Orcas Power and Light Cooperative
Tidal Power Preliminary Assessment and Planning Project

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Acronyms and Abbreviations

AEP	Annual Energy Production
Argonne	Argonne National Laboratory
BA	Biological Assessment
BCR	benefit-cost ratio
BESS	battery energy storage system
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DAHP	Washington Department of Archaeology and Historic Preservation
DER	distributed energy resources
DNR	Washington State Department of Natural Resources
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESMO	Energy Storage Microgrid Optimization
FERC	Federal Energy Regulatory Commission
FMP	fishery management plan
FONSI	Finding of No Significant Impact
GHG	greenhouse gas
HAPC	Habitat Areas of Particular Concern
IEC	International Electrochemical Commission
IUCN	International Union for Conservation of Nature
JARPA	Joint Aquatic Resource Permit Application
kW	kilowatt
kWh	kilowatt-hour
MPA	Marine Protected Area
MSA	Magnuson-Stevens Fishery Management Act
MW	Megawatt
NEPA	National Environmental Policy Act
nm	nautical mile(s)
NMFS	National Oceanic and Atmospheric Administration National Marine Fisheries Service; *also NOAA Fisheries*
NMS	NOAA Office of National Marine Sanctuaries
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Oceanic and Atmospheric Administration National Marine Fisheries Service; *also NMFS*
NOS	National Ocean Service (of NOAA)
NPDES	National Pollutant Discharge Elimination System
NREL	National Renewable Energy Laboratory
NWP	Nationwide Permit
OPALCO	Orcas Power and Light Co-Operative
PNNL	Pacific Northwest National Laboratory

PNW	Pacific Northwest
PV	photovoltaic; or present value
SEPA	State Environmental Policy Act
Services	NOAA Fisheries Service and U.S. Fish & Wildlife Service
SHPO	State Historic Preservation Office
SRKW	Southern Resident Killer Whale
SUP	Special Use Permit
TEAMER	Testing and Access to Marine Energy Research
U&A	Usual and Accustomed
U.S.	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
UTM	Universal Transverse Mercator
W	watt
WA	Washington State
WDFW	Washington State Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation

1. Introduction

Orcas Power and Light Cooperative (OPALCO) received a grant from the Washington State Department of Commerce's Clean Energy Fund 4 (CEF4) to investigate clean energy alternatives to help OPALCO modernize their electrical grid. This award was to assess a preliminary design for a potential tidal energy project located in the Rosario Strait, WA. Tidal energy could increase resilience and energy independence for island communities, particularly during winter months when solar microgrids have lower production.

OPALCO is a non-profit cooperative electric utility providing service in San Juan County. To prepare for expected near-term electrical capacity shortfalls and long-term load doubling, OPALCO has been exploring local power generation options to ensure resilience, reliability, and ability to support beneficial electrification and regulatory clean energy goals. OPALCO is investigating the feasibility of installing one floating tidal turbine in the waters of the San Juan archipelago.

Tidal energy is harnessed from the motion of tides turning turbines installed in the water column to convert into electricity. Unlike the variability in solar and wind conditions, tidal currents are a reliable and predictable form of energy potential. Areas with high tidal ranges and strong currents present the best potential for capturing tidal energy.

Funding from CEF4 supported a pilot study to investigate the testing capacity of Rosario Strait for tidal power output and tidal turbine technology to generate electricity that supports OPALCO's microgrid for their island service area. This study area focused specifically off the eastern shore of Blakely Island within Rosario Strait. All information gathered for this report comes from a combination of publicly available resources, published scientific research, previous reports, and OPALCO's engagement with regulatory agencies and Washington tribes.

OPALCO produced this report to present a summary of information related to a potential deployment and operation of floating tidal technology in the Salish Sea, Washington (WA), specifically off the eastern shore of Blakely Island within Rosario Strait. Blakeley Island is a low-populated island located within the San Juan archipelago, approximately 1.5 miles (2.4 kilometers [km]) south of nearby Orcas Island. Rosario Strait has been identified as a tidal resource hotspot (Yang et al. 2021; Calandra et al. 2023) and is considered an optimal location for the deployment of floating tidal turbine technology.

OPALCO was supported in this effort by 48 North Solutions, Inc., Environmental Sciences Associates, and Argonne National Laboratory (Argonne).

Previous research was previously conducted regarding site analyses and existing conditions to determine a preferred location within the Salish Sea for the deployment of tidal turbine technology (e.g., Yang et al. 2021, Calandra et al. 2023). This report builds upon their efforts and results that demonstrate the potential of western Rosario Strait for a tidal power project.

