



# Makah Tribe Strategic Energy Plan

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2. Pacific Northwest National Laboratory
3. Spark Northwest
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MAKAH INDIAN NATION



DIAHT, WAATCH, OSETT, TSOO-YESS, BAADAH



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## Makah Strategic Energy Plan Summary

The U.S. Department of Energy (DOE) Energy Technology Innovation Partnership Project (ETIPP) connects remote and island communities, regional partners, and the DOE national laboratories to support communities seeking to build resilience in their energy systems. Located in the remote northwest corner of Washington State, the Makah Tribe faces several energy challenges including frequent power outages and the potential for an extended outage due to an earthquake or tsunami. The Tribe joined ETIPP in 2022 to address those challenges, seeking to build energy resilience and sovereignty in the community. The Makah Tribe, Spark Northwest, the Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL) collaborated to develop this strategic energy plan.

The long-term energy vision of the Makah Tribe includes increasing energy efficiency in the community, improving energy management capacity, and developing renewable energy generation and storage sufficient to independently power the reservation for one year. The ETIPP team worked with Makah leadership, staff, and community members to identify a set of community priorities, values, and goals to guide energy development as the Tribe takes the incremental steps toward their vision for energy sovereignty. Those energy values include ecosystem-based management, energy sovereignty and project ownership, workforce development and capacity, economic opportunity, community well-being and priorities, and emergency disaster resilience.

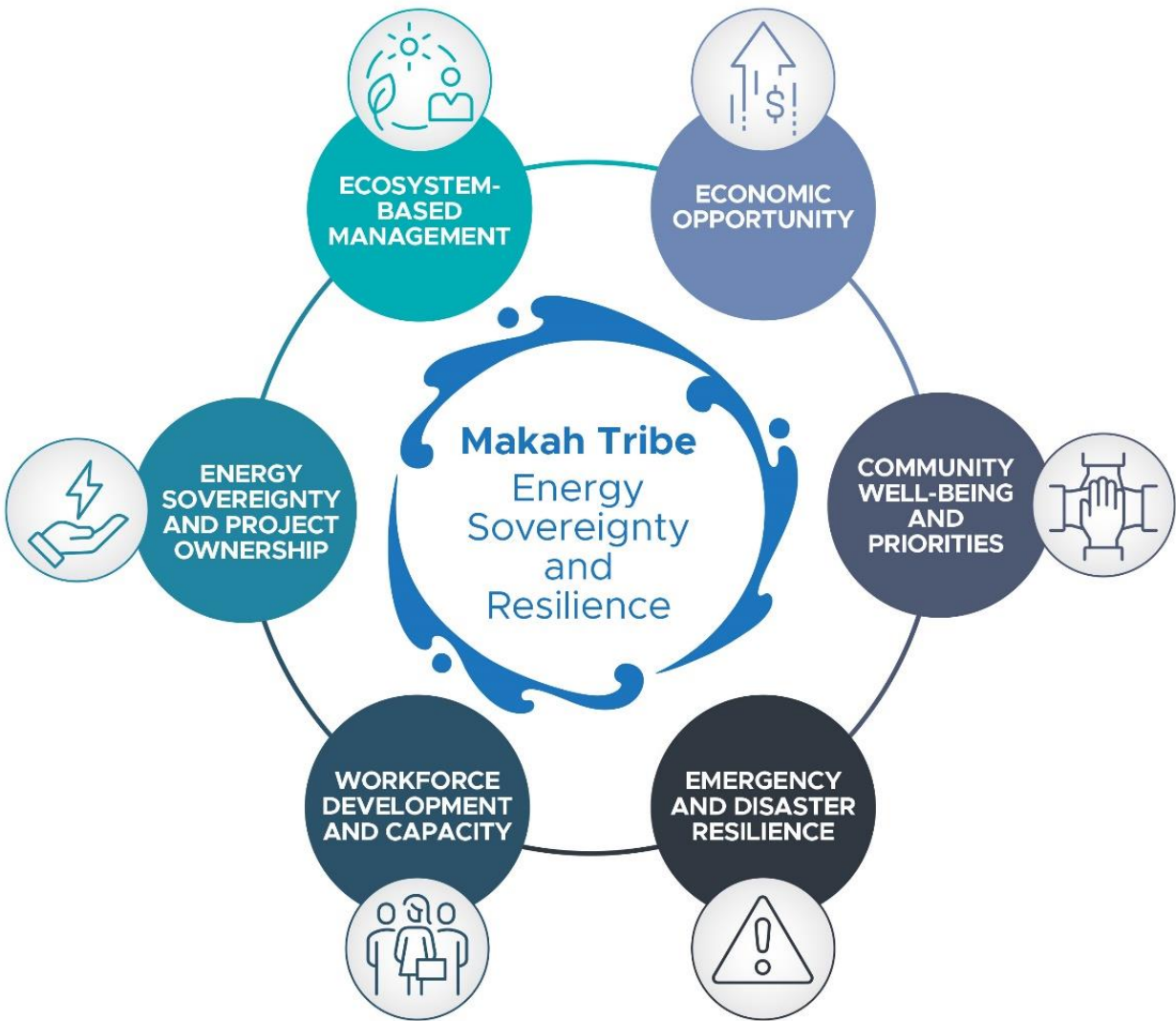
To understand what would be needed for a year of energy independence, the PNNL team conducted an assessment to determine the current energy usage of the Tribe and modeled several scenarios for future energy use. After conducting some preliminary resource assessments and following conversations about a variety of technology types, the Makah team asked that solar and wind be evaluated for the future scenarios for a variety of reasons including cost, feasibility, and resource availability. The technical team estimated how those types of energy generation could contribute to the energy independence goal of the Tribe. The energy baseline and resource assessment produced the following key findings:

- As of 2023, the Makah Reservation has 1,692 residents and 616 households and was in the 75<sup>th</sup> percentile nationally of energy costs (average energy costs divided by household income). Neah Bay is a remote coastal community and at the end of their transmission line; local services are limited and power outages are common, especially in the winter when high winds and storms are common. Since 2017, there has been an average of approximately 6 outages annually, with an average outage duration of about 10 hours.
- The current annual load, based on data from 2022, is 20,746 megawatt hours (MWh). Modeled future scenarios for 2040 predict a 27%–35% increase in electricity use depending on population growth and the degree of energy efficiency and electrified technologies adopted in the community.
- Despite the cloudy reputation of the Olympic Peninsula, solar energy is a viable option, albeit one with high seasonal variability. The total maximum potential rooftop, ground-mount, and carport photovoltaics (PV) in Neah Bay is 4.8 MW of nameplate capacity, 2 MW from selected Tribal and privately-owned buildings, and 2.8 MW from residential rooftops. This 4.8 MW of solar PV could meet roughly 24% of the annual energy demand of the Tribe.
- The wind resource in Neah Bay and surrounding Makah lands is highly variable due to complex terrain and coastal proximity; however, there are a few locations that may be suitable for small-scale wind development ( $\leq 100$  kW). Depending on the turbine model and wind conditions, on average, a single turbine could meet roughly 0.5% of the annual energy demand of the Tribe.
- Due to the seasonal nature of wind and solar energy, a combination of the technologies has the potential to provide the most consistent energy generation year-round. The wind resource is stronger in the winter, coinciding with more frequent outages and higher energy demand, while solar is stronger in the summer when there tends to be less wind. An open clearing above the Makah Wellness Center is a promising location for the colocation of wind and solar PV. Based on a desktop analysis of the site, there is space for the potential layout for nine Northern Power Systems (NPS) 100C-21 turbines, and 2–4 MW of ground mount solar PV. Together, these nine turbines and 2–4 MW of solar PV could produce between 2,200–3,400 MWh of electricity annually, equivalent to 15%–24% of Neah Bay’s 2022 electricity consumption, or 8%–12% of the highest projected 2040 demand.
- The Tribe has collaborated with other external groups to evaluate the potential of biomass and marine energy. Marine energy is typically divided into two categories, tidal and wave energy, but can also refer to generating energy from salinity or thermal changes in the ocean. Biomass energy 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, or urban waste. Summaries of those investigations are included in this plan.
- The plan considers priority projects that were identified by Tribal leadership and the community, including the establishment of several Resilience Hubs throughout the community, developing

reliable funding streams, establishing partnerships with organizations that can help advance energy goals, and building energy management capacity within the Tribal organization.

This strategic energy plan is a living document that will evolve as technologies change and as the Tribe grows its renewable energy needs. While priorities may shift due to funding availability or timely opportunities for development, energy development will occur in accordance with the Tribe's energy values.

## Makah Energy Values



# Acronyms and Abbreviations

AC	alternating current
ANP	advanced nuclear power plant
BDT	bone dry ton
BESS	Battery Energy Storage System
BOEM	Bureau of Ocean Energy Management
BPA	Bonneville Power Administration
Btu	British Thermal Unit
BDT	Bone Dry Ton
CO <sub>2</sub>	Carbon Dioxide
DC	Direct Current
DNR	Department of Natural Resources
DOE	U.S. Department of Energy
E2C	Energy to Communities
ETIPP	Energy Technology Innovation Partnership Project
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
GW	gigawatt
HOMER	Hybrid Optimization of Multiple Energy Resources
IRC	International Residential Code
ITC	Investment Tax Credit
kW	kilowatt
kWh	kilowatt hour
MACRS	Modified Accelerated Cost-Recovery System
MMBtu	metric million British Thermal Units
MTC	Makah Tribal Council
MW	megawatt
MWh	megawatt hour

m/s	meters per second
NPS	Northern Power Systems
NREL	National Renewable Energy Laboratory
NSRDB	National Solar Radiation Database
O&M	Operations and Maintenance
PNNL	Pacific Northwest National Laboratory
PUD	public utility district
PV	photovoltaics
VPP	virtual power plant
WEC	Wave energy converter
WSU	Washington State University

## Glossary

Alternating current	Electric current that switches direction.
British Thermal Unit	The amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit.
Direct current	Electric current that flows in one direction.
Solar irradiance	The amount of solar radiation received by a surface, measured in Watts per meter squared, or $W/m^2$ .
Kilowatt	One thousand watts.
Kilowatt hour	One thousand watt hours. Typically used to measure electricity consumption.
Megawatt	One thousand kilowatts.
Megawatt hour	One thousand kilowatt hours.
Microgrid	A group of interconnected loads and distributed energy resources within a clearly defined electrical boundary that acts as a single controllable entity with respect to the grid. Can connect and disconnect from the grid.
Nameplate capacity	Also known as rated capacity, the maximum rated output of electric power production equipment. Commonly expressed in megawatts.
Power	The rate at which energy can be delivered, measured in Watts, or W.
Watt	Unit of electrical power.
Watt hour	Unit of electrical energy equal to one watt of power supplied for one hour.

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# Introduction

This energy plan is the result of a collaborative effort between the Makah Tribe, Spark Northwest, the Pacific Northwest National Laboratory, and the National Renewable Energy Laboratory. Reflective of the nature of this effort, the report follows a co-authorship model with some portions, including the introduction and values, written in the first person by the Tribe. The technical analysis sections also use “we”. Starting in the Energy Baseline section, use of we represents the technical team who describe the analyses they completed with input and direction from the Tribe. It was important to the entire project team that, as a community plan, this report reflect the Tribe’s voice and illustrate that this was a collaborative effort wherever possible.

## The Makah Tribe

The Makah Tribe (or Tribe) is a federally recognized Tribe located in Neah Bay, Washington. The Makah are a place-based people whose home since time immemorial has been the remote northwestern tip of the Olympic Peninsula (Figure 1). The existence and well-being of the Makah people has always been closely tied to the ocean and environment. The Makah people have a long history of

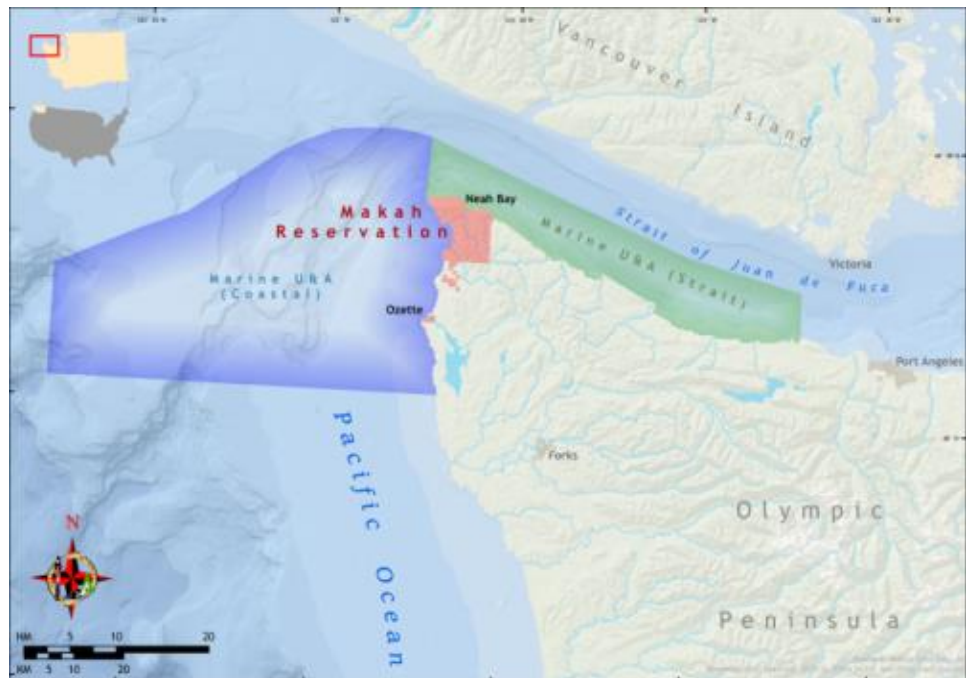


Figure 1. Location of the Makah Reservation on the northwestern tip of the Olympic Peninsula and the Tribe’s Usual and Accustomed fishing areas along the coast and in the Strait of Juan de Fuca (source: Makah Tribe).

resilience, both to changing ocean conditions and to the risks our coastal community faces from earthquakes and tsunamis. The Tribe's energy supply is vulnerable due to our remote location, potential for earthquake and tsunami events, and the impacts of climate change. Recognizing that vulnerability, work investigating renewable energy and increased energy efficiency in the community began in 2005 (Table 1).

The Makah Tribal Council (MTC) has identified the need to integrate the compounding risks of climate change into ongoing planning processes as the community evaluates options for the relocation of critical infrastructure due to the risk of extreme events. Similar efforts are ongoing throughout the Tribe’s natural resource management and are also highlighted in our ongoing climate resilience work. We believe that

relocation and climate adaptation planning present an opportunity to comprehensively review our energy systems and renewable energy options to increase energy reliability, provide energy resilience during emergencies, and work toward our goal of energy sovereignty. Therefore, the objective of this plan is to outline a pathway to continue to build a sovereign and resilient energy system for the community. The MTC envisions using this plan to inform strategic-level decision-making and future energy policy.

*Table 1. Makah Energy Projects*

<b>Date(s)</b>	<b>Projects</b>
<b>2005</b>	Wind and hydroelectric energy feasibility study
<b>2006</b>	Wave energy feasibility study (up to Federal Energy Regulatory Commission permit)
<b>2013</b>	Solar energy feasibility and cost-benefit analysis
<b>2018</b>	Carbon footprint and energy audit; some solar installed
<b>2019</b>	Biomass energy feasibility study with Washington State University (WSU) (ongoing)
<b>2021–2022</b>	Wave energy converter feasibility study (desalinization focus)
<b>2022–present</b>	Energy Storage for Social Equity Award: scoping and implementation of microgrids and resilience hubs. Scoping complete, implementation underway as of early 2025.
<b>2022–present</b>	Energy Technology Innovation Partnership Project Award (ETIPP): strategic renewable energy plan, outreach, and communication

The Makah Tribe is a customer of the Clallam County Public Utility District (PUD). Power outages due to storm events are common (between 6–8 every winter) and can last for several hours or days. The single road into the reservation (State Route [SR] 112) is not well maintained, and landslides, mudslides, and flooding regularly leave the Makah community cut off from the rest of the state, meaning timely repairs can be challenging. For example, in November 2021, a landslide on SR 112 left the Tribe isolated for five days until food and fuel deliveries could get through on forest roads. Extreme weather will continue to exacerbate the conditions that can lead to power outages and limited access via SR 112, including landslides and increasingly frequent and severe storms. While many homes and buildings have backup generators, we are looking to increase how much backup generation comes from local renewable resources and to have greater coverage within the community. Surveys conducted during climate change planning efforts have indicated that the extended power

outages disproportionately impact elders and other vulnerable populations within Neah Bay. Also of concern is that some of the electricity received from Clallam PUD is generated from hydropower, which has negative impacts for salmon recovery and thus does not align with our energy values or sovereignty goals.

In addition to planning for regularly occurring short-term power outages, we are also looking to build energy resilience for possible extreme events. The Makah Reservation is located adjacent to the Cascadia

Subduction Zone, capable of producing a magnitude 9.0 earthquake. Most of the Makah Tribe's critical infrastructure (including energy infrastructure) as well as 60% of homes are currently located within the tsunami inundation zone. In the event of a major disaster, the Makah Tribe could be without outside assistance for up to a year. The ability to independently and locally re-electrify Tribal infrastructure and homes in case of a major event, as well as for smaller and more frequent blackouts, is essential to public health, public safety, and resilience. This plan outlines our objectives and priorities for building energy sovereignty and reliability for the current community and generations to come.

The plan has four sections: (1) an energy vision that outlines our values, priorities, goals, and objectives that will guide decisions about technology choices, siting, and the scale of renewable energy projects; (2) a characterization of the current and future electricity needs and resource assessments of solar, wind, marine energy, and biomass; (3) descriptions of projects identified as priorities; and (4) information regarding how the Tribe can continue to build internal capacity in the energy space, both to scope and implement energy projects, as well as communicate with the community about options for households to build their own energy resilience. This plan is an outcome of the Makah Tribe's partnership with several organizations as part of the ETIPP,<sup>1</sup> supported by the U.S. Department of Energy (DOE). ETIPP connects remote and island communities, regional partners, and DOE's national laboratories to support communities as they seek to build resilience in their energy systems. The Makah Tribe, Spark Northwest, the Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL) collaborated to develop this strategic energy plan as part of the second cohort of ETIPP communities.

## Makah Energy Vision

Any energy development that occurs in Neah Bay must be consistent with the goals and values of the Makah Tribe. The energy values, goals, and priorities outlined below were developed through input from a community dinner and ideas generated in a workshop in December 2022 with the core Makah ETIPP team, members of the Makah Tribal Council, Makah community members and staff, and ETIPP partner organizations. The Makah ETIPP team and partners then worked together to synthesize the community and workshop contributions into the vision statement and values below. This section outlines the overarching vision for the Tribe's energy development, as well as the metrics the Tribe will use to evaluate and prioritize potential projects.

### Vision Statement

The Makah Tribe will exercise our inherent sovereign authority over a fully independent energy system. The Makah Tribe will own this system, which will be established with Makah values. It will support community resilience and economic development consistent with an ecosystem-based management approach, supporting and protecting Makah cultural practices and treaty resources in perpetuity.

Consistent with this vision, we recognize the need to:

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<sup>1</sup> For more information, see <https://www.nrel.gov/state-local-tribal/energy-technology-innovation-partnership-project.html>.

1. Support and empower the Makah Tribal organization and homeowners to improve energy efficiency.
2. Develop the capacity and institutional infrastructure for the Tribe to manage our local energy development and enhance our ability to engage at the regional and national level through hiring dedicated energy staff, growing our knowledge of energy policies, and establishing partnerships that will support our energy goals.
3. Implement renewable energy generation and storage sufficient to independently power the reservation for one year.

## Energy Values

As we work toward our goal of energy sovereignty, we will evaluate potential renewable energy development opportunities to ensure they are consistent with our values (Figure 2) and the project considerations outlined below, and will prioritize projects that provide multiple benefits to the community.

