of shading from tall trees to the south	N/A	N/A
Clinic	66.2	68,000	33
Clinic parking lot	46	38,900	13
Early Childhood Education	50	52,100	32
Fitness Center	Not recommended because of shading from the Health Clinic to the south and tall trees to the west	N/A	N/A
Hatchery	Not recommended because of shading from tall trees to the east	N/A	N/A
Longhouse	45; not recommended because of roof structural concerns	45,500	104[1]
Tribal housing	4	4,200	11
Wastewater Treatment Plant buildings	50	43,400	17
Wastewater Treatment Plant drain field	Not recommended; Washington Department of Health prohibits building structures over any areas in the drain field and reserve areas	N/A	N/A

3.1.4.1 Clinic Parking Lot

The Clinic parking lot was identified as a location of interest for carport-mounted solar PV. Two parking areas can each accommodate 23-kW arrays (Figure 6), generating up to 38,900 kWh annually (13% of the Clinic's 2022 consumption: 206 MWh). The other parking areas experience significant shading from the Clinic, Fitness Center, and trees, and carport solar PV is not recommended.

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[1] The Education and Longhouse buildings share the same meter.

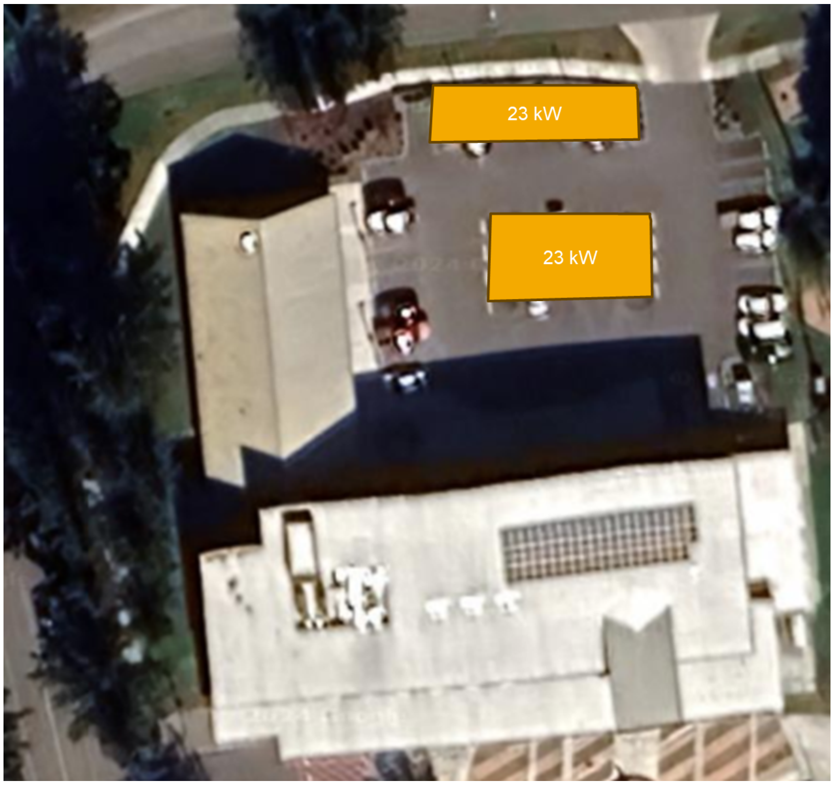

Figure 6. Potential Clinic carport solar PV

3.1.4.2 Casino Parking Lot

The Casino parking lot was identified as another location of interest for carport-mounted solar PV. Up to 1,676 kW of solar PV could be installed (Figure 7). These arrays could generate up to 1,600 MWh annually, equivalent to nearly all the PGST Administrative Campus's 2022 electricity consumption: approximately 1,600 MWh.

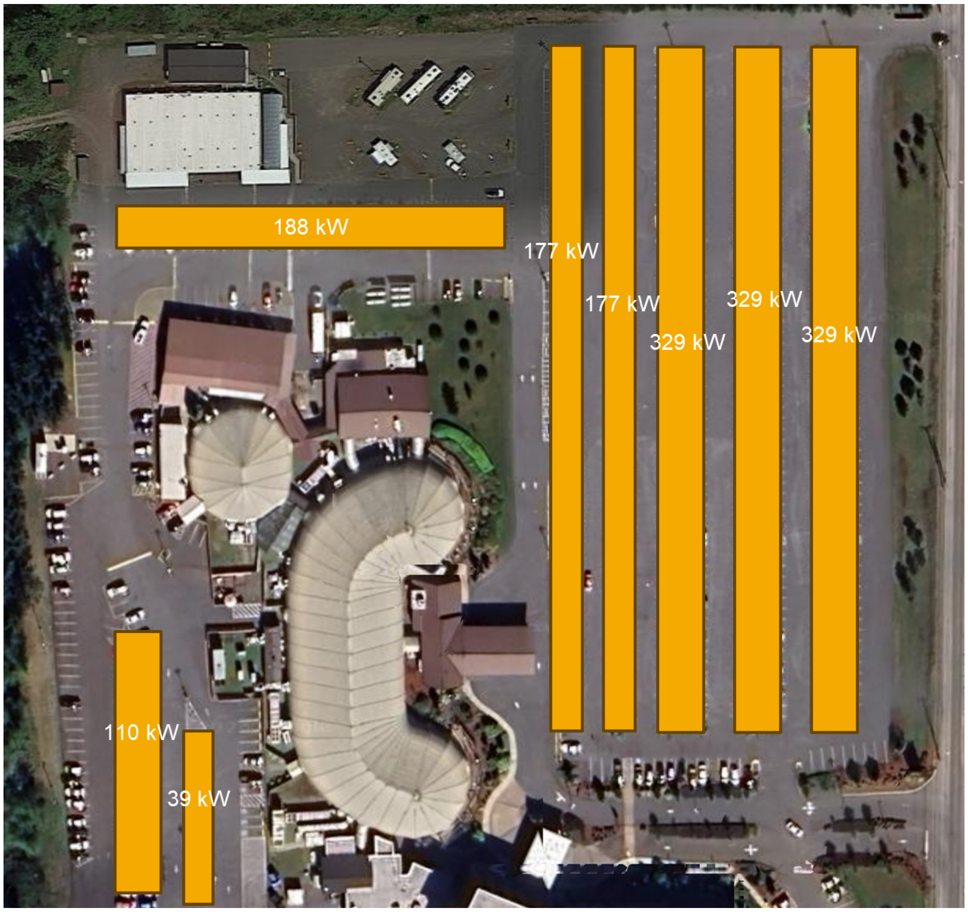

Figure 7. Potential Casino carport solar PV

3.1.4.3 Wastewater Treatment Plant Drain Field

The Wastewater Treatment Plant drain field was identified as a location of interest for ground-mounted solar PV because it is a large, open area located near the Tribally owned casino and hotel. Initial research indicated deploying ground-mounted solar PV between the drain field cells might be possible. However, the Washington Department of Health prohibits building structures over any areas in the drain field and reserve areas (Washington State Department of Health 2024). As such, pursuing solar PV on the drain field is not recommended. However, solar PV suitability was assessed for two buildings south of the drain field (Figure 8). These buildings have the potential for 32 kW and 18 kW of solar PV, respectively, and could generate up to 27,100 kWh and 16,300 kWh annually, respectively (17% of the Wastewater Treatment Plant's 2022 consumption: 254 MWh).

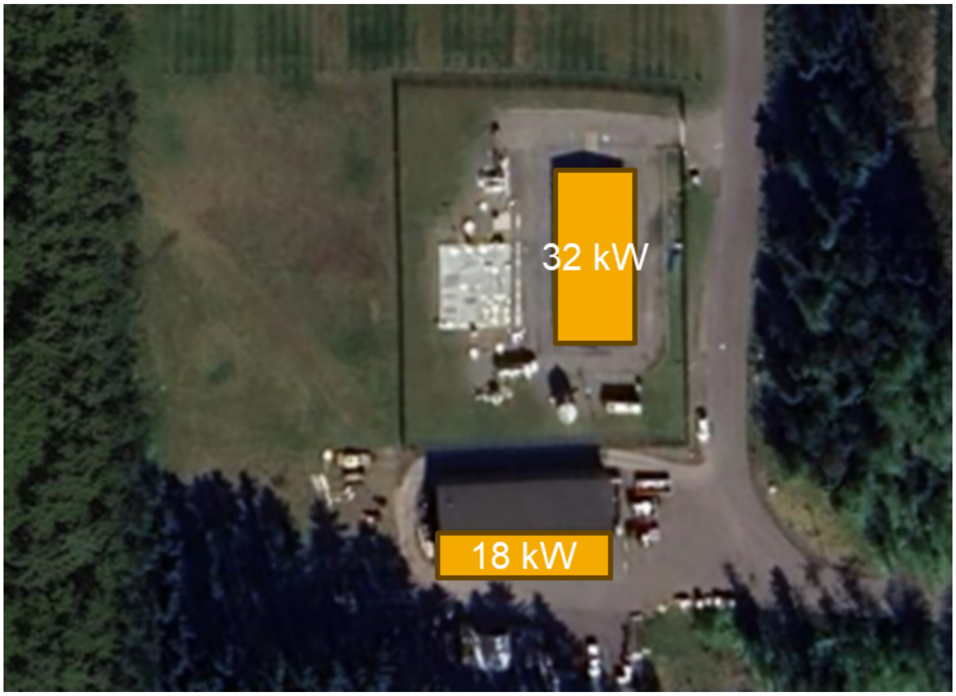

Figure 8. Potential Wastewater Treatment Plant rooftop solar PV

3.1.4.4 Tribal Housing

The upper south-facing side of the housing building receives minimal shading from the Longhouse. However, existing skylights limit the space available for solar PV. The roof has the potential for up to 4 kW of solar PV (Figure 9), which could generate up to 4,200 kWh annually (11% of the building's 2022 consumption: 39 MWh).

Figure 9. Potential housing rooftop solar PV. Existing skylights (covered by orange box) will reduce the amount of space available.

3.1.4.5 Children and Family Services/Police

No solar PV is recommended on the rooftop of the CFS/Police building because of shading from tall trees to the south.

3.1.4.6 Fitness Center

No solar PV is recommended on the rooftop of the Fitness Center because of shading from the Health Clinic to the south and tall trees to the west.

3.1.4.7 Hatchery

No solar PV is recommended on the rooftop of the Fitness Center because of shading from the Health Clinic to the south and tall trees to the west.

3.1.4.8 Beach Shelter

The beach shelter, located on Point Julia, has the potential for up to 3.5 kW of solar PV (Figure 10), which could generate up to 3,700 kWh annually.

Figure 10. Potential beach shelter rooftop solar PV

3.1.5 Recommendations

Table 4 shows short- (<5 years), medium- (5–10 years), and long-term (10+ years) recommendations for advancing solar PV at PGST. High-level budget and staffing considerations are provided for reference but should be further investigated and refined as recommendations are implemented.

It should be noted these solar PV projects have simple payback periods of ~22/23 years. Grants and tax incentives could shorten the payback period and make these projects more attractive to PGST.

Table 4. Solar PV Recommendations

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Develop an O&M plan for existing and future solar PV installations	Develop an O&M plan for existing and future solar PV installations that aligns with PGST's typical operations. O&M plan components can include the following: Performance monitoring: checking PV systems are operating as expected Preventive maintenance: cleaning, inspecting panels and electrical connections, performing other scheduled maintenance, and so on.	Short term	Low cost	Maintenance staff, minimal training
Determine the feasibility of solar PV on all existing government buildings, parking lots, and other available open areas	Identify other potential areas for PV and conduct assessments of potential installations.	Short term	Low cost	PGST staff: solar technician, energy manager, facilities and maintenance staff, and others as needed

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Create a priority list of PV projects based on additional considerations	Considerations when prioritizing solar PV projects include the following: Potential for energy generation Cultural/visual constraints If rooftop-mounted: roof condition/structure (does not require replacement in next 25 years; must be able to support additional weight from panels) Shading, including future vegetation growth and new buildings from campus development. Based on these considerations, some candidates for prioritization include the Clinic and the Early Childhood Center. Developing a more comprehensive list based on the above criteria is also recommended.	Short term	Low cost	PGST staff: solar technician, energy manager, facilities and maintenance staff, and others as needed
Solicit and review solar installer bids	Research and contact several solar installers to get multiple bids. Ensure any selected installers are licensed, bonded, and insured to install solar projects in the area.	Short term	Low cost	PGST staff: solar technician, energy manager, facilities and maintenance staff, and others as needed
Compare and select solar installer bids	Evaluate bids and understand contract terms. Discuss and understand any available tax incentives, potential tax implications, financing options, the terms of the installer's contract, warranties, maintenance agreements (if any), and contingencies if the installer closes its business.	Short term	Low cost	PGST staff: solar technician, energy manager, facilities and maintenance staff, and others as needed

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Research and procure a portable solar trailer for use during power outages	Portable solar trailers with optional battery energy storage could provide electric power to PGST residents and critical infrastructure during an unexpected power outage. Investigate the possibility of procuring a solar trailer for PGST.	Short term	Variable cost depending on system size and components	PGST staff: solar technician, energy manager, facilities and maintenance staff, and others as needed
Pursue solar PV development on campus building rooftops	Once sites have been evaluated and prioritized and bids have been requested and reviewed, proceed with solar PV project development.	Short to medium term	Residential-scale solar PV costs around $3,000/kW and will likely be more expensive given the Tribe's location	PGST staff: solar technician, energy manager, facilities and maintenance staff, and others as needed
Engage and educate PGST residents on solar PV	Engage with and educate local stakeholders on the potential benefits and pathways of installing solar PV locally.	Short to medium term	Low cost	PGST staff: solar technician, energy manager, facilities and maintenance staff, and others as needed
Investigate options for installing solar PV in the broader PGST community	Options to investigate can include community solar, where a single, larger solar PV array can be owned by multiple individuals, sharing its benefits; or creating a program to support residents interested in pursuing solar by helping them access resources such as information, vendor lists, and incentive options.	Short to medium term	Low cost	PGST staff: energy manager, environmental outreach and education coordinator, solar technician, and others as needed

3.2 Renewable Energy Technologies for Future Consideration

In addition to solar PV, PNNL conducted resource assessments for wind energy, marine energy, and bioenergy on PGST lands. Of the additional technologies evaluated, only wind energy and bioenergy have some potential applicability for the Tribe. The results of the resource assessments are included in this section for future consideration by PGST.

3.2.1 Wind Resource Assessment

Wind power is a renewable source of electricity generated by harnessing the kinetic energy from wind. Wind power is primarily generated with wind turbines, which are commercially available in a range of sizes and designs. Like solar power, wind power can allow communities to generate their own electricity, reducing reliance on fossil fuels and utility providers, while lowering the greenhouse gas emissions associated with electricity generation. Wind systems are designed to generate power for 20–30 years.

Incorporating wind into an energy portfolio provides various benefits, beginning with renewable energy generation. In addition, wind turbines have small land use footprints allowing for land co-use for crops, grazing, pollinator planting, and other uses. Wind speeds at turbine heights tend to be higher at night and in the winter in many U.S. locations, making wind energy complementary to solar energy. On PGST lands, wind resource models predict the highest winds at turbine heights to occur during the evening and during winter. Challenges for adding wind to an energy portfolio include the limited availability of service providers, particularly for small turbines. Wind turbines can also pose challenges including wildlife impacts and radar interference, particularly for larger turbines. Wind turbines should be sited at a distance from the known eagle nesting areas on PGST lands. Permitting and zoning for wind turbines can be difficult at any turbine size. Sound emissions, shadow flicker, and ice throw are all challenges associated with wind energy that can be mitigated with proper setback distance from human environments and property lines.

For a small distributed wind turbine with a rated power capacity within 100 kW, installation costs between 2020 and 2023 ranged from $2,200 to $10,600/kW, with an average of $6,200/kW. For midsize and large distributed wind turbines with rated power capacities greater than 100 kW, installation costs between 2020 and 2023 ranged from $1,500 to $5,300/kW, with an average of $2,750/kW. O&M costs are a significant expense for wind farms and large distributed wind projects but are typically minimal for small distributed wind projects. O&M costs are typically around $35 per kW per year for small distributed wind turbines and around $20 per kW per year for midsize and large distributed wind turbines (PNNL 2024; Distributed Wind Project Database[1]).

The sites selected for wind resource assessment were the result of collaborative approaches between PGST and PNNL. PGST proposed the clearing west of the Casino and the drain field locations for wind assessments, and PNNL provided assessments for comparison at the windiest sites at the PGST trust and new lands, Point Julia and the clearing east of Hood Canal Drive (Table 5). Wind will not be considered at Point Julia because of the cultural and historical significance of this site; however, the estimates are included in this report for comparison.

At each site, three high-resolution wind resource datasets provided a range of wind speed estimates: Global Wind Atlas,[2] WIND Toolkit,[3] and Wind Report.[4] A potential wind energy project is considered feasible if the annual average wind speed at 50 meters (m) above ground at a site of interest meets or exceeds a 5 meters per second (m/s) threshold. At each of the four sites, the estimated 50-m annual average wind speeds hovered around the threshold of 5 m/s. Wind speed estimates ranged between 4.4 and 5.0 m/s at the clearing west of the Casino, 4.8

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[1] Distributed Wind Project Database https://www.pnnl.gov/distributed-wind/market-report/data

[2] Global Wind Atlas https://globalwindatlas.info/en

[3] Wind Resource Database https://wrdb.nrel.gov/data-viewer

[4] Wind Report https://www.newrootsenergy.com/wind-report-modeling-tools

and 5.1 m/s at the drain field, 4.7 and 5.4 m/s at Point Julia, and 4.9 and 5.7 m/s at the clearing east of Hood Canal Drive. Figure 11 shows the annual average 50-m wind speed at PGST trust and new lands.

Table 5. Wind Energy Assessments for Sites on PGST Lands

Turbine Model	Bergey Excel 10	Eocycle EOX S-16	Northern Power Systems 100-28	EWT DW 54-900	GE 2 ME-116
Nameplate capacity	15 kW	25 kW	100 kW	900 kW	2.3 MW
Hub height	37 m	24 m	37 m	50 m	80 m
Minimum setback radius from property lines	46 m	35 m	56 m	85 m	152 m
Maximum tree/building height within 150-m radius of turbine	22 m	6 m	13 m	13 m	12 m
Single turbine energy estimate: Clearing west of Casino	15 MWh – 21 MWh	29 MWh – 39 MWh	129 MWh – 168 MWh	810 MWh – 1,119 MWh	4,052 MWh – 5,158 MWh
Single turbine energy estimate: drain field	19 MWh – 22 MWh	36 MWh – 42 MWh	156 MWh – 176 MWh	1,017 MWh – 1,176 MWh	4,778 MWh – 5,314 MWh
Single turbine energy estimate: Point Julia	18 MWh – 26 MWh	34 MWh – 47 MWh	150 MWh – 195 MWh	965 MWh – 1,340 MWh	4,594 MWh – 5,826 MWh
Single turbine energy estimate: clearing east of Hood Canal Drive	22 MWh – 30 MWh	41 MWh – 55 MWh	167 MWh – 216 MWh	1,104 MWh – 1,524 MWh	4,870 MWh – 6,159 MWh

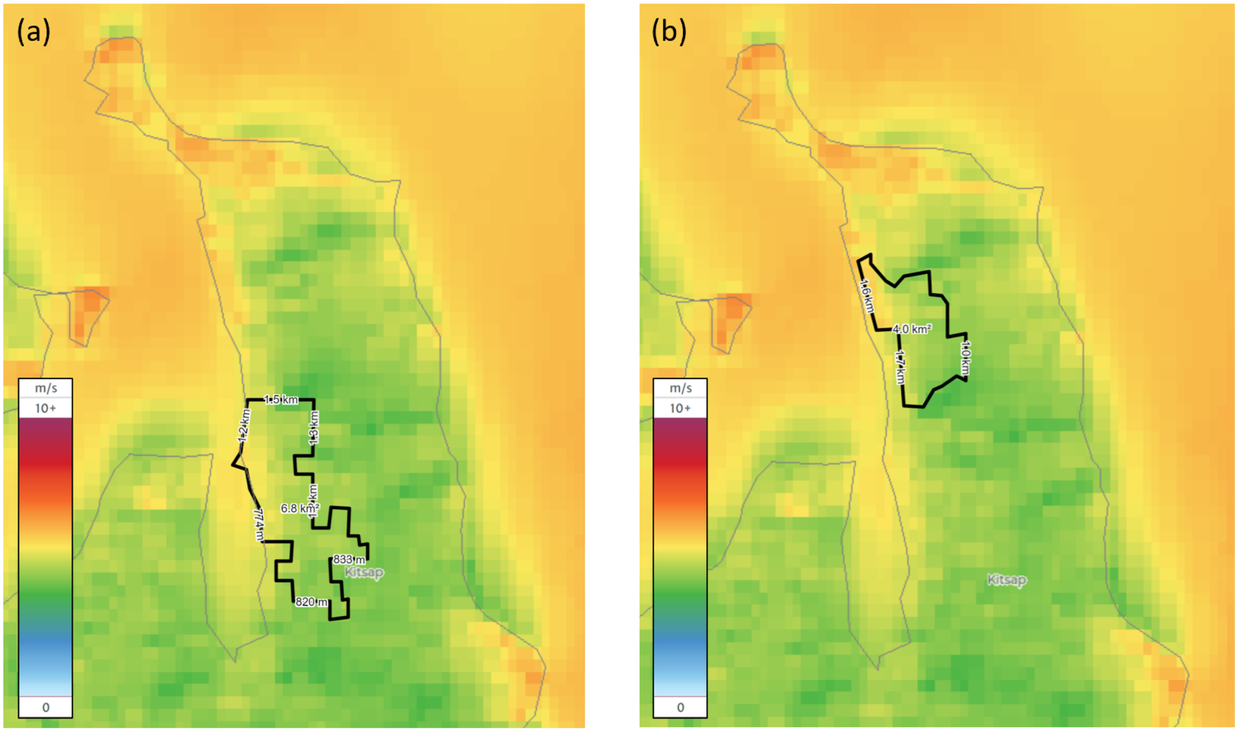


Figure 11. Annual average 50-m wind speed from Global Wind Atlas outlining Port Gamble S’Klallam a) trust and b) new lands.