The report is organized into the following sections: project objective (Section 1.1); project location (Section 1.2) and its existing environmental conditions (Section 1.2.3); tidal turbine technology (Section 1.3); a summary of tribal engagement to date (Section 2); a summary of regulatory engagement to date (e.g., agencies engaged, applicable permits, and agency feedback) (Section 3); an economic analysis (Section 4); and conclusion (Section 5). All references are cited at the end of the report in Section 6, followed by meeting minutes presented in Attachment 1.

1.1 Project Objective

OPALCO is a non-profit cooperative electric utility providing service in San Juan County, WA, in the heart of the Salish Sea. As an island community, San Juan County is at risk of unreliable electricity, as the vast majority of OPALCO's power is transported using submarine cables connected to the grid on mainland WA. When service is disrupted on the mainland, San Juan County can be subjected to long wait times as repairs are beyond their control. Therefore, OPALCO is committed to implementing local energy generation resources and microgrids that strengthen the resilience of infrastructure, increase safety and reliability for its service area, while keeping rates affordable.

As the United States (U.S.) shifts to decarbonize and achieve its net-zero goals by 2050 (DOS 2021), WA has followed suit with its own mandated target of reducing overall greenhouse gas (GHG) emissions to 95 percent below 1990 levels and achieving net-zero GHG emissions (RCW 70A.45.020). As the climate emergency accelerates, the OPALCO grid is evolving to meet the pressing needs to decarbonize and increase local energy resilience. To prepare for expected near-term electrical capacity shortfalls, and long-term load doubling, OPALCO has been exploring local generation options to ensure resilience, reliability, and ability to support beneficial electrification and regulatory clean energy goals.

Tidal energy is more powerful than wind energy because water is denser than air (PNNL 2023a); therefore, it produces exponentially more power at the same turbine diameter and rotor speed (PNNL 2023b). Additionally, tidal power is more predictable and consistent than either offshore wind (PNNL 2023c) or solar energy (PNNL 2023d)—both are intermittent and less predictable—making tidal energy an alluring renewable energy source to pursue (PNNL 2023b). While solar is minimal in the winter in the Pacific Northwest (PNW), tidal power is strong and predictable year-round. Notably, it can also be farmed within a fraction of the surface area that solar requires.

OPALCO investigated the feasibility of installing one floating tidal turbine in the waters of the San Juan archipelago, WA. This project would serve as a pilot to test the capacity of the Rosario Strait site and tidal turbine technology to generate electricity that supports OPALCO's microgrid for their island service area. As the first project of this type in WA State, several uncertainties remained that would need to be addressed as feedback is received throughout the design, implementation, and operation phases of this type of project. OPALCO, along with their teaming partners, engaged with Tribes and regulatory agencies to gain initial feedback and recommendations to incorporate into future decisions and design choices.

1.2 Project Location

The project would be in Rosario Strait off the eastern shore of Blakely Island of the San Juan Islands in the Salish Sea. The greater area of the Salish Sea, San Juan Islands, and Rosario Strait are described below.

1.2.1 Salish Sea and Puget Sound

The Salish Sea is an inland sea located between British Columbia (BC) and WA (**Figure *1***). This waterbody includes the Georgia Strait, Strait of Juan de Fuca, and Puget Sound. It comprises the waters from Olympia, WA north to Campbell River, BC, and west to Neah Bay, WA. The Salish Sea encompasses the archipelago of the San Juan Islands, wherein the tidal turbine would be deployed in Rosario Strait (**Figure 2**).

Over the last 20 years, the number of protections over this water body have steadily increased as environmental impacts from water quality to marine species have increased. For example, from 2002 to 2015 the total number of marine species at-risk in the Salish Sea has doubled (EPA 2021). Of these species, the killer whale (*Orcinus orca*) is viewed as an indicator species (i.e., a species used to infer the conditions of its habitat) for the Salish Sea, of which the Southern Resident Killer Whale (SRKW) is listed as an endangered species under the U.S. Endangered Species

Act (ESA) (70 FR 69903). In the U.S., the Environmental Protection Agency (EPA), through the Puget Sound National Estuary Program, works in close coordination with local and state agencies, as well as Tribes, to further the recovery effort of this waterbody.

With the ever-increasing focus on restoring the Salish Sea, proposed in-water projects are carefully considered by the regulatory agencies for environmental impacts. Therefore, conducting thorough engagement early and continuously over the lifetime of this project is key to expediting the permitting process and limiting conflicts among users of the Salish Sea.