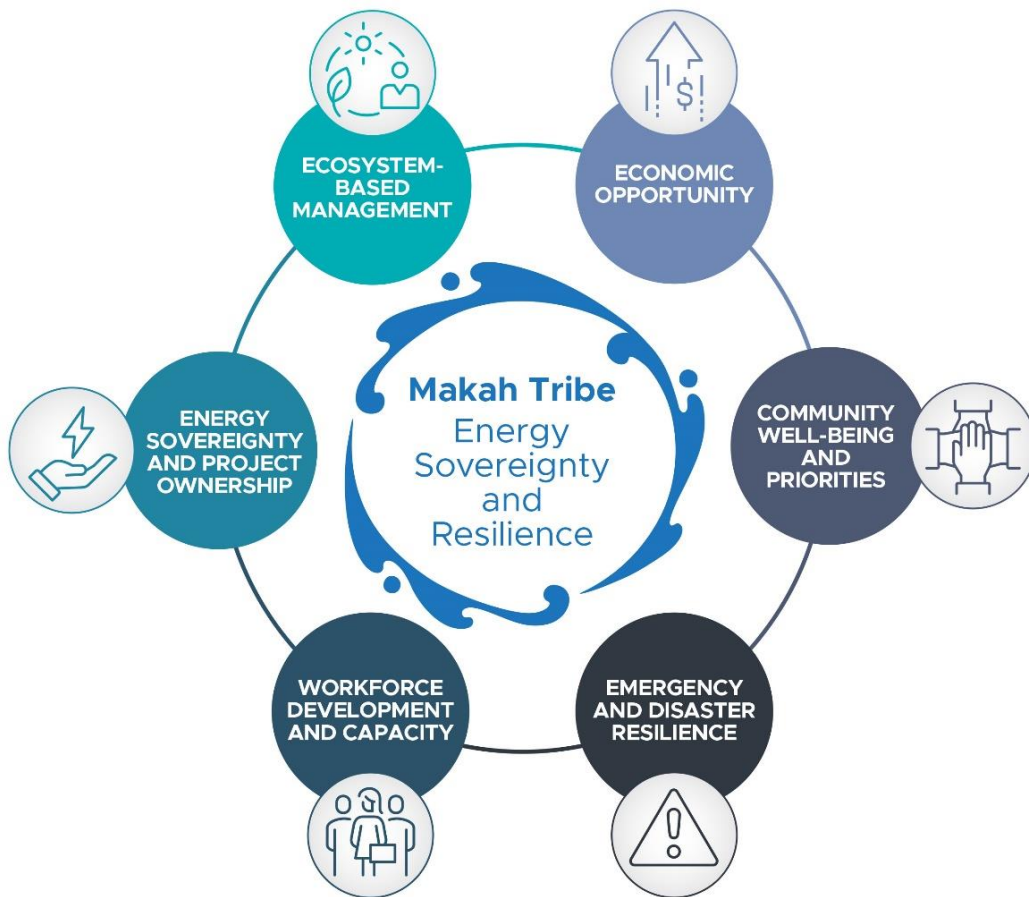


Figure 2. Makah energy values developed with input from Makah members and staff.

1. **Ecosystem-Based Management:** Makah is a natural resource Tribe, dependent on marine and terrestrial resources to sustain our culture, food security, and economy, and as such, will only support projects where the environmental impacts are understood by Makah technical staff. We will prioritize projects that minimize negative impacts to the environment, natural resources, and

the exercise of treaty rights. Our approach to evaluating energy infrastructure is to consider it in the context of ecosystem-based management to ensure we uphold our trust responsibility to manage and protect Tribal resources. To that end, environmental impacts must be fully evaluated prior to considering any project.

**Project considerations:**

- a. Does energy development interfere with any treaty-reserved resources? If so, what is the extent of the potential impacts?
  - b. Does the project use existing infrastructure or require new development? As able, we will seek to use existing infrastructure for our energy development, while acknowledging that may not be possible for some types of technology. We will also seek to prioritize projects that include nature-based solutions.
  - c. Is there a plan for ongoing monitoring of impacts and the ability to remove the energy infrastructure if unanticipated negative impacts occur? We will be unlikely to consider energy development proposals that do not include environmental monitoring and contingency plans.
  - d. Does the project support or advance environmental management or climate resilience goals? This could include things like supporting water needs, reducing reliance on hydropower, or improving local air quality.
2. **Energy Sovereignty and Project Ownership:** A core component of our energy vision is advancing our sovereignty through increased oversight, ownership, and local generation of energy. Therefore, we will prioritize projects that advance this goal, support community-wide energy independence, and that the Tribe is able to own and control. We will require agreements to be in place to assure the Tribe's authority prior to any construction.

**Project considerations:**

- a. Was this project initiated by the Tribe or by outside interests?
  - b. Has the proposal recognized the Makah Tribe's authority and decision-making throughout the lifetime of the project (planning and design, siting, access, monitoring, operations, removal, decommissioning)? To what degree does the project contribute to the goal of energy independence? This could include metrics like how much of the reservation could be powered by the local energy generation or the management structure overseeing the operation.
  - c. Will the Tribe own the project from the onset, and if not, is there a pathway for eventual Tribal ownership?
3. **Workforce Development and Capacity:** Energy projects should be built, maintained, and operated to the extent possible, with local workforce capacity in Neah Bay. If no one in the community currently has the skills for maintenance and operation, project proposals should include plans to develop the capacity required to manage the project locally. Funding to support workforce development and build local capacity should be integrated into projects wherever possible.

**Project considerations:**

- a. Will the project create jobs in the community, and if so, how many and what types of jobs? Factors that will be considered include, but are not limited to, the length of employment, wages, and the ability to learn transferable skills.
  - b. Does the project include training opportunities for existing and new staff?
  - c. Are there technological constraints that preclude a project from realistically being maintained locally? Any such projects must include a maintenance plan with equipment and maintenance costs outlined as part of an initial assessment.
4. **Economic Opportunity:** We will prioritize projects that reduce energy costs and barriers to economic development and those that explicitly support economic development in the primary sectors in Neah Bay, including tourism, forestry, and fisheries. We also acknowledge that projects that may advance some of the other energy values, in particular emergency and disaster resilience, may require different economic considerations than the ones outlined below.

**Project considerations:**

- a. Is the project economically viable?
  - b. Does the project reduce barriers to economic development in Neah Bay?
  - c. What is the economic impact of the project? For example, does the project reduce household energy costs or reduce costs for the Tribal organization?
  - d. Does the project generate revenue for the community?
5. **Community Well-being and Priorities:** Energy development has the potential to address priority well-being concerns identified by the community. Overarching community priorities include, but are not limited to, improving community resilience, well-being, and resource availability.

**Project considerations:**

- a. Does the project reduce barriers to housing availability?
  - b. Does the project reduce household energy burdens?
  - c. Does the project address water availability issues?
  - d. Does the project address household air quality issues?
  - e. Does the project support the well-being of potentially vulnerable members of the community such as children and elders?
6. **Emergency and Disaster Resilience:** Our location means we are subject to regular but short-term power outages and are also at risk from a low-probability but high-consequence earthquake and tsunami. A primary goal of energy development is building resilience for both possibilities. Therefore, projects will be evaluated by how they are able to contribute to community resilience to both short-term and extended power outages.

**Project considerations:**

- a. Can the energy generated be utilized by the Tribe during an emergency or routine power outage? If so, how long is the project able to provide power?
- b. Does the project support or facilitate relocation efforts?
- c. What is the planned location of the project? Is it outside of the tsunami inundation zone, or if not, could it be moved out of the tsunami inundation zone as other critical infrastructure is relocated?
- d. Does the project help with grid stabilization<sup>2</sup>?

An example of working through these considerations to evaluate a specific project can be found in the Priority Projects section of the plan. The following section describes the current electricity needs for the Tribe and potential renewable energy resources that could be used to help meet future energy needs locally.

## Energy Baseline

Evaluating the potential impact of energy development and characterizing future energy needs requires an understanding of current energy uses and challenges. As of 2023, the Makah Reservation has 1,692 residents and 616 households and is in the 75<sup>th</sup> percentile nationally of energy burden (average energy costs divided by household income) (Ma et al. 2019). Its remote location means that local services are limited and power outages are common, especially in the winter. Between October 2017 and December 2022, there was an average of just under 6 outages annually with an average duration of about 10 hours (Figure 3). The longest outage during those years came in December 2018 and was 52.7 hours. About half of outages (48.6%) were caused by trees or limbs falling on powerlines, and a little over one-third were unplanned Bonneville Power Administration (BPA) outages (Figure 4). The unplanned outages category includes interruptions due to equipment failure, accidents, human error, or similar factors besides trees or limbs which are counted independently. Many Tribal government buildings and homes rely on diesel generators or wood stoves for backup power and heating, as repairs can take hours or days. Supplementing this backup capacity with locally generated energy would help the community given the cost, limited storage capacity of diesel, and conditions that can at times make it difficult to get additional fuel to the community.

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<sup>2</sup> Grid stabilization involves adding a complementary set of energy generation resources into a microgrid such that seasonal asymmetries and large swings or variabilities in energy generation are reduced or controlled, particularly with respect to electricity demand. For example, energy storage supports grid stabilization because it allows generated energy to be saved and used at a later date. Microgrid control systems are another strategy for grid stabilization. Microgrid hybrid generation software (e.g., Hybrid Optimization of Multiple Energy Resources [HOMER], HOPP) and technical assistance surrounding hybrid microgrids (e.g., Energy to Communities Expert Match) can help evaluate to what extent a project supports grid stabilization.

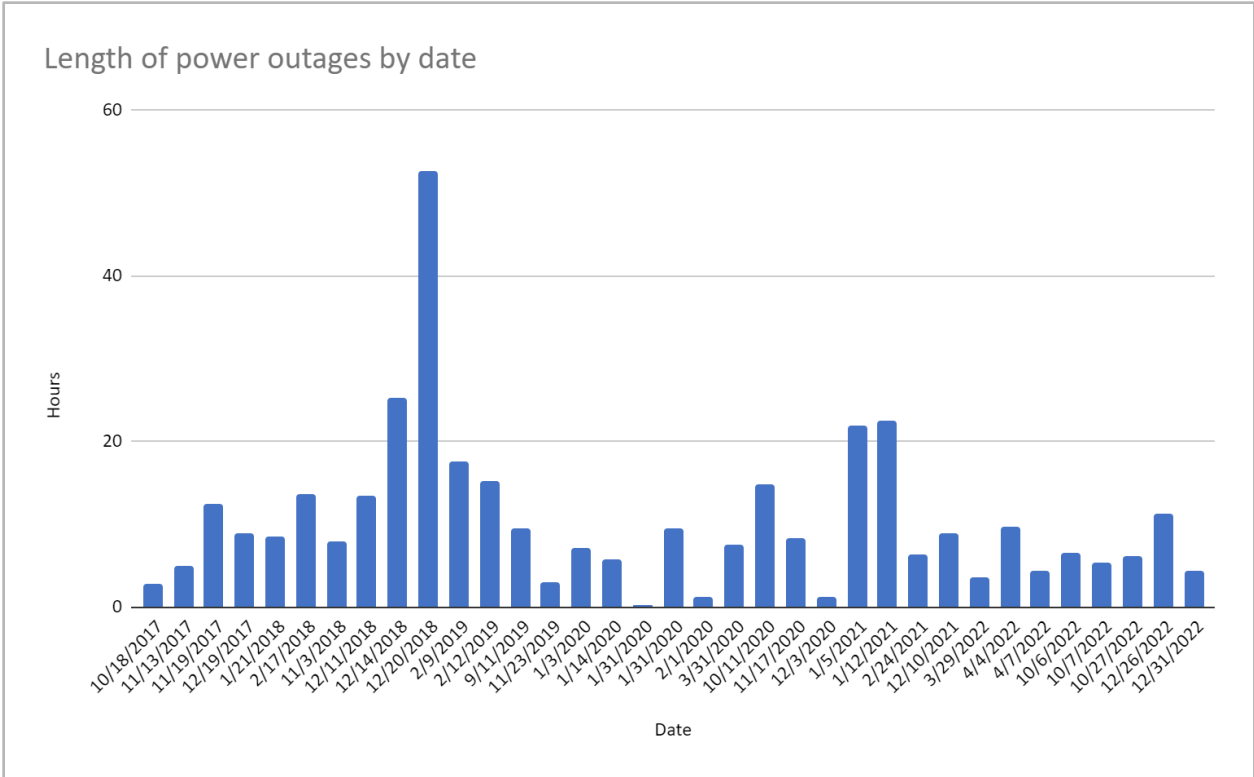


Figure 3. Power outages in Neah Bay, Washington, between October 2017 and December 2022 (source: Clallam PUD)

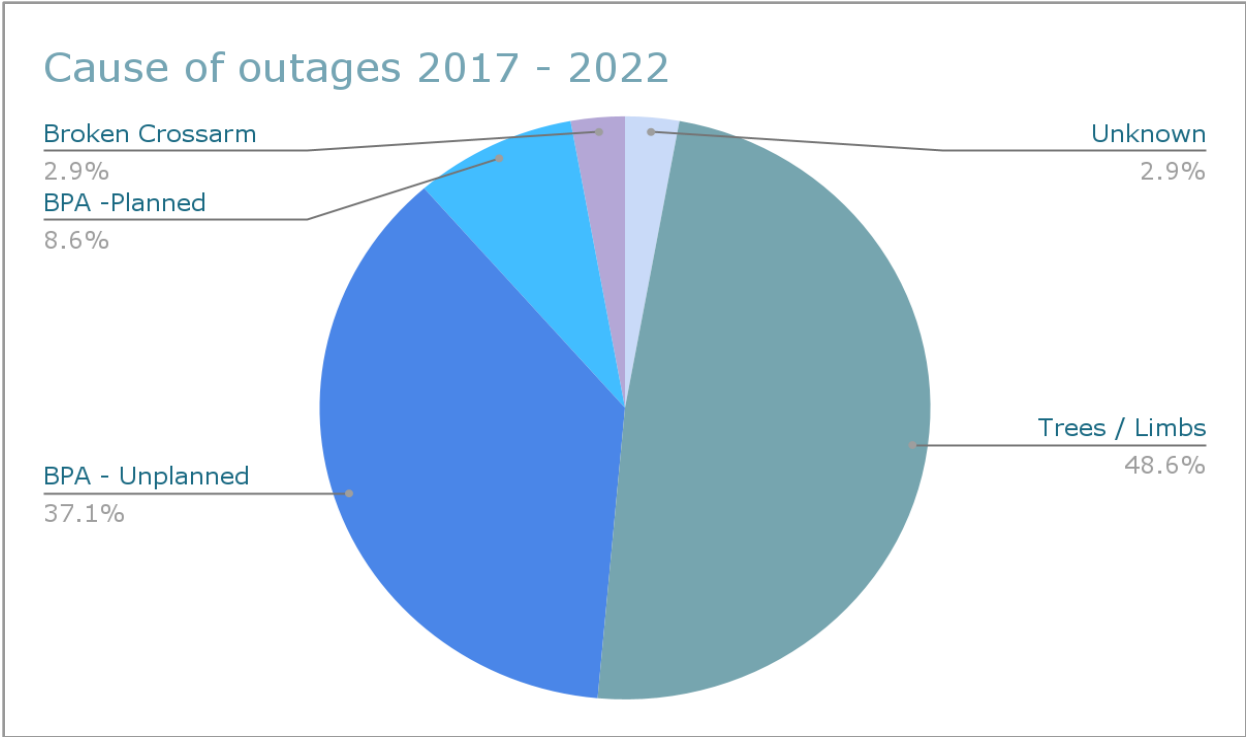


Figure 4. Causes of power outages in Neah Bay (source: Clallam PUD)

These outages can be very problematic given the distance between Neah Bay and the nearest locations that have vital services. There is a small health clinic in Neah Bay; the next-closest full-service emergency medical facilities are located in Forks (1-hour drive), and Port Angeles (2-hour drive). Many community members also regularly travel to Seattle for medical services (4 hours by car and ferry). Outside of medical needs, the nearest major grocery stores and many other services are also located in Port Angeles, adding to fuel costs faced by community members.

### Current Loads

Characterizing the current loads and establishing an energy baseline helps to model growth and future electricity needs. This process can also be used to explore how energy development will contribute to the electricity needs now and in the near future and determine seasonal variation in electricity consumption to evaluate the energy generation potential of different types of renewable energy technologies.

Clallam PUD provided monthly electric load information for Neah Bay from January 2022 to February 2023. The total annual load was 20,746 megawatt hours (MWh), with a peak load of 6.6 megawatts (MW) in December 2022, and a 5% addition for losses and unmetered loads. Total monthly electricity consumption and peak electricity demand vary seasonally, with the highest consumption in the winter months (Figure 5).

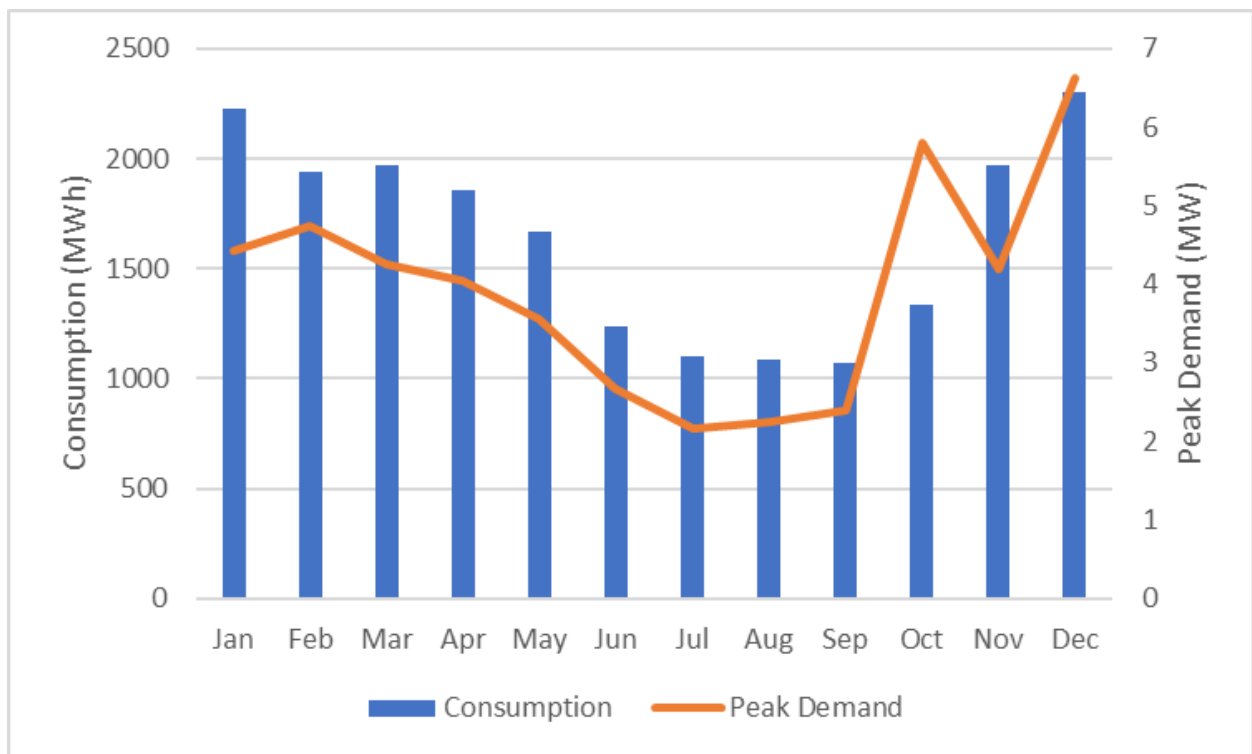


Figure 5. Monthly electricity consumption and peak electricity demand for Neah Bay (2022). Peak demand is the moment in time when there is the highest power draw while consumption is the total monthly use (source: Clallam PUD).

## Future Electricity Demand Scenarios

The ETIPP technical team considered three scenarios of potential future electricity demand to inform energy planning: Business-as-Usual, Low Adoption, and High Adoption (Figure 6). These estimates can provide guidance on whether electricity demand is likely to increase or decrease in the future, and by how much. All scenarios include the projected population growth in Neah Bay and the associated increase in electricity needs. The scenarios vary by the rates of adoption of energy efficiency measures, electric vehicles, and heat pumps. These scenarios were developed in an attempt to capture realistic pathways, rather than theoretical maximum or minimum future demand. Demand was modeled out to 2040, assuming no major future technology changes during that time frame and a linear change in demand.

Several assumptions were made as part of this analysis. Based on information from Tribal staff, the ETIPP technical team estimated the population will increase by approximately 1.5% annually and set the baseline for electric vehicles to five vehicles. The Makah Tribe does not currently have any specific electric vehicle targets, but the Clean Vehicles Program in Washington State has a goal that all new light-duty vehicles sold, purchased, or registered must be electric by 2035.<sup>3</sup> Based on that target and guidance from Tribal staff, the scenario assumes one vehicle per capita that travels an average of 30 miles per day and that a typical electric vehicle traveling 30 miles per day uses 11.81 kWh of electricity (Cantu 2023).