The estimated wind speed ranges were converted to energy estimates for five commercially available wind turbines with rated power capacities ranging from 15 kW to 2.3 MW (Table 5). A loss assumption of 19% was accounted for in the estimates, representing loss because of downtime for planned or unplanned maintenance, weather and environmental impacts, and line and transformer loss. The site with the highest wind resource potential—the clearing east of Hood Canal Drive—has estimated annual wind energy generation potentials of 30 MWh with a single 15-kW wind turbine up to >6,000 MWh using a single 2.3-MW wind turbine. However, the clearing east of Hood Canal Drive is at the greatest distance from energy demand centers and infrastructure, requiring the installation of transmission at additional cost. Table 5 also includes the maximum tree and building height that can exist within 150 m of the wind turbine. To complement such an analysis, Figure 12 shares the maximum heights of common trees in northwestern Washington.

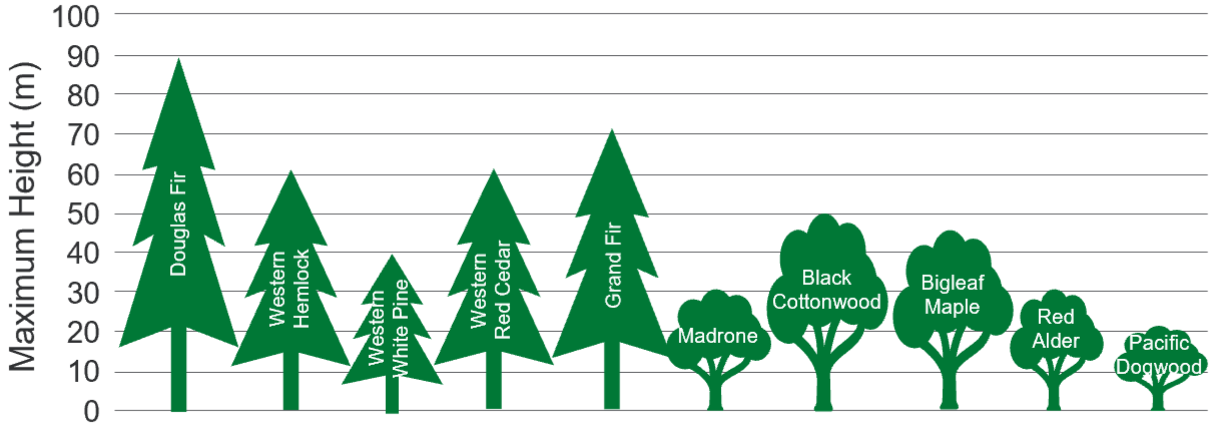


Figure 12. Tree height considerations for northern Washington, with heights sourced from Barts (2018).

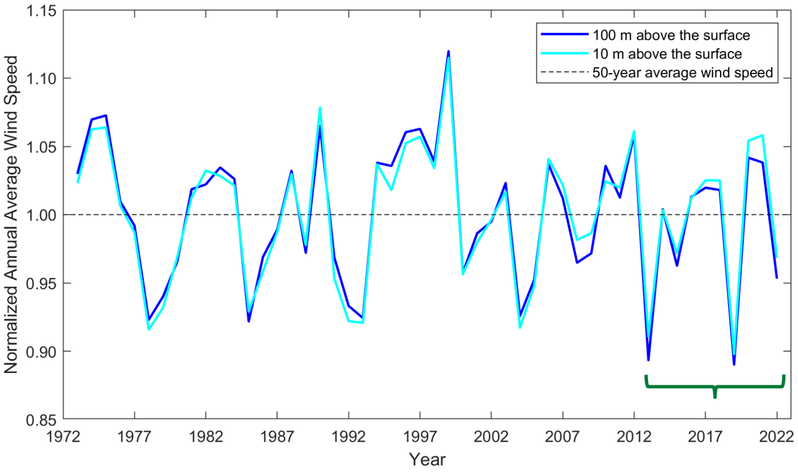
PGST requested information about potential changes in the long-term availability of its wind resource. To assess the trends, the reanalysis model ERA5,[1] which assimilates meteorological observations, was examined for a 50-year period (Figure 13). Over the most recent decade, wind speeds tended to be slightly lower than the 50-year average, indicating wind speeds could be on a gradual decline in the area. Long-term trends in the wind resource change for various reasons, including tree growth, vegetation clearing, and urbanization.

$$\textit{Normalized Annual Average Wind Speed} = \frac{\textit{Annual Average Wind Speed}}{\textit{50-Year Average Wind Speed}}$$

Normalized Annual Average Wind Speed = 1
wind speed that year matches the 50-year average wind speed

Normalized Annual Average Wind Speed > 1
wind speed that year exceeded the 50-year average wind speed

Normalized Annual Average Wind Speed < 1
wind speed that year was below the 50-year average wind speed



Over the most recent decade, wind speeds tended to be slightly lower than the 50-year average: The 10-year normalized average wind speed between 2013 and 2022 = 0.98–0.99

Figure 13. Normalized annual average wind speeds at PGST lands for the last 50 years from ERA5.

3.2.1.1 Recommendations

The wind resource on PGST lands hovers near the threshold for feasible wind energy development, with the best wind resource (clearing east of Hood Canal Drive) located at a

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[1] ERA5 hourly data on single levels from 1940 to present https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels?tab=download

distance from PGST facilities and infrastructure. However, considerations about environmental impact, infrastructure location, wind power costs, and the cultural and historical significance of potential sites make wind energy a less desirable technology for PGST in the near term. In particular, wind energy was deprioritized because of potential impacts to wildlife, including the bald eagle population.[1] Future actions to further investigate wind energy potential could include the following:

- Work with subject matter experts such as wildlife experts or biologists to understand potential environmental impacts from wind and develop a mitigation plan.
- Evaluate potential incentives and grants that could reduce the cost of wind energy projects. For example, a small wind turbine on PGST trust land could become more cost-effective if placed at a farm or rural small business that qualifies for a U.S. Department of Agriculture (USDA) Rural Energy for America Program (REAP) grant.

3.2.2 Bioenergy Resource Assessment

Biomass energy (bioenergy) refers to the electric or thermal energy produced from organic feedstocks. The feedstock used for biomass energy production can come from several types of streams such as agricultural, forest wood, wood processing, animal, industrial, and urban waste. Agricultural products can be purpose-grown for biomass energy, such as poplar, or can be byproducts, such as crop residue. Other sources such as landfill gas and municipal solid waste are also considered renewable; however, they are not commonly included in biomass energy assessments and are instead considered waste-to-energy solutions.

Bioenergy can provide power and/or heat through several technologies. Combustion burns the feedstock for heat or electricity generation. Gasification breaks down the feedstock into syngas (synthesis gas; a mixture of carbon monoxide and hydrogen), which can be used to generate electricity. Anaerobic digestion breaks down the feedstock into biogas, which can be used for heat or electricity generation. Landfill gas uses methane produced by landfills to generate electricity. Cogeneration generates both useful heat and electricity. Pyrolysis produces biofuels, for use primarily in transportation.

As of the date of this study, PGST had not assessed the available biomass produced by its residents or commercial operations (e.g., marine and forest), so a full assessment of the bioenergy potential for PGST could not be completed. However, PGST was interested in understanding how it may be able to explore bioenergy further.

There are several factors to consider when investigating the use of biomass for energy generation:

- The availability of biomass feedstock should be consistently reliable over time, both in quantity and quality, to ensure consistent and reliable energy generation. Importing feedstock would not be feasible because of transportation costs.
- The specific type(s) of biomass feedstock will impact collection and transportation methods, costs, and feedstock processing requirements (e.g., chipping or grinding, mixing, and drying).

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[1] Conversations with PGST leadership revealed that populations of bald eagles resided on trust and new lands. Since wind energy can impact avian populations in a variety of ways, including habitat loss and physical impact, PGST opted to not potentially disrupt existing populations with a wind energy project.

- A biomass plant will need access to supplies of power, fuel, and water as well as wastewater discharge. Thermal generation plants should be located near a consistent thermal load, and power generation plants should have a nearby point of interconnection to the local grid. The site should include space for storage of the feedstock; more storage is required for seasonally variable feedstocks and for increased resilience (i.e., more on-site fuel supply). Access for delivery trucks should also be considered.

3.2.2.1 Recommendations

Bioenergy may be viable for PGST and is worth exploring further. Next steps include characterizing available feedstock types and amounts, considering potential use cases (i.e., providing consistent baseload energy to reduce utility bills, balance peak electricity demand by producing electricity only during peak hours, or providing heat and/or power to critical facilities), selecting the desired energy output and potential end uses, and identifying suitable locations.

3.2.2.2 Case Study

Nenana, Alaska

The small town of Nenana, Alaska (population 363), has invested in a bioenergy boiler to supply heat to community buildings. This boiler uses biomass (wood chips) left over from nearby logging operations (bought from the Alaska Department of Nature Resources) as a fuel source and provides heating to the local school, fire station, and library. Since 2020, Nenana has relied on 14 grants from organizations such as the USDA Rural Energy Pilot Program and the U.S. Forest Service Community Wood Energy and Wood Innovation Grant Program (Voegele 2023).

The boiler is from Biomass Energy Techniques, a company that specializes in biomass-based energy solutions to create customized applications for users ranging from simple residential systems to small commercial applications.[1] The system in Nenana is 80% efficient and offsets almost 50,000 gallons of fuel per year. The system will also create biochar, a carbon-rich organic waste material, that can be used for soil enrichment and will create another revenue source for the community.

3.3 Renewable Energy Technologies Considered but Not Recommended

3.3.1 Marine Energy Resource Assessment

Marine energy is a renewable energy resource where energy is created by the movement of the ocean. This is typically divided into wave energy and tidal energy, though energy can also be created from gradients in temperature or salinity. Wave energy devices capture the movement of the waves, such as up and down or side to side. Wave energy is not feasible near PGST; wave energy development for grid-scale applications typically requires more open ocean conditions, such as the coast of Washington State.

Tidal energy typically refers to capturing energy in places where water is flowing quickly because of tidal changes. As the tide rises, it pushes water from one place to another, which can create currents. Tidal energy devices have not yet converged on one design—they can look like wind turbines underwater (called axial flow turbines; Figure 14a, b) but can have different

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[1] Biomass Energy Techniques Inc. website https://biomassenergytechniques.com/

numbers of blades. Another tidal generation technology looks more like lawnmower blades (called cross-flow turbines; Figure 14c, d).

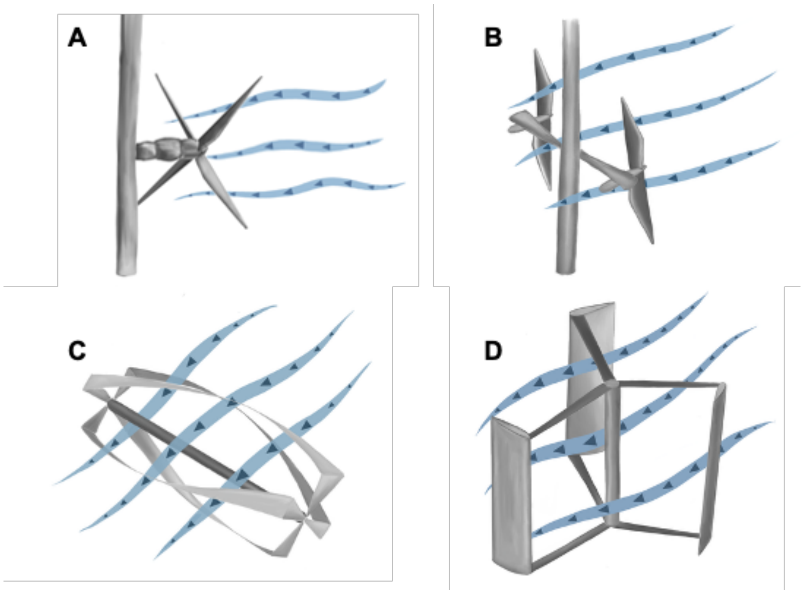

Figure 14. Axial flow turbines (a, b) rotating on the axis of the incoming water flow, whereas cross-flow turbines (c, d) rotate across the flow. Illustrations by Candace Briggs, PNNL.

A review of National Oceanographic and Atmospheric Administration (NOAA) tidal current data for locations near PGST showed there are not any areas with sufficiently high current speeds to make the use of tidal energy viable for PGST. Because of this lack of resources and considering PGST’s strong cultural and economic ties to the ocean, the use of marine energy is not recommended at this time. Specifically, the Tribe aims to avoid potential impacts and interferences to fisheries.

4.0 Microgrid Assessment

DOE defines a microgrid as “a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid” (DOE 2012). In simple terms, a microgrid is a small power system that can operate connected to the larger grid or by itself in stand-alone mode. A microgrid comprises the combination of power generation and storage resources (e.g., renewables, batteries, fuel-fired generators), distribution infrastructure (e.g., wires, switchgear, protective devices, transformers), and loads being supplied with electricity. Loads powered by a microgrid can range from several loads or buildings to a small town or large campus.

Microgrid technology emerged to address reliability concerns, ensuring critical power infrastructure remained operational even during power grid failures. Consequently, most early microgrids were primarily fueled by fossil fuels. However, the current definition of microgrids has emerged from a combination of these reliability needs as well as other goals—including reducing carbon emissions, lowering electricity costs, and increasing the deployment of renewable energy. This has resulted in renewable energy sources, such as solar PV or wind turbines, being added to fuel-fired generation to power microgrids. Typically, microgrids are configured to operate either in parallel with a utility grid or autonomously if there is a grid outage or if there is no utility feed available.

Säzän worked with Spark Northwest and MZ Solar Consulting in partnership with PGST and the Washington State Department of Commerce Solar Plus Storage for Resilient Communities Technical Assistance program to evaluate the feasibility of implementing a microgrid system on the Tribal campus. Säzän evaluated three microgrid concepts for the ability to achieve the following goals:

- Provide resilient power to prioritized facilities for a design-case 7-day outage scenario
- Avoid impacts to trees on-site, underground utilities, and future campus developments
- Develop a solar and battery energy storage system (BESS) demonstration project with lower project complexity to support constructability, maintenance, and operations.

The three concepts are summarized next; more information can be found in the Säzän report.

4.1 Concept 1: Clinic Critical Loads

This concept was prioritized and is planned for implementation by PGST. It supports the existing Clinic Generator Panel G1 by adding a solar and battery storage component to the existing diesel generator. This system would provide resilient power to 50% of Panel G1 loads for a 7-day outage beginning early January.

This system was developed in response to the Tribe’s feedback on other concepts and a desire for low complexity for a first solar and storage installation on campus. It reduces trenching and site impacts by reducing system size and using the building wall for locating some equipment. The suggested hybrid inverter equipment combines switching, solar inverter, and controls into a single compact form factor to further reduce system complexity and costs.

System components include expanding the existing 25.4-kW_{DC} array on the Clinic rooftop by 66.2 kW_{DC} to a total of 91.6 kW_{DC}, a 122.9-kWh BESS, and the existing 150-kW generator.

4.2 Concept 2: Early Childhood Education/Clinic Combined

This concept combines the Early Childhood Education and Clinic buildings into a single solar and storage microgrid. This system would provide resilient power to 75% of system loads for a 7-day outage beginning in early January.

This system is significantly more complex than Concept 1 and is not recommended for development. Siting battery equipment on the highly constrained campus was a recurring challenge through this study and is a key issue with this system. In addition, the distance between the building's electrical panels would require complex trenching and sitework to interconnect. Major system components and evaluated locations on-site are shown in the concept site plan in a separate report from Säzän.

Although this microgrid concept is not recommended, solar-only projects for the Early Childhood Education building were found to be feasible and can provide significant annual cost savings through net metering while laying the groundwork for incorporating a future battery storage system.

System components include expanding the existing 25.4-kW_{DC} array on the Clinic rooftop by 70.5 kW_{DC} to a total of 95.9 kW_{DC}, a 50-kW_{DC} array on the Early Childhood Education rooftop, an 880-kWh BESS, and the existing 150-kW generator from the Clinic.

4.3 Concept 3: Education/Longhouse/Elder's Buildings

This concept would combine the Education, Longhouse, and Elder's buildings into a single solar and storage microgrid. This project would use a 45-kW solar array on the roof of the Longhouse and medium-scale battery equipment near the existing utility transformer, with a new gas generator to provide 100% of building loads for a 7-day outage in early January.

Although this was evaluated as a constructable system, it is not recommended for development for the following reasons:

- Site constraints: buried water and sewer utilities surrounding the buildings to the south and east; important gathering areas and natural view corridor on the north and west
- Uncertainty around new facility construction location and potential shading impacts
- Longhouse roof structural concerns
- Elder's and Education building roofs are poor choices for solar (north facing).

In winter, outage resilience is determined primarily by the generator fuel available. In other seasons, however, when sufficient solar power is available to recharge the battery during the day, a utility outage can last much longer and not require as frequent operation of the generator.

Smaller systems focusing on critical loads may also be feasible; however, the uncertainty around future development adjacent to the building makes the risk of solar shading and exterior battery location a concern. The Longhouse is the only of the three buildings that appeared to have unobtrusive areas to install batteries inside the building, but rooftop solar is of concern as discussed previously. System components include a 45-kW_{DC} array, a 153.6-kWh battery energy storage system, and a 75-kW gas generator with 500-gallon liquid petroleum tank.

4.4 Recommendations

In 2024, PGST applied for and received a Washington Department of Commerce Clean Energy Grant to pursue the implementation of microgrid Concept 1. The project is expected to be completed in the next 5 years. Following the implementation of the Concept 1 microgrid, PGST could evaluate pursuing the microgrids described in Concepts 2 and 3. Because Concepts 1 and 2 overlap, adding solar PV and BESS to the Early Learning Center in the future may be possible, but the Clinic will already have panels.

5.0 Energy Infrastructure Analyses

PNNL conducted a series of additional energy infrastructure analyses to identify opportunities and recommendations for PGST to achieve its energy vision. These analyses included the following:

- Energy audits
- Critical infrastructure analysis
- Electric vehicle analysis
- Geothermal resource analysis.

The Tribe follows state standards for energy infrastructure in buildings and is also seeking to enhance its implementation of efficient energy infrastructure in future building investments. PGST is reliant on the rigorous Washington Energy Code as part of its Design & Construction Standards. Any building requiring a Title 24 permit will require compliance with the Washington Energy Code. Washington State also has Clean Building Performance standards that take effect in 2026–2028, though these will cover only buildings greater than 50,000 ft^2 and may not be applicable to PGST. The Tribe would like to support the integration of efficient energy technologies in future building investments such as solar PV, electric vehicle (EV) readiness, energy efficiency measures, and ground source heat pumps. Related standards and expectations could be documented in a set of Owner's Project Requirements to inform those bidding and developing the Tribe's future construction projects.

5.1 Energy Audits

PNNL conducted an on-site energy and water evaluation (energy and water audit) for PGST to assess energy and water use at four of the Tribal facilities and identify efficiency opportunities. This assessment can serve as a template for similar efficiency and electrification improvements that can be identified and pursued in other PGST facilities not audited during the ETIPP.

The on-site evaluation was conducted on April 11, 2024, to assess energy efficiency, water efficiency, and electrification opportunities. Electrification measures are intended to convert existing propane-fueled equipment to electric-powered equipment. The total floor space evaluated was 49,595 ft^2, which includes the Administration, Youth Center, CFS/Police, and Early Childhood Education buildings. The estimated annual cost savings of the identified efficiency measures is $15,818 with estimated annual electricity and propane consumption savings of 398 million British thermal units (MMBtu; 116,732 kWh) and 259 MMBtu (2,826 gallons), respectively. The estimated cost to implement all identified measures is $156,480, which yields a simple payback period of 9.9 years and a savings-to-investment ratio (SIR) of 1.3, excluding potential incentives provided by PSE. With PSE incentives, the total estimated simple payback is reduced to 8.9 years.

Table 6 summarizes the energy and energy cost savings, investment cost, and potential incentives for PGST.

For additional information about the energy auditing process and results, refer to the Energy and Water Assessment for PGST report that was provided to PGST in September 2024.

Table 6. Summary of Recommended Energy and Water Efficiency Measures for the PGST Audited Buildings

	Electricity Savings		**Propane Savings**		**Total Savings ($/yr)**	**Investment ($)**	**Simple Payback (yr)**	**SIR**	**Potential PSE Incentives**
	MMBtu/ yr (kWh/yr)	**$/yr**	**MMBtu/ yr (gal/yr)**	**$/yr**					
HVAC controls	189 (55,319)	$4,317	0	$0	$4,317	$3,571	0.8	15.0	$0
Heating/cooling	-101 (-29,695)	($1,941)	248 (2,709)	$4,957	$3,016	$98,760	33	1.8	$678
Lights (exterior)	2 (610)	$57	0	$0	$57	$2,221	39	1.2	$274
Domestic hot water	-4 (-1,043)	($106)	7 (71)	$130	$24	$13,957	582	0.0	$1,200
Roof	287 (84,185)	$7,614	0	$0	$7,614	$31,655	4.2	4.1	$14,000
Weatherization	25 (7,356)	$699	4 (46)	$91	$790	$6,316	8.0	0.6	$0
Project Total	**398 (116,732)**	**$10,640**	**259 (2,826)**	**$5,178**	**$15,818**	**$156,480**	**9.9**	**1.3**	**$16,152**

HVAC = heating, ventilation, and air conditioning

5.1.1 Energy and Water Efficiency Project Financing

Funding is a key consideration when evaluating the implementation of energy and water efficiency projects for a building portfolio. Table 7 describes common avenues for funding efficiency projects and provides some considerations for PGST as it explores energy efficiency projects (Better Buildings n.d.). Other less common funding avenues such as leases, commercial property-assessed clean energy (PACE), efficiency-as-a-service, and on-bill financing (OBF) and repayment (OBR) may also be available depending on the scale of the project.