1.2.2 San Juan Islands and Rosario Strait

Through a U.S. Department of Energy (DOE)-funded Testing and Access to Marine Energy Research (TEAMER) project (PNNL-32302, Environmental Information for Siting and Operation of Floating Tidal Turbines in U.S. Waters), the Pacific Northwest National Laboratory (PNNL) assessed five potential locations for a tidal energy project within the waters of the San Juan archipelago. Based on multiple factors including, but not limited to, tidal flow, presence/absence of protected species, suitable benthic habitat, and vessel traffic, Rosario Strait near Blakely Island was identified as a viable site.

If tidal generation is deployed at this location, the site could host up to four tidal turbine devices. An interconnection between the turbine(s) and OPALCO's grid would be via an existing 18-inch (46-centimeter) conduit on northwest Blakely Island that OPALCO installed in 2004. This interconnection would connect to a substation on Blakely Island where the energy would then be transmitted, via OPALCO's 69 kilovolt transmission system, to the surrounding islands along existing subsea power cables.

1.2.3 Existing Conditions

Existing conditions of the proposed project location in Rosario Strait were assessed by PNNL to determine the optimal location for tidal energy within the Salish Sea. Focusing on Rosario Strait, the following existing conditions are described: tidal conditions and bathymetry; protected biological resources (i.e., endangered and/or threatened) known to occupy the area and any designated critical habitat; and other marine users that utilize the waters in and around the project area (i.e., recreationists and commercial fishers).

Figure 1: Reference map for the Salish Sea bioregion with boundary highlighted in white (Flower 2020)