Heat pumps are the most efficient method of providing heating with electricity; by design, heat pumps for space heating also add air conditioning.<sup>4</sup> Shifting to heat pumps from non-electric or less-efficient electric space and water heating to heat pumps supports several Tribal energy goals. Therefore, we evaluated the change in electric demand that stem from different rates of heat pump adoption. These scenarios also assume that buildings without air conditioning or standard air conditioners would shift to heat pumps for cooling. Based on heating fuel data from the U.S. Census Bureau American Community Survey and Washington State heat pump data (American Housing Survey 2021), the following breakdown was estimated for current residential heating and cooling in Neah Bay:

- Residential heat: 15% non-electric, 80% electric resistance (electric furnaces, baseboard heat, wall heaters, radiant heat, or space heaters), and 5% heat pumps
- Residential cooling: 70% none, 25% standard air conditioners, and 5% heat pumps
- Water heating: 15% non-electric, 85% electric resistance, and 0% heat pump.

The PNNL technical team modeled the change in electricity demand between this baseline and the scenarios using the PNNL Facility Energy Decision System modeling tool<sup>5</sup> and typical home values for Neah Bay and the Pacific Northwest region based on Census data (USCB 2021) and the Residential Energy Consumption Survey (EIA 2023). The evaluation of commercial and Tribally owned buildings was informed by an energy audit study conducted in 2019 (Cascadia 2019). Of the 16 buildings audited, 3 had heat pumps, 12 received recommendation to add heat pumps, and 1 was not recommended for a heat pump installation due to resilience needs (e.g., concern that a heat pump, as opposed to a fuel source, would not be able to provide heat during an electricity outage unless there is a backup electricity source).

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<sup>3</sup> For details, see <https://app.leg.wa.gov/wac/default.aspx?cite=173-423&full=true>

<sup>4</sup> For more information on heat pumps, see: <https://www.energy.gov/energysaver/heat-pump-systems>

<sup>5</sup> Tool available at <https://feds.pnnl.gov/>

These buildings were not included in the heat pump analysis because the report did not provide estimates of electric use associated with heat pumps.

Consistent with the community goals, this analysis only considered electric demand and did not include other fuels. While electrifying buildings and vehicles increases electric demand, as electrification increases, the use of other fuels will decrease supporting Tribal environmental goals.

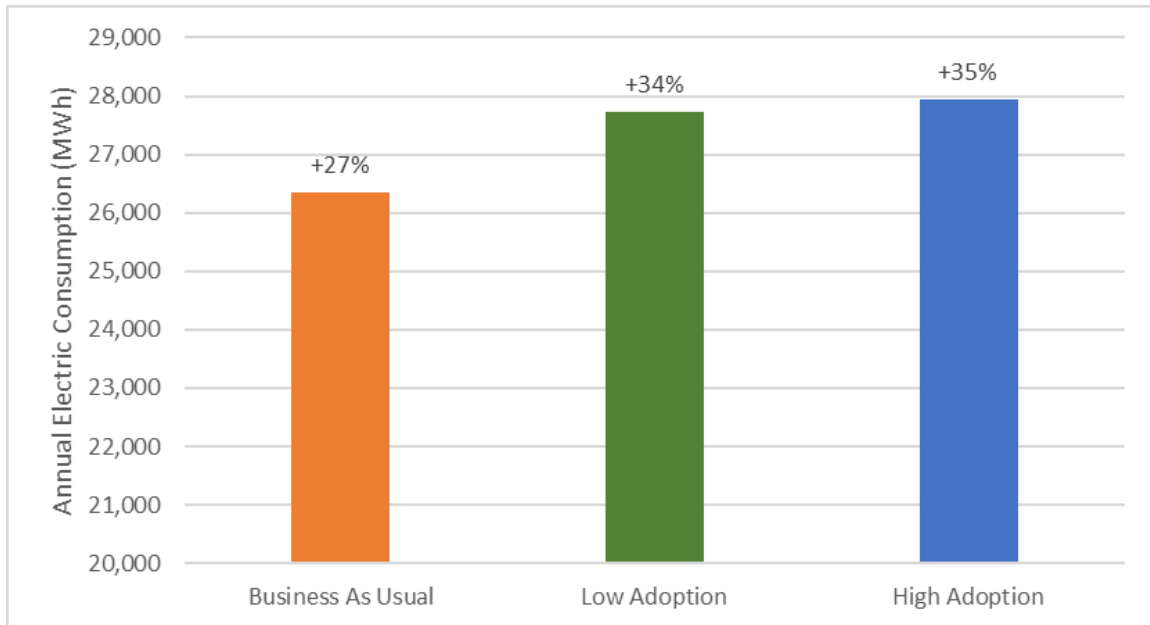


Figure 6. Estimated electric consumption by 2040 for three modeled scenarios

#### Scenario details:

1. Business-as-Usual: population growth
2. Low adoption of electrified technologies and energy efficiency (Low Adoption): population growth, 25% adoption of electric vehicles, 25% adoption of heat pumps for space heating/cooling and water heating, and 8% additional electric efficiency by 2040
3. High adoption of electrified technologies and energy efficiency (High Adoption): population growth, 75% adoption of electric vehicles, 75% adoption of heat pumps for space heating/cooling and water heating, and 14% additional electric efficiency by 2040.

These scenarios predict a 27%–35% increase in electricity use from present day. Figure 6 shows the annual electricity consumption in 2040 for each scenario, and Figure 7 shows the contributions of each component to the 2022 (baseline) load to arrive at overall consumption in the High Adoption scenario.

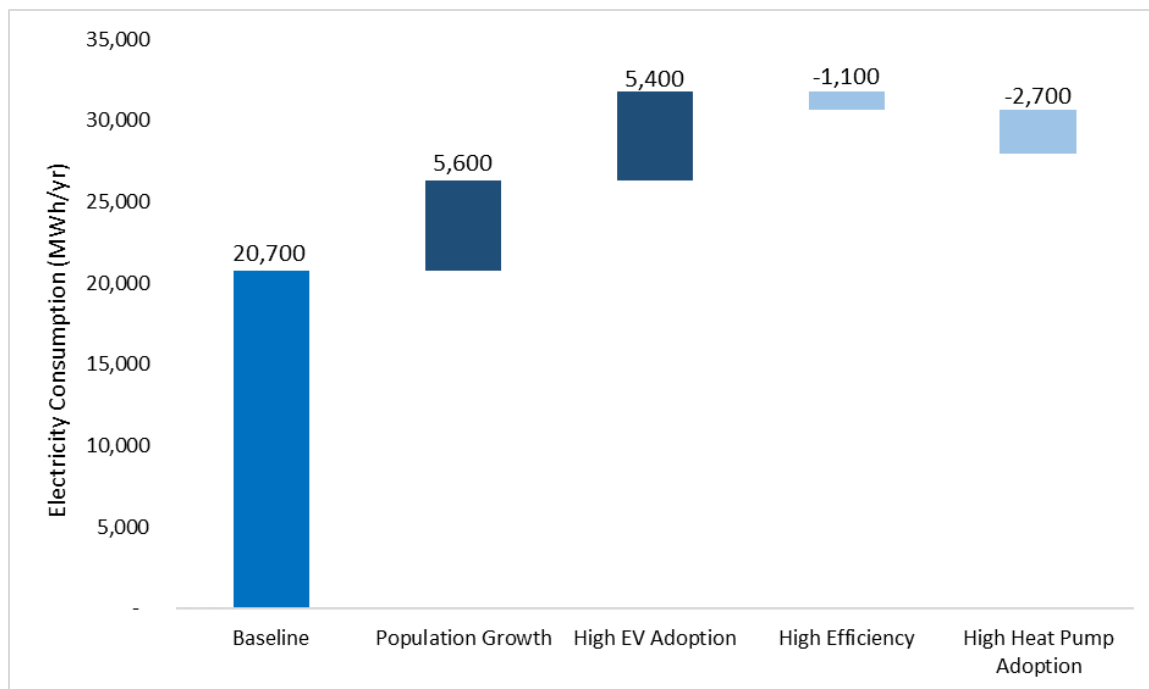


Figure 7. Contribution of population growth and electrification adaptations to future electricity loads by 2040 in Neah Bay under the High Adoption scenario

## Scenarios To Meet a Year of Energy Independence

Meeting the energy vision of independently powering the reservation for one year will require a mix of energy generation and storage. The following scenarios provide examples of generation and storage combinations that could meet the goal. These scenarios are based on the energy needs for the 2040 instantaneous electricity demand for the Business-as-Usual scenario.

### Meeting 100% of Annual Demand with a Ground-Mount Solar + Storage Microgrid + Backup Diesel Generation

Operating as an islanded microgrid for an entire year with ground mount solar would require a 143–180-MW photovoltaic (PV) array, along with a 46–56-MW/547–683-MWh battery and 8–10 MW of backup diesel generation. This PV array, if ground-mounted, would require approximately 429–540 acres of land. If deployed as a single contiguous parcel of land, the solar array could cost approximately \$206–\$259 million. If the array were split into separate arrays, the cost would be higher. The battery would cost approximately \$180–\$220 million.

### Meeting 100% of Annual Demand with a Ground-Mount Solar + Wind + Storage Microgrid + Backup Diesel Generation

Operating as an islanded microgrid for an entire year with ground-mount solar and nine Northern Power Systems (NPS) 100C-21 turbines (100 kW each) would require a 139–174-MW PV array, along with a 44–55-MW/545–681-MWh battery and 8–10 MW of backup diesel generation. This PV array, if ground-mounted, would require approximately 417–522 acres of land. If deployed as a single contiguous parcel

of land, the solar array could cost approximately \$200–\$250 million, or higher, if split into separate arrays. The battery would cost approximately \$173–\$216 million.

## Renewable Energy Resource Assessments

The following section contains descriptions of the energy generation potential for several types of renewable energy technologies. At this time, the Makah Tribe is primarily interested in solar and small-scale land-based wind energy; however, some exploratory work has also been done outside of ETIPP on wave energy and energy generation using biomass. An overview of the work done on those technologies is provided here for a more complete picture of the current potential renewable energy options. While these technologies are highlighted in this plan, the Tribe is not limiting themselves and will explore and complete due diligence on other forms of renewable energy as technologies evolve and options change.

For solar and wind, the PNNL technical team evaluated the energy generation potential at specific sites based upon guidance from the Makah ETIPP team, feedback from Makah staff, energy potential, and construction considerations. The energy generation potential of the evaluated sites is described both as the raw potential energy generation and in the context of what it would contribute toward the year of energy independence scenario. One of the Tribe's energy goals is to prioritize the use of existing infrastructure or already-cleared land for energy projects. Thus, the solar assessment focuses on rooftop PV potential. Specifically, the solar assessment quantifies how much ground-mount PV required for one year of energy independence could be offset by rooftop PV deployments.

### Solar Resource Assessment

#### Introduction to Solar Power

Solar power, also known as solar energy, is a renewable source of energy 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 consist of 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 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. Solar PV systems are designed to generate power for 20–30 years (Wiser et al. 2020). At the end of their 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. In 2017, the Washington State Legislature passed Senate Bill 5939, which requires manufacturers of solar panels to finance the takeback and reuse or recycle all solar PV modules purchased after July 2017 at no cost to the end user, the implementation of which is expected to begin in July 2025.<sup>6</sup>

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<sup>6</sup> See <https://ecology.wa.gov/waste-toxics/reducing-recycling-waste/our-recycling-programs/solar-panels> for status of Washington DOE solar panel recycling

Solar PV is installed at a range of scales to meet different needs, from powering individual homes to entire communities. Residential rooftop PV capacity typically ranges between 5–20 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 over 2 MW, providing power to dozens or hundreds of homes. 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 up to over 1 GW for the largest projects. Figure 8 shows examples of residential, community, and utility-scale PV in Washington State.



Figure 8. Residential solar installation on housing on the Spokane Indian reservation (left), community-scale solar that is part of the Decatur Island Microgrid project (504 kW; middle), and Lund Hill, a utility-scale photovoltaic plant in Klickitat, Washington (194 MW; right). Photo credits from left to right: DOE Office of Indian Energy Policy and Programs 2019, (<https://www.energy.gov/indianenergy/articles/doe-funded-solar-project-helps-spokane-tribe-reduce-homeowners-monthly-energy>), Opalco Energy, (<https://www.opalco.com/save/community-solar/decatour-island-microgrid-project/>), and Iberdrola (<https://www.iberdrola.com/about-us/what-we-do/solar-photovoltaic-energy/lund-hill-photovoltaic-plant>).

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), but can be significantly higher in remote or rural areas. In 2020, the average levelized cost of utility-scale ground-mount PV ranged from \$0.035 to \$0.05 per kilowatt-hour and was \$0.12 per kilowatt-hour for residential PV.<sup>7</sup>

Operations and maintenance for solar PV is relatively simple, especially for fixed-axis systems, because they have no moving parts. Operations and maintenance tasks include periodic cleaning of the modules, vegetation management, system inspection, and corrective maintenance. In Neah Bay, 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, due to the resource's inherent intermittency and variability. As a result, integrating other generation technologies, such as small-scale wind, along with energy storage, can help smooth out these fluctuations in electricity generation.

When it comes to siting solar PV, considerations vary depending on the mount type, be it rooftop, carport, or ground-mount. In general, an ideal site should have a south-facing orientation, 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 take into account, 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 approximately 2–4 lb/ft<sup>2</sup>. Rooftop solar PV typically necessitates around 100 ft<sup>2</sup> per kW<sub>DC</sub> of suitable rooftop space, which is defined as facing west,

<sup>7</sup> See <https://www.energy.gov/eere/solar/sunshot-2030#:~:text=2030%20Goals%20Detailed,contributing%20to%20greater%20energy%20affordability> to see how the cost of solar has declined in recent years and goals to continue to improve the affordability of solar energy.

southwest, south, southeast, or east, not being excessively tilted ( $<60^\circ$ ), not experiencing excessive shade, and having an uninterrupted footprint of at least 100 ft<sup>2</sup>. Considerations for ground-mount solar include factors such as slope, soil type, and ground cover. Ideally, 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. In general, ground mount PV typically requires 5–7 contiguous acres per MW<sub>DC</sub> 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.<sup>8</sup> For communities interested in deploying solar, DOE’s *Solar Power in Your Community* guidebook is a good place to start,<sup>9</sup> as is the *Energy Transitions Playbook*.<sup>10</sup>

### Overview of the Solar Resource in Neah Bay

Neah Bay has a global horizontal irradiance resource that averages 3.2 kWh/m<sup>2</sup>/day. Solar estimates for Neah Bay come from the NREL National Solar Radiation Database (NSRDB), which contains decades of solar radiation data covering the United States and some international locations (Sengupta et al. 2018). 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 9).

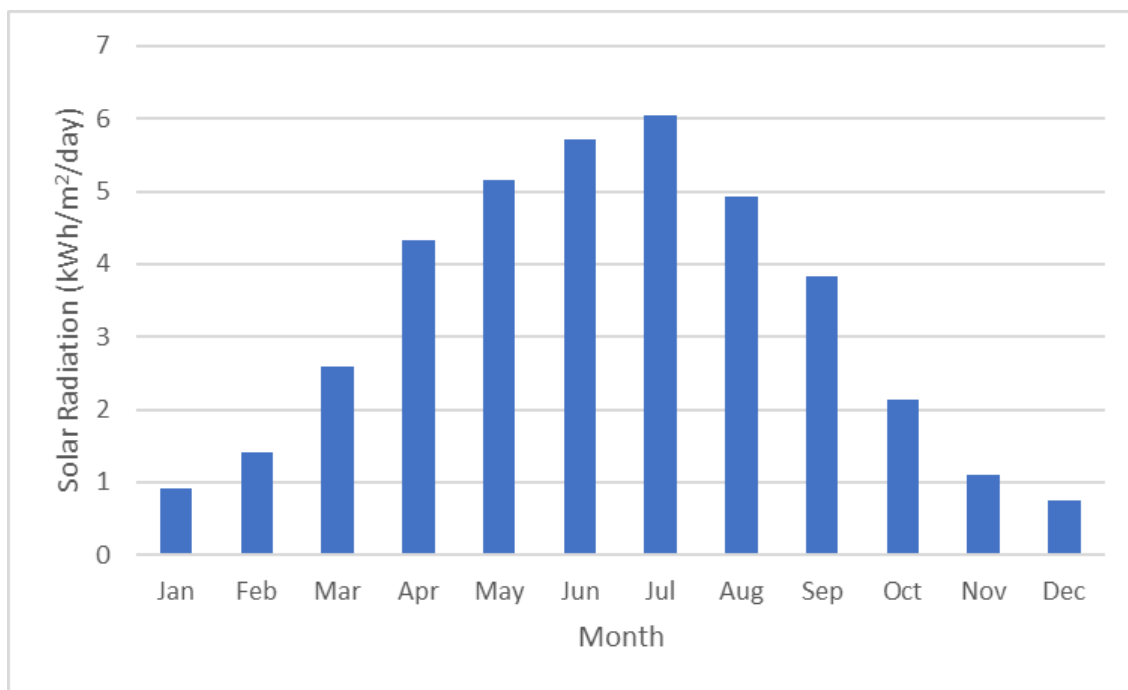


Figure 9. Monthly variation of solar radiation available in Neah Bay (NSRDB)

<sup>8</sup> For more information, see <https://www.energy.gov/eere/solar/solar-rooftop-potential>.

<sup>9</sup> See [https://www.energy.gov/sites/default/files/2023-03/Solar\\_Power\\_in\\_Your\\_Community\\_Guidebook\\_March2023.pdf](https://www.energy.gov/sites/default/files/2023-03/Solar_Power_in_Your_Community_Guidebook_March2023.pdf).

<sup>10</sup> See <https://www.eere.energy.gov/etiplaybook/>.

The NSRDB distills many years of solar radiation data into a single typical meteorological year, 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<sup>11</sup> uses these data to estimate the energy production of user-defined solar PV systems (Dobos 2014).

According to PVWatts, a 100-kW solar PV array facing due south and tilted 30° will generate 105 MWh over a typical year in Neah Bay.

To be consistent with the Makah Tribe's goal of prioritizing the use of existing infrastructure over new land development, the suitability of existing Tribally owned properties and residential rooftops for PV is the focus of this assessment, as opposed to ground-mount solar PV. However, there are some areas that are already cleared that were evaluated for ground-mount solar. It is important to note that this assessment only investigates maximum potential; it does not consider factors such as costs, incentives, permitting, or owner acceptance. The results from this assessment should be interpreted as an upper limit of the amount of PV that could be deployed on Tribally owned properties and residential rooftops.

## Solar on Tribal Properties

An assessment of the technical potential for solar was performed for selected Tribally owned properties, as well as several privately owned properties. The list of properties was compiled through conversations with Tribal staff. Each property was assessed using satellite imagery to estimate available area for solar PV. This assessment made the following assumptions:

- Rooftop:
  - Whole roof available for solar PV.
  - Only included flat, south-, east-, and west-oriented roof areas and assumed orientation was due south, east, or west.
  - Included a small reduction in available rooftop area to account for existing mechanical equipment, maintenance access, sharp changes in roof angle, small outcrops, etc.
  - Did not take into account rooftop age, need for replacement, or repairs that would be needed prior to solar PV installation.
  
- Carport:
  - Assumed carports could be installed over parking stalls.
  - All panels are oriented due south.
  
- Ground mount:
  - Assumed all ground area within specified boundary is available for solar.
  - All panels are oriented due south.
  
- All:
  - Did not exclude shaded areas or include a shading loss factor.

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<sup>11</sup> See <https://pvwatts.nrel.gov/>.

Due to these assumptions, some areas included in the assessment will not be appropriate for solar because of shading, existing mechanical equipment, or areas that cannot fit rectangular panels. As such, the rooftop area estimate should be considered as the upper limit of available area.

Next, NREL’s PVWatts tool was used to estimate the technical potential for PV generation on each property. PVWatts estimates the electricity output of a PV system based on the location, available area, module and type, tilt angle, azimuth, and other user-defined inputs. Table 2 shows the nameplate capacity (maximum rated output) of solar PV for each property included in the analysis, as well as the acreage that the same nameplate capacity of ground-mount PV would occupy.

*Table 2. Nameplate Capacity of Solar PV for Selected Tribal and Privately Owned Buildings in Neah Bay, Washington, and the Equivalent Amount of Ground-Mount PV*

<b>Solar Type</b>	<b>Location</b>	<b>DC System Size (kW)</b>	<b>Equivalent Area of Ground-Mount PV (acres)</b>
Rooftop	Marina	56	0.29
Carport	Marina	59	0.29
Rooftop	Gym and community center	96	0.48
Carport	Gym and community center	264	1.32
Rooftop	MTC –SR Citizen Bldg.	40	0.2
Rooftop	Sophie Trettevick Health Ctr-Wellness	78	0.39
Ground	Sophie Trettevick Health Ctr-Wellness	304	1.52
Rooftop	Forestry	22	0.11
Rooftop	MTC – Ambulance Bldg.	6	0.03
Rooftop	Community Hall	43	0.22
Rooftop	MTC – Public Safety	50	0.25
Rooftop	Early Childhood Development Center	360	1.8
Rooftop	Commercial dock	64	0.32
Rooftop	Business complex	20	0.10
Rooftop	Big Salmon	10	0.05
Rooftop	Filet plant	38	0.19
Rooftop	Roads maintenance	11	0.06
Rooftop	Short-term rental housing	32	0.16
Rooftop	Water treatment plant	11	0.06
Rooftop	Transfer station	68	0.34
Rooftop	Fish hatchery	308	1.54
Rooftop	Lutheran church	40	0.2
Rooftop	Assembly of God church	25	0.13
Rooftop	Presbyterian church	12	0.06

Developing PV on the rooftops and parking lots listed in Table 2 could result in up to 2 MW of nameplate capacity. The same nameplate capacity of ground-mount solar PV would occupy up to 10 acres of land.