Table 7. Energy Efficiency Funding Avenues

Funding Avenue	Description	Key Considerations
Self-funded	The building owner pays for the projects directly using its own funds (capital or operating).	• Most simple and direct method for funding projects. • The financial benefits of the project are fully captured by the building owner.
Debt or loan	The building owner borrows funds from banks or other lenders to finance the project.	• Added cost to the project. • Access to capital may not be available for all types of projects.
Energy savings performance contracts (ESPC)	An energy service company installs the project and is paid from the cost savings the project creates.	• May be an option for owners with large projects or that are interested in bundling several smaller projects. • May require little to no upfront cost for the owner. • Some projects may not qualify for ESPC, especially if savings are relatively low.

5.1.2 Recommendations

Table 8 shows a set of energy auditing recommendations for PGST.

Table 8. Energy Audit Recommendations

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Complete energy and water audits of the remaining PGST campus buildings.	Select additional buildings to complete energy and water audits for and engage appropriate staff or consultants to conduct the audits. Use the results to inform next steps for energy and water efficiency project implementation.	Short term	Low to medium cost, depending on the number of buildings	PGST facilities staff or energy manager

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Work with PSE to identify energy rebates and other incentives for energy efficiency projects.	When completing additional energy and water audits, work with PSE to understand the potential energy rebates and incentives that might be available for project implementation. Consider these rebates when estimating the potential cost of efficiency measures.	Short term	No cost	PGST facilities staff or energy manager
Develop a prioritized list of efficiency projects for implementation and explore funding opportunities for those projects.	Collect and compare bids for recommended energy and water efficiency projects and determine eligibility for grants/outside funding. Select and prioritize projects for implementation based on costs and potential benefits (e.g., energy and water consumption savings, cost savings, building occupant benefits).	Short term	No cost	PGST facilities staff or energy manager
Implement energy and water efficiency projects.	Select projects for implementation and engage appropriate staff or external contractors to execute the projects. When implementing projects, consider whether any could be bundled to reduce disruption to operations and optimize costs.	Short to medium term	Variable cost	PGST facilities staff or energy manager/external contractors
Develop and implement a process to periodically review energy and water use by building and complete energy audits/retro-commissioning on a schedule.	Develop a process that aligns with PGST's operations to periodically review energy and water use by buildings. This process could also include conducting energy and water audits as well as retro-commissioning studies for PGST buildings on a set schedule.	Short to medium term	No cost	PGST facilities staff or energy manager

5.2 Critical Infrastructure Analysis

As part of the ETIPP, PNNL worked with PGST to conduct a vulnerability analysis of critical energy and water infrastructure on PGST lands. Because of its remote location on the northern tip of the Kitsap Peninsula in Washington State, the Tribe relies on a single road (Hansville Road) to connect with the rest of Kitsap County, and electricity is supplied by a single transmission and a single distribution cable. These conditions mean weather-related power outages can take hours to resolve, and any disruptions to the road can quickly isolate the Tribe during emergencies. These factors make designing and implementing hazard-resilient critical infrastructure especially important.

This analysis identified critical infrastructure, analyzed potential hazards or threats to that infrastructure, and suggested strategies for improving the infrastructure's resilience. This report also briefly considers currently planned resilience work, including by PSE, Kitsap County, and an independent renewable energy project in the early stages of development.

Critical infrastructure was identified through conversations with PGST staff and Tribal Council members and is defined as assets and systems that provide functions necessary for the Tribe's way of life. Critical infrastructure identified in this analysis includes critical buildings, backup generators, water/sewer infrastructure, and PSE infrastructure.

Potential hazards or threats to infrastructure—and the associated level of risk—were identified by overlaying geographic information system layers of the geographical extents of known hazards over a map of the PGST lands and critical infrastructure. Known hazards include the following:

- Coastal bluff erosion and landslides
- Drought and high heat
- Earthquakes
- Sea level rise and coastal flooding
- Tsunamis
- Wildfires
- Severe weather and windstorms
- Terrorism, cyberattacks, and vandalism.

Various hazards put the PGST at risk and should be considered both in resilience improvement efforts and potential renewable energy siting efforts (Table 9). In particular, earthquakes, coastal flooding and sea level rise, and severe weather and windstorms could have implications for siting locations, materials and construction considerations, and incorporation of mitigation measures in energy and resilience planning. For additional information about how risks were determined and specific recommendations, refer to the Improving Resilience for the Port Gamble S'Klallam Tribe Critical Infrastructure report which was provided separately to PGST.

Table 9. Summary of Hazards, Risk Level, and Critical Infrastructure with the Potential for the Highest Risk at PGST.

Hazard or Threat	Risk Level	Infrastructure at Highest Risk
Coastal bluff erosion and landslides	High	Houses along bluff edge; water reservoirs on landslide-prone areas
Earthquakes	High	All infrastructure at risk; older buildings are more susceptible to damage

Hazard or Threat	Risk Level	Infrastructure at Highest Risk
Sea level rise and coastal flooding	High	Hatchery and Hatchery backup generator; other infrastructure at Point Julia
Tsunami	High	Hatchery and Hatchery backup generator; other infrastructure at Point Julia
Wildfire	Low	PSE transmission lines
Severe weather and windstorm	High	PSE transmission lines, Elder's Center, Early Childhood Education Center
Terrorism, cyberattack, vandalism	Moderate	PSE substations

Recommendations

Suggested strategies for improving resilience of critical infrastructure were chosen based on various resources such as Federal Emergency Management Agency (FEMA) disaster planning guides, PNNL, NOAA, and Homeland Security resources and by using tools such as the Technical Resilience Navigator.[1] Table 10 shows a subset of critical infrastructure resilience recommendations for PGST. Additional resilience recommendations and detailed analysis on hazards relevant to the PGST lands can be found in the Improving Resilience for the Port Gamble S'Klallam Tribe Critical Infrastructure report which was provided separately to PGST.

Table 10. Critical Infrastructure Resilience Recommendations

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Explore coastal bluff erosion mitigation measures.	Erosion mitigation can include beach nourishment, runoff mitigation, upper bluff protection, and so on.	Medium to long term	Variable cost	Contractor; PGST staff: environmental planner
Consider adopting relevant earthquake and tsunami codes.	Building codes can be applied to new construction and existing buildings and address both structural and nonstructural building components.	Medium to long term	Variable cost	PGST staff: construction, building supervisor
Consider seismic construction when planning new developments or renovating existing buildings.	Seismic construction strategies include foundation isolation, shear walls, shock absorbers, and flexible or reinforced building materials.	Medium to long term	Medium to high cost	PGST staff: construction, building supervisor

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[1] Technical Resilience Navigator https://trn.pnnl.gov/

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Establish zones of protection around critical infrastructure to reduce wildfire risk.	Create defensible space using noncombustible ground cover and vegetation management proximity zones around critical infrastructure.	Short term	Low to medium cost	PGST staff: maintenance
Develop response plans for quick load shedding during emergency events.	Create emergency plans to prioritize critical loads during emergency events or unplanned outages.	Short term	Low cost	PGST staff: energy manager, safety coordinator, utilities
Develop vegetation management plans near critical infrastructure.	Create regularly scheduled plans to trim/remove dead foliage from around critical infrastructure to reduce the risk of damage during a severe weather event.	Short term	Low cost	PGST staff: maintenance
Prepare emergency flood mitigation for vulnerable equipment/facilities located at Point Julia.	Emergency flood mitigation includes the use of sandbags, temporary flood barriers, and flood wrapping. Need for flood mitigation might increase as sea levels rise.	Short term	Low to medium cost	PGST staff: maintenance, facilities

5.3 Electric Vehicle Analysis

PGST was interested in understanding the EV charging needs to meet growing EV adoption for PGST’s staff, visitors, and fleet. The project team evaluated EV adoption scenarios assuming varying degrees of vehicle electrification and vehicle turnover to estimate charging infrastructure needs.

5.3.1 Electric Vehicle Overview

EVs are vehicles that can be powered by an electric motor that draws electricity, at least in part, from a battery. Some EVs are all-electric and operate exclusively on a battery (BEVs), whereas others are plug-in hybrids (PHEV) with an internal combustion engine (ICE) in addition to a battery(U.S. Department of Transportation 2025); see Figure 15 for an illustration of the difference between the two types. PHEVs operate as conventional ICE vehicles when not in electric mode, whereas BEVs operate solely on electricity. The analysis conducted for PGST focused primarily on BEVs, referred to in this report as EVs or all-electric vehicles.

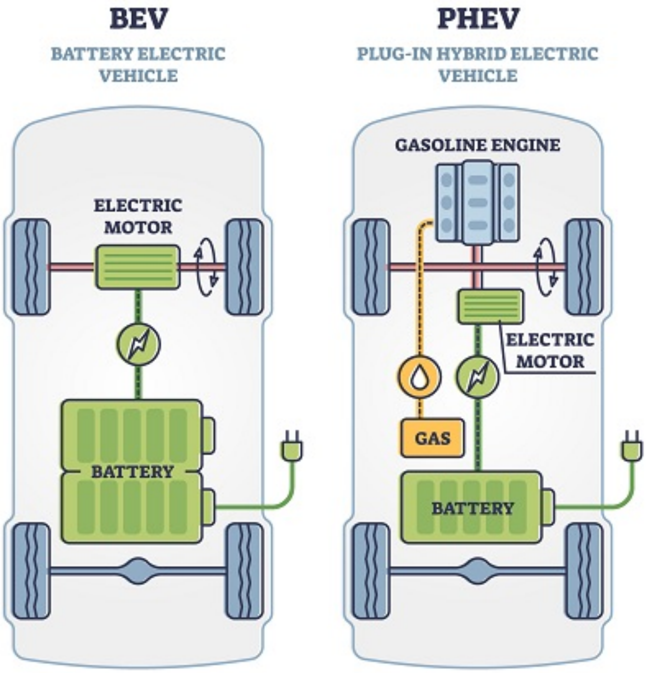
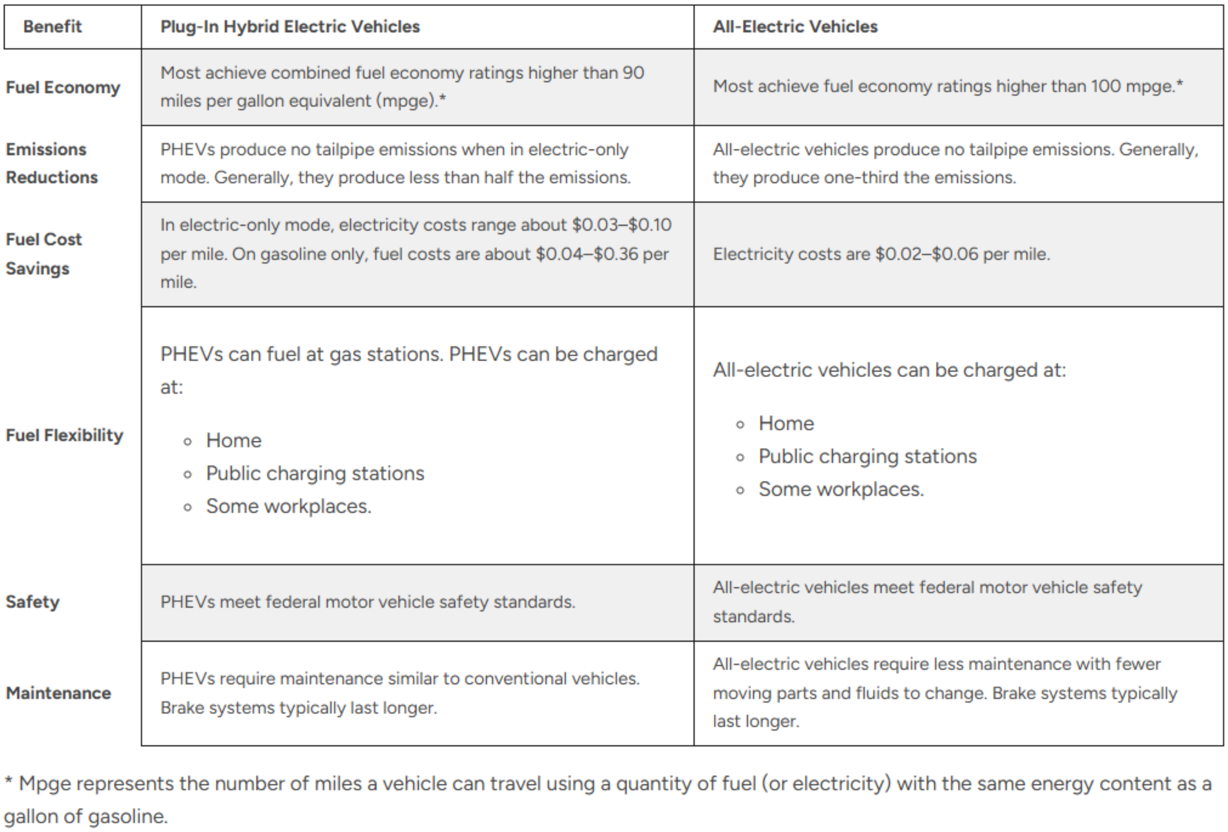


Figure 15. BEVs vs. PHEVs. Source: U.S. Department of Transportation (2025)

5.3.1.1 Benefits and Challenges of Electric Vehicles

Transitioning toward EVs from conventional ICE vehicles can offer various benefits and some potential challenges. Benefits of EVs typically include lower cumulative cost of ownership, lower fueling costs, lower maintenance costs, and higher fuel economy (Figure 16). EVs also emit fewer (in the case of PHEVs) or no (in the case of BEVs) tailpipe emissions and are responsible for fewer life-cycle greenhouse gas emissions (U.S. Department of Transportation 2025). Electrifying the PGST fleet and supporting community members and visitors with EV infrastructure will allow the Tribe and community to experience some of these benefits and support the goals of PGST's Climate Action Plan. There are also potential challenges to consider when transitioning from ICE vehicles to EVs—primarily challenges related to meeting vehicle operational demands and charging demands. These challenges can be avoided or addressed through proactive planning. It is important to ensure EVs will be able to meet operational needs because they have different duty cycles and “fueling” requirements from ICE vehicles. Although most current EV technology is best suited for short- to medium-length trips because of vehicle ranges and sizes, technology is quickly improving to accommodate longer trips and increased operational demands. Technology improvements include continued improvements to vehicle driving range and load capacity as well as increased public charging infrastructure availability to support longer trips. Although the cumulative cost of EVs is lower than that of ICE vehicles, the upfront cost is usually higher. The federal Clean Vehicle Tax Credit and Washington State EV Instant Rebate Program are both designed to help lower the upfront cost of EV purchases. PGST may also qualify for grant funding to help cover the costs of vehicles and infrastructure. These programs may change over time and should be confirmed when considering EV purchases.



Benefit	Plug-In Hybrid Electric Vehicles	All-Electric Vehicles
Fuel Economy	Most achieve combined fuel economy ratings higher than 90 miles per gallon equivalent (mpge).*	Most achieve fuel economy ratings higher than 100 mpge.*
Emissions Reductions	PHEVs produce no tailpipe emissions when in electric-only mode. Generally, they produce less than half the emissions.	All-electric vehicles produce no tailpipe emissions. Generally, they produce one-third the emissions.
Fuel Cost Savings	In electric-only mode, electricity costs range about \$0.03–\$0.10 per mile. On gasoline only, fuel costs are about \$0.04–\$0.36 per mile.	Electricity costs are \$0.02–\$0.06 per mile.
Fuel Flexibility	PHEVs can fuel at gas stations. PHEVs can be charged at: ○ Home ○ Public charging stations ○ Some workplaces.	All-electric vehicles can be charged at: ○ Home ○ Public charging stations ○ Some workplaces.
Safety	PHEVs meet federal motor vehicle safety standards.	All-electric vehicles meet federal motor vehicle safety standards.
Maintenance	PHEVs require maintenance similar to conventional vehicles. Brake systems typically last longer.	All-electric vehicles require less maintenance with fewer moving parts and fluids to change. Brake systems typically last longer.

* Mpge represents the number of miles a vehicle can travel using a quantity of fuel (or electricity) with the same energy content as a gallon of gasoline.

Figure 16. Benefits of electric vehicles. Source: DOE (n.d.-a).

5.3.1.2 Electric and Conventional Vehicle Comparison

The cost-effectiveness of EVs in a particular application (e.g., fleet, personal use) depends on factors such as the upfront and maintenance costs of the vehicle, the number of trips and miles traveled annually, and the local costs of gasoline and electricity. DOE's Alternative Fuels Data Center (AFDC) provides a calculator that allows users to compare the cost of operating two vehicles of their choice.[1] To provide a more locally relevant comparison for PGST, the project team used the AFDC calculator to compare the most-commonly sold conventional vehicle in Washington State in 2023—a Toyota RAV4—with the Hyundai Ioniq 6 EV. The comparison uses the default inputs provided by the calculator for vehicle costs, number of trips, distance traveled, and others as summarized in Table 11.

Table 11. Inputs for Conventional and Electric Vehicle Comparison

Recommendation	Description
Conventional vehicle	2023 Toyota RAV4 AWD 4cyl 2.5L Automatic (S8) Gasoline
Conventional vehicle cost	\$31,185

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[1] DOE Alternative Fuels Data Center https://afdc.energy.gov/calc/

Recommendation	Description
Conventional vehicle fuel economy (city/highway)	25/33 mpg
Electric vehicle	2023 Hyundai Ioniq 6 Standard Range RWD cyl L Automatic (A1) EV
Electric vehicle cost	$49,990 (no tax credits assumed)
Electric vehicle fuel economy (city/highway)	26/29 kWh/100 miles
Gasoline price	$4.54 (2023 annual average based on U.S. Energy Information Agency [EIA] Data[1]
Average daily driving distance	34 miles
Days per week	5 days/week
Weeks per year	49 weeks/year
Percent time on highway for daily use	45%
Other trips annual mileage	3,596
Percent time of highway for other trips	80%
Location	Washington State

The results of the comparison are shown in Table 12, and the cumulative cost of ownership by year is shown in Figure 17. In this example, the Hyundai Ioniq 6 has a lower cumulative cost of ownership over 15 years.

Table 12. Conventional and Electric Vehicle Fuel Use and Cost Comparison Results Using AFDC Calculator

Vehicle	Annual Fuel Use	Annual Electricity Use	Annual Fuel/Electricity Cost	Annual Operating Cost	Cost per Mile	Annual Emissions (lbs CO_2)
2023 Toyota Rav4	397 gallons	0 kWh	$1,803	$4,060	$0.34	9,530
2023 Hyundai Ioniq 6	0 gallons	3,007 kWh	$303	$2,408	$0.20	663

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[1] U.S. Energy Information Administration https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0u_pte_swa_dpg&f=m

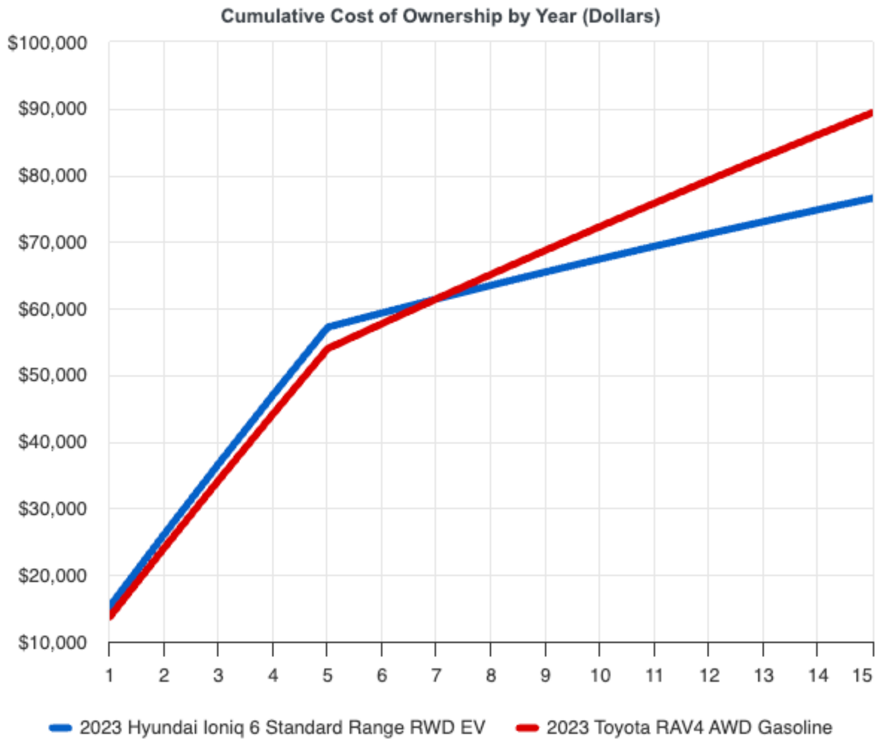

Figure 17. Conventional and electric vehicle cost of ownership comparison. Source: DOE (n.d. -b).

This example is intended to illustrate how to compare various vehicle types in terms of fuel economy and cost of ownership, but results will vary with different inputs. Figure 18 shows the cost of ownership comparison for additional vehicle types.