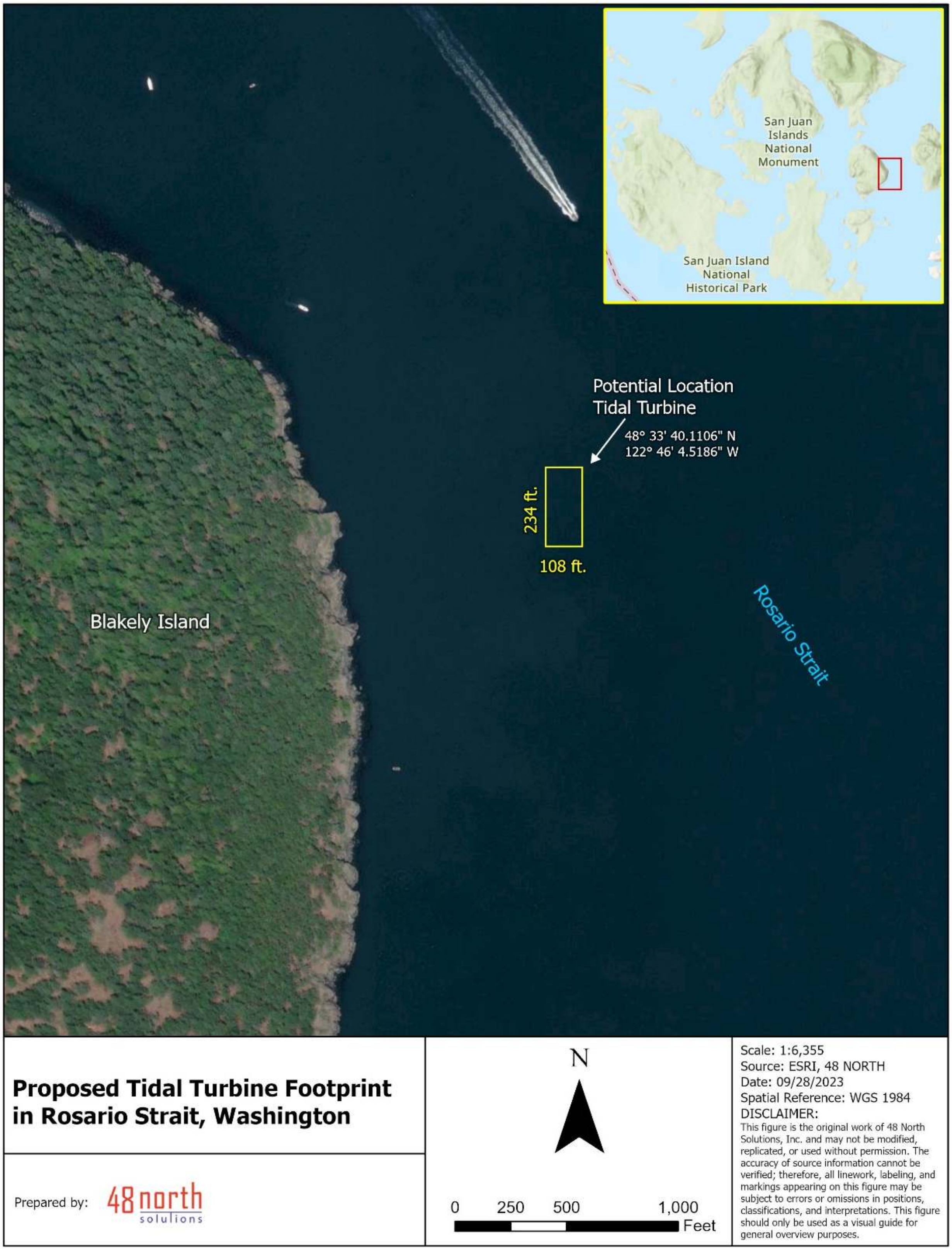

Figure 2: Proposed project location within Rosario Strait

A) Tidal Conditions and Bathymetry

This section describes Rosario Strait's tidal and current conditions, bathymetry, tidal power density, and kinetic energy flux, as determined by recent tidal studies of the Salish Sea and other reports. Tidal power density and kinetic energy flux through a channel cross section are commonly used to characterize the tidal energy resource at a hotspot[1] (Yang et al. 2021). Overall, among sites investigated within the Salish Sea, Rosario Strait is one of the top three locations for tidal flow, the other two being Admiralty Inlet and Middle Channel (**Figure 3**).

Tide and Current Conditions

Tides in the Salish Sea are mixed diurnal and semi-diurnal patterns, predominantly semi-diurnal (Yang and Wang 2013). As a result, tides in the Salish Sea exhibit a strong spring-neap tidal cycle and diurnal inequality (Yang et al. 2021). The mean tidal range in Rosario Strait south of Orcas Island is 4.94 feet (ft.; 1.5 meter [m]).

To determine the optimal site for a future tidal turbine deployment, the following factors were considered: magnitude of tidal current speed and any temporal and spatial variabilities (e.g., tidal asymmetries in flow direction and magnitude); spring-neap tidal cycle; eddy currents; and diurnal inequality (Yang and Wang 2013; Rao et al. 2016; Brown et al. 2019; Lewis et al. 2019; Guillou et al. 2020; Yang et al. 2021). These site characteristics have been measured and modeled for Rosario Strait and used to determine tidal power density and kinetic energy flux and generation potential for the tidal channel cross section.

Rosario Strait has a maximum current speed that exceeds 6.56 feet per second (ft./s; 2 meters per second [m/s]); however, greater than 80 percent of the time current speed is less than 3.28 ft./s (1 m/s); i.e., current speed exceeds 3.28 ft./s (1 m/s) approximately 20 percent of the time (Yang et al. 2021). The average cross-sectional current speed for Rosario Strait is 2.89 ft./s (0.88 m/s; Yang et al. 2021), but it varies considerably both temporally and spatially through the channel. The current magnitude exceeds 8.20 ft./s (2.5 m/s) during both peak flood and ebb, exhibiting stronger currents toward the western deeper side of the channel (Yang et al. 2021). During peak ebb, positive velocities occur on the eastern shallower side of the channel, indicating eddy currents produced by the presence of Cypress Island across the channel (Yang et al. 2021). During spring and neap ebb, Rosario Strait has a maximum tidal energy at spring tide of 10.3 ft./s (3.14 m/s), and minimum tidal energy at neap tide of 5.91 ft./s (1.80 m/s; **Figure 4**) (Yang et al. 2021).

[1] Yang et al. (2021) defined tidal energy hotspot as a tidal channel, or a section of the channel, that has strong tidal currents that exceed a mean current speed criterion of 1.64 ft./s (0.5 m/s).