## Solar Pathways: Existing and Planned Residential Rooftops

In addition to Tribally owned properties, residential buildings in Neah Bay were also assessed for rooftop PV potential. This assessment utilized existing studies that estimate rooftop solar potential based on satellite and LIDAR data. NREL's Rooftop Solar Photovoltaic Potential in the U.S (Gagnon et al. 2019) was used to estimate maximum potential for rooftop PV based on total residences in the Makah Indian Reservation from the American Community Survey (U.S. Census Bureau 2023). This included assuming an average of 1,500 ft<sup>2</sup> rooftop area per residence in Neah Bay, as estimated by Tribal staff involved in the project. This analysis did not take into account rooftop age, need for replacement, or repairs prior to solar PV installation.

Based on this analysis, developing all reasonable residential rooftops in Neah Bay could result in up to 2.8 MW of rooftop solar PV nameplate capacity and displace up to 14 acres of ground-mount solar PV.

## Solar Summary

Despite the cloudy reputation of the Olympic Peninsula, solar energy is a viable option, albeit one with high seasonal variability. The total maximum potential rooftop, ground-mount, and carport PV in Neah Bay is 4.8 MW of nameplate capacity, 2 MW from the selected Tribal and privately-owned buildings, and 2.8 MW from residential rooftops.

# Wind Resource Assessment

## Introduction to Wind Energy

Wind energy is the kinetic energy of the wind converted into electrical energy using a wind turbine with a rotor and an electrical generator. Wind turbines vary in size (turbine generator heights ranging from 15 m to more than 100 m and blade lengths ranging from 1.5 m to 60 m or more) and generating capacity (less than 1 kW to greater than 10 MW) and are therefore customizable to the energy needs of homeowners, businesses, communities, and utilities (Figure 10). Utility-scale wind energy tends to involve wind farms (onshore or offshore) composed of many turbines, and the energy generated can be transported long distances to centers of demand. Distributed wind energy can involve one or more wind turbines of any size that are sited near the infrastructure they supply energy to. Distributed wind customers include remote off-grid cabins, residences, farms, industrial facilities, and local utilities. Both utility-scale and distributed wind energy projects depend on a suitable and reliable wind resource; distributed wind has the additional need of optimizing the locations of turbines so that they are close to where the energy is needed, but far enough away from obstacles that reduce the available wind resource, such as buildings and trees. Modern wind turbines are designed to last for around 20–30 years. At the end of a turbine's life cycle, options exist to either repower the turbine (put new turbine equipment atop existing towers) or

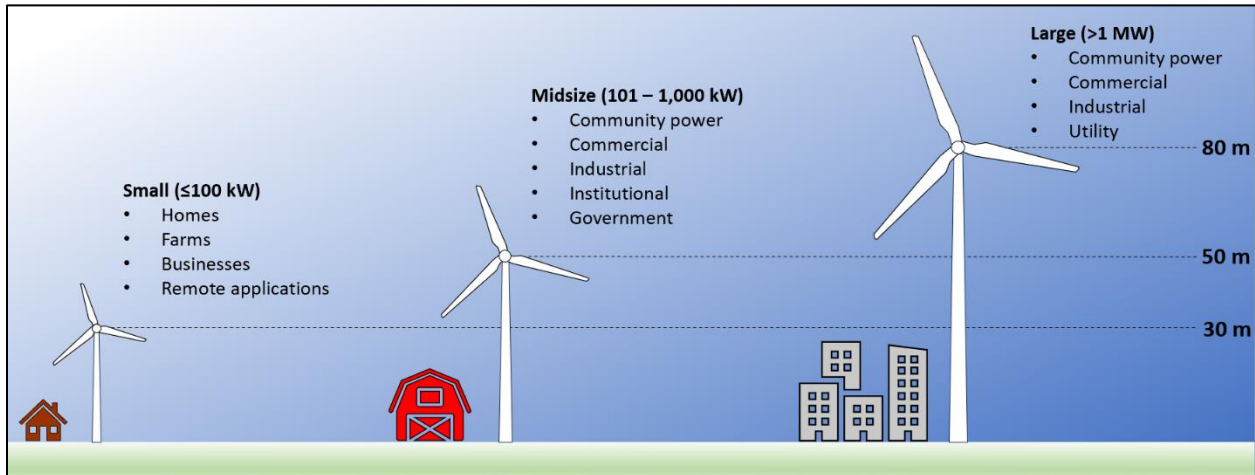


Figure 10. Scales and applications of distributed wind (Lindsay Sheridan, PNNL)

decommission (remove) the turbine. Various degrees of removal (and therefore associated costs) are available for wind turbines, such as whether the foundation is left or removed and backfilled with clean dirt. Turbine component recycling is in a nascent stage, though widespread research and efforts are in place to advance recycling capabilities.

## Overview of the Wind Resource in Neah Bay

The wind resource in Neah Bay and surrounding Makah lands is highly variable due to complex terrain and coastal proximity (Figure 11). The fastest winds occur atop the high terrain to the south and west of Neah Bay and along the northwestern and western coastlines of Cape Flattery. Wind speeds are often assessed at 50 m above ground when considering wind energy because that height is a midpoint across the range of common distributed wind turbine hub heights, which is the distance from ground to the generator in the center of the turbine blades. Three high-resolution wind models (Global Wind Atlas<sup>12</sup> [Davis et al. 2023]; WIND Toolkit<sup>13</sup> [Draxl et al. 2015a; Draxl et al. 2015b; King et al. 2014]; and Wind Report<sup>14</sup> 2023) provide estimates of the wind resource in Neah Bay and the surrounding Makah lands, given in meters per second (m/s). Along the Cape Flattery coastline, annual average wind speeds at 50 m above ground level could reach between 6.7 m/s and 7.4 m/s. Atop the high terrain to the west of Neah Bay, the fastest annual average wind speeds at 50 m are estimated at 6.6 m/s to 8.4 m/s. South of Neah Bay, the fastest annual average wind speeds at 50 m are found in the high terrain and range between 6.0 m/s and 8.0 m/s. These wind speed ranges exceed the rule-of-thumb threshold (5 m/s) for economically feasible wind development for a hub height of 50 m, suggesting that areas on Makah lands include suitable places for exploring land-based, small-scale distributed wind power. It is important to note that the locations of the highest wind resource are located at a distance from the major Neah Bay load center, making transmission an important consideration. Conversely, the valleys south of Neah Bay are estimated to have

<sup>12</sup> Access the Global Wind Atlas here: <https://globalwindatlas.info/en>

<sup>13</sup> Information about the WIND toolkit can be found here: <https://www.nrel.gov/hpc/wind-dataset.html>

<sup>14</sup> Access Wind Report here: <https://www.newrootsenergy.com/wind-report-modeling-tools>

annual average wind speeds at 50 m as low as 2.9 m/s. Given the diversity in the wind resource and land cover (trees, clearings, buildings, etc.) at Neah Bay and the surrounding Makah lands, care must be taken to appropriately site wind energy deployment.

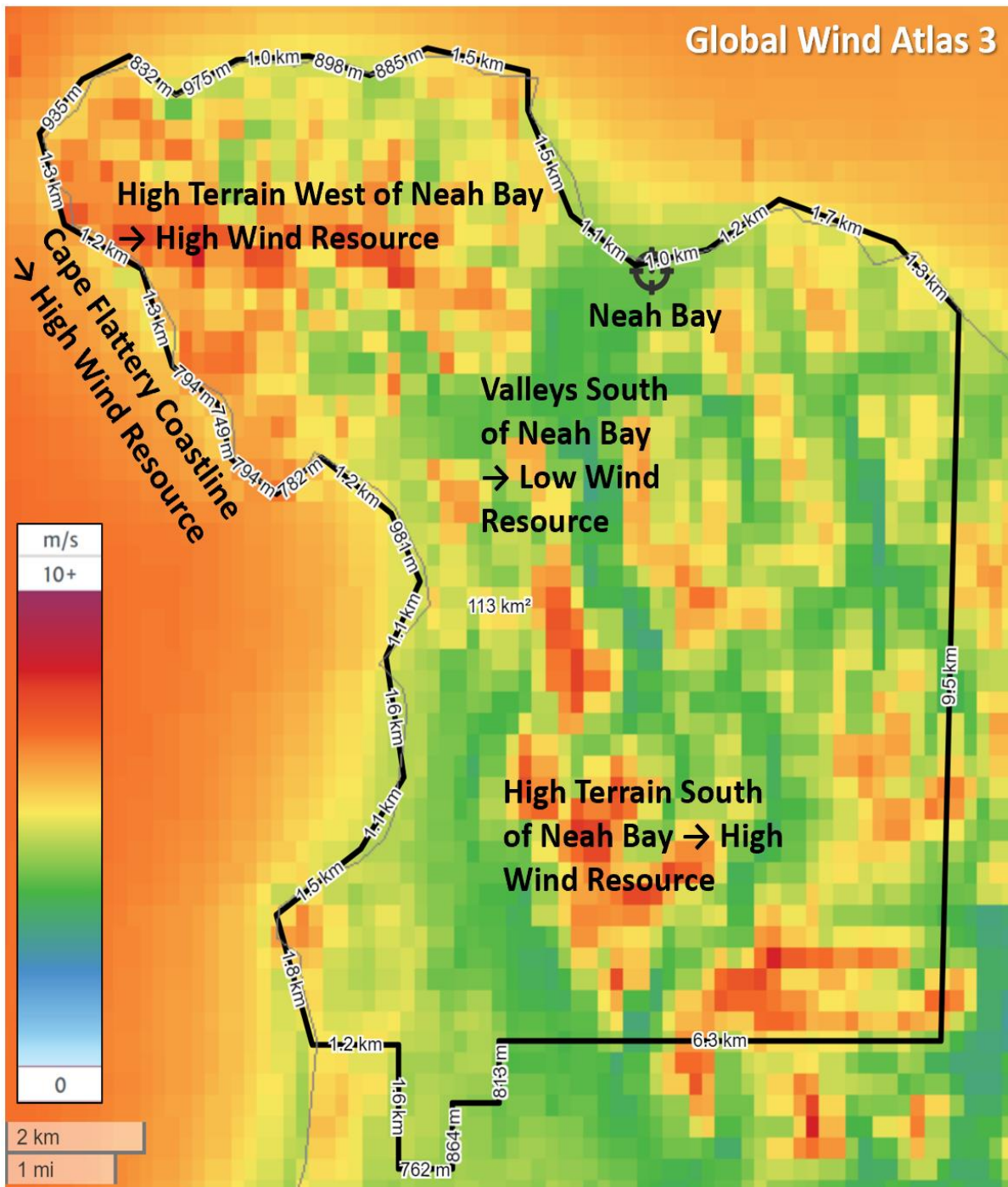


Figure 11. Wind speed at 50 m above ground level in Neah Bay and the surrounding Makah lands

## Wind Resource Assessment and Energy Potential for Specific Neah Bay Locations Turbine Options

Discussions with the Makah ETIPP team indicated interest in a small wind energy project (involving turbines with a capacity of 100 kW or less) dedicated to offsetting the energy of a specific load, similar to a project in Maui County, Hawaii, that utilizes three 10-kW wind turbines to power 66%–90% of their landfill and recycling facility’s annual energy needs.<sup>15,16</sup> Therefore, three commercially available small wind turbine models were assessed in various locations for their energy generation potential: the Bergey Windpower Excel 15 (15 kW), the Eocycle EOX S-16 (25 kW), and the NPS 100C-28 (100 kW) (Table 3). All three turbine models are capable of being mounted on tilt-up towers, which allow the turbine to be lowered in advance of extreme weather, such as hurricanes and typhoons. While those types of storms are not a problem on the Washington coast, the coast often experiences high winds in the winter and in lower elevations winds can be expected to hit 90 to 100 mph once every 100 years. A data collection site on a well exposed ridge at roughly 2,000 feet near the ocean has recorded winds in excess of 100 m.p.h. almost every winter (WRCC, ND), making the capability to lower an important quality for any turbine installed around Neah Bay. The following wind resource assessments consider the typical turbine hub heights for both standard and tilt-up towers to allow for comparison of a variety of options. Several of the tilt-up towers are at lower heights (and therefore lower wind resource since wind speeds increase with height) than the standard tower offerings, which produces a trade-off for consideration between the damage prevention capabilities of tilt-up turbines and lower anticipated energy generation.

Table 3. Specifications for the Small Wind Turbines Evaluated for Makah

<b>Manufacturer/Model</b>	<b>Bergey Windpower Excel 15</b>	<b>Eocycle EOX S-16</b>	<b>NPS 100C-21</b>
Nameplate Capacity	15 kW	25 kW	100 kW
Typical Hub Height	37 m	24 m	37 m
Tilt-Up Tower Hub Height	30 m	24 m	23 m
Rotor Diameter	10 m	16 m	21 m
Maximum Design Wind Speed	60 m/s	52.5 m/s	59.6 m/s
Design Lifetime	30 years	30 years	20 years

### Priority Sites for Potential Wind Deployment

Based on initial assessments, the most promising site for wind deployment on Makah lands is the clearing above the Wellness Center (48.357759, -124.58037). This location is optimal for a variety of reasons, including good wind resource, distant obstacles, and proximity to transmission infrastructure and facilities

<sup>15</sup> <https://www.mauinews.com/news/local-news/2015/01/wind-turbines-to-generate-power-savings-at-dump/>

<sup>16</sup> <https://www.pnnl.gov/distributed-wind/market-report/data>

that could use the energy. Initial discussions with the Makah ETIPP team prompted investigations into three additional sites, one along the Waatch River and two elevated clearings near the west coast of the reservation. These options were ultimately deemed suboptimal due to wildlife concerns, high wind concerns, and the proximity of trees and wetlands that would make finding feasible wind deployment locations challenging. Wind resource and siting analysis regarding these sites is provided in Appendix A.

### Makah Wellness Center Wind Potential

Siting turbines requires taking into account a number of factors related to optimizing the energy generation potential and minimizing impacts on people and the environment. The predominant wind directions above the Wellness Center are from the west and west-southwest, with a secondary component from the southeast (Figure 12). The predominant wind directions complement wind turbine deployment along the access road above the Wellness Center, which is oriented north-northwest to south-southeast and follows the highest terrain in the clearing.

The rotor diameter is the diameter of the circular area swept by the wind turbine blades and the setback distance of a wind turbine is how far the turbine tower is distanced from nearby structures. PNNL recommends a setback of at least the sum of half the rotor diameter plus the hub height in all directions in order to: (1) avoid interference with neighbors/property lines, and (2) allow for enough space to raise and lower the tower for maintenance or extreme weather should a tilt-up tower be selected. To minimize the impact of turbulence generated by obstacles such as buildings and trees (which decrease the available wind resource), PNNL recommends that the turbine hub height be at least 10 m above the height of any obstacles within a 150-m radius.

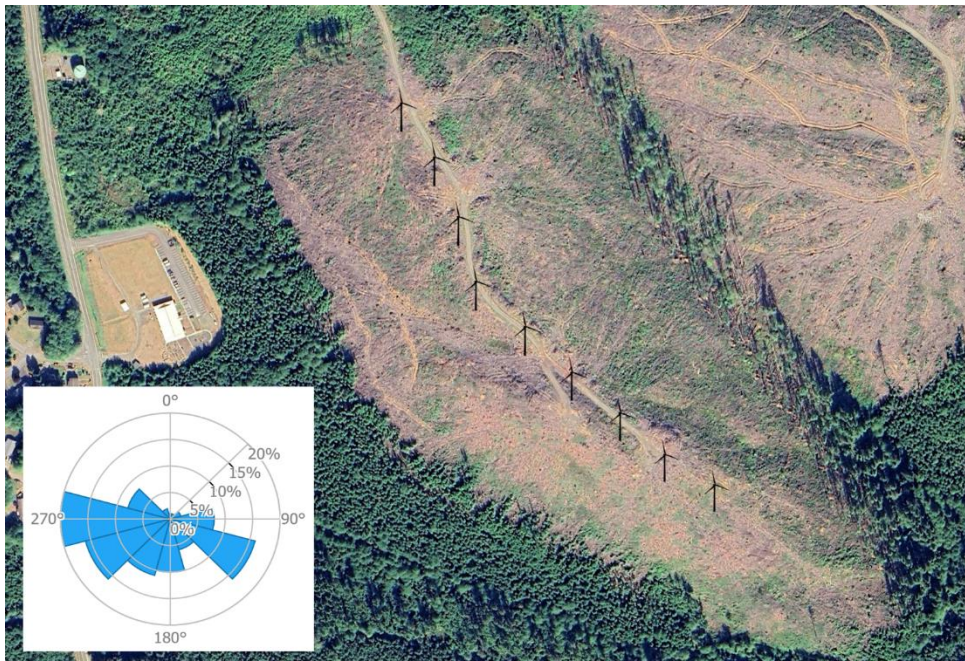


Figure 12. Potential turbine layout for NPS 100C-21 turbines above the Wellness Center and wind rose depicting predominant wind directions (Global Wind Atlas; Davis et al. 2023)

To minimize the impact of turbulence generated by upwind turbines, this analysis employs a spacing of eight rotor diameters between wind turbines in lines parallel to the predominant wind direction and three rotor diameters between wind turbines in lines perpendicular to the predominant wind direction. Additionally, based on the Makah Tribe’s values, turbine layouts are optimized for the highest terrain in the priority sites with a focus on already-disturbed land. Wetland areas are avoided in the turbine layouts due to their significance for wildlife populations and the structural expense involved for wind deployment on unstable ground.

Using the rotor diameters and typical turbine hub heights for each turbine model (Table 3), we determined the maximum quantity of each model of wind turbine that could be deployed along the access road above the Wellness Center (Table 4). Figure 12 provides a visual layout using the turbine model with the largest spacing requirement, the NPS 100C-21.

*Table 4. Location and Quantity of Turbines That Could Be Deployed Using a Three-Rotor Diameter Spacing Perpendicular to the Predominant Wind Direction*

<b>Site</b>	<b>Coordinates</b>	<b>Excel 15</b>	<b>EOX S-16</b>	<b>NPS 100C-21</b>
Above Makah Wellness Center	48.357759, -124.58037	17 turbines	11 turbines	9 turbines

### Loss Assumptions

Along with properly siting a small wind project to optimize the available wind resource and distance to the load it will power, additional factors must be considered when estimating wind energy production. Table 5 provides a list of factors that lead to wind turbine power production loss along with the typical ranges experienced by wind projects and the assumptions made for Neah Bay. PNNL assumed a total loss value of 19% for any potential Neah Bay wind projects. This loss value seems large when compared with the loss assumptions employed by a variety of small wind generation estimation tools (typically ~10%); however, recent comparisons of tool estimates with actual small wind turbine production showed that the tools tended to overestimate actual energy production, sometimes strongly, which urges a more cautious approach (Sheridan et al. 2022).

Table 5. Typical Wind Energy Project Losses and Assumptions Used for the Neah Bay Wind Analysis

Loss Category	Typical Range	Notes	Neah Bay Assumption
Availability	4%–6%	Downtime for maintenance (planned or unplanned)	5% (average)
Wake (Array)	0–15%	Dependent on quantity of turbines and arrangement of array relative to predominant wind directions	1% (wakes accounted for in area recommendations)
Turbine Performance	1%–3%	Dependent on state of technology	2% (average)
Electrical	2%–3%	Line and transformer losses	3% (average)
Environmental	1%–10%	Weather impacts (icing, pausing during extreme winds); downtime due to wildlife migration	7% (higher, due to local weather and wildlife conditions)
Curtailement	0–3%	When generation exceeds demand; potentially necessary for grid balancing	1% (lower-end expectations)
<b>Total</b>	<b>12%–25%</b>		<b>19%</b>

### Wind Resource and Energy Estimates

The wind energy estimates in Table 6 show that a single small wind turbine will not offset a significant amount of the total Makah demand (<2%); however, wind energy may be able to provide a good portion of energy needed for a specific local load, such as a community building.