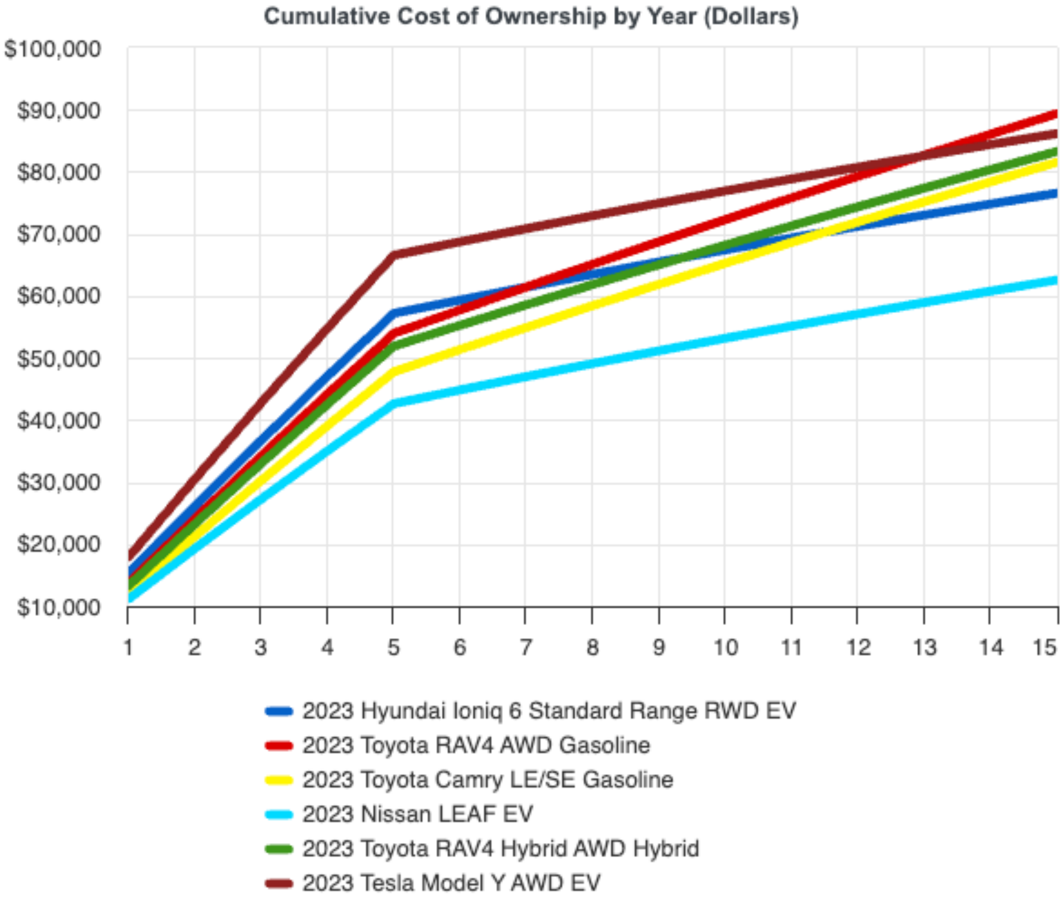

Figure 18. Comparison for additional vehicle types. Source: DOE (n.d. -b).

5.3.1.3 Types of Electric Vehicle Chargers

To support the adoption of EVs, users will need access to reliable charging infrastructure at home, fleet facilities, their workplace, or other public destinations. Charging infrastructure is typically described using the following terminology: station location, EV charging port (also called charger), and connector (DOE n.d.-b). These can be defined as follows:

- Station location: The physical location of the charging port. The location can have one or more ports.
- EV charging port (or charger): The charging infrastructure that may have one or more connectors and can charge one or more vehicles at a time.
- Connector: The physical device that is used to charge the vehicle.

Charging equipment is typically classified by how quickly it can charge a vehicle. Figure 19 provides an overview of the three main types of chargers, including how quickly they can charge a vehicle and the most common types of connectors they use: AC Level 1, AC Level 2, and DC fast charging.

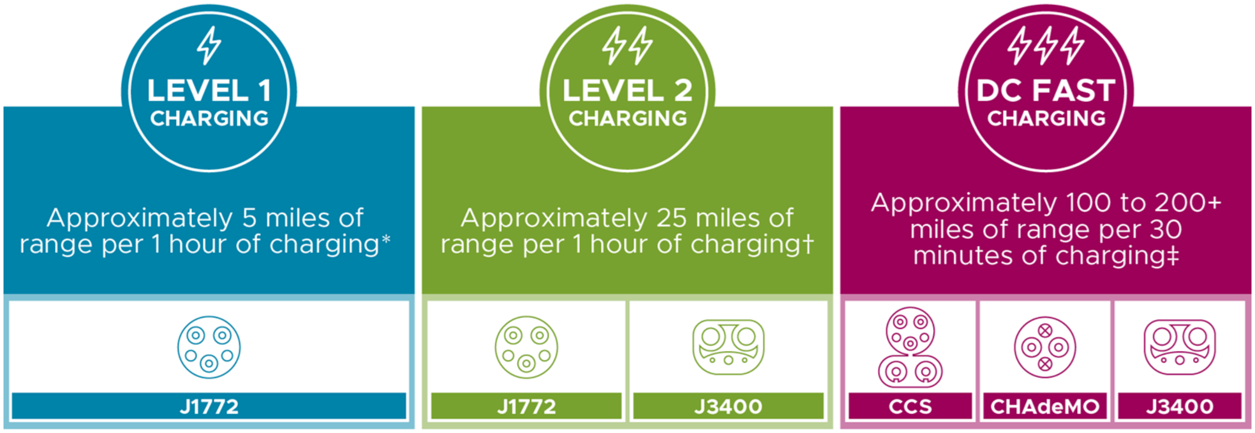

Figure 19. Overview of vehicle charger types

Level 1 chargers are more often used for at-home charging; Level 2 chargers may be found at homes but also in public and workplace charging setups; and DC fast chargers are more typical for public charging.

5.3.2 Considerations for Electric Vehicle Analyses

This section describes some key considerations for the analysis of EV adoption and charging infrastructure needs for PGST.

5.3.2.1 Charging Station Locations

There are three Level 2 charging stations in the vicinity of the PGST Reservation: one at The Point Casino with four ports, one at the Kitsap Transit George's Corner Park and Ride with four ports, and one at a nearby Albertsons grocery store with two ports.[1] There are additional stations located near Port Ludlow, Poulsbo, and Bainbridge Island; Figure 20 shows these locations on a map. Additional charging stations are likely to be needed to support EV adoption for PGST.

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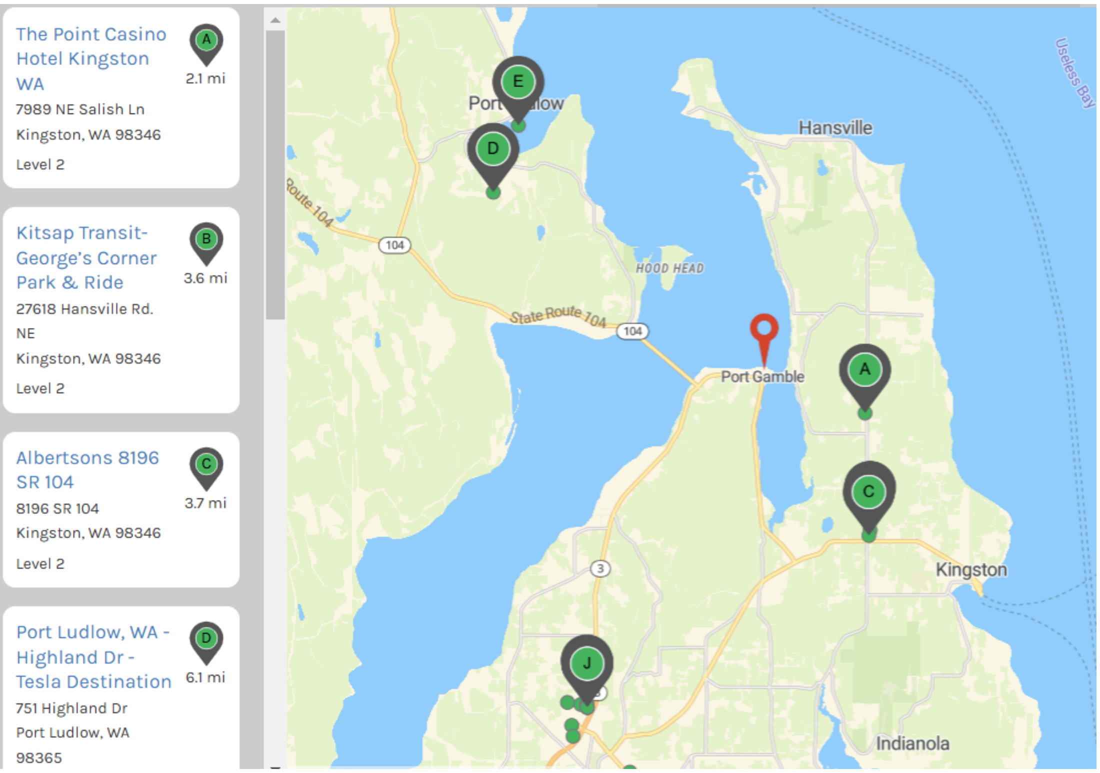
[1] DOE EV Charging Locations https://afdc.energy.gov/fuels/electricity-locations#/find/nearest?fuel



The Point Casino Hotel Kingston WA
7989 NE Salish Ln
Kingston, WA 98346
Level 2

Kitsap Transit-George's Corner Park & Ride
27618 Hansville Rd. NE
Kingston, WA 98346
Level 2

Albertsons 8196 SR 104
8196 SR 104
Kingston, WA 98346
Level 2

Port Ludlow, WA - Highland Dr - Tesla Destination
751 Highland Dr
Port Ludlow, WA
98365

Figure 20. Electric vehicle charging station locations near the PGST Reservation. Source: DOE (n.d. -b).

5.3.2.2 Policy Drivers

Policy can be an important driver for how quickly a technology such as EVs is adopted in a community. An example of a policy that may influence PGST's adoption of EVs is Washington State's 2022 Move-Ahead Washington, a transportation package that establishes a nonbinding goal of having all passenger and light-duty vehicles sold, purchased, or registered in the state to be electric by 2030 (S.B. 5974 2022). Although achieving this goal will be challenging (Interagency Electric Vehicle Coordinating Council 2024), the policy may influence the types of vehicles sold in Washington State and may make EVs more common. Other driving policies include state and federal incentives to reduce the cost of purchasing an EV (Washington State Department of Commerce 2025; DOE n.d.-a) and utility programs that support the installation of EV charging infrastructure—such as PSE's Up & Go Electric program.[1] Some jurisdictions, such as the City of Seattle (Ordinance 125815), have established EV readiness ordinances that require new construction projects to plan for (and in some cases install) EV charging infrastructure. More information on EV readiness considerations and examples can be found in Appendix C.

5.3.2.3 Charging Infrastructure Cost

Electric vehicle charging infrastructure can have multiple configurations, and installation costs can vary widely. Cost considerations for charging infrastructure include the following:

- One-time costs (ICF 2025):

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[1] PSE EV Basics https://www.pse.com/en/pages/electric-cars

  - Electric infrastructure upgrades: In some instances, upgrades to the electrical infrastructure itself (e.g., wiring, panels) may be required to install an EV charger.
  - Charging equipment: The costs of the charging equipment itself can vary based on the charging level (1, 2, or fast), connector type, location, output, and other factors.
  - Installation: Costs may vary based on location, number and type of the infrastructure, local design, permitting and construction costs, and other factors.
- Ongoing costs:
  - Electricity: Costs of the electricity used to charge the EV. The costs incurred will depend on the ownership structure for the charger; for example, a charger's owner may opt to be reimbursed for electricity costs by charging users on a per-kWh, session, or length-of-time basis or may opt to provide the charging as a free-of-charge service.
  - Maintenance: May include inspecting and cleaning cables along with other activities to keep the charger functioning in optimal condition.

Other costs may be incurred depending on the charger's ownership structure. For example, if the charger will be connected to a charging network, initial networking costs may be required and periodic fees assessed to keep the charger connected to the network. In addition, under some ownership models a charger may be owned by one party but installed at a location owned by a third party—in which case there may be lease or other similar costs involved.

It is sometimes most cost-effective to install EV chargers in groups of four or more, considering the electrical upgrade and construction costs at each site. Multiple chargers at a given location can also increase the overall reliability of the charging location for EV drivers.

5.3.3 Analysis Results

5.3.3.1 Fleet

The fleet analysis focused on understanding the high-level fleet electrification trajectories and potential charging needs for PGST. However, fleet electrification is highly dependent on fleet characteristics and behavior and requires a more detailed assessment. Table 13 shows a summary of the factors and assumptions made for the PGST fleet EV analysis.

Table 13. Fleet Charging Infrastructure Factors and Assumptions

Factor	Considerations	Assumptions for Analysis
Number of vehicles	PGST's fleet comprises 85 vehicles of a variety of types: light-duty (e.g., sedans or passenger sport utility vehicles [SUVs]), trucks, buses, and other commercial vehicles. The number and types of vehicles to be electrified will affect the quantity and type of charging infrastructure needed.	70 of the light-duty vehicles in PGST's fleet could be electrified. Other vehicle types may be electrified in the future but were not included in this analysis.

Factor	Considerations	Assumptions for Analysis
Vehicle usage	The number of trips vehicles take on a periodic basis, the distance traveled, and the amount of downtime available for each vehicle can affect charging patterns and charging infrastructure needs. Vehicles used daily for extended trips will need more frequent and longer-lasting charges than vehicles used less frequently or for shorter trips.	Apart from fisheries and police vehicles, most fleet vehicles are used during business hours, allowing overnight and weekend charging. The total daily distances traveled vary by department but typically do not exceed 50 miles/day.
EV types	There are two main types of EVs that may replace existing vehicles: all-electric vehicles and PHEVs. The charging needs for each vehicle type are different.	Fleet vehicles would be replaced with all-electric vehicles, not PHEVs.
Charging station location	The location where vehicles are housed and their travel distances and routes can influence the distribution of charging infrastructure and the number of chargers needed.	Vehicles will be charged at a central location, to be determined by PGST.
Charger-to-vehicle ratio	Depending on the fleet's needs, a single charger may be able to support more than one vehicle. Often, a ratio of 1.5 EVs per charger is used, but a 2:1 ratio may also be possible (DOE n.d.-c). Fleets with little downtime may require a 1:1 EV-to-charger ratio.	2:1 EV-to-charger ratio.

Three fleet electrification scenarios were evaluated:

- Scenario 1: Follows Washington State's Move-Ahead Washington plan of 100% EV sales by 2030 and assumes PGST's fleet vehicle turnover rate is 10 years per vehicle.
- Scenario 2: Follows Washington State's Move-Ahead Washington plan of 100% EV sales by 2030 and assumes PGST's fleet vehicle turnover rate is 15 years per vehicle.
- Scenario 3: Based on a 5-year delay to PGST's 2024 Climate Action Plan, which recommends PGST transition 10 passenger vehicles, 5 trucks, and 1 bus per year from 2027 to 2030 for a total of 48 vehicles over 3 years. It is now unlikely the original goal can be achieved by 2030, but the intention remains to meet this goal now by 2035. For this analysis, the scenario focuses on light-duty vehicles; buses are not included in the projected vehicle count. After achieving 45 EVs by 2035, this scenario projects a 10-year vehicle turnover rate. Note the Climate Action Plan suggests the installation of 10–15 chargers distributed throughout the reservation to support the proposed fleet electrification.

Figure 21 and Table 14 show the percentage of PGST's fleet that would be electrified through 2050 under each scenario and the associated demand for EV charging. Scenario 3 is the most likely scenario given current resources and planning timelines. The number of chargers and locations for fleet electrification will need to be determined upon further analysis of fleet patterns, but it is estimated at least 35 chargers will be needed to support significant fleet electrification in the long term.

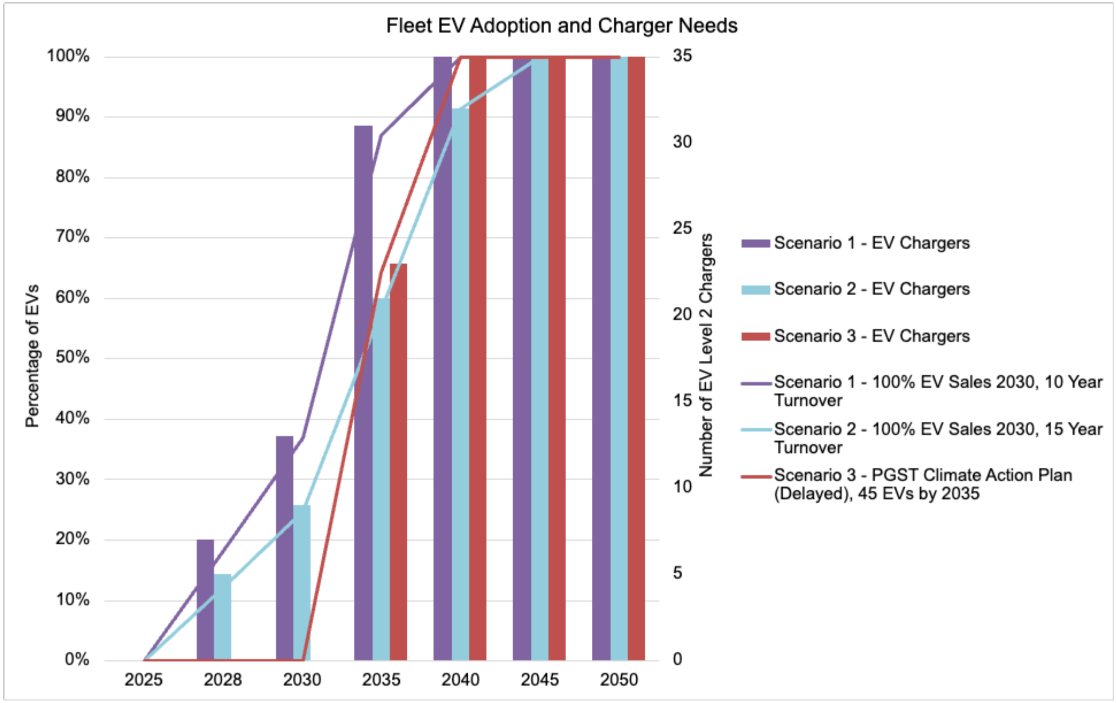

Figure 21. PGST fleet electrification scenarios

Table 14. Fleet EV and Charger Estimations

	Year (20XX)																				
	25	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
Scenario 1: EVs	0	3	8	13	19	26	33	40	47	54	61	68	70	70	70	70	70	70	70	70	70
Scenario 1: Chargers	0	2	4	7	10	13	17	20	24	27	31	34	35	35	35	35	35	35	35	35	35
Scenario 2: EVs	0	2	5	9	13	17	22	27	31	36	41	45	50	55	59	64	69	70	70	70	70
Scenario 2: Chargers	0	2	3	5	7	9	11	14	16	18	21	23	25	28	30	32	35	35	35	35	35
Scenario 3: EVs	0	0	0	0	0	0	0	11	23	34	45	52	59	66	70	70	70	70	70	70	70
Scenario 3: Chargers	0	0	0	0	0	0	0	6	12	17	23	26	30	33	35	35	35	35	35	35	35

5.3.3.2 Workplace

The workplace EV analysis focused on understanding how PGST may be able to meet future charging infrastructure needs for its administrative campus staff and visitors. Table 15 shows a summary of the factors and assumptions made for the PGST workplace EV analysis. Note all vehicles were assumed to be light-duty vehicles.

Table 15. Workplace Charging Infrastructure Factors and Assumptions

Factor	Considerations	Assumptions for Analysis
Number of vehicles	PGST estimates at its peak the administrative campus may receive approximately 275 vehicles/day, including staff and visitors. This applies primarily to weekdays; and during weekends the number decreases significantly.	275 vehicles/day per weekday
Charging behavior	According to the 2023 EV driver survey, 28% of EV owners who have access to workplace charging use it weekly and 22% use it daily (Plug In America 2023). This means not every vehicle visiting the administrative campus will be charging there every day—some charging may happen at home or at a public charging port.	Apply the weekly and daily charging assumptions listed
Charger type	In a workplace or retail setting, Level 2 and fast DC chargers are more common.	Preference for Level 2 chargers
Vehicle downtime	Staff and visitor behavior—including how long they stay on campus or charge their vehicle—will affect the number of EV chargers needed. This variable can be adjusted through various parking policies (e.g., providing a time limit for parking at an EV charger).	Each Level 2 charger can provide two charges/day, assuming an average charging time per vehicle of 3 hours and switching time between EVs

Three electrification scenarios for the vehicles visiting the PGST campus were evaluated:

- Scenario 1: Follows Washington State's Move-Ahead Washington plan of 100% EV sales by 2030 and assumes the individual vehicle turnover rate is 10 years per vehicle.
- Scenario 2: Assumes a slower electric vehicle rollout—100% EV sales by 2045 instead of 2030—and assumes the individual vehicle turnover rate is 10 years per vehicle.
- Scenario 3: Assumes a slower electric vehicle rollout—100% EV sales by 2045 instead of 2030—and that the individual vehicle turnover rate is 15 years per vehicle.

Figure 22 and Table 16 show the percentage of total visitors to the PGST campus that would be using EVs under the three scenarios and the number of chargers needed to support them. Under the assumptions listed in Table 15, we estimate one EV charger will be needed for every 5–7 EVs visiting the PGST campus. If all 275 vehicles visiting PGST campus are electrified, approximately 38 Level 2 chargers would be needed to support their charging needs (assuming a mix of home and workplace charging).

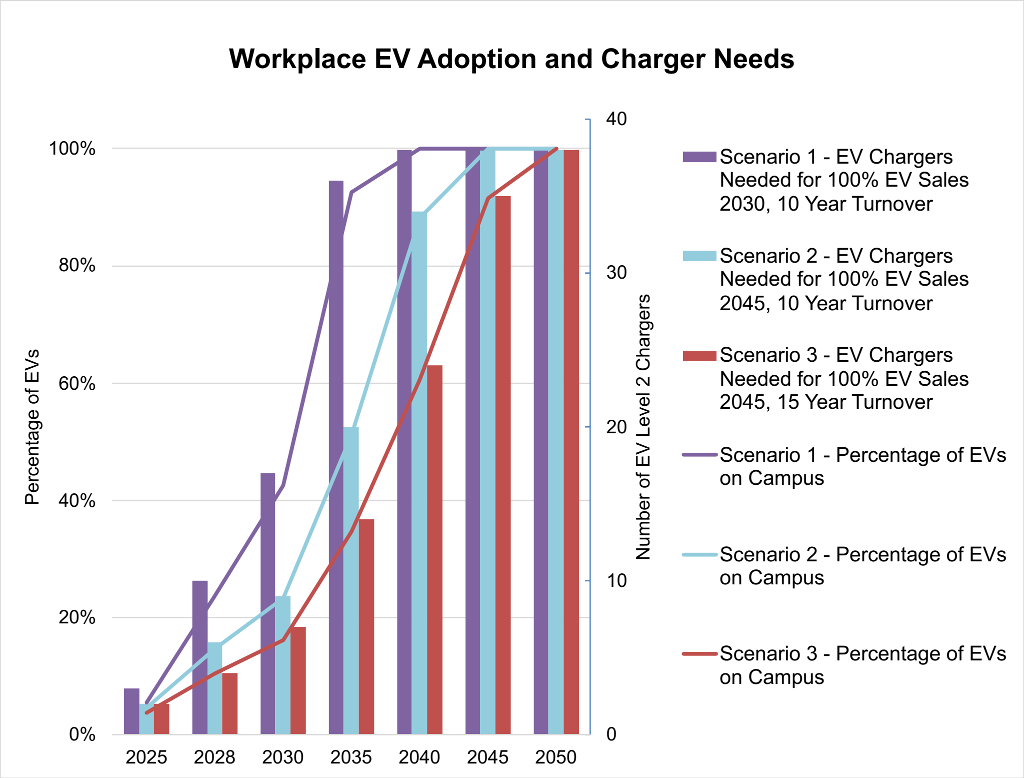

Figure 22. Workplace EV adoption and charger needs projected from 2025 to 2050 at the PGST main campus.