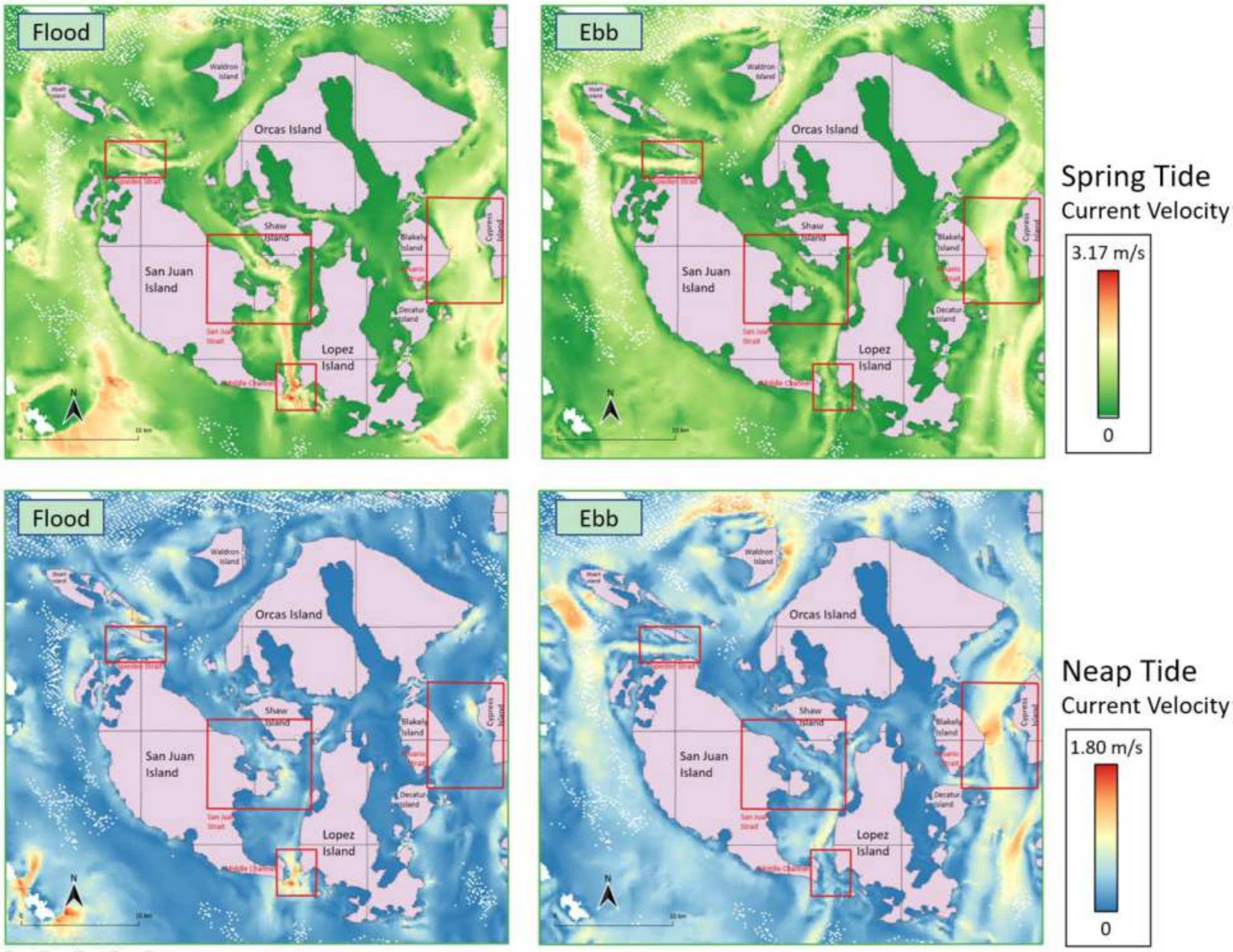

Figure 3: Current velocities in the San Juan archipelago

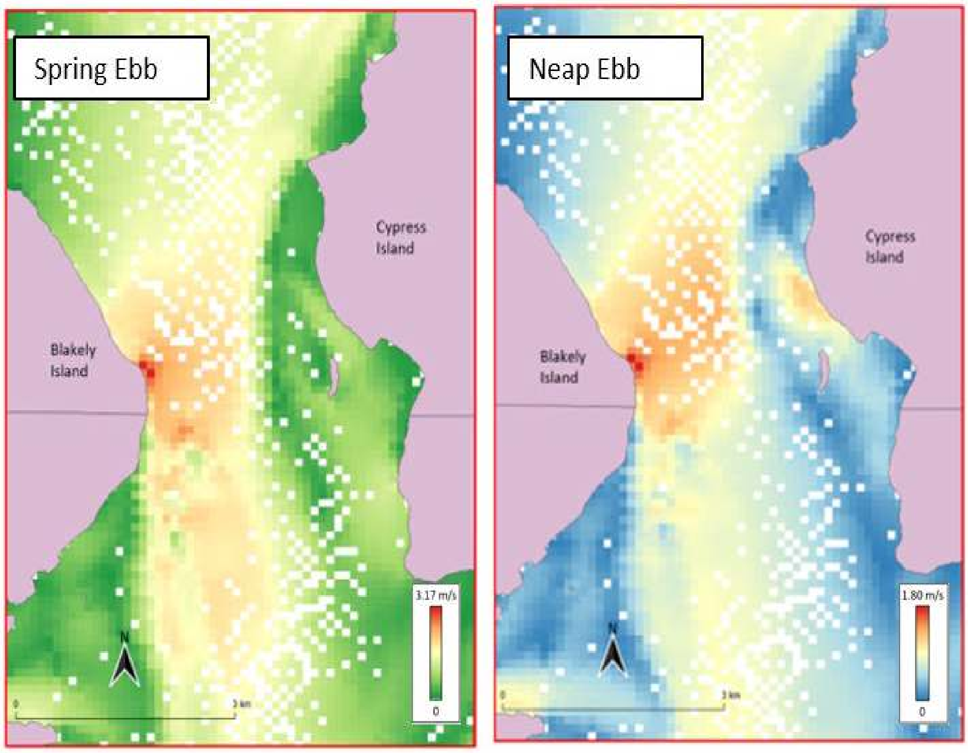

Figure 4: Tidal velocity (m/s) maps for Rosario Strait, during periods that have the highest recorded relative velocity (Yang et al. 2021). White pixels denote areas without sufficient data.

A common way to characterize a tidal energy hotspot is to determine its tidal power density and kinetic energy flux (Yang et al. 2021). Tidal power density (measured in watts per square meter [W/m^2]) is a function of both seawater density and current speed. Mean kinetic energy flux (measured in kilowatts [kW]) through a channel cross section is a function of the time-averaged tidal power density (W/m^2) and area (m^2) of the cross section (Yang et al. 2021). Rosario Strait has a maximum power density slightly greater than 3 kW/m^2 near the western (left) side of the channel, which is the site targeted for the tidal turbine