Table 6. Annual Average Wind Speed, Estimated Annual Energy Generation, and Percentage of Makah Total Energy Demand (19,578 MWh) for a Single Wind Turbine Deployed Above the Makah Wellness Center

Turbine	Hub Height (m)	Wind Resource Year	Annual Average Wind Speed (m/s)	Estimated Annual Energy Generation (MWh)	Percentage of Makah Demand a Single Turbine Would Meet
Excel 15	30 (tilt-up)	Average	5.4–5.9	28–34	0.1–0.2
		Low	4.9–5.4	23–29	0.1
		High	5.8–6.3	32–39	0.2
Excel 15	37 (standard)	Average	5.6–6.2	31–37	0.2
		Low	5.2–5.7	26–32	0.1–0.2
		High	6.0–6.6	36–43	0.2
EOX S-16	24 (tilt-up/standard)	Average	5.1–5.6	56–68	0.3
		Low	4.7–5.2	49–60	0.2–0.3
		High	5.5–6.0	65–77	0.3–0.4
NPS 100C-21	23 (tilt-up)	Average	5.1–5.6	120–149	0.6–0.8
		Low	4.7–5.1	99–126	0.5–0.6
		High	5.4–6.0	141–173	0.7–0.9
NPS 100C-21	37 (standard)	Average	5.6–6.2	152–186	0.8–0.9
		Low	5.2–5.7	129–159	0.7–0.8
		High	6.0–6.6	177–213	0.9–1.1

Wind energy generation potential is strongly influenced by the time of year. Around Neah Bay, wind speeds are fastest in the winter and slowest in the summer, which leads to a similar pattern for wind energy generation estimates above the Wellness Center (Figure 13).

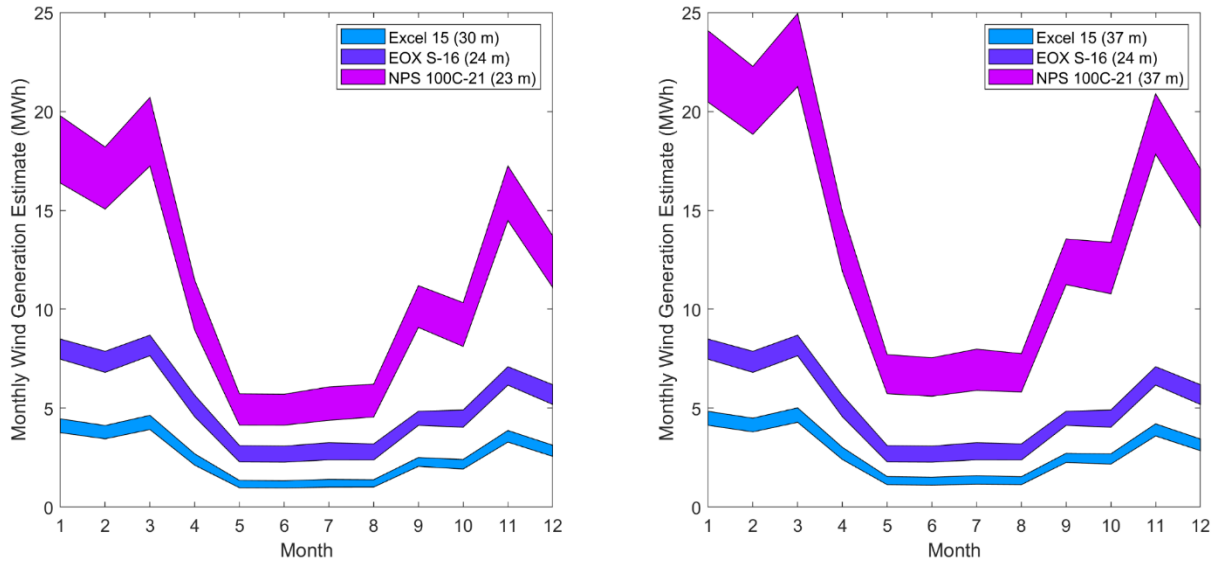


Figure 13. Monthly wind generation estimates for a single turbine above the Makah Wellness Center on a tilt-up tower (left) and a standard tower (right) for an average wind resource year

While wind energy using small wind turbines would not offset a significant amount of the Neah Bay community energy demand, it could be conveniently located and impactful for offsetting some of the energy used by the Wellness Center. The clearing above the Wellness Center has space for 17 Bergey Excel 15 turbines, 11 Eocycle EOX S-16 turbines, or 9 NPS 100C-21 turbines, which have the potential to generate up to 476–629 MWh, 616–748 MWh, or 1,080–1,674 MWh, respectively, depending on the tower selection. It is important to recall that wind is an intermittent resource, so grid-connection and/or energy storage systems should be considered alongside plans involving wind turbines to provide energy reliability.

### Environmental Considerations

Wind turbines can impact birds, bats, and other migratory species through collision and habitat disruption, though their impacts on avian species are small relative to other sources. Loss et al. (2015) categorized avian mortality in the United States and found that cause-specific deaths range from billions (cat predation) to hundreds of millions (building and automobile collisions), to tens of millions (power line collisions), to hundreds of thousands (wind turbines). Proper siting of wind projects includes taking into account the habitats and migratory paths of birds and bats.

Small wind turbines, such as the one considered in this plan, are less likely to cause wildlife impacts than large turbines. A study performed by Morris and Stumpe (2015) found no turbine-related avian deaths during a 2007–2012 study on small wind turbines in Maine. Distributed wind projects are also more likely to be sited in already disturbed or developed areas. The *U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines* (USFWS 2012) provides a tiered approach to assessing potential wildlife impacts and does not expect distributed wind projects to need to go beyond preliminary site evaluations.

## Human Environment Considerations

In addition to ecological considerations, wind turbines can influence the environment that people experience through effects on sound, shadows, and radar. However, these can be mitigated through planning and design, as described below.

### Sound Emissions

Modern wind turbines have features capable of controlling sound emissions. Sound emissions can also be mitigated with proper distances between turbines and nearby residences (Figure 14). The three small wind turbines evaluated in Table 3 have sound emissions ratings similar to the hum of a refrigerator (30–50 db(A) at the source) at proper distances. The Bergey Excel 15 is rated at 48.5 db(A) at a 60-m distance (Bergey Windpower 2023). The Eocycle EOX S-16 is rated at 47.7 db(A) at a 60-m distance (Eocycle 2023). The NPS 100C-28 is rated at approximately 50 db(A) at a 50-m distance (Northern Power Systems 2023). Thus, we recommend siting the turbines >60 m from nearby residences or facilities used by the community.

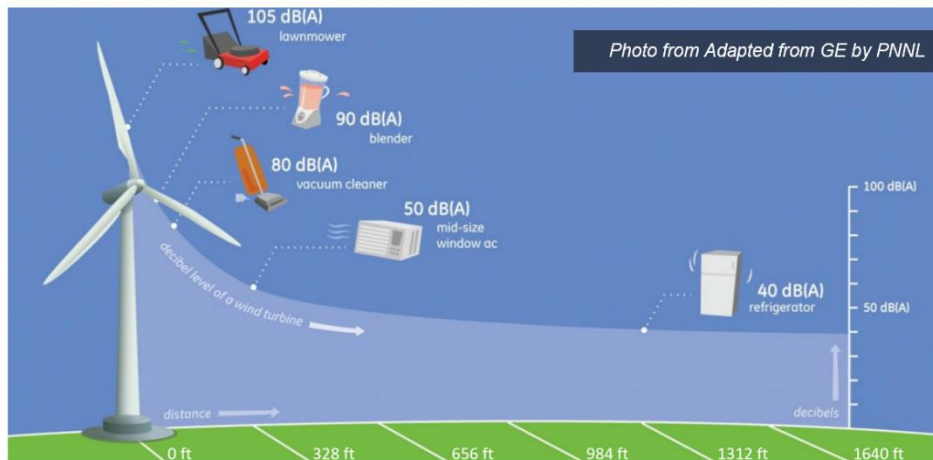


Figure 14. Sound impacts of wind energy

### Shadow Flicker

Shadow flicker occurs when rotating wind turbine blades cast shadows on the ground or nearby structures, usually at sunrise and sunset. As computer models can accurately predict when, where, and to what degree shadow flicker will occur, concerns can be mitigated with proper setback distances between turbines and nearby residences. Shadow flicker assessment is typically part of a wind project design phase.

### Radar Impacts

The Federal Aviation Administration operates an Air Route Surveillance Radar (ARSR-4 3D) at the former Makah Air Force Station (Bradsher 2020). Karlson et al. (2014) and Colburn et al. (2020) found that existing and proposed utility-scale wind farms would impact the data accuracy from an ARSR-4 3D because the fast-moving blades of the wind turbines appear in scans despite clutter mitigation filters.

Colburn et al. (2020) noted that turbines sited further away from the radar only had the tips of the blade scanned, which had less of an impact on the accuracy of airplane height detection.

These findings further support the inclination for small wind turbine deployment on Makah land instead of taller turbines with larger blades. For turbines with tip heights exceeding 60 m, wind energy developers must file a Notice of Construction with the FAA in order to preserve navigable airspace and radar and military compatibility. None of the turbines in Table 3 have tip heights that exceed 60 m.

## Cost Considerations

The average installed cost for new small wind turbines (<100 kW capacity) between 2020 and 2022 ranged from \$4,000/kW to nearly \$8,000/kW (Orrell et al. 2023). The average installed cost includes equipment purchase, installation, foundation, permitting, zoning, transportation, taxes, inspection, engineering and design, and financing. Operations and maintenance costs for small wind turbines are ~\$35/kW/year (Orrell et al. 2023).

# Marine Resource Assessment

## Introduction to Marine Energy

Marine energy is an emerging method for generating renewable energy from the ocean. Marine energy is typically divided into two categories, tidal and wave energy, but can also refer to generating energy from salinity or thermal changes in the ocean. Wave energy devices capture motion of waves, such as surging or up and down motions. Wave energy converters (WEC) still have many different archetypes, and the industry does not yet have consensus on which devices are ideal for different locations. Tidal energy captures the energy of moving water as the tide rises and pushes water from one place to another. These devices often look like wind turbines underwater but can vary in the number of blades.

## What To Consider When Evaluating Marine Energy Options

Both wave and tidal energy require certain ocean conditions to be considered viable options, so the first step in evaluating marine energy options is to evaluate the tidal current speeds and wave energy generation potential to determine what type of marine energy may be feasible and where. Viable areas for tidal energy typically have average current speeds greater than 1 m/s, and suitable areas for wave power have greater than 30 kW/m in average wave power (or the average amount of kinetic energy contained in a location's ocean waves per meter of its crest length). There are more factors that go into determining appropriate areas for wave energy than tidal energy (e.g., wave period [the time in seconds it takes for a wave to pass from crest to crest], size of the wave energy converter, proximity to shoreline) but it is common to use a location's *significant wave height* (or the mean of the largest third of waves passing through a location) as a basic approximation for wave energy potential. The following significant wave heights will roughly translate to these levels of energy generation: 0–0.5 m= very low; 0.25–1 m= low; 0.75–2 m= moderate; 1.5–3 m= high; > 2.5 m= very high. Marine energy is still an emerging field, and sometimes the design can be customized or chosen based on the preferences of the entity deploying a device. For example, the Makah Tribe may be interested in choosing a device based on environmental impacts by evaluating if and how different devices interact with treaty-reserved resources or cultural

practices. The following sections describe a few of the ways that marine energy devices can vary and potential impacts of those variations.

### Mooring Considerations

Marine energy devices can be connected to the seafloor in a variety of methods, including with mooring lines, gravity-based foundations, or pilings. Mooring lines are particularly variable, in that device design varies in the number of mooring lines, as well as how taut the lines are, which influences the total footprint of the device mooring. If considering a design that is anchored via mooring lines, the full footprint of the mooring lines may impede other ocean activity, such as fishing, and the full footprint may act as a de facto marine protected area. Gravity-based foundations are heavy bases that support the weight of the device, plus the dynamic forces on the device from the moving water; these foundations are more commonly used for tidal turbines. Gravity-based foundations have a smaller footprint in the water than mooring lines, but may have other environmental impacts, such as changing the habitat in the surrounding area or scouring around the bottom of the foundation; fish also may reef or aggregate near the base. Pilings are connected to the bottom by pile-driving or screwing into the sea floor. These require less seafloor area but potentially require more specialized equipment and often have environmental consequences in the construction phase, such as loud noises.

### Installation, Operations, and Maintenance Considerations

Marine energy devices have different support needs over the course of their deployment and operation. A factor in choosing the type of device may include evaluating whether a marine energy device can be installed or maintained with existing maritime infrastructure. This may include limits imposed by boats or cranes that might be able to assist in pulling the device in and out of the water. A smaller system or an array of smaller systems (as opposed to one large system) is likely to be more manageable by local expertise. Maintenance may include activities such as removing the device from the water to clean for biofouling or replace worn-out parts.

### Depth Considerations

Tidal and wave generators can be located at various depths in the water column. Both wave and tidal energy resources are typically most energetic at the surface, but the devices are not always located at the surface. This can be for practical reasons, such as breaking waves and changing pressure differences at the surface being more difficult to engineer around. Societal or environmental reasons may drive device placement; being able to see the device from the surface may be less desirable for the Tribe, so understanding what the device looks like from the surface could be a factor when choosing between devices. Other trade-offs include that a device with less visibility on the surface might be more likely to be accidentally hit by a boat, but a device that is on or nearer to the surface may be easier to access for maintenance. Additionally, species of interest may typically be located at a specific depth, which could be avoided by choosing one design over another.

## Overview of Tidal Energy Resource

Some tidal energy resources exist near Neah Bay. As the tide enters and exits the Strait of Juan de Fuca, currents develop at Cape Flattery. Existing models (Yang et al. 2021) show that there may be areas that have potential for tidal energy, but there are no areas that exceed an average of 1 m/s based on the modeled work, which has resolution on the order of 50 m for coastal areas like Cape Flattery (Figure 15). Because tidal energy development is typically only viable when average current speeds are greater than 1 m/s, tidal energy is unlikely to be a significant contributor to Makah's energy profile in the near future. However, models with higher resolution or actual field tests may reveal more precise and smaller locations near Cape Flattery with faster average speeds that could be explored in the future.

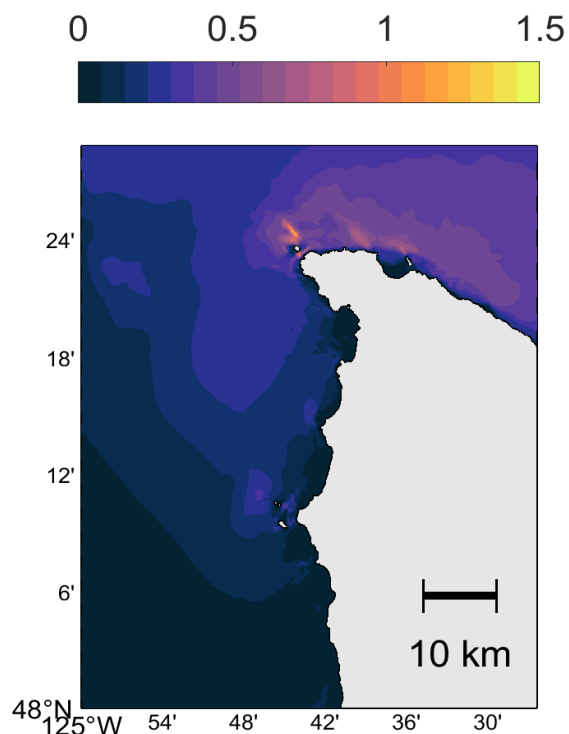


Figure 15. Average tidal current speeds (m/s) near the Makah reservation

## Overview of Wave Energy

Wave energy potential is stronger and more feasible in Neah Bay than tidal energy, but wave energy conversion is also an emerging technology. The most likely options for pursuing a wave energy converter in the near future would be demonstration projects, which would benefit from significant outside funding if they are to be a cost-effective method of energy generation.

## Wave Energy History and Other Related Work

The Makah Tribe has investigated wave energy several times as far back as 2001. The first project was a partnership with Finavera Renewables to deploy four of their 250-kW “Aquabuys” off the coast of Hobuck Beach. The facilities for taking in the generated power would have been located on Hobuck Beach where there is nearby transmission. This project received a 5-year license for a pilot project from the Federal Energy Regulatory Commission (FERC).<sup>17</sup> The project included plans for monitoring the environmental impact of the device, with stipulations that the license and permits could be revoked if significant local environmental impacts were observed. Construction never began on the project, and it was officially canceled in 2009, with concerns about economic feasibility.

In 2021–22, a research study was conducted to clarify how the Tribe may consider using its wave energy resources to address Tribal priorities relating to emergency preparedness, environmental change, and freshwater shortages. The technical report describing this work (*Exploring Wave Energy to Support the*

<sup>17</sup> A description of the project, environmental assessments, and technical device information are available here: <https://tethys.pnnl.gov/project-sites/makah-bay-offshore-wave-pilot-project>

*Sovereign Interests of the Makah Tribe*) can be obtained with permission from the Makah Tribe. It includes basic computational models that assess wave-powered desalination potential in Neah Bay in comparison to the Tribe’s historical freshwater production. This report also includes detailed background on wave energy conversion technology and discusses Makah-based applications for wave energy in Neah Bay in comparison to alternative options. Further work from qualified personnel (e.g., fishing, cultural areas) is needed to fully evaluate siting for a wave energy installation such as the ones evaluated in this work. However, for analytical purposes, the report assessed four representative locations: Waadah Island, Cape Flattery, Breakwater, and Hobuck Beach, based on wave energy density and proximity to Tribal infrastructure.

In 2023, PNNL completed a study to simulate brine discharge from wave-powered desalination (a byproduct of reverse osmosis desalination) at the same four locations, with the intent of building on the previous work (Wang et al. 2023). The study included calculations for the amount of discharge produced by one or multiple wave energy converters at each location, then where the discharge would move over time with the discharge being released at the surface of the ocean. The model showed that there is rapid flushing from the tidal changes, and many of the scenarios show the change in salinity as less than 0.01 ppt. Hobuck Beach has less dilution (and remains saltier from the discharge) than the site at Cape Flattery, likely due to the stronger tidal flows at Cape Flattery.

### Wave Energy Generation Potential

While wave energy is an emerging technology, there is significant potential near Neah Bay. This analysis shows the approximate potential for differently sized devices to generate power. All the previous project work highlighted the region off of Hobuck Beach as the area with the most wave energy potential near the Makah reservation, so this analysis focuses on a site approximately one mile from the beach. Sites farther from the coast have higher power (Figure 16), but also would present higher costs for transmission, which can cost millions of dollars per mile for underwater lines.

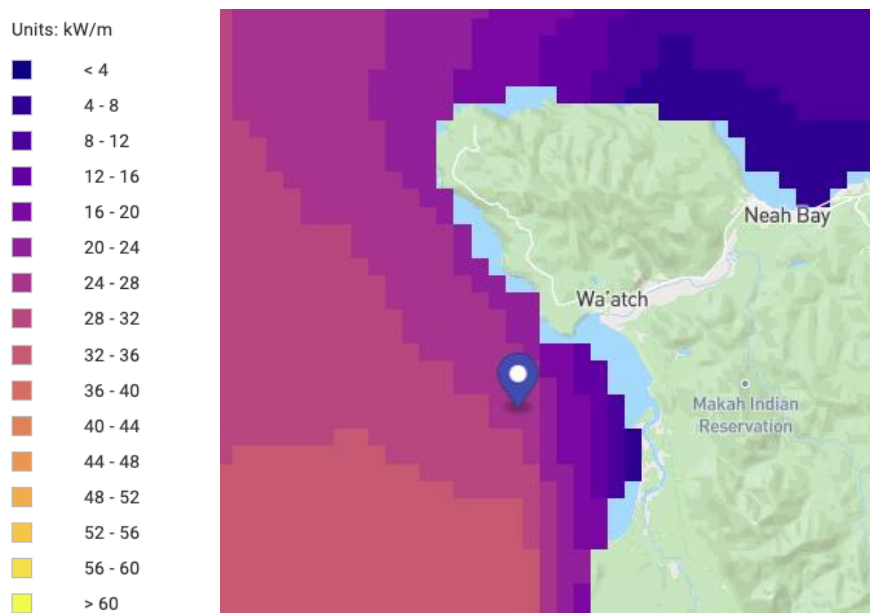


Figure 16. Annual average omnidirectional wave power (kW/m) near the Makah reservation (NREL Marine Energy Atlas)

Generally, there is higher energy potential in the winter months, which is complementary to both power needs and other resources, such as solar, which may be unavailable in the wintertime (Figure 17).