Table 16. Workplace EV and Charger Estimations

	Year (20XX)																						
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Scenario 1: EVs	15	28	45	65	89	117	144	172	199	227	254	275	275	275	275	275	275	275	275	275	275	275	275
Scenario 1: Chargers	3	4	7	10	13	17	20	24	28	32	36	38	38	38	38	38	38	38	38	38	38	38	38
Scenario 2: EVs	13	21	30	40	52	64	77	92	107	123	141	159	178	199	220	243	266	275	275	275	275	275	275
Scenario 2: Chargers	2	3	5	6	8	9	11	13	15	17	20	22	25	28	31	34	37	38	38	38	38	38	38
Scenario 3: EVs	10	16	22	29	36	44	53	63	73	84	96	108	121	134	149	167	183	199	216	233	252	270	275
Scenario 3: Chargers	0	0	0	0	0	0	0	6	12	17	23	26	30	33	35	35	35	35	35	35	35		

5.3.3.3 Community

The EV charging infrastructure needs for PGST's broader community of 400 households were analyzed using NLR's Electric Vehicle Infrastructure Projection (EVI-Pro Lite) tool[1] using the following assumptions:

- Two vehicles per household, 800 vehicles in total.
- EVI-Pro Lite inputs:
  - Focused on models and projections for the Bremerton-Silverdale-Port Orchard, Washington area.
  - Types of vehicles: 34% sedans, 38% sport utility vehicles (SUVs), 22% pickup trucks, 6% vans
  - 24% of vehicles are PHEVs
  - 99% of drivers have access to home charging (prepopulated in the model to reflect region-specific estimates)
  - The model was run with 8,000 vehicles and scaled to 800 (model inputs started at 2,500 vehicles).

Table 17 shows the estimated number of chargers needed to support 800 vehicles in the PGST area. Note this is a preliminary estimate and the level and number of chargers needed can change depending on driver behavior, vehicle types, availability of other charging infrastructure in the area, and other factors.

Table 17. EV Charging Infrastructure Needs for Community EV Adoption. Source: EVI-Pro Lite Model

Charging Port Type	Location	Number of Ports	Notes	Charging Port Type
Level 1	Single family	227	Can support PHEVs	Single family
	Multifamily	1	-	Multifamily
Level 2	Single family	523	Multiple ports may be needed for households with more than one vehicle	Single family
	Multifamily (shared private)	3	More may be needed depending on multifamily occupancy	Multifamily (shared private)
	Workplace (shared private)	9	-	Workplace (shared private)

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[1] DOE EVI Pro-Lite Tool https://afdc.energy.gov/evi-x-toolbox#/evi-pro-ports

Charging Port Type	Location	Number of Ports	Notes	Charging Port Type
	Public	25	Installed in public locations such as retail stores, recreation or community centers, healthcare facilities, education facilities, and around neighborhoods	Public
DC fast charging (150 kW+)	Public	2	-	Public

5.3.4 Recommendations

Recommendations for EVs are summarized in Table 18.

Table 18. Electric Vehicle Recommendations

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Understand EV charging infrastructure incentives	Explore federal, state, and local incentives, including any that may support installation of residential charging infrastructure. Incentive options may include the following: • Federal level: tax credits for EVs and chargers; National Electric Vehicle Infrastructure (NEVI) program (2022–2026) grants • State level: Washington EV instant rebate program, EV infrastructure tax exemption, grants Utility level: PSE Up & Go Electric Program.	Short term	Low cost	PGST staff: energy manager

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Identify local EV charger installation requirements and costs	Engage with PSE to identify EV charger installation needs and costs, including upgrades to electrical service and equipment. Assess the potential for workplace EV charging at the Health Clinic and potentially other fleet, workplace, and community locations. Investigate building codes, parking ordinances, and zoning ordinances for EV charging infrastructure.	Short to medium term	Low cost	PGST staff: energy manager
Fleet electrification: conduct a detailed fleet electrification needs assessment	Evaluate in detail the driving requirements and potential aggregated parking/charging locations for fleet vehicles. Conduct outreach with fleet vehicle users to determine interest and potential concerns regarding fleet electrification and EV charging.	Short term	Low cost	PGST staff: energy manager
Fleet electrification: identify lessons learned from existing projects	Coordinate with the EV charging installation project manager at the Point Casino to discuss lessons learned and any recommendations.	Short term	Low cost	PGST staff: energy manager
Fleet electrification: develop a detailed electrification plan and begin implementation	Complete sizing analysis and refine vehicle fleet inventory and electrification plan in close coordination with ongoing campus planning efforts.	Short to medium term	Variable cost	PGST staff: energy manager, departmental staff
Community: focus on education and outreach regarding transportation electrification technologies and potential benefits	Coordinate with the housing program to assess resident interest in EVs and provide relevant educational materials.	Short to medium term	Low cost	PGST staff: energy manager, housing program staff

5.4 Ground Source Heat Pump Analysis

PGST requested the ETIPP team to provide an overview of ground source heat pumps (GSHPs), also known as geothermal heat pumps, and explore the applicability of this technology for its campus. This section provides an overview of the technology and O&M considerations and describes the results of the PGST-specific analysis. There are multiple examples of GSHP installations nationwide, many of which are tracked by DOE's Geothermal

Heat Pump Case Studies Map.[1] In the Pacific Northwest, Seattle Public Schools has installed GSHPs in 15 schools, eliminating gas-fired boiler systems and generating a 30%–77% reduction in weather-normalized energy use. These projects have been so successful that Seattle Public Schools now intends to retrofit two to three schools each year (DOE 2024a).

5.4.1 Technology Overview

Ground source heat pumps are one the of the most efficient types of HVAC systems available. High efficiencies are achieved by using the ground as a heat exchange medium. Just 30 feet below the surface of the earth, ground temperatures remain constant almost year-round, which makes exchanging heat much easier. Although many portions of the country experience extreme air temperature swings that affect the efficiency of air source heat pumps, the ground remains at a relatively constant temperature.

There are two types of GSHPs: water-to-water heat pumps (WWHP) and water-to-air heat pumps (WAHP). WWHPs use water as the heat transfer medium to circulate cooled or heated water through the building to condition it. Some examples of water distribution systems (also called hydronic systems) are radiant floors, fan coil units, air handling units, and radiators. WAHPs use air as the heat transfer medium to circulate heated or cooled air throughout the building. GSHPs typically comprise three major components: the heat pump, ground heat exchanger (GHX), and circulating equipment. Heat pumps are located indoors (typically in a mechanical room) and use electricity to augment the temperature of the ground loop fluid by increasing the temperature in heating mode and decreasing it in cooling mode. The circulation system circulates the heated or cooled air or water throughout the building. This system comprises pumps (for WWHPs) or fans (for WAHPs) and the accompanying interior HVAC equipment such as air handling unit or fan coil unit. Figure 23 shows the components of a WWHP.

The third portion of a GSHP is the GHX, which is responsible for transferring heat to and from the ground via a heat transfer fluid (usually water or a mixture of water and glycol). Ground heat exchangers come in several different configurations grouped into four main categories: 1) open loop, 2) closed loop vertical, 3) closed loop horizontal, and 4) pond or water loop. Figure 24 shows various GHX configurations. Open loop GHXs comprise two or more wells called supply well(s) and injection well(s). Both supply and injection wells can range in depth but are generally similar in depth to water wells because they must be deep enough to access groundwater. A submersible pump is installed at the bottom of the supply well, which pumps groundwater to the heat pump. The water is circulated through the heat pump where heat is either extracted (heating mode) or rejected (cooling mode); water is then transferred back into the groundwater via the injection well. This type of GHX configuration is highly efficient because of the deep depths achieved, which leads to the most stable groundwater temperatures. However, open loop systems do have some disadvantages. For example, open loop systems cannot be installed everywhere, and adequate water supply must be available. In addition, some states have regulations that prohibit or limit the distribution of geothermal well water into ground or surface water. In addition, this type of configuration requires the most pumping energy to circulate fluid from the supply well up to the heat pump.

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[1] DOE's Geothermal Heat Pump Case Studies https://www.energy.gov/eere/geothermal/geothermal-heat-pump-case-studies

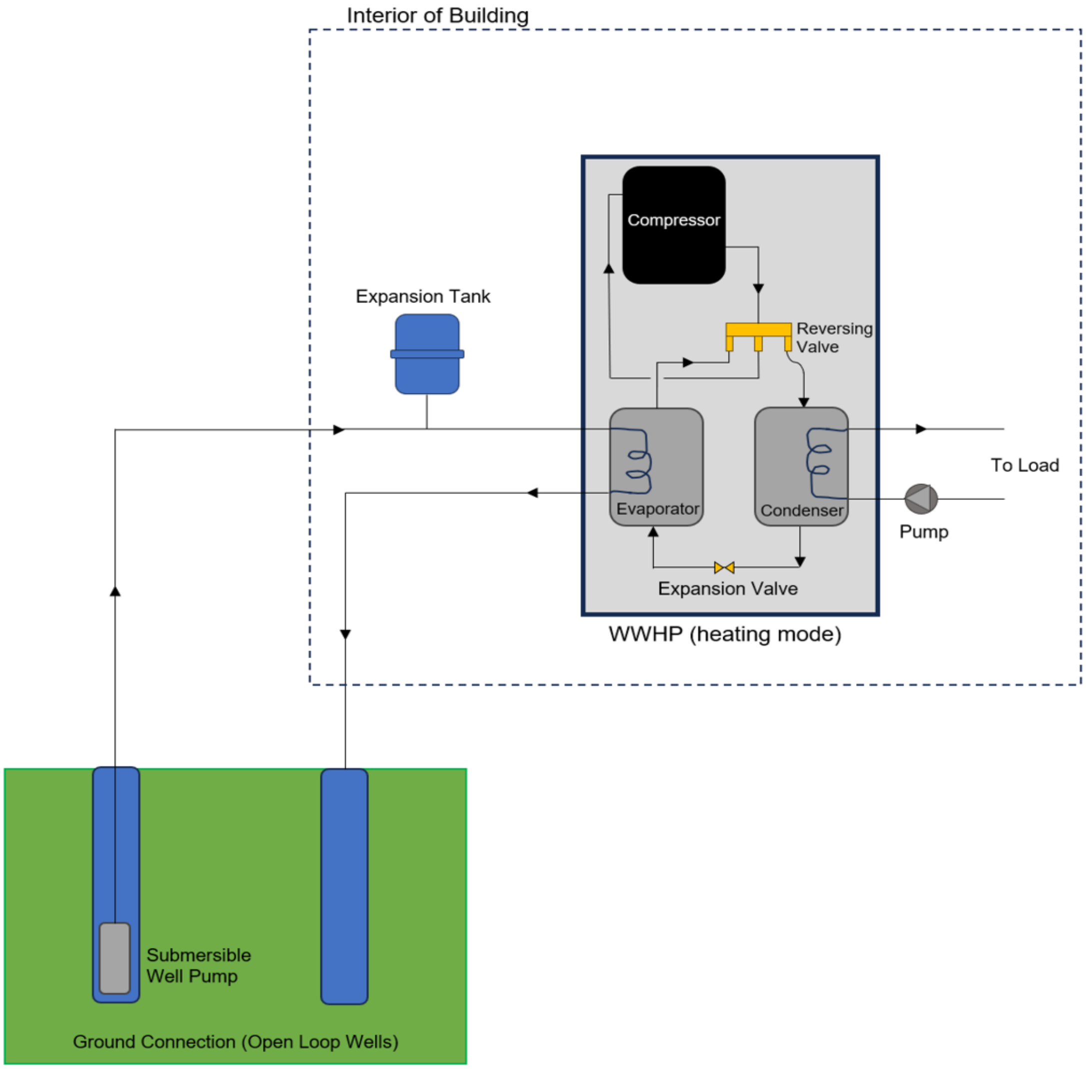

Figure 23. Components of a water-to-water ground source heat pump

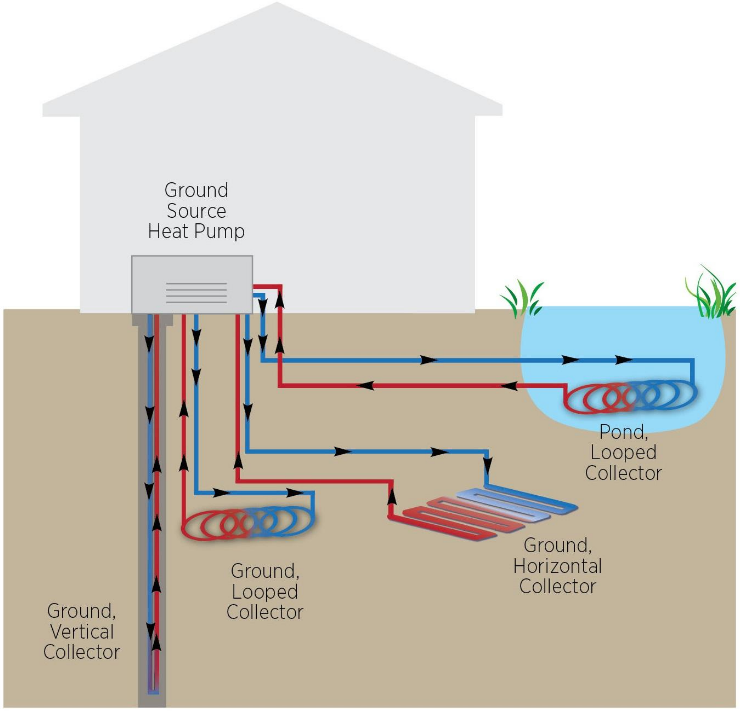

Figure 24. Ground heat exchanger configurations. Source: PNNL (2003).

Closed loop GHXs do not exchange water directly with the ground. Instead, all water (or water glycol mix) is contained within piping that is buried in the ground. In a horizontal closed loop configuration, piping is buried 4–6 feet in the ground in a horizontal manner (DOE n.d.-d). This configuration of piping provides ample heat transfer area between the ground and pipe; however, it requires the largest amount of open land to install.

Vertical closed loop GHXs have piping that is installed vertically into a borehole that has a diameter of approximately 4 inches. The number and spacing of boreholes depend on the capacity of the system, but a general rule is one borehole per ton of system capacity (IGSHPA n.d.). These types of GHX generally require less area than horizontal configurations. Two pipes, connected at the bottom with a U-bend to form a loop, are inserted into the borehole, which is then filled with grout to improve heat transfer performance. Each borehole is connected via a horizontal pipe buried within the ground and then connected back to the heat pump in the building. Each borehole is around 100–400 feet deep, and boreholes are spaced around 20 feet apart. This configuration is the most common type of GHX used in commercial and larger buildings because of the smaller land requirements.

Pond loop or water loop GHX configurations are the least common. These types of GHX have a plate-and-frame heat exchanger or looped exchanger placed within a body of water such as a pond, lake, or ocean. Heat is exchanged with the body of water instead of with the ground. Pond loop systems require a body of water large enough to accommodate the capacity of the system without raising the temperature of the water body more than 1°F. These systems are typically the most economical because no drilling to trenching is required, avoiding those costs. However, because a sufficiently large water body is required, these systems are very location dependent but can be an excellent fit for locations near water.

When deciding which type of GSHP system will be the best fit, there are a few important considerations:

- **Building/campus size:** GHSPs can provide heating and cooling to a single building or campus comprising multiple buildings. If the building or campus being considered is commercial and large (>10,000 ft^2), either an open loop geothermal system or closed loop vertical GHX should be used. Although a horizontal closed loop system could provide sufficient heating and cooling to a large building, its large area requirements may make it impractical for a campus application.
- **Land availability:** Land availability goes hand in hand with building size. As mentioned, horizontal closed loop systems require the most space to install and are generally used where plenty of open land is available, building size is small (residential or small commercial), or well/borehole drilling is difficult and costly (such as drilling in hard rock, e.g., metamorphic rock). Vertical closed loop systems require less land availability than horizontal loop systems and are commonly used for large commercial buildings where sufficient open space is not available. If space is limited, however (such as in an urban location), boreholes can be drilled underneath parking lots or in landscaped areas. Once the borehole(s) is installed, landscaping can be introduced over the borehole(s), or a parking lot can be installed over the top of the borehole(s). Open loop geothermal systems require even less space than closed loop vertical and should be considered if space is an issue and sufficient groundwater is available.

  As a rule, less than 5,000 ft^2 of obstacle-free area is required for residential to small commercial systems; 5,000–12,500 ft^2 for average commercial systems; and 12,500–43,560 ft^2 for large commercial systems. Greater than 43,560 ft^2 (i.e., more than an acre) of obstacle-free area is required for large commercial to district-scale GSHP systems.
- **Water availability:** Open loop geothermal systems require a certain groundwater flow rate to maintain system capacity. The flow rate depends on the size of the system installed and will need to be evaluated by an engineer. Groundwater is not a limiting factor for closed loop systems. Therefore, if no groundwater is available, a closed loop system will need to be installed.
- **Soil and geology type:** Soil and geology are important for two reasons: drilling/trenching and system capacity. Soil type has a direct impact on system sizing and capacity for closed loop systems. Dense soil with high moisture content such as clay is ideal. Loose sediments such as sand have poor thermal conductivity and are much less conducive to installing a GSHP. Because open loop systems use the temperature of the groundwater for heat transfer, ground conductivity is not a significant factor in system sizing. For closed loop systems, however, high ground thermal conductivity is desired. The higher the thermal conductivity of the ground, the larger the system capacity (meaning higher heating and cooling output). This is desirable because it will reduce GHX length, reducing project costs. For closed loop vertical GHX, look for dense rock with high water content such as igneous rock.

  Soil and geology type also impact drilling or trenching. If bedrock is close to the surface, trenching may not be possible. If this is the case, a closed loop vertical or open loop system will need to be installed. Conversely, if rock is exceptionally hard—such as with metamorphic rock—drilling a well or borehole for open loop or vertical systems will be difficult and expensive. In this case, a horizontal GHX could be a better fit, depending on land availability and building size.

- **Cost:** Cost is always a concern in any building project and should be minimized where possible. A preliminary economic assessment should be performed before a GHX type is chosen. Because there are many factors that make up the cost of a GSHP, it is difficult to say which system may be most cost-effective. Cost-effectiveness depends on several of the variables listed previously such as soil and geology type and availability of groundwater. As a rule, GSHPs cost $7,765/ton ±$4,632/ton to install and $109/ton ±$94/ton to operate and maintain.

  Several tools exist to help assess the economic feasibility of GSHPs. The first is REopt,[1] a web-based tool designed to optimize renewable energy systems (GSHPs included) for a building or campus. This tool optimizes a vertical closed loop GSHP based on location and building characteristics. The second tool is called the GSHP Screening Tool[2] and functions similarly to REopt—however, this tool is specific to GSHPs and provides additional information on economics and performance.

- **Local regulations:** Local and national regulations must be adhered to when designing and installing any GSHP project. These regulations impact a project in various ways depending on the location. In Washington State, for example, the Washington Advisory Council has published guidance on the minimum standards for the construction of GSHPs.[3] These standards outline drilling practices for boreholes and open loop wells in the state of Washington. In this state, open loop systems are permitted; however, other states may not allow the discharge of water into ground or surface water. In such cases, open loop systems would not be allowed. This code also outlines the necessary setback from water wells and provides guidance to avoid contamination of ground and surface water during installation.

Once the appropriate type of GSHP has been chosen and designed, the GSHP will need to be installed. It is important to choose a contractor that has the appropriate accreditations and experience for GSHPs. The International Ground Source Heat Pump Associate (IGSHPA) has gathered and maintains a directory[4] of certified businesses and professionals, which may be helpful when choosing a contractor. In addition to this resource, the Geothermal Exchange Organization provides a state-by-state directory[5] that identifies various professionals for GSHP services such as consultants, engineers, and contractors.

5.4.2 Operational and Maintenance Considerations

Similar to air source heat pumps, GSHPs typically require less maintenance than traditional HVAC systems such as furnaces, boilers, and chillers. However, maintenance personnel should be trained in the new maintenance for the GSHP if one is installed and consider the following specific maintenance requirements for each GSHP component:

- The GHX is durable and has few moving parts, making maintenance simple. Maintenance for the fluid loop primarily consists of cleaning strainers (open loop) and maintaining proper pressure and glycol concentrations (closed loop). Fluid pumps require standard pump maintenance.

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[1] REopt https://www.nrel.gov/reopt/

[2] Oak Ridge National Laboratory (ORNL) GSHP Screening Tool https://gshp.ornl.gov/

[3] WA State Legislature Title 173 https://app.leg.wa.gov/wac/default.aspx?cite=173-160-453#:~:text=(a)%20A%20ground%20source%20heat,the%20public%20water%20supply%20wells.