deployment (**Figure *5***; Yang et al. 2021, Calandra et al. 2023). Rosario Strait is a demonstrated tidal energy hotspot with a mean kinetic energy flux of 72,833 kW (Yang et al. 2021).

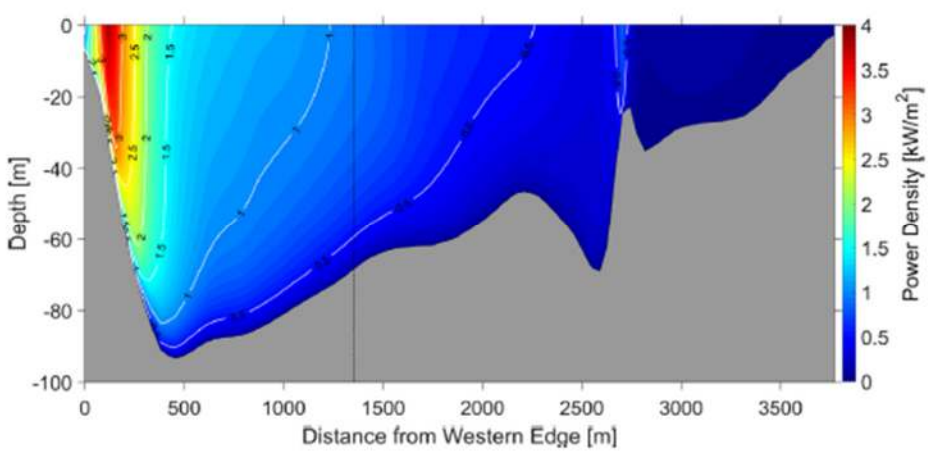

Figure 5: Power density (kW/m^2) profile for Rosario Strait, reaching a maximum of greater than 3 kW/m^2 on the west end of the channel, closer to Blakely Island. Figure as shown in Calandra et al. 2023.

Bathymetry

Rosario Strait has a mean water depth of 196.85 ft. (60 m; Yang et al. 2021). The seafloor sediment composition is mainly unconsolidated sand and mud with some rocky outcroppings. This presents an appropriate substrate for anchoring the tidal turbine device in this area. Bathymetric results were determined by the NOAA's National Ocean Service, which conducted surveys throughout the Salish Sea from 2015-2017 with the purpose to update tidal current predictions (**Figure *6*;** Kammerer et al. 2021, Calandra et al. 2023).