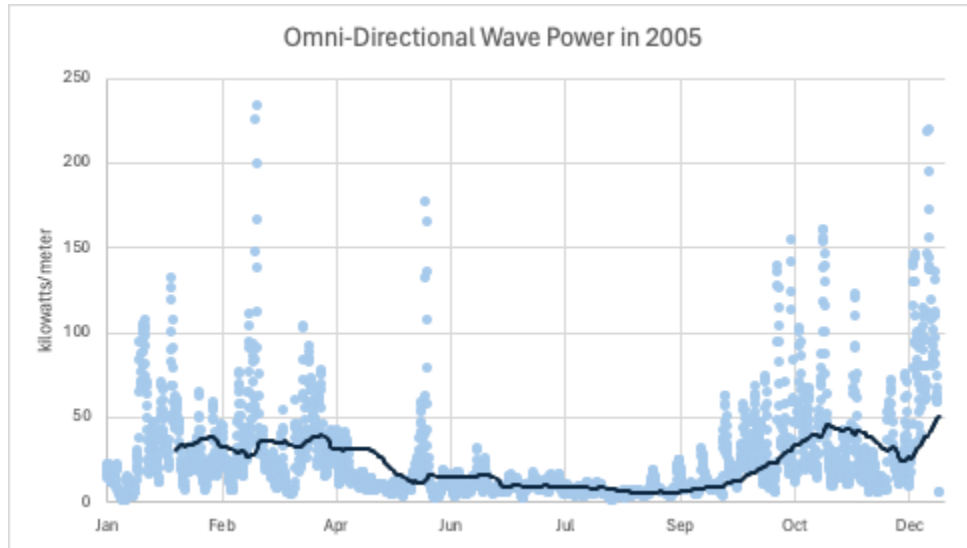


Figure 17. Example of wave power availability at one location off Hobuck Beach with 180-minute intervals (light blue) and time averaged (dark blue). 2005 is used as a representative year.

## Wave Energy Next Steps

Significant outside funds will likely be needed to pursue wave energy. To be ready for private funding or federal grant opportunities, the Tribe could internally decide the amount of power they would want for a potential demonstration project to be valuable, as well as the locations that could align with Tribal energy needs and avoid or minimize negative impacts to fishing and cultural sites.

## Biomass Resource Assessment

Biomass energy 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 by-products, such as crop residue. Other sources such as landfill gas and municipal solid waste are also considered renewable; however, they are not commonly included within biomass energy assessments and are instead considered waste-to-energy solutions.

There are several factors to be considered 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. The specific type(s) of biomass feedstock will impact collection and transportation methods, costs, and feedstock processing requirements (e.g., chipping or grinding, mixing, drying). 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 a consideration.

The biomass energy potential for the Makah Tribe was analyzed in a preliminary study conducted in 2023 by WSU (Washington State University Energy Program 2023). In the report, WSU highlighted the wood-based feedstock potential in Neah Bay through a biomass availability analysis. The results showed that there is potential to reliably obtain more than enough biomass to heat a new 50,000-square-foot school. The availability analysis was performed by first utilizing a Washington State Department of Natural Resources calculator to determine the approximate amount of biomass available in the surrounding areas. The estimate was compared to details obtained from the Makah Tribe and the U.S. Forest Service to calculate a range of 3,825 to 11,475 bone dry tons (BDT) of non-timber forest biomass that Makah could obtain per year.

Utilizing a nearby biomass boiler facility and similar nearby schools as references, WSU determined that the annual heating load required by a new school for the Tribe would be approximately 260 MMBtu. This would require approximately 18 BDT of biomass per year (assuming 17.5 MMBtu/BDT (Howard 1988) and 85% efficiency), which is significantly less than the total potential biomass available. Even if the school heating system required the 300–350 BDT/year that a nearby, slightly larger school consumes, significant biomass potential remains. Considering the expected surplus in available biomass, WSU highlighted the potential feasibility for a local biomass processing plant. Having a local processing plant would reduce overall cost compared to purchasing pre-processed biomass for a single school and could produce economic benefits from the sale of excess wood chips. WSU reported that prices may range from \$35–55/BDT before delivery.

The results of the school heating analysis showed that a large percentage of the school building's daily average heating demand could be covered by a biomass boiler capable of delivering 50,000 Btu/hour, which optimizes boiler efficiency and utilization. WSU identified a potential boiler for the 50,000 Btu/hr. case and also listed several commercially available options that are oversized. Biomass boilers run best when close to maximum capacity, therefore, the boiler should be undersized relative to the expected peak load. To supply loads that exceed the biomass boiler capacity, WSU specified that a fuel oil or propane boiler with a relatively quick response and wide modulation range should be included as a secondary backup system. This boiler would be used only during the limited number of hours per year when heating demand exceeds 50,000 Btu/hr. In addition, this fuel-fired boiler could be sized considerably larger to meet the 99% of conditions to provide additional resilience.

WSU recommends an in-depth techno-economic feasibility analysis to elaborate on the potential of using biomass energy to expand to other schools and critical infrastructure. Further study of the potential for a biomass processing and wood chipping facility is also discussed as future work. Lastly, WSU discusses the potential for a combined heat and power study to explore the feasibility of a district heating and

electricity system for multiple buildings. These options may enable utilization of the 57,000–170,000<sup>18</sup> MMBtu/year that may be possible.

## Implementing the Energy Vision

Achieving energy sovereignty will be an incremental process that will require taking the information outlined above regarding potential energy generation and making decisions about what combinations of locations, technologies, and storage options make sense given the Tribe’s priorities and the costs and benefits of energy development. The Makah Tribe identified three needs, described in detail in the Makah Energy Vision section, to reach their energy vision and advance their energy sovereignty: energy generation and storage to power the reservation for one year, improved energy efficiency, and greater institutional capacity. Options for addressing these needs are discussed in the following sections. The first part provides an introduction to energy storage and an example of how collocating different technologies plus storage could contribute toward powering the reservation for one year. This section also provides an example of how the considerations outlined in the values section could be used to evaluate projects and discusses a few potential projects that were identified by the community, Makah Tribal Council, and Makah staff. The Capacity Building section includes information on various ways to build household and institutional capacity, including educational and financial resources, as well as outreach and communication materials developed as part of the ETIPP project.

## Microgrids

A microgrid is a group of interconnected loads and distributed energy resources that act as a single controllable entity with respect to the grid. 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. Microgrids vary in size and complexity, from a single facility to a multi-customer system.

Microgrids are often composed of five components: energy supply, energy storage, loads, controls, and a utility interconnection. Energy can be supplied by distributed renewable sources like solar PV, distributed wind, or marine energy, or other resources such as a biomass plant or diesel generation. Battery energy storage systems or thermal energy storage provide energy storage capacity. Loads powered by a microgrid can range from a single building to an entire neighborhood or college campus. Controls allow the microgrid to balance power supply and demand. Finally, unless the microgrid is in a remote site or isolated from the grid, a utility interconnection provides coupling with the grid. During normal operations, the microgrid is connected to the utility grid, drawing power when its own energy supplies are not sufficient to meet the load. During grid blackouts, microgrids can “island,” or disconnect from the utility grid, continuing to provide power to critical loads.

In the context of Neah Bay, a microgrid powered by a combination of the resources described in previous sections could support energy reliability (everyday uninterrupted supply) and resilience (reliable power during extreme events). Because Neah Bay relies on a single power line, any disruption to that

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<sup>18</sup> This is a theoretical maximum value, assuming 100% capacity factor. The actual capacity factor and therefore usable energy may be much lower depending on the selected end use and technology.

transmission infrastructure can result in extended power outages. Because all the electricity powering the microgrid would be generated locally, it would be less vulnerable to disruptions in transmission caused by storms or other natural disasters and would incur fewer power losses associated with transmission.

Some challenges associated with microgrid development include high costs and regulatory hurdles. Typical community-scale microgrid costs average around \$2 million/MW, and power from a microgrid is generally more expensive than power from the utility grid. This is because microgrids have several layers of redundancy to achieve high reliability, and microgrids tend to be built upon existing distribution circuits, which might require upgrades. Additionally, microgrids require high-bandwidth networked telecommunications. Because microgrids are an emerging technology, the regulatory landscape is still in flux. When connected to the grid, microgrids sell excess generation or buy electricity when needed. This requires an interconnection agreement with the local power utility, which can be complicated, expensive, and time-consuming. Additionally, tariff and rate structures that price the value microgrids provide have not been fully established. Finally, in most jurisdictions, only the local utility has franchise rights to distribute or sell power. Microgrid owners are not allowed to sell power to other customers, which complicates the creation of multi-customer microgrids.

## **Potential Solar and Wind Colocation at the Makah Wellness Center**

Wind and solar have been identified as target technologies and, because of the contrasting seasonal energy generation, a combination of wind and solar would provide the most consistent energy generation year-round. Additionally, it is possible to collocate the technologies if consideration is given to their respective space needs.

An open clearing above the Makah Wellness Center is a promising location for the co-location of wind and solar PV. Figure 18 shows a potential layout for nine NPS 100C-21 turbines. Based on a desktop analysis of the site, 2–4 MW of ground-mount solar PV could be sited to the southwest and northeast of the wind turbines. Together, these nine turbines and 2–4 MW of solar PV could produce between 2,200–3,400 MWh of electricity annually, equivalent to 15%–24% of Neah Bay’s 2022 electricity consumption, or 8%–12% of Neah Bay’s projected 2040 electricity consumption under the High Adoption scenario.

The Wellness Center consumed 85 MWh in 2017, which could be generated with a single NPS 100C-21 turbine, or less than 100 kW of solar PV. Additionally, the Sail River Heights neighborhood has 46 homes that consume approximately 540 MWh over the course of a year. This amount of electricity could be generated with five NPS 100C-21 turbines, 500 kW of solar PV, or a combination of the two. The power consumption of the Wellness Center and the Sail River Heights neighborhood could be generated with six NPS 100C-21 turbines, 600 kW of solar PV, or a combination of the two. This does not mean that wind turbines or solar PV alone could provide reliable power to the Wellness Center or the Sail River Heights neighborhood. Rather, over the course of a year, the power produced by these renewable power sources could offset some of the power consumed by the Wellness Center or the Sail River Heights neighborhood. In order to provide reliable power at every moment of the day, a battery energy storage system would need to be installed to provide power when the sun is not shining or the wind is not blowing.



Figure 18. A potential layout for nine NPS 100C-21 turbines and 2-4 MW of ground-mount solar PV

## Evaluating Potential Priority Projects

One method for evaluating potential renewable energy projects in Neah Bay is by understanding how development would contribute toward the Makah goal of sufficient renewable energy generation and storage capacity to independently power the Reservation for one year, as is demonstrated in the Resource Assessment section of the plan. However, while energy sovereignty is the goal, the Tribe will not pursue energy development that interferes with the ability to exercise our treaty rights. This includes energy development with negative impacts on treaty-reserved resources, cultural practices, and those that require compromises to the Tribe's jurisdiction to oversee activities on our lands and waters. To that end, the Tribe will be looking for energy projects that are consistent with our self-determination and provide multiple benefits to the community. To ensure consistency and transparency in the way that projects are evaluated, proposed energy projects will be initially screened using the criteria outlined in the Energy Project Evaluation Worksheet (Appendix C).








































































### Priority Projects Identified by Tribal Leadership and Community

Several projects and policy initiatives have been identified as potential priority actions by the Makah Tribal Council and the community. Achieving energy sovereignty will not happen all at once; it will be an incremental process through which projects need to be planned in a thoughtful manner given the availability of financial resources, the readiness of the technology, the community benefits, and the timing that makes logical sense given the vision for community development. Determining whether to proceed and how to prioritize projects is at the discretion of the Tribe; the considerations outlined with the Makah energy values will be used to help with those determinations. Table 7 represents the outcome of discussions about how to tentatively prioritize the initiatives discussed in this plan (or grid-scale







expansions of them) while considering the achievability now, as well as appropriate sequencing of infrastructure and policies, and outlines which energy values are satisfied by each initiative. It should be emphasized that where a project is located should be considered fluid; a funding opportunity or change in the policy landscape could result in a shift in the priority of a particular project or action.

Priority 1 contains projects that are realistically achievable, will help address multiple goals (e.g., emergency resilience in addition to energy), or will facilitate actions in lower tiers (e.g., hiring a Tribal energy lead to oversee policy and infrastructure development). The projects identified as top priorities also collectively meet all of the major energy goals, balancing the need for focusing on economic outcomes (cost savings or revenue generation) with resilience objectives where financial concerns are a portion, but not the driving force of the project. Projects in Priority Levels 2–4 require increasing levels of funding and oversight ability on the Tribe’s part and include projects that the Tribe itself has less direct control over, like improving transmission infrastructure. Also, within those tiers are energy technologies that may not be the right fit for Neah Bay at the moment but could become good options in the future as technology evolves. An additional factor for prioritizing locations for energy development is whether the infrastructure location is outside the tsunami inundation zone.

Table 7. Potential priority actions that could help advance Makah energy sovereignty. The icons show which Makah energy values are supported by each initiative. This was determined using the considerations outlined in the energy values section.

	<b>Technology and Infrastructure</b> <b>Priorities:</b> Renewable Energy Deployment and Energy and Emergency Resilience	<b>Policy and Energy Management Priorities:</b> Capacity Building, Energy Management, and Policy Development
<b>Priority One</b>	<ul style="list-style-type: none"> <li>• Create resilience hubs at the Sophie Trettevick Indian Health Center, Makah Early Childhood Education Center, and Energy Storage for Social Equity locations     </li> <li>• Install solar panels on Tribal buildings and add energy storage as economically feasible     </li> </ul>	<ul style="list-style-type: none"> <li>• Hire a Tribal energy lead    </li> <li>• Develop reliable funding streams   </li> <li>• Establish partnerships with organizations that can help with energy goals       </li> </ul>
<b>Priority Two</b>	<ul style="list-style-type: none"> <li>• Support installation of solar panels on residential homes and add energy storage as economically feasible     </li> <li>• Add circulation to water storage powered by renewables    </li> <li>• Improve transmission infrastructure    </li> </ul>	<ul style="list-style-type: none"> <li>• Workforce development   </li> <li>• Tribal policy to ensure energy efficiency and solar readiness for new buildings      </li> </ul>
<b>Priority Three</b>	<ul style="list-style-type: none"> <li>• Utility-scale solar power    </li> <li>• Small-scale wind  </li> <li>• Small-scale marine energy  </li> <li>• Biomass energy  </li> </ul>	<ul style="list-style-type: none"> <li>• Explore ownership of transmission infrastructure      </li> </ul>
<b>Priority Four</b>	<ul style="list-style-type: none"> <li>• Evaluate grid-scale storage options   </li> </ul>	<ul style="list-style-type: none"> <li>• Explore Tribally owned utility options      </li> </ul>

**Makah Energy Values**

-  = Ecosystem-based management
-  = Economic opportunity
-  = Energy sovereignty and project ownership
-  = Community well-being and priorities
-  = Workforce development and capacity
-  = Emergency and disaster resilience

## Capacity Building

### Community Education

In order 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:

- **Makah Days, August 2023.** PNNL and Spark Northwest staffed an information booth to provide general solar and energy efficiency information to homeowners. A solar suitcase was on display to offer a hands-on opportunity for adults and youth to get familiar with solar technology (Figure 19). The solar suitcase is a self-contained solar power kit with a battery, lightbulbs, and outlet that can be used for hands-on education as well as an emergency power supply. Utilizing the suitcase as an educational and real-world application tool helps highlight what solar can bring to the community and how each member can play a role. It also helps highlight other innovative energy opportunities for the community to discuss. In this vein, PNNL and Spark Northwest also distributed handouts on heat pumps and solar energy.

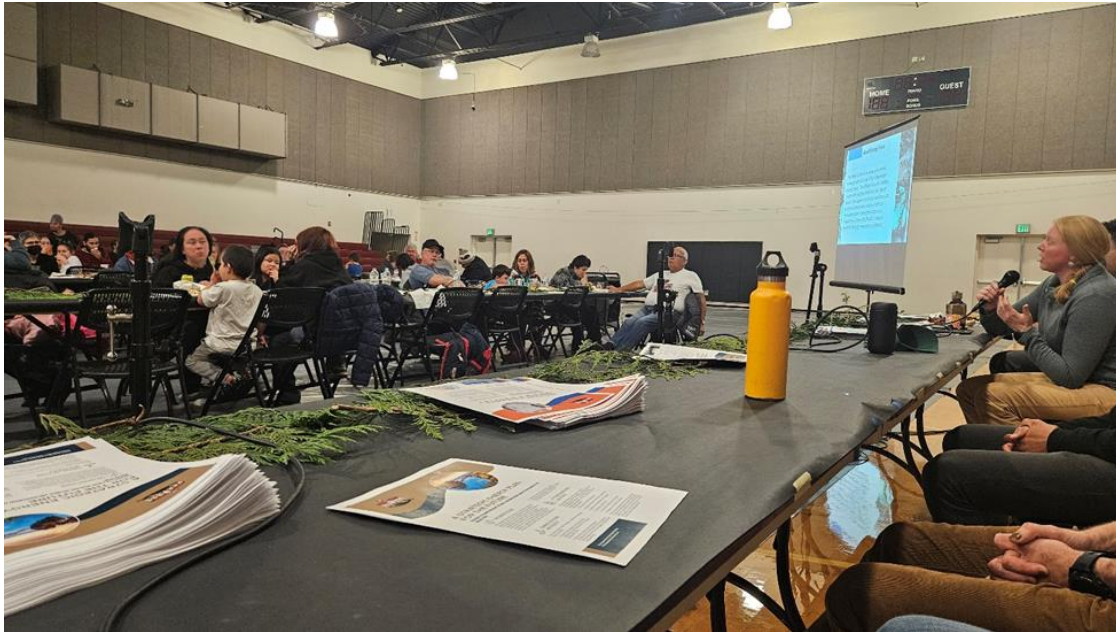


Figure 19. Solar suitcase kit on display at Makah Days

- **Community Dinner, June 2023.** The Makah Tribe held a community event focused on outreach from the environmental departments at the Tribe. Members of the Makah ETIPP team were present to introduce the ETIPP technical assistance, explain the objective to support the Tribe in developing the strategic energy plan, and solicit input from community members on energy goals and visions, as well as thoughts on the types of projects the Tribe should pursue. There was significant interest in household renewable energy options, the connection between water and climate, and the desire to reduce energy costs and increase energy self-sufficiency. PNNL created

a poster for the event summarizing the effort to develop a strategic energy plan and provided information on different renewable energy technologies.

- **Community Dinner, November 2024.** Representatives from PNNL, NREL, and Spark Northwest traveled to Neah Bay to share outcomes of the strategic energy planning process with the community (Figure 20). Attendees were invited to interact with the technical experts by filling out a “bingo” card with different energy topics. Over 100 community members of all ages attended.



*Figure 20. ETIPP team presenting highlights from the strategic energy plan during the 2024 community dinner. (Photo credit: PNNL)*

One of the ETIPP objectives was to build local capacity in energy decision-making and to develop communication materials that could be used to inform the community about the strategic energy plan and renewable energy options. The ETIPP team developed the following community-focused engagement materials; materials for the public are accessible at the links in Table 8.

Table 8. Makah Energy Outreach and Communication Materials

Outreach Material	Description	Target Audience	Potential Outreach Channels
Short Slide Deck	Can be presented in 10 minutes and provides an overview of the strategic energy plan	General public	Community dinner, senior lunch, Council meeting
Long Slide Deck	Summarizes all work from the strategic energy plan project, including technology-specific results	Council members, technical audience	Council meeting, Planning Department meeting
Strategic Energy Plan Summary	High level overview of plan including values and priorities	Council members, technical audience	Council meeting, Community meetings, Whale Tale
Technical Flyers	Overview of solar, wind, and heat pump technologies, costs, incentives, and the next steps to move forward	Homeowners	Community dinner, Makah Days, Washburn's, Post Office, website and/or social media, Makah All listserv, Whale Tale

The following are ideas and resources for potential future community education activities:

- **Group purchase campaign.** Targeted education and outreach campaigns can be an effective way to mobilize homeowners or business owners to implement new technologies. These campaigns typically consist of a competitively selected contractor that can offer a group discount rate, a series of educational workshops where attendees can get all the information they need at once directly from the experts, and a limited time offer to motivate participants to make a decision. Campaigns typically focus on a single technology at a time, such as solar PV, heat pumps, or electric vehicles.<sup>19</sup>
- **K-12 education.** The following resources provide examples of how renewable energy technologies can begin to be incorporated into K-12 curriculum:
  - The Solar Suitcase, created by We Care Solar, is a self-contained solar power system that can be used for hands-on education as well as an emergency power supply (<https://wecaresolar.org/solar-suitcase/product-information/>).
  - KidWind provides free K-12 classroom activity guides related to wind energy and electricity basics (<https://www.kidwind.org/activities>).

<sup>19</sup> For more information see <https://solarizenw.org/> or <https://sparknorthwest.org/project/it-is-time-to-talk-about-heat-pumps/>.