[4] IGSHPA Member Directory https://igshpa.org/business-directory/

[5] Find a Pro! https://geoexchange.org/find-a-pro/

The heat pump requires similar maintenance to an air source heat pump. However, because there is no exterior condensing unit, maintenance for the interior heat pump is even more simple than for an air source heat pump. DOE has published guidance on the maintenance of air source heat pumps (which applies to GSHPs).[1] Typical maintenance includes tasks such as inspecting ducts, filters, and blowers and checking for refrigerant leaks.

- Circulating equipment maintenance is the same as for any other system. Maintenance best practices can be found in the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)'s Standard for Inspection and Maintenance of Commercial Building HVAC Systems.

5.4.3 Port Gamble Assessment

The Port Gamble area primarily comprises unconsolidated sediments and glacial till (Schuster 2005) as shown in Figure 25. These types of rocks have low thermal conductivity compared to other rock and soil types. Given this limitation, a GSHP at Port Gamble may still be viable but may require additional GHEX length or additional boreholes to achieve the desired system capacity ratings. PGST may also have access to shallow and deep aquifers (Terracon 2018) that could be used for GSHP systems, but additional investigation would be required to understand any potential environmental impacts.

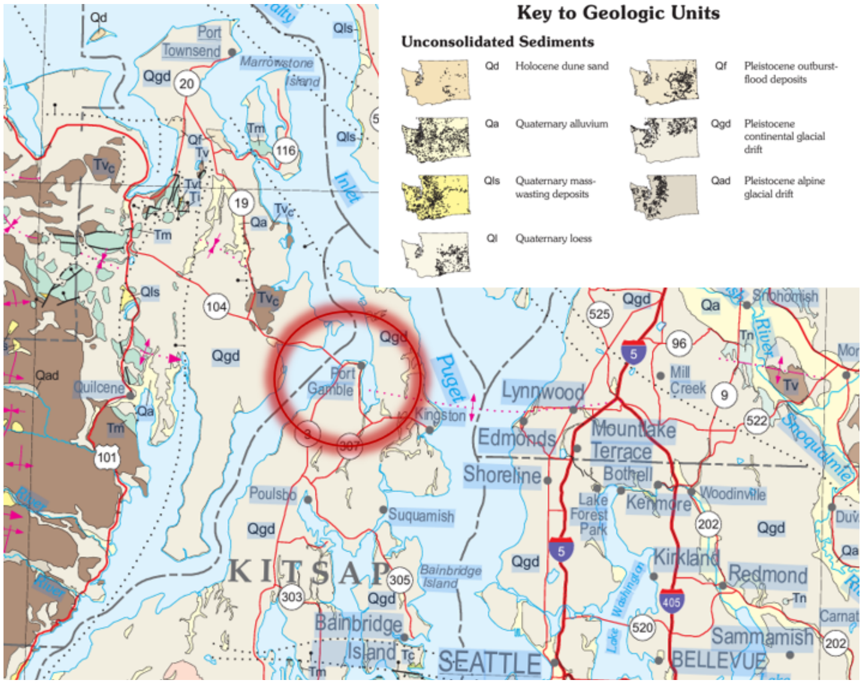

Figure 25. Zoom-in of Washington State Geologic Map for Port Gamble Area. Source: Schuster (2005).

5.4.4 Recommendations

Recommendations for GSHPs are summarized in Table 19.

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[1] DOE Heat Pump Maintenance https://www.energy.gov/energysaver/operating-and-maintaining-your-heat-pump

Table 19. Ground Source Heat Pump Recommendations

Recommendation	Description	Time Frame	Budget Considerations	Staffing Considerations
Consider installing ground source pumps for new construction buildings or as a replacement for HVAC systems during a planned upgrade	Work with a consultant to evaluate the feasibility of GSHPs for new construction buildings or future HVAC system replacements. If viable, consider GSHPs as an option and work with a qualified contractor to scope and install the project.	Short term	Traditional GSHPs cost around $13,084 per ton installed (Shonder and Walker 2024)	Installation and maintenance contractor, consultant, or other staff

6.0 Energy Workforce Development Framework

By integrating insights gained from community engagement and capacity building initiatives, along with consultations with PGST, the project team formulated the following proposed framework designed to assist PGST in developing its energy workforce.

6.1 Mission

The Port Gamble S'Klallam Tribe of Indians' Energy Workforce Development Framework aims to bridge skill gaps, create employment opportunities, and promote sustainable economic growth through comprehensive hands-on workshops and training. The framework is designed to empower PGST members by facilitating access to meaningful educational opportunities, particularly within the renewable projects that impact the Tribe. The goal is to ensure members are well-prepared and equipped to hold sustainable and impactful careers, contributing to the overall economic growth of the community.

6.2 Objective

PGST aims to equip individuals with the skills and knowledge necessary for careers in the renewable energy sector, thereby promoting sustainable economic growth and environmental stewardship within the Tribe and surrounding communities. To achieve this objective, PGST is engaging closely with renewable energy and community partners through community-focused education that disseminates energy knowledge. The framework approach includes hands-on learning opportunities and the cultivation of energy advocates.

Many underserved and overburdened communities lack access to economic development opportunities and the educational resources essential for their advancement. It is crucial to recognize the significance of economic development strategies because they could positively impact thousands of individuals across multiple generations. To support the Energy Workforce Development Framework, the Tribe has partnered with Spark Northwest and secured funding to offset some costs associated with facilitating and participating in training programs that the Tribe has already implemented and will continue to offer.

6.3 National and State Energy Workforce Growth Trends

The renewable energy industry is generally divided into five technology areas: electric power generation, energy efficiency, fuels, motor vehicles, and transmission. Since 2020, 48% of new energy jobs are in the renewable energy space, with renewable energy jobs representing 5% of all new jobs in the United States in 2023 (DOE 2024b). In 2023, transmission, distribution, and storage employment grew by 3.8%; solar employment grew by 5.3%; and energy efficiency employment grew by 3.4%.[44] The industry sectors that saw the highest job growth from 2022 to 2023 were utilities and construction. Although energy job sectors are growing and more job demand and opportunity is increasing, employers are reporting difficulty in hiring qualified candidates. For example, 48% of motor vehicle employers and 43% of energy efficiency employers reported it was difficult to find qualified workers because of lack of experience, training, and skills or because they had insufficient qualifications.[44]

In Washington State, there were 4,351 solar PV jobs reported in 2020; in 2025, it is estimated this could increase to 5,738 and potentially to 11,213 jobs by 2030. Similarly, battery storage jobs were reported at 2,051 in 2020 but estimated to potentially increase to 5,563 in 2025 and

11,557 jobs in 2030 (Truitt et al. 2022). In 2020, energy efficiency had 1,140 reported jobs, but estimates show in 2025, there could be 3,167—increasing to 4,927 jobs in 2030.[45] All these estimates show an increase in job demand for innovative energy-related occupations in Washington State.

6.4 Port Gamble S'Klallam Tribe's Current Workforce: Opportunities and Challenges

PGST has an established workforce, the majority of which resides within Kitsap County; 39% of employees are Tribal members as of a meeting with PGST human resources on November 1, 2024 (Melody Bidtah and Jennifer Wright-Tom, pers. comm.). Although PGST has one energy job currently, its workforce possesses a variety of transferable skills applicable to energy job fields (Appendix A). Many of these positions are directly applicable to the innovative energy industry, such as grant writer, facilities manager, and energy resilience coordinator. Skills of a construction and maintenance laborer or carpenter laborer can directly transfer into an energy field, or an individual can choose to get additional training—for example, a solar PV installation certification. According to the DOE Workforce Development Blueprint, many transferable skilled workers in current occupations fall into three categories—direct, refocus, and reboot—which the blueprint defines as follows:

- **Direct:** Essentially the same core qualifications, technical knowledge, skills, and work environment, with a high likelihood of recruitment and retention in the sector.
- **Refocus:** Similar work, but some skill or knowledge upgrading is likely required to increase the chance of successful transition.
- **Reboot:** The work is very different; there is a need to invest significant effort to qualify for a position (SCEP 2023).

Many of the positions in PGST's current workforce fall within a potential refocus category and would require some training or education in innovative energy technologies or energy efficiency, for example, to apply to the energy workforce. In discussions with PGST's human resources department, it consistently has a strong applicant pool for openings in the Housing, Facilities, and Utilities departments. The departments that have hiring difficulties tend to be Health, Legal, and Finance. It is also important to note in many cases PGST staff could acquire additional training to support PGST's energy vision while remaining in their current positions. More research is needed to understand the hiring landscape and employability in the renewable energy sector in and around Kitsap County—as well as determination of level of interest by current employees and community members—prior to development of a training program.

Challenges may arise as the Tribe develops its energy workforce. Motivating individuals to seek career advancement opportunities or additional training can be difficult, especially if it involves forfeiting pay or taking time off work. Other barriers include lack of transportation to training facilities, limited online access, and general time constraints. In addition, finding childcare during training sessions can be problematic.

To address these issues, Spark Northwest—in partnership with PGST—applied for and received additional Clean Energy Prize funds through the DOE. The primary objective of the Prize was to establish new or use existing partnerships to support renewable energy projects in rural or remote regions of the United States. The secondary objective was to develop renewable energy initiatives that enhance resilience, safety, reliability, and availability of energy while minimizing the negative environmental impacts of energy production in these communities. This funding allowed Spark Northwest to offer stipends and travel reimbursements to participants.

As an education and training provider, it is crucial for PGST to consider and accommodate potential barriers to reaching a broad and diverse pool of workers. PGST has Tribal members living off-reservation, both in-state and out-of-state. To make energy training accessible to them, offering both in-person and online training options would be beneficial.

A table of resources relevant to implementing the Energy Workforce Development Framework can be found in Appendix B.

6.4.1 Capacity Building

6.4.1.1 Internal ETIPP Capacity Building

PNNL brought in technical experts to present on various energy technologies to build capacity within PGST. These presentations covered solar energy, geothermal energy, marine energy, wind energy, bioenergy, microgrids, and EVs. Presentations often included an overview of the technology or technologies, considerations for implementation, case studies of real projects, potential opportunities available on PGST land, cost estimates, and resilience considerations. The team provided summary slides for each topic that the Tribe can use for future reference.

6.4.1.2 Community Engagement and Education

Spark Northwest pursued a comprehensive strategy to raise Tribal member awareness and involvement in the ETIPP project. The components of the strategy included the following:

- Engaging partners early in the planning process
- Customizing workshops to community needs
- Fostering positive social-emotional experiences with energy technology
- Providing regular mentorship opportunities through workshops for energy champions
- Holding regular monthly meetings with Tribal stakeholders
- Maintaining a presence in the community by participating in community events and gatherings.

The training project began in fall 2024. To raise awareness of the Strategic Energy Plan and build support among Tribal members, the following community education activities were completed throughout the energy planning process (Figure 26). The “Energy 101” and the Mock Roof Installation training epitomized the transformative power of experiential learning. With the hands-on teaching style of Remote Energy, the education partner, participants were encouraged to go beyond theoretical learning by engaging in practical applications and installation.

- **Energy 101:** The curriculum, designed by Remote Energy, introduced participants to the basic principles of electricity such as AC/DC current, calculating loads, and PV system management to encourage discussions about possible projects for their Tribes. After the lecture-based presentation and classroom discussion, students went outside to conduct experiments in the sunshine with multimeters and water pumps and handled small solar modules. Spark Northwest and Remote Energy hosted four workshops in 2024 and plan four more in 2025.

- **Mock Roof Installation:** Participants who were eager to continue their education after Energy 101 were invited to expand their understanding of system measurements and calculations and physically interact with larger-scale solar arrays. Over 2 intensive days, participants immersed themselves in hands-on curriculum where they assembled systems on prebuilt mock roof installations and grappled with real-world challenges. They conducted two 2-day courses on campus at Northwest Indian College in Bellingham with a total of 14 attendees. These courses included a lecture-based presentation and interaction with tools and solar panels (November 2023) and a hands-on application course with wiring circuits, installing panels, and determining system size (May 2024). Courses were customized to the community's needs and input. Spark Northwest and Remote Energy hosted two workshops in 2023–2024 and plan to host two more in 2025. Spark Northwest and Remote Energy also conducted surveys to obtain feedback from all workshop participants on the quality of curriculum, presentation, and impact on their knowledge.
- **High School Senior Credit Recovery Suitcase Build:** From August 5 to 8, 2024, Spark Northwest facilitated a technical Energy 101 course and a solar suitcase build for high school seniors. The program included a 1-day Energy 101 course, using an in-house curriculum. For the solar suitcase build, Spark Northwest used We Share Solar Technology and curriculum, guiding students through the theoretical aspects, construction, troubleshooting, and system expansion. The solar suitcase is a comprehensive 250-watt battery backup system. It features solar charge and load regulation, circuit breakers for switching and safety, and sockets for lights and charging 12-volt and 5-volt DC appliances such as mobile phones, computers, and e-readers. Two solar suitcases along with physical and online curriculum were procured for the Tribe for continued learning and emergency use.

Figure 26. Leadership and learning take many forms. Tribal Council and Tribal members build a future together and empower students and community members through solar education. Photos from Spark Northwest.

As a result of these training initiatives, four Indigenous energy champions emerged. These individuals demonstrated high engagement with the material, contributed to shaping the approach, and promoted broader participation. They are now equipped to facilitate energy-related discussions, identify leaders, and advance their Tribes toward energy planning independence.

6.5 Workforce Development Case Studies

The case studies presented in this section show examples of programs that are either available to PGST Tribal members or that PGST could consider replicating in its workforce development efforts.

1. Tulalip Tribes[1]

The Tulalip Tribes Tribal Employment Rights Office (TERO) Vocational Training Center offers 14-week free construction training courses to Tribal members and non-Native spouses and parents. Upon completion of the course, students will earn a certificate from Renton Technical College or South Seattle Community College. The program comprises hands-on shop experience, strength building, engagement in outreach programs, exposure to various trades, visits from guest speakers, and classroom instruction. Classes offered in the program include blueprint reading, trades math, construction skills, structural trade finishes, electrical, plumbing, foundations, CPR, first aid, flagger certification, Occupational Safety and Health Administration (OSHA) certification, energy efficiency, and soft skills. This program helps prepare students for a career in construction or to continue in another educational or apprenticeship program. This program is held at the TERO Vocational Training Center in Tulalip, Washington. The program seeks to connect with the community not only by providing training and career pathways for students but also by creating local partnerships for mutually beneficial opportunities for the students to practice their skills, such as building 13 tiny homes for the Low-Income Housing Institute in Seattle.

2. Puyallup Tribe of Indians[2]

The Puyallup Tribe of Indians Workforce Development Program aims to provide Tribal members with meaningful employment opportunities and the ability to develop their job skills and increase future employment eligibility. The program offers 240 hours of full- or part-time employment to successful applicants within Tribal departments that need additional staff. The workforce development program also offers three other program options for those who have or desire a specific skill set. The first is the “Clean Our Rez Program” where employees work 240 hours cleaning up the reservation; the second is the cemetery maintenance program, which offers 240 hours of cemetery maintenance and funeral preparations. The third option is Elder’s trash pickup. In addition to employment, the workforce development staff can also provide employment services such as interview practice, resume development, computer skill support, and assistance in acquiring certifications. This program is open to Puyallup Tribal members 18 years of age and older and can be extended for another term if performance is satisfactory. This program provides Tribal members with job skills essential for future employment either within the Tribe or at outside employment.

A similar program at PGST could help Tribal members receive on-the-job training in departments of PGST’s choosing, potentially providing opportunities for “in-house” training of energy-related positions. This could also be an opportunity for program participants to access workforce development resources provided in this plan and training developed by Spark Northwest.

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[1] Tulalip TERO Vocational Training Center https://tvtc.tulaliptero.com/

[2] Puyallup WFD https://www.puyalluptribe-nsn.gov/employment-training-programs-services/workforce-development-program-wfd/

6.6 Recommendations

Table 20 shows recommendations for PGST to expand and implement its Energy Workforce Development Framework. All these recommendations could be implemented near term.

Table 20. Workforce Development Recommendations

Focus Area	Recommendation	Considerations
Ongoing community engagement	Promote awareness, education, and participation to facilitate understanding of renewable energy benefits within the community, encouraging local support and participation.	Host workshops to promote energy knowledge through community-centric education, using hands-on learning tools and nurturing energy champions. Interdepartmental involvement: • Secure funding (Grants Dept.) • Curriculum development (Education Dept.) • Training center/use Northwest Indian College (NWIC) satellite site at PGST (Education Dept.) • Training, connection to resources outside of Tribe (Human Resources) Job placement (Human Resources).
Skills development	Continue to provide and participate in comprehensive training programs that cover the latest technologies and practices in renewable energy, including solar, wind, and bioenergy.	• Facilitate Energy 101 workshops • Conduct renewable energy demonstrations at community events • Disseminate energy information (i.e., rebates and grants to community members) • Facilitate solar PV fundamentals course for the community • Mentor energy champions to allow replication and continued knowledge growth regarding renewables Information tracking (outcomes, impacts, and success metrics).

Focus Area	Recommendation	Considerations
Certification and credentials	Offer and/or connect potential employees to certification programs that validate the skills and competencies of participants, enhancing their employability.	• Identify transferable skills from current PGST workforce as well as pathways to energy careers (Appendix A) • Establish partnerships with educational institutions, industry experts, and organizations such as NWIC or other certificate programs to enhance training opportunities and certifications • Provide scholarships and financial support for Tribal members pursuing higher education or technical training in renewable energy fields • Develop and implement training programs and workshops to address identified skill gaps Facilitate long-term employment in the renewable energy sector through internships, apprenticeships, and job placement programs.
Job placement	Facilitate connections between trainees and employers in the renewable energy industry to ensure successful job placements.	• Consider TERO as a resource to help Tribal members with on-the-job training Invite local unions and contractors to provide input on training programs.
Continued learning and education	Establish pathways for ongoing education and professional development to keep the workforce updated with industry advancements.	• Consider developing a certificate program for Tribal members at their NWIC campus Support energy champions facilitating energy courses using the solar suitcase and its accompanied curriculum: https://learningwesharesolar.thinkific.com/pages/welcome-page.
Tribal government and stakeholder engagement	As PGST advances its energy initiatives, cultivating its energy workforce and engaging with Tribal government and essential stakeholders will be imperative for long-term success.	• Maintain open communication with Tribal government • Collaborate with public, private, and nonprofit employers • Engage individuals seeking jobs or looking to advance their careers • Partner with training providers: ○ Higher education providers ○ Career and technical institutions Community-based organizations.

7.0 Funding Opportunities

PGST is interested in pursuing funding opportunities for on-site energy installations, upgrades, analysis, workforce, planning, and other developments aligned with the Tribe's energy vision. This Strategic Energy Plan is intended to be a useful resource to pursue these funding opportunities (for example, to support grant writing); in some cases, having a Strategic Energy Plan may be a prerequisite for funding opportunities. Energy funding opportunities are dynamic and are expected to emerge and change over time, meaning the landscape of available options will evolve as PGST executes its energy vision. Therefore, to account for this uncertainty and ensure the information remains relevant, this section presents an overview of types and likely sources of funding opportunities.

7.1 Types of Funding Opportunities

Energy funding opportunities can be for planning, technical assistance, workforce, implementation, or two or more of these.

Planning funds are useful at the early stages of projects. This funding can help lay the organizational groundwork for communities and Tribes to control follow-on steps that align energy concepts with community priorities. Planning funds may coincide with technical assistance, wherein communities partner with technical organizations and experts who specialize in certain topic areas (such as those described throughout this Strategic Energy Plan) to co-evaluate location-specific energy feasibility, requirements, and trade-offs. Technical assistance funds typically deliver funding to technical experts for their analysis and, in some cases, such as ETIPP, deliver funding to communities so they can more deeply participate in and control the technical assistance process and outcomes. ETIPP,[1] Energy to Communities (E2C),[2] the Solar Energy Innovation Network,[3] and Communities Local Energy Action Program[4] are examples of currently operating technical assistance programs. Of these, E2C has perhaps the most intensive (NREL 2025a) and most accessible (NREL 2025b) technical assistance options. In-Depth Partnerships provides $4 million to develop tailored and actionable strategies with community members, utility stakeholders, and technical experts over a multiyear year period. Expert Match partners communities with specific technical experts in an identified background for 6- to 10-week periods at no cost to the community.

Workforce funding opportunities are intended to employ and sustain Tribal staff capacity for energy deployments and upkeep. When searching for workforce funding opportunities, it is important to consider whether the Tribe's capacity priorities are for planning (e.g., determining whether to partner with an energy developer, deciding where an energy site should be located, community outreach), construction (e.g., installing solar panels over a few-month period), or maintenance (e.g., cleaning solar panels or inspecting batteries on an ongoing basis) to align opportunities with Tribal needs.

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[1] ETIPP Technical Assistance https://www.nrel.gov/state-local-tribal/etipp-technical-assistance.html

[2] E2C Program https://www.nrel.gov/state-local-tribal/energy-to-communities.html

[3] Solar Energy Innovation Network https://www.nrel.gov/solar/market-research-analysis/solar-energy-innovation-network.html

[4] LEAP Pilot https://www.nrel.gov/news/program/2024/nrel-technical-assistance-advances-community-clean-energy-goals-through-communities-leap-pilot.html

Further, it is helpful to consider energy projects are typically intensive initially (e.g., demand high workforce for construction) and low-maintenance afterward (e.g., require inconsistent workforce over time). These factors, collectively, have impacts on workers and workforce funding requirements and should be considered when navigating workforce funding opportunities for energy projects.

Although workforce funding opportunities finance Tribal capacity, implementation funding opportunities are designed to pay for the raw materials, equipment, and external personnel needed to build or execute energy projects and typically become most relevant toward the final stages of an energy concept. Funding for implementation can come in various formats and agreements, including upfront grants and prizes (least restrictive and most flexible) as well as loans, loan guarantees, rebates, tax credits, and subsidies (requiring upfront investments that may break even or yield returns over time). Funding opportunities also can involve “cost shares” wherein communities are required to pay for a subset of the grant’s allowance using their own funds.

7.2 Funding Opportunity Sources

Energy funding opportunities often come from the following:

- Federal sources
- State agencies
- Local or philanthropic sources.