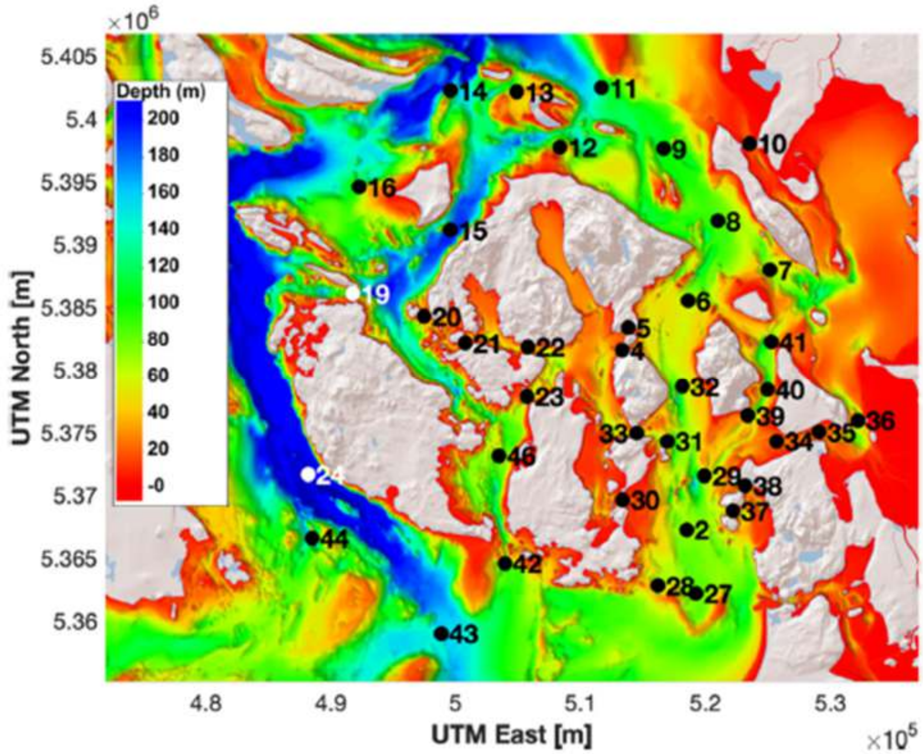

Figure 6: Bathymetric rendering of the San Juan archipelago including Rosario Strait (Calandra et al. 2023).

B) Protected Biological Resources

Threatened and Endangered Species

Those species listed as threatened or endangered under the federal Endangered Species Act (ESA) of 1973 and associated critical habitats in the vicinity of the proposed tidal project area presented in this section. Most are found at least periodically in the San Juan Islands or have designated critical habitat in the immediate vicinity of where the project would be located. Only species that are listed as either endangered or threatened by NOAA Fisheries and/or the USFWS are included here, but it is important to note that other marine and avian species are present within the San Juan archipelago that are not included in this report.

Three (3) species are listed as endangered under the ESA (**Table 1**). They include the Southern Resident Killer Whale (SRKW, *Orcinus orca*), humpback whale (*Megaptera novaeangliae*), and bocaccio rockfish (*Sebastes paucispinis*). These species have ranges and critical habitat within the San Juan archipelago, some within Rosario Strait and nearshore waters off Blakely Island.

Six (6) species are listed as threatened under the ESA. They include chinook salmon (Puget Sound evolutionarily significant unit [ESU]; *Oncorhynchus tshawytscha*), steelhead (Puget Sound DPS; *O. mykiss*), green sturgeon (Southern DPS; *Acipenser medirostris*), yelloweye rockfish (*S. ruberrimus*), bull trout (*Salvelinus confluentus*), and marbled murrelet (*Brachyramphus marmoratus*). Additionally, NOAA Fisheries has proposed listing the sunflower sea star (*Pycnopodia helianthoides*) as threatened under the ESA, as of March 16, 2023 (88 FR 16212). These species have ranges and critical habitat within the San Juan archipelago, some within Rosario Strait and nearshore waters off Blakely Island.

Table 1: ESA-listed Species That May Be Present in the Project Area

Common Name (Scientific Name)	ESA Status	Critical Habitat in Project Area
Marine Mammals		
Killer Whale, Southern Resident DPS (*Orcinus orca*)	Endangered	Yes
Humpback Whale, Mexico DPS (*Megaptera novaeangliae*)	Threatened	No
Humpback Whale, Central America DPS (*M. novaeangliae*)	Endangered	No
Fishes		
Bocaccio, Puget Sound-Georgia Basin DPS (*Sebastes paucispinis*)	Endangered	Yes
Chinook Salmon, Puget Sound ESU (*Oncorhynchus tshawytscha*)	Threatened	Yes[1]
Steelhead, Puget Sound DPS (*O. mykiss*)	Threatened	No
Green Sturgeon, Southern DPS (*Acipenser medirostris*)	Threatened	No
Yelloweye Rockfish, Puget Sound-Georgia Basin DPS (*S. ruberrimus*)	Threatened	Yes
Bull Trout (*Salvelinus confluentus*)	Threatened	No
Birds		
Marbled Murrelet (*Brachyramphus marmoratus*)	Threatened	No
Echinoderms		
Sunflower Sea Star (*Pycnopodia helianthoides*)	Proposed Threatened	N/A