- Solar Energy International provides teacher training and support for incorporating solar into their curriculum (<https://www.solarenergy.org/solar-in-the-schools/>).

## **Tribal Staff Capacity Development**

As the Makah Tribe pursues the projects outlined in the strategic energy plan, it is imperative to equip Tribal staff members with the necessary skills and knowledge for successful planning, implementation, and operation of renewable energy initiatives. Hiring a dedicated energy project manager has been identified as a high priority to ensure success in the implementation of this energy plan. This position would research, develop, plan, and manage projects to accomplish the Tribe's energy plan and coordinate with other departments, commercial entities, and the community to facilitate cooperation on energy and conservation projects. A draft job description for this position is included in Appendix B.

## **Job Creation and Workforce Development**

The community of Neah Bay experiences high unemployment and underemployment. The Makah Tribe is interested in using renewable energy projects to build a skilled workforce within the community, enhance employment opportunities, and promote sustainable economic growth.

In the near term, local construction contractors could begin developing skills to assist with solar installation and maintenance, as well as energy efficiency and weatherization. Table 9 summarizes potential training providers that offer classes and workshops as well as potential partnership opportunities.

Table 9. Training Opportunities and Potential Partnerships to Develop an Energy Workforce

Organization	Website	Description
GRID Alternatives	<a href="https://gridalternatives.org/what-we-do/Tribal-program">https://gridalternatives.org/what-we-do/Tribal-program</a>	Partners with Tribes to identify, develop, finance, and implement solar power projects that include education and hands-on training
Solar Energy International	<a href="https://www.solarenergy.org/">https://www.solarenergy.org/</a>	Offers online and in-person classes on solar system design and installation with some free introductory courses
Northwest Indian College	<a href="https://www.nwic.edu">https://www.nwic.edu</a>	Includes hands-on solar and energy audit training within their engineering program located at the Lummi campus
Remote Energy	<a href="https://www.remoteenergy.org">https://www.remoteenergy.org</a>	A local nonprofit organization that provides customized training, both online and in-person for Tribal communities
Red Cloud Renewables	<a href="https://www.redcloudrenewable.org/">https://www.redcloudrenewable.org/</a>	Offers a solar pre-apprenticeship program at their solar facility in South Dakota that is open to Native Americans from all Tribes
Center For Energy Workforce Development	<a href="https://getintoenergy.org/eif-2-0/">https://getintoenergy.org/eif-2-0/</a>	Offers a free 120-hour online course that provides the fundamentals needed to enter any energy career path
Midwest Renewable Energy Association	<a href="https://www.midwestrenew.org/online-courses/">https://www.midwestrenew.org/online-courses/</a>	Offers online solar courses, including North American Board of Certified Energy Practitioners certification
Shoreline Community College	<a href="https://www.shoreline.edu/programs/clean-energy-technology/clean-energy-technology-and-entrepreneurship-certificate.aspx">https://www.shoreline.edu/programs/clean-energy-technology/clean-energy-technology-and-entrepreneurship-certificate.aspx</a>	Offers an Energy Technology and Entrepreneurship Certificate
Native Renewables	<a href="http://www.nativerenewables.org">www.nativerenewables.org</a>	Nonprofit organization based in Arizona that raises money to install affordable off-grid solar electric systems for homes on Tribal land and provides training to Native Americans to complete the installations

## Funding Resources

Implementing the Makah energy plan is expected to be a long-term endeavor involving multiple projects and funding sources. The funding landscape will evolve over time, including the near-term and long-term outlooks described below. This section focuses on the opportunities relevant to the themes described above in the plan and applicable to Tribal governments or organizations. Note that this section provides initial information and is not tax or financial advice. Individual circumstances will vary, and it is recommended to consult the guidance and regulations associated with each opportunity and work with a lawyer or other professional as needed. Continued engagement with Spark Northwest is also an option for support navigating the evolving funding landscape.

### Federal Funding Opportunities

The federal funding landscape is large, diverse, and experiences periodic changes in opportunities. Generally, there are three types of financial support for energy projects: grants, loans and financing, and tax credits. Many resources are available to help Tribes navigate the current funding opportunities and how they may align with and support projects.

Some of these resources include, but are not limited to:

- Grants.gov (<https://www.grants.gov/search-grants>): Allows users to search by eligibility, including federally recognized Tribes and funding category, including energy.
- DOE Office of Energy Efficiency and Renewable Energy Current Funding Opportunities (<https://www.energy.gov/eere/funding/eere-funding-opportunities>): List of current open Office of Energy Efficiency and Renewable Energy funding opportunities.
- DOE Office of Indian Energy Policy and Programs Current Funding Opportunities (<https://www.energy.gov/indianenergy/current-funding-opportunities>): List of current open funding opportunities issued by the DOE Office of Indian Energy Policy and Programs.
- American Cities Climate Challenge Renewables Accelerator (<https://cityrenewables.org/ffold/>): Allows users to search by applicant type, project type, project phase, and funding type.
- The U.S. Department of Agriculture, in particular, has numerous ongoing grant and loan programs that can support rural energy projects, including projects for Tribally owned businesses. Contact a State Energy Coordinator<sup>20</sup> or other representative to navigate these.
- The Federal Emergency Management Agency Building Resilient Infrastructure and Communities program can support a range of adaptation and resilience activities. It may align with infrastructure development as part of planned relocation from the tsunami inundation zone. The program has also previously supported renewable energy microgrids at Tribal community facilities (<https://www.fema.gov/grants/mitigation/learn/building-resilient-infrastructure-communities>).<sup>21</sup>
- The DOE Grid Resilience State/Tribal Formula Grants Program provides non-competitive funding allocations for designated states and Tribes. The funding allocations and application

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<sup>20</sup> See <https://www.rd.usda.gov/contact-us/state-energy-coordinators> for more information.

<sup>21</sup> For example, a \$9 million clean energy microgrid for Tribal health care facilities has been selected for further review as part of the Fiscal Year 2022 competition (<https://www.fema.gov/grants/mitigation/learn/building-resilient-infrastructure-communities/after-apply/previous-subapplication-status/fy22-status>).

process may change in future years (<https://www.energy.gov/gdo/grid-resilience-statetribal-formula-grants-program>).

- The DOE Energy Improvement in Rural and Remote Areas program may be aligned with many types of projects contemplated in this Plan. It does not currently have a funding opportunity announcement or notice of intent but is generally expected to recur in Fiscal Years 2024–2026 (<https://www.energy.gov/oced/era>).

## State and Other Funding Opportunities

At the state level, the Washington State Department of Commerce has established the Energy Program in Communities unit within the Energy Division and State Energy Office. Through this initiative, a variety of new funding opportunities are anticipated to launch in 2025.

Philanthropic resources, though not extensively covered here, can also provide valuable support. The nonprofit organization GRID Alternatives established the Tribal Solar Accelerator Fund in 2018, with philanthropic support from private foundations. Funds are distributed annually through three grant programs to support new solar projects in Tribal communities (Table 10).

*Table 10. Summary of Select Anticipated State and Other Funding Opportunities*

<b>Funding Opportunity</b>	<b>Agency</b>	<b>Scope Summary</b>	<b>Timing</b>
Energy Programs in Communities ( <a href="https://www.commerce.wa.gov/epic/">https://www.commerce.wa.gov/epic/</a> )	Washington Department of Commerce	Funds to implement energy efficiency retrofits, solar PV, and grid resiliency/reliability	To be announced in 2025
Tribal Solar Accelerator Fund: Facility and Residential Project Grants ( <a href="https://tribalsolar.org/grants/facility-residential-grant/">https://tribalsolar.org/grants/facility-residential-grant/</a> )	GRID Alternatives	Tribal facility and residential solar implementation	To be announced in 2025
Tribal Solar Accelerator Fund: Energy Plan Grants ( <a href="https://tribalsolar.org/grants/plan-grant/">https://tribalsolar.org/grants/plan-grant/</a> )	GRID Alternatives	Can be used to compensate the energy planning team, hire consultants, and cover the costs of public meetings	To be announced in 2025
Tribal Solar Accelerator Fund: Gap Funding Grants ( <a href="https://tribalsolar.org/grants/matching-grant/">https://tribalsolar.org/grants/matching-grant/</a> )	GRID Alternatives	Can be used as cost-share for state or federal grant programs	To be announced in 2025

Philanthropy Northwest Thriving Communities Grants ( <a href="http://philanthropynw.org/epa-environmental-justice-thriving-communities-grantmaking-program">http://philanthropynw.org/epa-environmental-justice-thriving-communities-grantmaking-program</a> )	Philanthropy Northwest	Home energy efficiency, emergency preparedness and disaster resilience, and environmental job training	March 31, 2025
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## Searching for Funding

The funding opportunity landscape is dynamic, and this section has provided only a snapshot of select opportunities based on current information. The listings below may be helpful resources for continuing the search for funding during the implementation of this plan.

- DOE Office of Indian Energy funding dashboard: <https://www.energy.gov/indianenergy/current-funding-opportunities>
- Department of Housing and Urban Development Build for the Future Funding Navigator: <https://www.buildinghub.energy/build-for-the-future-funding-navigator>
- Bureau of Indian Affairs Access to Capital Clearinghouse: [https://www.bia.gov/atc/search?page=1&sortBy=date\\_added\\_desc&sortGrantsFirst=true](https://www.bia.gov/atc/search?page=1&sortBy=date_added_desc&sortGrantsFirst=true)
- Office of Clean Energy Demonstrations *Federal Energy Funding for Rural and Remote Areas*: [https://www.energy.gov/sites/default/files/2023-10/OCED\\_Rural-Remote%20Fed%20Overview.pdf](https://www.energy.gov/sites/default/files/2023-10/OCED_Rural-Remote%20Fed%20Overview.pdf)
- FundHubWA (<https://fundhub.wa.gov/>): A portal of state and federal climate and clean energy funding opportunities for home, business, or community
- Puget Sound Recovery Acceleration Funding Tool (<https://experience.arcgis.com/experience/6f12941d99644b0e93deaed86f1674f0/page/Home/?views=Active-Announcements>): A database of national, state, and regional funding opportunities (not energy-specific).
- Tribal Climate Change Guide (<https://tribalclimateguide.uoregon.edu/funding>): Information on grants, programs, and plans that may assist Tribes in addressing climate change through a broad range of sectors.
- Tribal Funding Registry (<https://www.tribalfunding.org/>): a free searchable database of funding opportunities for Tribes.

## Next Steps

This section elaborates on future energy management options that could advance Makah energy sovereignty. Many of these topics came up during the ETIPP project scoping, and their inclusion here is to provide information for the Tribe to consider as they evaluate how they want to move forward. However, including these in the plan should not be interpreted as a management recommendation.

## Energy Management Options and Other Technologies

### Tribal Building Codes

Building codes are one policy option for ensuring that new construction is built to be energy-efficient and compatible with the installation of energy generation technologies (i.e., has a roof appropriate for solar). State and local building codes do not apply on Tribal lands, even with federally funded buildings and housing, unless the Tribe has formally adopted building codes. Tribes that do not have formally adopted residential building codes default to the International Residential Code (IRC). However, the IRC does not take into account specific environmental, health, energy, and other factors that may be specific to the region and state.

Adopting and enforcing building codes can help support human health and environmental priorities within Tribes. Additionally, they can help ensure that contractors are adhering to safe, healthy, and sustainable building standards. However, many challenges prevent Tribes from adopting and enforcing building codes.

The Makah Tribe does not have formally adopted codes and defaults to the IRC. However, the Tribe did establish building codes specifically for the Sail River Heights development project. Those requirements contained a combination of IRC and Washington state residential building codes, including the Washington State Energy Code, Department of Labor and Industries electrical standards, and required certification and inspections by state-certified specialists (engineers, architects, etc.). Additionally, the requirements include compliance enforcement of the codes, which include notifications and fines. The Makah Tribe could consider adopting these requirements or similar requirements for all future residential development across the Tribe.

Some of the barriers to Tribal adoption of building codes include lack of information and outreach and lack of funding for the enforcement of code compliance. Building codes also require enforcement to be effective and have compliance. Enforcement includes permitting and punitive actions (fines or other penalties) for not meeting codes. Successful enforcement requires funding, program development, and workforce training. Alternatively, Tribes can hire external building code enforcement experts to ensure code compliance.

Many resources exist to help Tribes adopt and enforce building codes. Some informational resources include:

- DOE Building Energy Codes Program:

- Resource Guides on energy code compliance for designers, policymakers, and code officials: <https://www.energy.gov/eere/buildings/building-energy-codes-program>
- Regional Energy Efficiency Organizations: Though these groups primarily deal with state and local codes, they can be helpful as regionally knowledgeable resources (<https://www.energycodes.gov/>).
- Shared Enforcement of the Uniform Code and Energy Code: A guide prepared by New York State on increasing efficiency by sharing code administration and enforcement responsibilities with one or more other local governments or contracting with a private, non-governmental provider to perform code enforcement services. Sample agreements are included (<https://dos.ny.gov/system/files/documents/2019/05/how-book-may-2008.pdf>).
- Southwest Energy Efficiency Project: Publications on energy code implementation and enforcement (<https://www.swenergy.org/resources-publications/>).
- Environmental Protection Agency Tribal Green Building Toolkit: An assessment tool, with Tribal case studies, for identifying and prioritizing structures a Tribe may want to build and relevant code information for those structures (<https://www.epa.gov/green-building-tools-Tribes/Tribal-green-building-toolkit>).

### Makah Utility District

A number of Tribes in the United States have formed Tribal utilities for the purpose of owning and operating electric systems. There are several reasons for forming a Tribal utility, including the pursuit of self-determination and economic growth, workforce development, dissatisfaction with the existing utility, improving service reliability, and keeping rates as low as possible. Any utility, Tribal or otherwise, will have two distinct functions: (1) the operations side, and (2) the business side. Before forming a Tribal utility, it is imperative that Tribes fully understand the responsibilities, staff and capital needs, expertise, and risks involved. A thorough understanding of the components of the electric system is also essential (Figure 21).

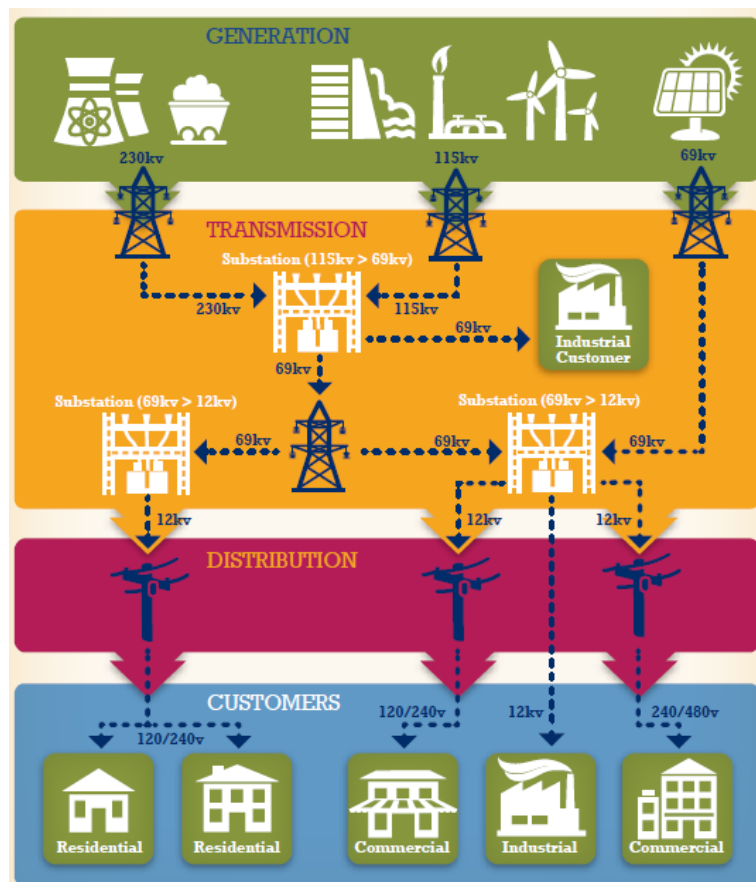


Figure 21. Example electric system and its components (Source: Tribal Utility Handbook, [https://www.bia.gov/sites/default/files/dup/assets/as-ia/ieed/ieed/pdf/Tribalutility\\_handbook.pdf](https://www.bia.gov/sites/default/files/dup/assets/as-ia/ieed/ieed/pdf/Tribalutility_handbook.pdf))

It is important to note that Tribal utilities do not need to own their own energy generation resources and can choose instead to purchase power from suppliers. Similarly, Tribal utilities can choose to purchase or lease existing distribution from utilities. With both generation and distribution, a cost-benefit analysis should be conducted to determine the best pathway. Consideration of other factors, such as who will operate and maintain the generation and distribution resources, are also important to consider and plan for.

The formation of a Tribal utility includes numerous recommended steps, including several assessments of the costs and potential revenue. Several resources exist to support Tribes in the process of determining if utility formation is the right pathway, including the following:

- The U.S. Department of Interior Indian Energy and Economic Development’s *Establishing A Tribal Utility Authority Handbook*: [https://www.bia.gov/sites/default/files/dup/assets/as-ia/ieed/ieed/pdf/Tribalutility\\_handbook.pdf](https://www.bia.gov/sites/default/files/dup/assets/as-ia/ieed/ieed/pdf/Tribalutility_handbook.pdf)
- The DOE Tribal Energy Program’s *Tribal Authority Process*: <https://www.energy.gov/indianenergy/articles/Tribal-authority-process-case-studies-conversion-reservation-electric>.

Additionally, capacity-building, technical assistance, and funding opportunities are available through a variety of federal funding sources and state and regional support programs. The Makah Tribe can also contact its ETIPP representatives if it needs further guidance on initiating the utility assessment process.

## Virtual Power Plants

Virtual power plants (VPPs) can provide many of the same energy services that centralized traditional power plants do, but through an interactive and distributed network of energy generation sources and participating energy consumers. This participation includes flexible and variable devices, such as electric vehicles, household batteries, and others shown in Figure 22. VPPs use a smart controller (or “VPP aggregator,” also called a control system) to monitor, forecast, transmit, and optimize power distribution within the network over time. By working together under a software-based control system, the VPP network is more efficient and adaptable in meeting community energy needs in comparison to the same distributed devices and consumers working in isolation. Thus, VPPs are a strategy for grid efficiency and stabilization, and provide a foundation for integrating new renewable energy deployments into a broader network.

VPPs are a compelling option for smaller communities, communities with local environmental priorities, and communities interested in taking a more active role in managing their energy generation portfolio. VPPs allow the community to site their renewable energy systems in preferred and distributed locations (e.g., rooftops). These distributed locations may help communities avoid the environmental impact that could occur under a much larger and full-scale renewable deployment (e.g., habitat destruction for a utility-scale solar farm). This approach also allows communities to work toward large renewable energy

generation goals through small steps, allowing for adaptability and reducing upfront costs in comparison to large deployments. This distributed and step-by-step approach reflects Nimiipuu Energy’s intended approach toward creating a Native-led VPP.<sup>22</sup>

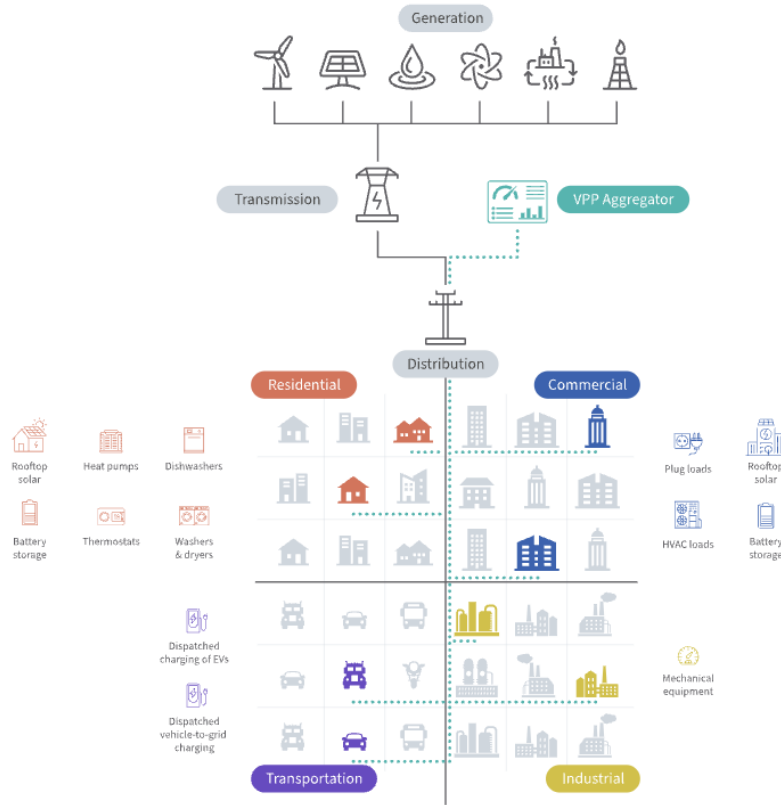


Figure 22. Schematic demonstrating where a VPP fits into the energy system. Source: [RMI](#).