Federal funds—such as those authorized through the Infrastructure Investment and Jobs Act in 2021 and Inflation Reduction Act in 2022, totaling $369 billion—are the largest sources of funding for innovative energy projects. However, these funding sources may evolve over time and with government changes. Tribes can access relevant funds directly from federal agencies or after they are allocated to smaller organizations and programs. For example, REAP[1] “provides guaranteed loan financing and grant funding to agricultural producers and rural small businesses for renewable energy systems or to make energy efficiency improvements” using USDA and Inflation Reduction Act funds. The U.S. Department of Interior (DOI) Department of Indian Affairs is, at present, issuing a Tribal Energy Development Grant[2] that “offers funding for Tribes to develop their energy business or expand their energy capabilities” alongside grants for Tribal broadband and business incubation. Some organizations and funding sources operate nationally but are less directly tied to federal funding.

These are selected examples of a larger body of federally funded and nationally based energy funding opportunities that are likely to evolve. There are resources to help navigate this evolving landscape. For example, national nonprofits, such as Elevate Energy,[3] operate with the mission of helping communities and Tribes navigate federal cash flows to identify and access these larger energy-related funding opportunities. Similarly, FundHubWA[4] is a web tool created by the

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[1] USDA Rural Energy For America Grants https://www.rd.usda.gov/programs-services/energy-programs/rural-energy-america-program-renewable-energy-systems-energy-efficiency-improvement-guaranteed-loans

[2] DOI Department of Indian Affairs Grants https://www.bia.gov/topic/grants

[3] Elevate https://www.elevatenp.org/

[4] Fund Hub WA https://fundhub.wa.gov/

Washington Department of Commerce to help Washington communities, Tribes, small businesses, and residents navigate federal energy funding opportunities.

Washington Department of Commerce is also the primary state-level distributor of relevant energy-related funds in Washington State. In 2024, PGST obtained a Washington Department of Commerce Clean Energy Grant, providing microgrid-related technical assistance. Washington Department of Commerce issues other more intensive and implementation-related forms of innovative energy funding. For example, Washington Department of Commerce's Energy Division[1] hosts programs that finance energy efficiency, weatherization, and carbon-reducing technologies and upgrades funded through the Washington Climate Commitment Act. As the energy funding landscape continues to evolve, the Washington Department of Commerce is likely to be a key resource and potential partner for PGST in funding the energy priorities outlined in this Strategic Energy Plan.

Finally, philanthropic options can be effective pathways for funding specific types of energy installations or upgrades. For example, in 2018, GRID Alternatives established the Tribal Solar Accelerator Fund,[2] a philanthropic fund to support solar energy and expand solar job opportunities in Tribal communities across the United States. Fundraising through philanthropic sources may be particularly viable for specific facilities, residents, or small businesses than relatively larger PGST Tribal government projects. PSE[3] also hosts energy incentives for residences and businesses.

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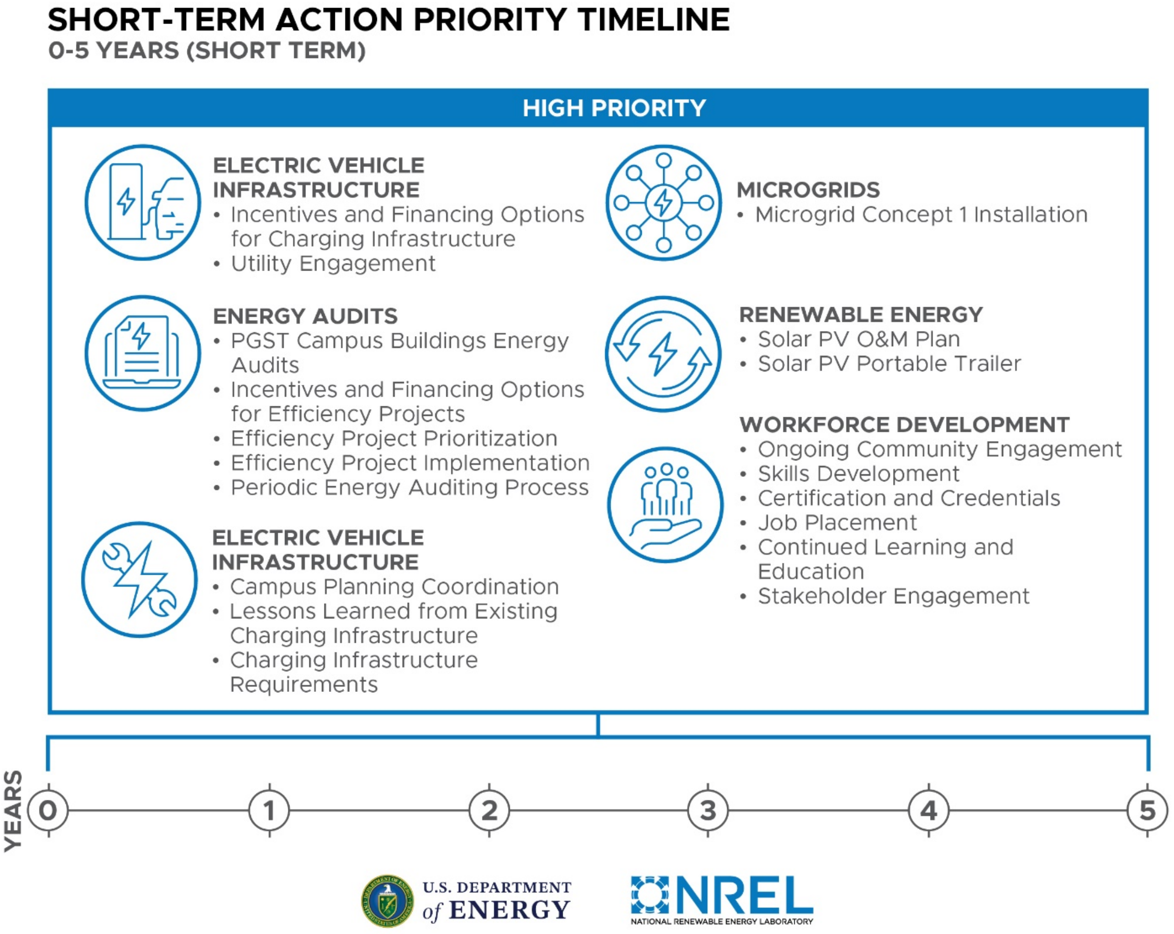
[1] WA State Climate Commitment Act https://www.commerce.wa.gov/cca/

[2] https://tribalsolar.org/

[3] Puget Sound Energy https://www.pse.com/

8.0 PGST Strategic Plan

The project team, with valuable input from the staff steering committee, developed a comprehensive list of actions for the Tribe's energy vision, which are detailed previously in the corresponding sections. Table 21 summarizes these recommendations by category and time frame: short-term (1–5 years), medium-term (5–10 years), and long-term (>10 years). The highest-priority items are further highlighted in Figure 27. Figure 28 illustrates the entire action priority timeline.



SHORT-TERM ACTION PRIORITY TIMELINE

0-5 YEARS (SHORT TERM)

HIGH PRIORITY

ELECTRIC VEHICLE INFRASTRUCTURE
- Incentives and Financing Options for Charging Infrastructure
- Utility Engagement

ENERGY AUDITS
- PGST Campus Buildings Energy Audits
- Incentives and Financing Options for Efficiency Projects
- Efficiency Project Prioritization
- Efficiency Project Implementation
- Periodic Energy Auditing Process

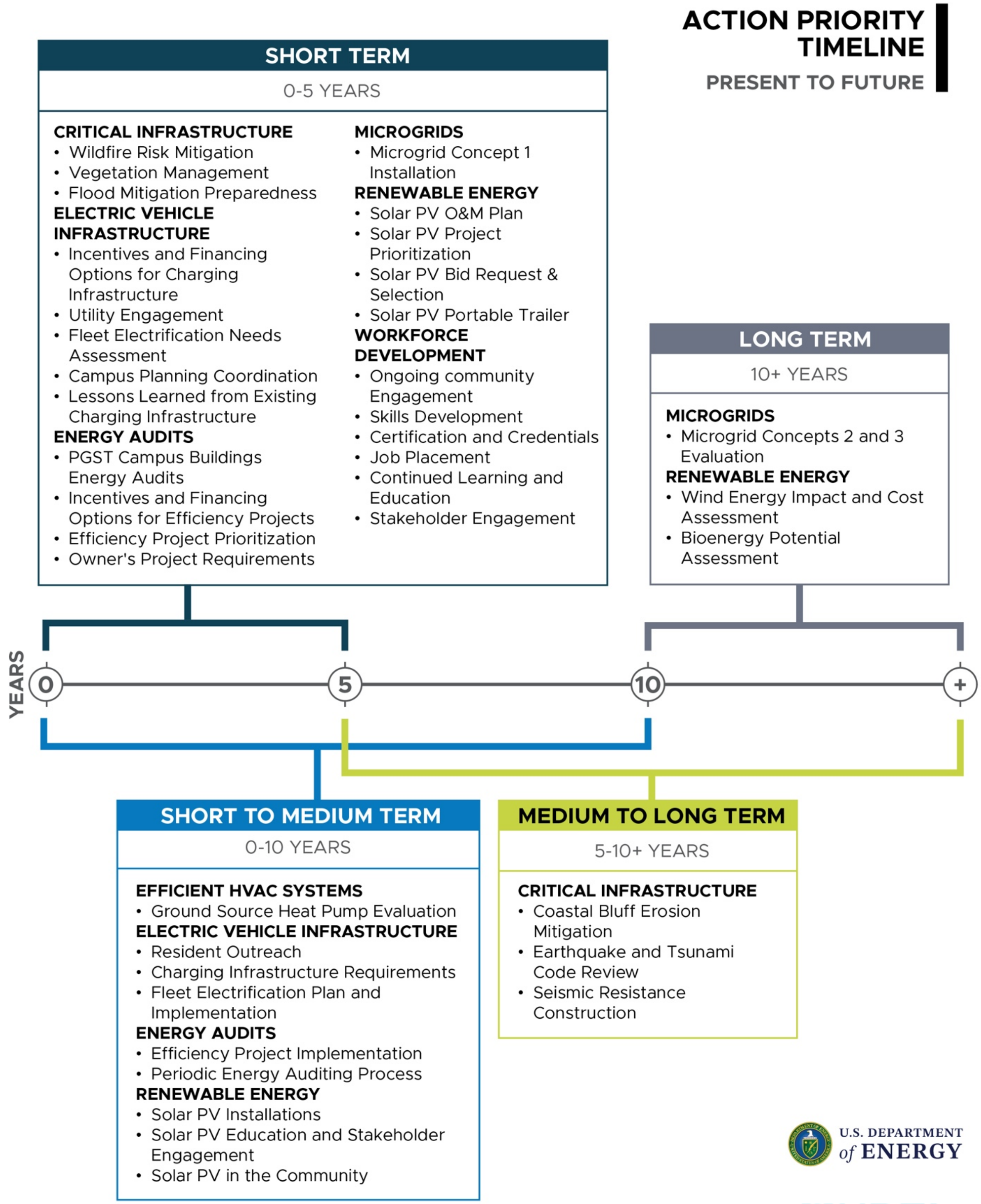
ELECTRIC VEHICLE INFRASTRUCTURE
- Campus Planning Coordination
- Lessons Learned from Existing Charging Infrastructure
- Charging Infrastructure Requirements

MICROGRIDS
- Microgrid Concept 1 Installation

RENEWABLE ENERGY
- Solar PV O&M Plan
- Solar PV Portable Trailer

WORKFORCE DEVELOPMENT
- Ongoing Community Engagement
- Skills Development
- Certification and Credentials
- Job Placement
- Continued Learning and Education
- Stakeholder Engagement

Figure 27. Short-term action priority timeline



ACTION PRIORITY TIMELINE

PRESENT TO FUTURE

SHORT TERM

0-5 YEARS

CRITICAL INFRASTRUCTURE
- Wildfire Risk Mitigation
- Vegetation Management
- Flood Mitigation Preparedness

ELECTRIC VEHICLE INFRASTRUCTURE
- Incentives and Financing Options for Charging Infrastructure
- Utility Engagement
- Fleet Electrification Needs Assessment
- Campus Planning Coordination
- Lessons Learned from Existing Charging Infrastructure

ENERGY AUDITS
- PGST Campus Buildings Energy Audits
- Incentives and Financing Options for Efficiency Projects
- Efficiency Project Prioritization
- Owner's Project Requirements

MICROGRIDS
- Microgrid Concept 1 Installation

RENEWABLE ENERGY
- Solar PV O&M Plan
- Solar PV Project Prioritization
- Solar PV Bid Request & Selection
- Solar PV Portable Trailer

WORKFORCE DEVELOPMENT
- Ongoing community Engagement
- Skills Development
- Certification and Credentials
- Job Placement
- Continued Learning and Education
- Stakeholder Engagement

LONG TERM

10+ YEARS

MICROGRIDS
- Microgrid Concepts 2 and 3 Evaluation

RENEWABLE ENERGY
- Wind Energy Impact and Cost Assessment
- Bioenergy Potential Assessment

SHORT TO MEDIUM TERM

0-10 YEARS

EFFICIENT HVAC SYSTEMS
- Ground Source Heat Pump Evaluation

ELECTRIC VEHICLE INFRASTRUCTURE
- Resident Outreach
- Charging Infrastructure Requirements
- Fleet Electrification Plan and Implementation

ENERGY AUDITS
- Efficiency Project Implementation
- Periodic Energy Auditing Process

RENEWABLE ENERGY
- Solar PV Installations
- Solar PV Education and Stakeholder Engagement
- Solar PV in the Community

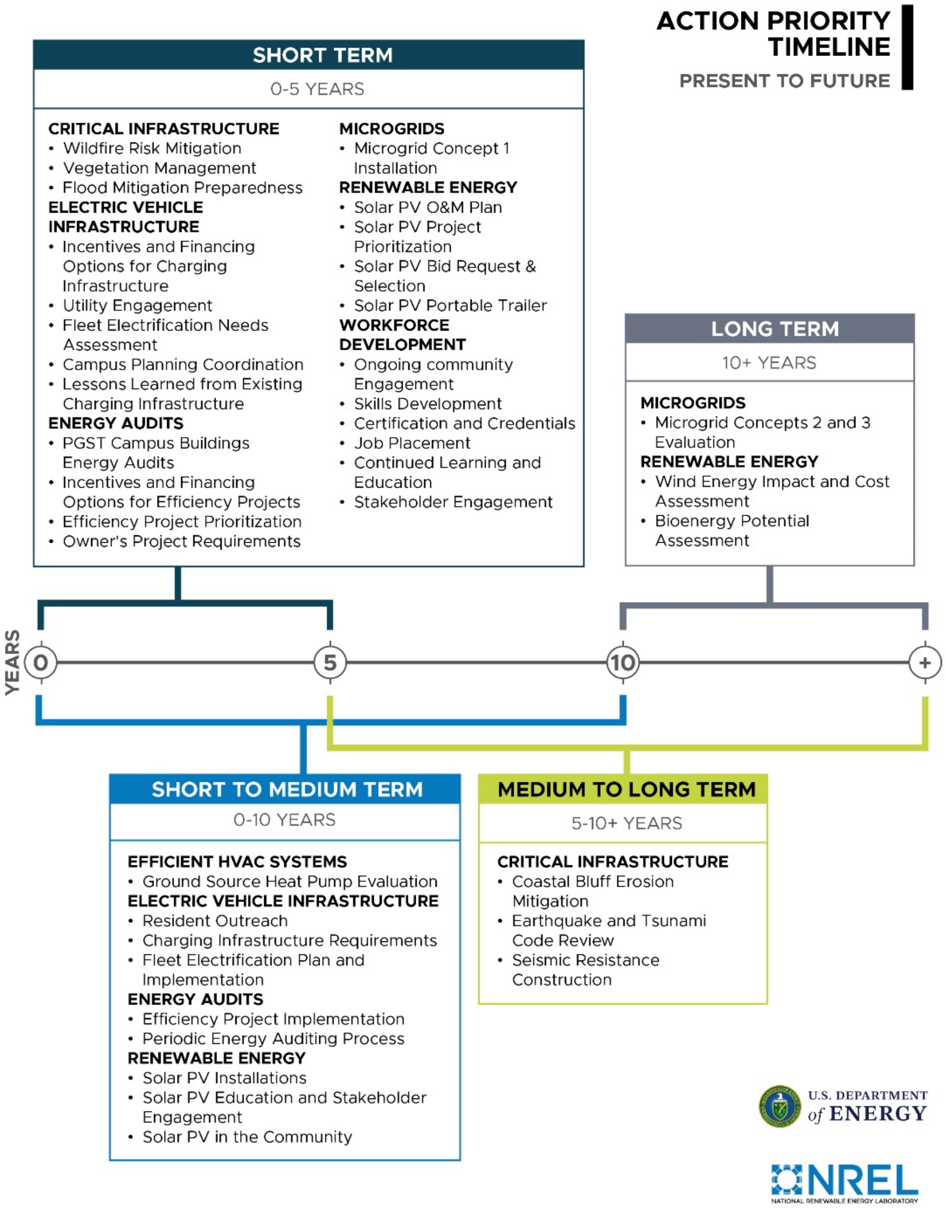
MEDIUM TO LONG TERM

5-10+ YEARS

CRITICAL INFRASTRUCTURE
- Coastal Bluff Erosion Mitigation
- Earthquake and Tsunami Code Review
- Seismic Resistance Construction

U.S. DEPARTMENT of ENERGY

NREL NATIONAL RENEWABLE ENERGY LABORATORY



ACTION PRIORITY TIMELINE

PRESENT TO FUTURE

SHORT TERM

0-5 YEARS

CRITICAL INFRASTRUCTURE
- Wildfire Risk Mitigation
- Vegetation Management
- Flood Mitigation Preparedness

ELECTRIC VEHICLE INFRASTRUCTURE
- Incentives and Financing Options for Charging Infrastructure
- Utility Engagement
- Fleet Electrification Needs Assessment
- Campus Planning Coordination
- Lessons Learned from Existing Charging Infrastructure

ENERGY AUDITS
- PGST Campus Buildings Energy Audits
- Incentives and Financing Options for Efficiency Projects
- Efficiency Project Prioritization
- Owner's Project Requirements

MICROGRIDS
- Microgrid Concept 1 Installation

RENEWABLE ENERGY
- Solar PV O&M Plan
- Solar PV Project Prioritization
- Solar PV Bid Request & Selection
- Solar PV Portable Trailer

WORKFORCE DEVELOPMENT
- Ongoing community Engagement
- Skills Development
- Certification and Credentials
- Job Placement
- Continued Learning and Education
- Stakeholder Engagement

LONG TERM

10+ YEARS

MICROGRIDS
- Microgrid Concepts 2 and 3 Evaluation

RENEWABLE ENERGY
- Wind Energy Impact and Cost Assessment
- Bioenergy Potential Assessment

SHORT TO MEDIUM TERM

0-10 YEARS

EFFICIENT HVAC SYSTEMS
- Ground Source Heat Pump Evaluation

ELECTRIC VEHICLE INFRASTRUCTURE
- Resident Outreach
- Charging Infrastructure Requirements
- Fleet Electrification Plan and Implementation

ENERGY AUDITS
- Efficiency Project Implementation
- Periodic Energy Auditing Process

RENEWABLE ENERGY
- Solar PV Installations
- Solar PV Education and Stakeholder Engagement
- Solar PV in the Community

MEDIUM TO LONG TERM

5-10+ YEARS

CRITICAL INFRASTRUCTURE
- Coastal Bluff Erosion Mitigation
- Earthquake and Tsunami Code Review
- Seismic Resistance Construction

Figure 28. Action priority timeline

Table 21. Short-, Medium-, and Long-Term Actions To Advance PGST's Energy Vision

Topic	Subtopic	Action	Description	Time Frame	Resilience	Capacity Building	Energy Efficiency	Energy System Transformation
Critical infrastructure	Wildfire risk mitigation	Wildfire risk mitigation	Establish zones of protection around critical infrastructure to reduce wildfire risk.	Short term	X			
	Severe weather mitigation	Vegetation management	Develop vegetation management plans near critical infrastructure.	Short term	X			
	Address critical infrastructure risk	Flood mitigation preparedness	Prepare emergency flood mitigation for vulnerable equipment/facilities located at Point Julia.	Short term	X			
Electric vehicle infrastructure	EV charging	Incentives and financing options for charging infrastructure	Explore federal, state, and local incentives, including any that may support installation of residential charging infrastructure.	Short term				X
	EV charging	Utility engagement	Engage with PSE to identify EV charger installation needs and costs, including upgrades to electrical service and equipment.	Short term				X
	EV charging	Utility engagement	Assess the potential of workplace EV charging at the Health Clinic with PSE.	Short term				X

Topic	Subtopic	Action	Description	Time Frame	Resilience	Capacity Building	Energy Efficiency	Energy System Transformation
	Fleet electrification	Fleet electrification needs assessment	Evaluate in detail the driving requirements and potential aggregated parking/charging locations for fleet vehicles.	Short term				X
	EV charging	Campus planning coordination	Complete sizing analysis and refine vehicle fleet inventory and electrification plan in close coordination with campus planning efforts.	Short term				X
	EV charging	Lessons learned from existing charging infrastructure	Coordinate with EV charging installation project manager at the Point Casino to discuss lessons learned and any recommendations.	Short term		X		X
Energy audits	Building energy audits	PGST campus buildings energy audits	Complete energy and water audits of the remaining PGST campus buildings.	Short term			X	
	Efficiency project implementation	Develop owner's project requirements	Develop a resource to inform those bidding and constructing future buildings of expectations for the integration of energy technologies such as solar PV, EV readiness, and energy efficiency measures.	Short term			X	X
	Efficiency project implementation	Incentives and financing options for efficiency projects	Work with PSE to identify energy rebates and other incentives for energy efficiency projects.	Short term			X	

Topic	Subtopic	Action	Description	Time Frame	Resilience	Capacity Building	Energy Efficiency	Energy System Transformation
	Efficiency project implementation	Efficiency project prioritization	Develop a prioritized list of efficiency projects for implementation and explore funding opportunities for those projects.	Short term			X	
Microgrids	Microgrid Concept 1 installation	Microgrid Concept 1 installation	Implement Microgrid Concept 1.	Short term	X			X
Renewable energy	Solar PV O&M	Solar PV O&M plan	Develop an O&M plan for existing and future solar PV installations.	Short term		X		X
	Solar PV implementation	Solar PV project prioritization	Create a priority list of PV projects based on additional considerations.	Short term				X
	Solar PV implementation	Solar PV bid request and selection	Solicit and review solar installer bids; select solar installer.	Short term				X
	Solar PV trailer	Solar PV portable trailer	Research the use of a portable solar trailer for use during power outages.	Short term	X			
Workforce development	Workforce development	Ongoing community engagement	Promote awareness, education, and participation to facilitate understanding of renewable energy benefits within the community, encouraging local support and participation.	Short term		X		

Topic	Subtopic	Action	Description	Time Frame	Resilience	Capacity Building	Energy Efficiency	Energy System Transformation
	Workforce development	Skills development	Continue to provide and participate in comprehensive training programs that cover the latest technologies and practices in renewable energy, including solar, wind, and bioenergy.	Short term		X		
	Workforce development	Certification and credentials	Offer and/or connect potential employees to certification programs that validate the skills and competencies of participants, enhancing their employability.	Short term		X		
	Workforce development	Job placement	Facilitate connections between trainees and employers in the renewable energy industry to ensure successful job placements.	Short term		X		
	Workforce development	Continued learning and education	Establish pathways for ongoing education and professional development to keep the workforce updated with industry advancements.	Short term		X		
	Workforce development	Stakeholder engagement	As PGST advances its resilient and innovative energy Initiatives, cultivating its energy workforce and engaging with essential stakeholders will be imperative for long-term success.	Short term		X		
Electric vehicle infrastructure	EV charging	Resident outreach	Coordinate with housing program to assess resident interest in EVs and provide relevant educational materials.	Short to medium term				X

Topic	Subtopic	Action	Description	Time Frame	Resilience	Capacity Building	Energy Efficiency	Energy System Transformation
	EV charging	Charging infrastructure requirements	Investigate building codes, parking ordinances, and zoning ordinances for EV charging infrastructure.	Short to medium term				X
	Fleet electrification	Fleet electrification plan and implementation	Fleet electrification: develop a detailed electrification plan and begin implementation.	Short to medium term				X
Energy audits	Efficiency project implementation	Efficiency project implementation	Implement energy and water efficiency projects.	Short to medium term	X		X	
	Energy auditing plan	Periodic energy auditing process	Develop and implement a process to periodically review energy and water use by building and complete energy audits/retro-commissioning on a schedule.	Short to medium term			X	X
Renewable energy	Solar PV implementation	Solar PV installations	Pursue solar PV development on campus building rooftops.	Short to medium term				X
	Solar PV in the community	Solar PV education and stakeholder engagement	Engage and educate PGST residents on solar PV.	Short to medium term		X		X
	Solar PV in the community	Solar PV in the community	Investigate options for installing solar PV in the broader PGST community.	Short to medium term				X

Topic	Subtopic	Action	Description	Time Frame	Resilience	Capacity Building	Energy Efficiency	Energy System Transformation
Efficient HVAC systems	Ground source heat pumps	Ground source heat pump evaluation	Consider installing ground source heat pumps for new construction buildings or replacing HVAC systems during a planned upgrade.	Short term			X	
Critical infrastructure	Coastal bluff erosion mitigation	Coastal bluff erosion mitigation	Explore coastal bluff erosion mitigation measures.	Medium to long term	X			
	Earthquake preparedness	Earthquake and tsunami code review	Consider adopting relevant earthquake and tsunami codes.	Medium to long term	X			
	Earthquake preparedness	Seismic resistance construction	Consider seismic construction when planning new developments or renovating existing buildings.	Medium to long term	X			
Microgrids	Additional microgrids	Microgrid Concepts 2 and 3 evaluation	Explore the implementation of Microgrid Concepts 2 and 3.	Long term	X			X
Renewable Energy	Wind energy feasibility	Wind energy impact and cost assessment	Work with subject matter experts such as wildlife experts or biologists to understand potential environmental impacts from wind and develop a mitigation plan. Evaluate potential incentives and grants that could reduce the cost of wind energy projects.	Long term				X

Topic	Subtopic	Action	Description	Time Frame	Resilience	Capacity Building	Energy Efficiency	Energy System Transformation
	Bioenergy feasibility	Bioenergy potential assessment	Characterize available feedstock types and amounts, consider potential use cases, select the desired energy output and potential end uses, and identify suitable locations.	Long term				X

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Appendix A

PGST Workforce Energy Transferable Skills to Energy Fields

Diversifying an individual’s expertise in renewable energy is critical to facilitate the lateral transfer of skills and knowledge to other trades such as construction, electrical work, and project management. By acquiring a comprehensive understanding of renewable energy systems, individuals can apply their specialized knowledge to various aspects of construction—including the design and installation of energy-efficient buildings and the integration of PV panels and wind turbines into new construction projects. Electricians with expertise in renewable energy can manage the wiring and maintenance of these systems, ensuring their safe and efficient operation. Furthermore, project managers with a deep understanding of current renewable energy projects can confidently oversee the planning, execution, and completion of these initiatives, coordinating between different trades to ensure seamless integration of all project components.

In addition, possessing a diverse skill set enhances a professional’s adaptability and value in the ever-evolving job market. As the renewable energy sector continues to expand, the demand for individuals capable of bridging the gap between various trades will grow. For example, a professional with experience in both renewable energy and HVAC systems can provide critical insights into optimizing energy use in heating and cooling applications. Similarly, a construction worker with knowledge of renewable energy can implement sustainable practices on job sites more effectively. Consider the case of sustainable construction projects that prioritize energy efficiency and environmental impact reduction. This versatility not only broadens career opportunities but also contributes to the overall success and sustainability of renewable energy projects by fostering a workforce equipped to address a wide range of challenges and innovations. Two detailed examples of energy pathways for existing positions are provided next. Table A.1 presents a more comprehensive list of existing work positions with transferable skills that could be applied to the energy space.

A.1 PGST Maintenance Worker

Transfer type: Refocus

Transferable skills: Carpentry, electrical, equipment assembly, vegetation management, vehicle maintenance

Potential career choice: Solar PV installer/technician

Education/experience:

- Option 1: Pursue a solar PV installation certification
  - Online options
    - https://www.solarenergy.org/training-schedule/?category%5b%5d=65&order=date
    - https://www.nabcep.org/education-training/
  - In-person option

    - Spark Northwest and NWIC partnership provided Energy and Solar 101 and mock roof trainings
- Option 2: Pursue solar apprenticeship program through established solar PV companies or programs such as Grid Alternatives.

A.2 PGST Position: Building Supervisor, Facilities Manager, or Maintenance Worker

Transfer type: Refocus

Transferable skills: Strategic planning, development of maintenance programs, building inspections, safety compliance, repairs, maintenance, emergency mitigation

Potential career choice: Energy efficiency specialist

Education/experience:

- Option 1: Western Washington University Energy in the Built Environment certificate (https://catalog.wwu.edu/preview_program.php?catoid=20&poid=9848)
- Option 2: Whole Building Design Guide (WBDG) online courses (https://www.wbdg.org/ce) and Building Science Education (BSE) online courses (https://bsesc.energy.gov/training-modules)
  - WBDG example courses include the following:
    - Achieving Sustainable Site Design Through Low-Impact Development Practices
    - Advanced Energy Storage Systems
    - Benefits of Hybrid Energy Systems for Resilience
    - Building Resilience Considerations and Strategies
  - BSE example courses include the following:
    - Whole Building Performance
    - Whole Building Retrofit Considerations
    - Life Cycle Analysis
    - Home Energy Incentives
    - Disaster Resistance and Resilience
    - Codes and Standards

Table A.1. Applicability and Transferable Skills of Existing Workforce to Energy Roles

PGST Position	Energy Technology Area(s)	Energy Field(s)	Transferable Skills	Energy Transfer
Building supervisor	Electric power generation Energy efficiency	Solar PV Microgrids Battery storage Green buildings	• Strategic planning • Development of maintenance programs • Building inspections and safety compliance • Repairs, maintenance, and emergency work	Refocus
Facilities manager	Electric power generation Energy efficiency Motor vehicles	Solar PV Microgrids Battery storage Green buildings Electric vehicles	• Maintenance and repair • Development of maintenance programs • Coordination of projects	Refocus
Maintenance worker	Electric power generation Energy efficiency Motor vehicles	Solar PV Microgrids Battery storage Green buildings Electric vehicles	• Carpentry • Plumbing and electrical • Equipment assembly • Vegetation management • Vehicle maintenance	Refocus
Grant writer	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Grant application process and submission • Research, analysis, monitoring, and reporting • Understanding federal/state/local rules and regulations	Direct
Senior grant writer and editor	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Grant application process and submission • Research, analysis, monitoring, and reporting • Understanding federal/state/local rules and regulations	Direct

PGST Position	Energy Technology Area(s)	Energy Field(s)	Transferable Skills	Energy Transfer
Construction and maintenance laborer	Electric power generation Energy efficiency Motor vehicles Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission	• Carpentry • Roofing • Siding • Concrete work • Construction and maintenance	Refocus
Construction carpenter laborer	Electric power generation Energy efficiency	Solar PV Green buildings	• Carpentry • Roofing • Siding • Concrete work • Construction and maintenance	Refocus
Construction foreman	Electric power generation Energy efficiency Motor vehicles Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission	• Construction planning • Project management • Budget management • Safety compliance	Refocus
Construction/ maintenance manager	Electric power generation Energy efficiency Motor vehicles Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission	• Strategy development • Maintenance and repair identification • Procurement, scheduling, and coordination • Building and property inspections	Refocus
Lead maintenance worker	Electric power generation Energy efficiency Motor vehicles Transmission	Solar PV Microgrids Battery storage Green buildings Utilities Electric vehicles	• Maintenance and repair identification • Building and property inspections • Communication in various roles	Refocus
Tribal energy resilience coordinator (planner)	Electric power generation Energy efficiency	Solar PV Microgrids Battery storage Green buildings Utilities	• Technical planning • Experience with grants and budgets • Community engagement	Direct

PGST Position	Energy Technology Area(s)	Energy Field(s)	Transferable Skills	Energy Transfer
Computer network technician	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Utilities	• Installation, maintenance, and troubleshooting of computers and related equipment • Network support.	Direct
Information technology trainer	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Utilities	• Computer applications and programs • Communication and presentation	Direct
Senior computer network technician	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Utilities	• Installation, maintenance, and troubleshooting of computers and related equipment • Network support	Direct
Senior system administrator	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Utilities	• Troubleshooting • Maintenance of computers and related equipment • Stability and security of installed systems	Direct
Deputy Tribal attorney	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Providing legal counsel • Contract review, drafting, and negotiation • Budget process	Direct
Environmental outreach and education coordinator	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Community outreach and education • Grant application process	Direct

PGST Position	Energy Technology Area(s)	Energy Field(s)	Transferable Skills	Energy Transfer
Environmental planner	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Knowledge of environmental issues/impacts • Environmental planning, natural resource management, restoration planning, shoreline management • Grant application process • Budget process	Direct
Environmental program manager	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Knowledge of environmental issues/impacts • Environmental protection planning • Restoration project management • Grant applications, budget process, report writing	Direct
Environmental scientist: water quality	Electric power generation	Marine energy	• Knowledge of environmental issues/impacts • Environmental monitoring • Proposal curation and grant submission • Technical analyses	Refocus
Environmental planner/ project manager	Electric power generation Energy efficiency Transmission	Solar PV Microgrids Battery storage Green buildings Utilities Transmission	• Knowledge of environmental issues/impacts • Construction planning • Permit application • Budget process	Direct
Planning director	Electric power generation Energy efficiency Transmission	Solar PV Microgrids Battery storage Green buildings Utilities Transmission	• Strategic planning • Budget process • Project management • Collaboration	Refocus

PGST Position	Energy Technology Area(s)	Energy Field(s)	Transferable Skills	Energy Transfer
Planning project manager	Electric power generation Energy efficiency Transmission	Solar PV Microgrids Battery storage Green buildings Utilities Transmission	• Knowledge of environmental issues/impacts • Grant applications • Construction planning • Permit applications • Budget process	Refocus
Senior planning project manager	Electric power generation Energy efficiency Transmission	Solar PV Microgrids Battery storage Green buildings Utilities Transmission	• Knowledge of environmental issues/impacts • Strategic planning • Grant applications • Construction planning • Permit applications • Budget process	Refocus
Safety coordinator	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Emergency preparedness • Disaster response and crisis management • Safety and health	Direct
Energy program manager	Electric power generation Energy efficiency Motor vehicles Fuels Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission Marine energy	• Strategic planning • Budget process • Grant application and technical assistance • Energy audits • Energy alternatives • Renewable energy	Direct
Senior utilities project manager	Electric power generation Energy efficiency Motor vehicles Transmission	Solar PV Microgrids Battery storage Green buildings Electric vehicles Utilities Transmission	• Strategic planning • Budget process • Grant and loan application • Management	Refocus

PGST Position	Energy Technology Area(s)	Energy Field(s)	Transferable Skills	Energy Transfer
Solar energy technician	Electric power generation	Solar PV Battery storage Microgrids Green buildings Utilities	• Inspection, diagnosis, repair, and troubleshooting of PV systems • Knowledge of building codes and regulations • Community engagement • Solar PV industry expertise	Direct
Utilities director	Electric power generation Energy efficiency Transmission	Solar PV Battery storage Microgrids Green buildings Utilities Transmission	• Strategic planning • Budget process • Maintenance and repair of facilities and equipment • Vegetation management • Customer service • Safety	Refocus
Utilities manager	Electric power generation Energy efficiency Transmission	Solar PV Battery storage Microgrids Green buildings Utilities Transmission	• Strategic planning • Budget process • Maintenance and repair of facilities and equipment • Vegetation management • Customer service • Safety • Statistical analysis and reporting.	Refocus
Utilities technician	Energy efficiency	Utilities Green buildings	• Utilities maintenance • Emergency mitigation • Vegetation management • Safety.	Refocus

Appendix B

Energy Workforce Development Resources

Table B.1 lists solar workforce development resources; Table B.2 lists sources of energy workforce development.

Table B.1. Solar Workforce Development Resources

Resource	Description	Source
DOE Solar Workforce Development	DOE's Solar Energy Technologies Office page dedicated to solar workforce development including research topics, initiatives, and additional resources.	https://www.energy.gov/eere/solar/solar-workforce-development
DOE Solar Design and Installation Training	DOE's Solar Energy Technologies Office page dedicated to providing resources for solar design and installation training.	https://www.energy.gov/eere/solar/solar-design-and-installation-training
DOE Solar Energy Resources for Job Seekers	DOE's Solar Energy Technologies Office page dedicated to providing resources for those seeking jobs in solar energy. Provides information about solar energy careers, job opportunities, and training opportunities.	https://www.energy.gov/eere/solar/solar-energy-resources-job-seekers
GRID Alternatives Job Training Partnerships	Grid Alternatives partners with local community-based organizations to provide hands-on experience in industry-relevant skills.	https://gridalternatives.org/get-training/job-training-partnerships
GRID Alternatives Tribal Program	Grid Alternatives works with Tribal communities to help them achieve their energy goals by providing training opportunities and installing solar energy equipment.	https://gridalternatives.org/what-we-do/tribal-program
Solar Energy International	Provides online solar and renewable energy training and certifications.	https://www.solarenergy.org/
Interstate Renewable Energy Council Solar Career Map	Solar career map showing routes of advancement in manufacturing, system design, project development, and installation and operations sectors.	https://www.irecsolarcareermap.org/
acWe Share Solar Suitcase Technology and Curriculum	Educational kit designed to offer students a hands-on learning experience with tools, electricity, and a solar PV system.	https://wesharesolar.org/solar-suitcase/

Table B.2. Energy Workforce Development

Resource	Description	Source
Interstate Renewable Energy Council Green Buildings Career Map	Green buildings career map showing routes of advancement in various sectors of energy efficiency.	https://greenbuildingscareermap.org/
Center for Energy Workforce Development	Hub for energy workforce events and resources.	https://cewd.org/
Alliance for Tribal Clean Energy	Provides no-cost renewable energy development support for Tribal nations.	https://tribalcleanenergy.org/#technical
Green Workforce Connect	Hub for energy resources including job opportunities, apprenticeship programs, educational resources, and helpful guides.	https://greenworkforceconnect.org/
DOE Office of State and Community Energy Programs Workforce Development Blueprint	Overview of process and benefits of workforce development in the energy industry, including resources, guides, and activities.	https://www.energy.gov/sites/default/files/2023-05/Workforce_Development_v05_508.pdf
DOE Apprenticeships and Workforce Development	Energy workforce resources including apprenticeship job finders.	https://www.energy.gov/apprenticeships-workforce-development
Pacific Northwest Center of Excellence for Clean Energy	Resource that provides information about education and career pathways in energy, educational curriculum, reports, publication, and funding opportunities.	https://www.cleanenergyexcellence.org/
Puget Sound Electrical Apprenticeship	Offers a choice of training within three electrical career paths.	https://www.psejatc.org/careers/programs-overview/
Shoreline Community College Clean Energy Technology and Entrepreneurship Certificate	Provides training toward a certificate in renewable energy technologies and entrepreneurship. Can also be used as part of an associate degree of the same name. Students will learn about building science, energy efficiency, electricity, safety, renewable energy technologies, project management, and more (on-campus course).	https://www.shoreline.edu/programs/clean-energy-technology/clean-energy-technology-and-entrepreneurship-certificate.aspx
Western Washington University Energy Studies Bachelor of Arts (BA) or Bachelor of Science (BS) degree	Provides two degree options in energy studies: Energy Policy and Management BA or Energy Science and Technology BS. Students learn energy policy, environmental science, energy business, energy efficiency, building science, and more (on-campus course).	https://www.wwu.edu/majors/energy-studies

Resource	Description	Source
Get Into Energy online course: Energy Industry Fundamentals	Free online course about energy and career path opportunities. The course offers 120 hours of instruction; students who complete the program will earn a credential.	https://getintoenergy.org/eif-2-0/
Western Washington University Energy Studies	Provides training toward a variety of energy science program options ranging from nondegree certificate options to BS degree options.	Certificates: https://energy.wwu.edu/wwu-energy-certificates-non-degree BA/BS: https://energy.wwu.edu/ba-energy-policy-and-management https://energy.wwu.edu/bs-energy-science-and-technology
Whole Building Design Guide online courses	Provides free online courses related to improved whole building performance and design for increased energy efficiency as well as courses on energy systems and storage and resilience.	https://www.wbdg.org/ce
Building Science Education online courses	Provides free online courses related to building design, maintenance, renovation, and construction to improve comfort, resilience, and efficiency.	https://bsesc.energy.gov/training-modules
Federal Emergency Management Agency (FEMA) National Disaster and Emergency Management University Curriculum and Programs	Provides free online and in-person courses related to a variety of topics including hazard mitigation, emergency management, critical infrastructure security, and emergency management and mitigation for Tribal governments.	https://training.fema.gov/ndemu/curriculum/
United Indians of All Tribes Foundation: Native Workforce Service Program (NWSP)	NWSP supports comprehensive employment and training activities while helping clients get the training and certifications needed to build a sustainable career.	https://unitedindians.org/community-services/native-workforce-services-program/
DOE webinar archive	Collection of free webinar series covering a wide range of topics related to building and construction.	https://www.energy.gov/eere/buildings/webinar-archives

Appendix C

Electric Vehicle Readiness Considerations and Examples

Electric vehicle readiness ordinances across various cities in the United States aim to support the adoption and ease of use of EVs by ensuring new construction is equipped with necessary EV charging infrastructure. Benefits of EV-ready requirements include increased cost efficiency and convenience for EV charging installations during construction and/or in the future. Expected savings come from lower labor and material costs as well as avoiding future construction-related disruptions.

Specific requirements differ by jurisdiction but commonly include the following considerations:

- Electrical capacity: Ensuring the building's electrical system has sufficient capacity to support the added load of EV charging stations, including future expansions
- Conduit and wiring: Installing conduit and cabling from the electrical panel to the designated EV charging locations to facilitate easy installation of charging stations later
- Dedicated circuits: Providing dedicated electrical circuits in parking areas to handle the power requirements of EV chargers without overloading existing electrical systems
- Panel capacity: Upgrading or installing electrical panels that can accommodate the additional breakers required for EV charging systems
- Parking spaces: Designating a certain percentage of parking spaces that are designed or prewired for future EV charging stations.

Electric vehicle readiness requirements exist in multiple cities across the United States including Seattle, Bellevue, and Redmond in Washington. Requirements vary by jurisdiction; examples include the following:

- Seattle (Ordinance 125815):
  - Multifamily residential buildings: New multifamily residential buildings must have EV-ready parking spaces, and 20% of the parking spaces must be designed to support the installation of Level 2 EV charging outlets. Requirements include the installation of electrical capacity, conduit, and wiring to support future EV chargers.
  - Commercial and mixed-use buildings: New commercial and mixed-use buildings must include EV charging infrastructure at a minimum of 10% of parking spaces. Similar to residential requirements, the requirements for commercial and mixed-use buildings involve conduit installation and electrical capacity to support future EV chargers.
- Los Angeles (Ordinance 186485):
  - Single-family residences and duplexes: New single-family residences and duplexes must have conduit installed to support future EV charging stations. In addition, electrical panels must be sized to support future EV charger(s).
  - Multifamily residences: 10% of parking spaces in new multifamily residences must be EV capable, which requires installing conduit and having sufficient electrical capacity to support the future installation of EV chargers. Additional parking must be EV ready, which in the context of the Los Angeles ordinance specifically requires parking spaces to be fully wired to support Level 2 EV charging stations.

  - Commercial buildings: For new construction, 30% of parking spaces must be EV capable and 10% of parking spaces must be EV ready.

Although there are currently no EV readiness requirements for PGST, proactively planning for EV charging can not only save money but also prepare Tribal infrastructure to meet future EV demand.

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