Although VPPs can provide a foundation for integrating new renewable energy devices on a rolling basis, there are enabling conditions and infrastructure that should be met before a VPP is installed in the first place. For example, a sufficient number of distributed generation and storage systems should be functioning prior to VPP installation. These systems should be interconnected through transmission (able to send and receive power), and their devices should be capable of monitoring so that they can send data to the VPP aggregator (control system). This (installing an interconnected and distributed network of devices) is the primary economic and infrastructural challenge of creating a VPP. Additionally, on a sociological level, participants in the VPP network should have a mindset and awareness of not just being *consumers* (as is typical under traditional power plants) but understand themselves as *prosumers*: participants that both produce and consume power from and for the broader community.<sup>23</sup> Finally, communities interested in a fully renewable and/or fully independent VPP should take care to analyze whether the communities’ energy needs can indeed be met through a collection of distributed generation

<sup>22</sup> For more information on Nimiipuu Energy see <https://www.nimiipuu.energy/>

<sup>23</sup> For more information on VPPs see [https://issuu.com/iebmmedia/docs/ieb116\\_digital/s/11497149](https://issuu.com/iebmmedia/docs/ieb116_digital/s/11497149)

deployments within their region (i.e., if their renewable resources and spatial capacity are feasible). This feasibility can be assessed through hybrid micro-grid planning software, such as HOMER<sup>24</sup> and HOPP.<sup>25</sup>

### Advanced Nuclear Power Plants

While not currently commercially proven, small modular reactors and microreactors are examples of advanced nuclear power plants (ANPs) that are intended to produce reliable and resilient electricity and energy. Domestically, ANPs have been under consideration for the past two decades. Designers, developers, and federal stakeholders, such as DOE and the U.S. Nuclear Regulatory Commission, have been evaluating both technical and regulatory solutions to support development and implementation of ANPs. More recently, ANPs have garnered federal and private funding to explore their potential as an alternative energy technology. The aim is for ANPs to leverage advancements in nuclear safety while providing scalable capacity that can produce both power and heat across grid-scale and remote scenarios. ANPs are also expected to require less frequent refueling intervals and have a small footprint compared to technologies with a similar output capacity, which may accommodate siting objectives and reduce negative impacts. As an *on-demand* energy resource, small modular reactors and ANPs also have the potential to notably reduce the size of renewable generation and storage needed within a hybrid micro-grid such as the ones being evaluated to achieve the Makah energy vision.

Though the ANP industry continues to advance designs and key tenets regarding the production and delivery of nuclear power to both existing and emerging markets, commercial feasibility is contingent on longer developmental timelines. The technologies and fuel for ANPs are unlikely to be available for use until well into the mid-2030s. Additional challenges related to nuclear fuel availability, spent nuclear fuel, and nuclear waste disposal also contribute to the complexity of implementation. Furthermore, implementing nuclear generators and management in a seismic area is a challenge that has been of historical concern on the Olympic Peninsula. While regulations were updated after the Fukushima nuclear accident and earthquake-tsunami in Japan, disposal of nuclear waste is a concern in places without central repositories. A nuclear plant must either store nuclear waste locally or transport it to a storage facility, which can be costly and difficult to secure. Finally, as untested designs move into the development phase, there remains a significant level of uncertainty regarding total costs of construction, funding to increase production of nuclear fuel, and long-term operation and sustainment costs which, to date, have been estimated, but not validated.

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<sup>24</sup> HOMER available at <https://homerenergy.com/>

<sup>25</sup> HOPP available at <https://github.com/NREL/HOPP>

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# Appendices

## Appendix A. Additional Wind Resource Assessment Information

Table A1: Location and Quantity of Wind turbines That Could Be Deployed for Additional Sites

Site	Coordinates	Excel 15	EOX S-16	NPS 100C-21
Waatch River	48.34374, -124.673487 to 48.364361, -124.629703	No optimal deployment locations	No optimal deployment locations	No optimal deployment locations
West Coast Clearing: South	48.349682, -124.685962	7 turbines	3 turbines	2 turbines
West Coast Clearing: North	48.356621, -124.695906	16 turbines	8 turbines	5 turbines

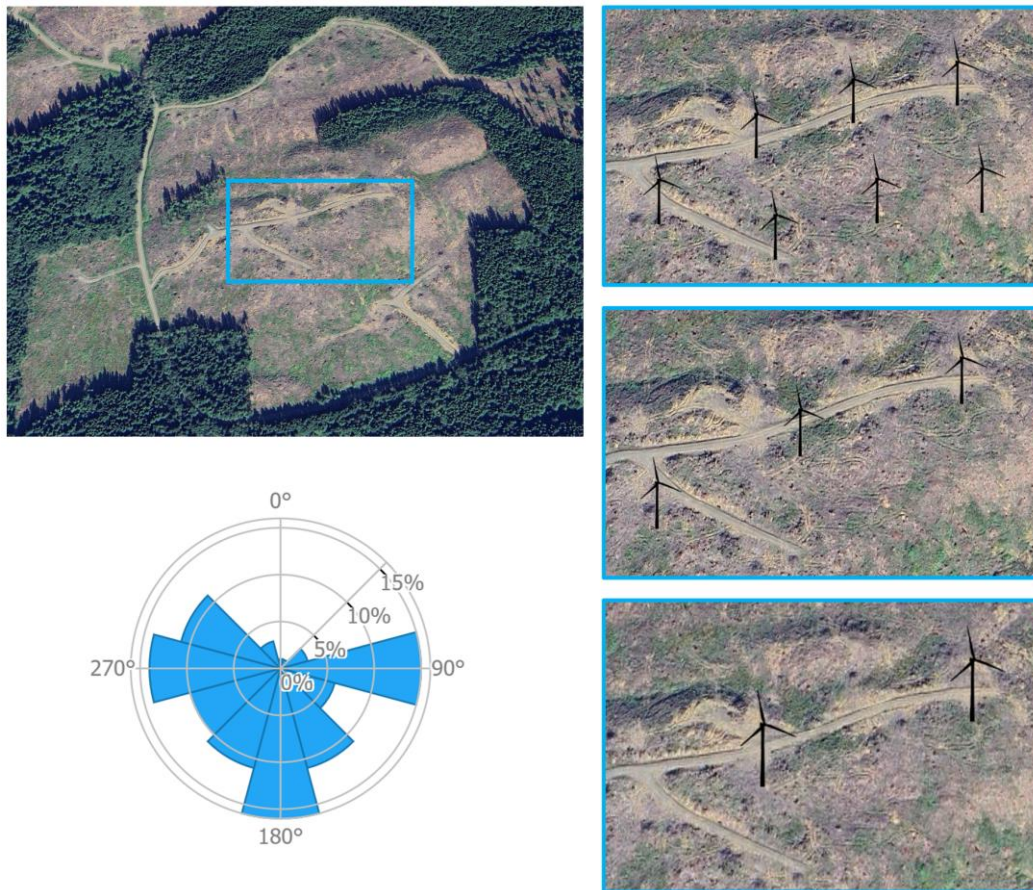
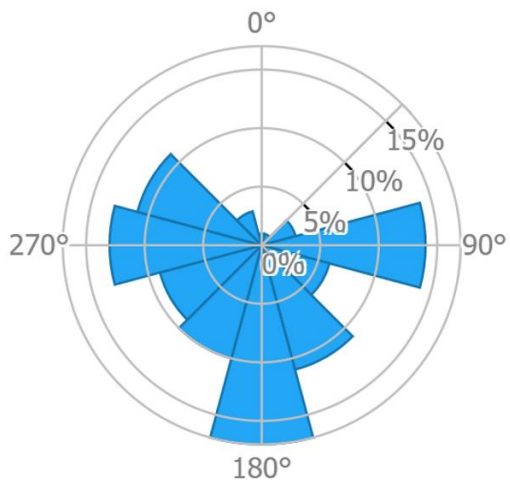


Figure A1: Map (upper left), wind rose (lower left), and potential wind turbine layouts at the West Coast Clearing: South for the Excel 15 (upper right), EOX S-16 (center right), and NPS 100C-21 (lower right)



*Figure A2: Wind rose (upper left) and potential wind turbine layouts at the West Coast Clearing: North for the Excel 15 (upper right), EOX S-16 (lower left), and NPS 100C-21 (lower right)*

Table A2: Annual Average Wind Speed Estimates for the Clearing Above the Makah Wellness Center and Additional Considered Locations for an Average Wind Resource Year

Site	23 m	24 m	30 m	37 m	50 m
Above Makah Wellness Center	5.1–5.6 m/s	5.1–5.6 m/s	5.4–5.9 m/s	5.6–6.2 m/s	6.0–6.6 m/s
	<i>Cleared; near infrastructure; wind models in agreement</i>				
Waatch River	2.9–5.7 m/s	2.9–5.7 m/s	3.1–6.0 m/s	3.2–6.2 m/s	3.4–6.6 m/s
	<i>Near infrastructure; wind models conflict; diverse land cover</i>				
West Coast Clearing: South	5.3–5.8 m/s	5.4–5.9 m/s	5.6–6.1 m/s	5.8–6.3 m/s	6.1–6.7 m/s
	<i>Cleared; further from infrastructure; wind models in agreement</i>				
West Coast Clearing: North	6.0–6.6 m/s	6.1–6.6 m/s	6.2–6.7 m/s	6.3–6.8 m/s	6.4–7.0 m/s
	<i>Cleared; further from infrastructure; wind models in agreement</i>				

Table A3: Annual Energy Generation Estimates for the Clearing Above the Makah Wellness Center and Additional Considered Locations for an Average Wind Resource Year

Turbine	Hub Height (m)	Wind Resource Year	Above Makah Wellness Center (MWh)	Waatch River (MWh)	West Coast Clearing: South (MWh)	West Coast Clearing: North (MWh)
Excel 15	30 (tilt-up)	Average	28–34	6–35	32–38	38–44
Excel 15	37 (standard)	Average	31–37	7–38	34–41	39–45
EOX S-16	24 (tilt-up/standard)	Average	56–68	15–69	64–75	76–86
NPS 100C-21	23 (tilt-up)	Average	120–149	24–156	142–173	180–213
NPS 100C-21	37 (standard)	Average	152–186	34–189	170–203	193–226

## Appendix B. Workforce Development

### Job Description for a Renewable Energy Project Manager

#### **Position Overview:**

The Makah Tribe seeks a highly motivated and experienced Renewable Energy Project Manager to lead and oversee the Tribe's renewable energy initiatives. The Project Manager will plan, coordinate, and implement renewable energy projects focusing on sustainability, environmental stewardship, community engagement, and workforce development. This position requires a strong background in renewable energy project management, technical expertise, and the ability to work collaboratively with various stakeholders. Candidates for this position should demonstrate the ability to perform under a high degree of autonomy, think creatively and thoughtfully about new program development, and manage multiple program components from initial design through full implementation and reporting.

#### **Description of Job:**

In developing these programs, the Program Manager will work closely with Tribal Leadership building decarbonization, weatherization, and local government teams to further the adoption of solar and other renewable energy technologies throughout the Tribe. The position will require engagement with industry leaders, coordination with local and federal programs, and partnerships with community organizations focused on solar and renewable energy.

Makah Tribe of Indians are committed to increasing the diversity of our staff and providing culturally responsive programs and services. Therefore, we encourage responses from people of diverse backgrounds and abilities.

#### **Responsibilities:**

- Develop and implement the Tribe's strategic plan for renewable energy projects, ensuring alignment with Tribal goals and objectives.
- Lead the identification, evaluation, and selection of renewable energy projects, including solar, wind, hydro, and biomass, based on feasibility, cost-effectiveness, and environmental impact.
- Coordinate and manage the entire project life cycle, including project planning, budgeting, scheduling, procurement, and execution and reporting to Tribal Council.
- Collaborate with internal departments, Tribal leadership/council, and external partners to ensure effective project implementation and stakeholder engagement.
- Liaise with regulatory agencies, utility companies, and other relevant entities to ensure compliance with all applicable regulations, permits, and agreements.
- Oversee the development of project proposals and grant applications to secure funding for current and future renewable energy projects.

- Monitor and evaluate project progress, performance, and risks, implementing corrective actions as necessary to ensure project success.
- Manage project budgets, track expenses, and provide regular financial reports to Tribal leadership and funding agencies.
- Foster community engagement and education on renewable energy initiatives, promoting awareness and participation within the Tribal community.
- Stay current on industry trends, emerging technologies, and regulatory changes related to renewable energy, providing recommendations for continuous improvement and innovation.

**Qualifications:**

- Bachelor's or technical degree in renewable energy, engineering, environmental science, or a related field. A master's degree is preferred.
- Proven experience in renewable energy project management, including planning, development, and execution.
- Strong knowledge of renewable energy technologies, systems, and best practices.
- Familiarity with Tribal law and regulations as well as federal, state, and local regulations related to renewable energy projects and environmental compliance.
- Demonstrated ability to manage multiple projects simultaneously, meet deadlines, and deliver results within budget constraints.
- Excellent communication and interpersonal skills, with the ability to effectively collaborate with diverse stakeholders and build productive relationships.
- Strong analytical and problem-solving skills, with the ability to identify and mitigate risks and make data-driven decisions.
- Proficiency in project management software, Microsoft Office Suite, and other relevant tools.
- Knowledge of grant writing and funding opportunities for renewable energy projects is a plus.
- Experience working with Tribal communities or in a Native American organization is desirable.

## Appendix C. Energy Project Evaluation Worksheet

	No	Somewhat	Yes
<b>Ecosystem-Based Management</b>			
Does energy development interfere with any treaty-reserved resources?			
Does the project use or upgrade existing infrastructure?			
Is there a plan for ongoing monitoring of impacts and the ability to remove the energy infrastructure if unanticipated negative impacts occur?			
Does the project support or advance environmental management or climate resilience goals?			
Elaborate on any potential impacts to treaty-reserved resources, monitoring plans, and describe the climate or environmental goals supported.			
<b>Energy Sovereignty and Project Ownership</b>			
Was this project initiated by the Tribe?			
Has the proposal recognized the Makah Tribe's authority and decision-making throughout the lifetime of the project (planning and design, siting, access, monitoring, operations, removal, decommissioning)?			
Will the Tribe own the project from the onset, and if not, is there a pathway for eventual Tribal ownership?			

Explain how this project would contribute to energy independence.

**Workforce Development and Capacity**

Will the project create jobs in the community?

Does the project include training opportunities for existing and new staff?

Can the project realistically be maintained locally?

If the project will create jobs, please elaborate on the number and types of jobs, as well as length of employment, wages, and ability to learn transferable skills.

**Economic Opportunity**

Is the project economically viable?

Does the project reduce barriers to economic development in Neah Bay?

Does the project generate revenue for the community?			
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Elaborate on the economic impact of the project and describe the funding sources.

**Community Well-being and Priorities**

Does the project reduce barriers to housing availability?			
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Does the project reduce household energy burdens?			
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Does the project address water availability issues?			
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Does the project address household air quality issues?			
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Does the project support the well-being of potentially vulnerable members of the community such as children and elders?			
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For any well-being priority checked *yes* or *somewhat*, please explain how the project would advance that goal. Please also describe any other community well-being benefits the project would generate that are not on this list.

**Emergency and Disaster Resilience**

Can the energy generated be utilized by the community during an emergency or routine power outage?

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Does the project support or facilitate relocation efforts?

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Will the project be sited outside of the tsunami inundation zone (TIZ)?

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Does the project help with grid stabilization?

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Please elaborate on the length of time the project could provide power during an outage, how it would help with grid stabilization, or explain why a project would be placed within the TIZ.

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## Appendix D. Offshore Wind Policy Statement

The following statement was prepared by Makah staff.

### Background

The Makah Tribe approaches governance, environmental management, and community development with the preservation of treaty rights and cultural practices and resources as priority considerations. This mindset also informs our strategic energy plan. It does not only outline possible options for solar or wind energy but also provides a comprehensive list of values and priorities that we will use to evaluate how a renewable energy project will provide benefits to our community and guide as we design or co-design development that is consistent with our goals. To date, the offshore wind process on the West Coast has been in direct conflict with our energy values and we cannot support the current efforts. As we have noted many times in our comments to the Bureau of Ocean Energy Management (BOEM), while we understand and support efforts to develop renewable energy, we cannot do so if it comes at the expense of our treaty-reserved rights, our natural resources, and our way of life. The purpose of this policy statement is to articulate the ways in which the offshore wind development process on the West Coast currently conflicts with our energy values, and our expectations for process adjustments on the part of BOEM. While we are making suggestions rooted in our values, we believe that these recommendations will increase transparency, enhance the recognition of Tribal treaty rights, and thus improve the process for all participants.

### Makah Energy Values

As outlined in the beginning of this plan, Makah Energy Values are ecosystem-based management, energy sovereignty and project ownership, workforce development and capacity, economic opportunity, community well-being, and emergency and disaster resilience. Below we have articulated how the West Coast offshore wind process is consistent with or conflicts with our energy values.

### Ecosystem-Based Management

As co-managers of our natural resources, we strive to make environmental management decisions that protect our resources and the ecosystems those resources need to thrive. Given our connection with the ocean, we are particularly concerned about the potential impacts to our treaty resources. One of the project considerations articulated in this plan is “Does energy development interfere with any treaty reserved resources? If so, what is the extent of the potential impacts?” The timeline of the BOEM leasing process is prohibitive to fully understanding the potential environmental impacts of offshore wind and the specific consequences for our treaty resources and cultural practices. In multiple comment letters,<sup>26,27</sup> we have specifically asked for improved habitat mapping, evaluation of changes to upwelling, identification of potentially impacted larval nurseries, and advocated for environmental management processes like marine-spatial planning and region-wide monitoring. We are on the front lines of climate change and understand the need to move quickly away from fossil fuels, but our experience with hydropower in Washington underscores the potential for damage that cannot be undone when development occurs without listening to and addressing Tribal concerns.

### Energy Sovereignty and Project Ownership

In addition to reducing emissions, our primary motivations for local renewable energy development are enhancing community resilience and energy sovereignty. The offshore wind process so far indicates a development that will compromise our sovereignty rather than support it. We are looking for a process

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<sup>26</sup> <https://www.regulations.gov/comment/BOEM-2023-0065-0233>

<sup>27</sup> <https://www.regulations.gov/comment/BOEM-2022-0009-0231>

that respects our treaty rights and our concerns and does not expect us to bear costs with no guarantees of energy or economic benefits. The current process is occurring without meaningful consultation and without adequate science, both of which are leading to failures to recognize the potential impacts to our treaty resources and for BOEM to meet their trust responsibility to the Makah Tribe. Impacts to our sovereignty cannot be mitigated, compensated, or substituted and if free, prior, and informed consent from affected Tribes cannot be achieved, then we believe the project should not move forward.

### Workforce Development and Capacity and Economic Opportunity

Given the potential impacts to our commercial fisheries and the unlikelihood that any of the predicted economic benefits associated with building, installing, and maintaining offshore wind structures will flow through Neah Bay, we are anticipating this process to result in economic damages as opposed to benefits for our community. The Port of Neah Bay has been identified as an unlikely candidate site for staging and integration, manufacturing/fabrication, and operations and maintenance activities.<sup>28</sup> Meanwhile, treaty fisheries support over 50% of our economy. We understand the constraints of direct economic benefits in Neah Bay, but we cannot simultaneously abide the consequences for our fisheries and once again be asked to bear the costs without receiving the benefits of this development. In addition to environmental impacts to our treaty fisheries, we are also concerned about the effects stemming from potential displacement of fishing effort into Washington waters from those who have traditionally fished in the Oregon Call Areas.

### Community Well-Being and Emergency and Disaster Resilience

The well-being of the Makah is tied to the health of our environment, in particular the ocean and our fisheries. Just as our treaty fisheries are an invaluable part of our economy, they are also a crucial component of our food security. While we understand the gravity of climate change and the need for swift action, the uncertainty regarding the environmental impacts coupled with the pace of offshore wind development on the West Coast puts our well-being at risk. Conversely, when we are part of the conversation from the beginning, we are able to collaborate on siting, scale, and data needs in a way that has the potential to result in multiple community well-being and resilience benefits, as has been demonstrated while we have scoped local renewable energy development.

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<sup>28</sup> NREL. The Impacts of Developing a Port Network for Floating Offshore Wind Energy on the West Coast of the United States. <https://www.nrel.gov/docs/fy23osti/86864.pdf>.