Key:
ESA = Endangered Species Act
ESU = Evolutionarily Significant Unit
DPS = Distinct Population Segment

[1]. Project area potentially overlaps with the edge of designated critical habitat for chinook salmon (Puget Sound ESU).

<u>Killer Whale, Southern Resident DPS</u>

Three pods (J, K, and L) are identified within the Southern Resident DPS of the Southern Resident Killer Whale (SRKW; *Orcinus orca*), which NOAA Fisheries listed as endangered on November 18, 2005 (70 FR 69903). During the late spring, summer, and fall, SRKW reside in the inland waters of Washington State (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound) and BC. SRKW critical habitat includes the Strait of Juan de Fuca, Puget Sound, Haro Strait, Rosario Strait, and the waters around the San Juan Islands (71 FR 69054), excluding areas shallower than 6.1 m (20 ft.). While Rosario Strait lies within SRKW designated critical habitat, SRKW density estimates are low for Rosario Strait, the northern side of the Strait of Juan de Fuca, and San Juan Channel (Olson et al. 2018) (**Figure 7**). The project area is within SRKW designated critical habitat; however, the location of the proposed project would lie outside of major SRKW migration routes and avoid the areas of highest SRKW density (Olson et al. 2018).

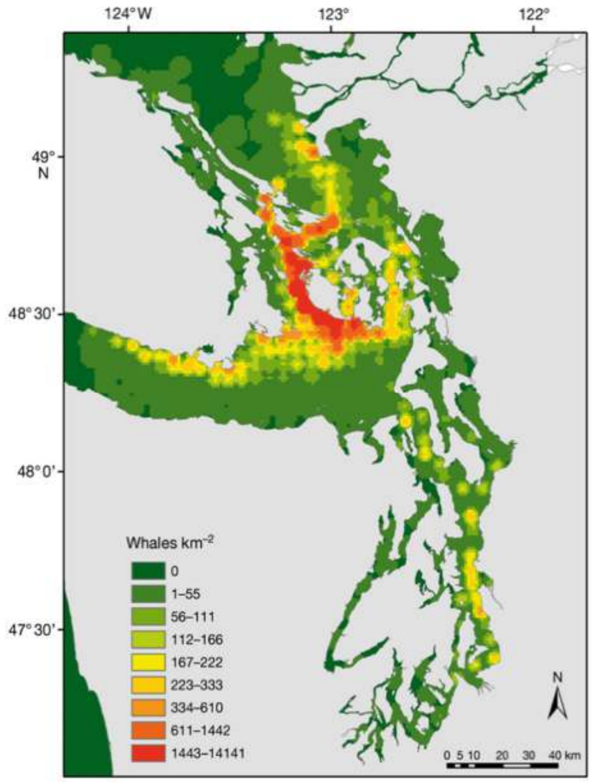

Figure 7: Southern Resident Killer Whale density (number of SRWK per km^2) based on effort-corrected data in the Salish Sea, 1976-2014 (Olson et al. 2018).

<u>Humpback Whale, Mexico, and Central America DPS's</u>

NOAA Fisheries has listed four (4) DPS's of humpback whales as either threatened or endangered, including the Mexico DPS (threatened) and Central America DPS (endangered) June 9, 2022 (81 FR 62259). These humpback populations migrate south to overwinter in warmer waters but are sighted within waters of WA and BC from June to October (Falcone et al. 2005). NOAA Fisheries designated critical habitat for these humpback populations that includes WA's outer coast and U.S. waters of the Strait of Juan de Fuca (86 FR 21082). The designated critical habitat does not include the waters surrounding the San Juan Islands, waters off Blakely Island, or Rosario Strait, where the proposed project would be located.

While annual humpback whale sightings are increasing within Washington's inland waters, historically they have been rare (Everitt et al. 1980; Osborne et al. 1988; Falcone et al. 2005; CRC 2017; Calambokidis et al. 2017, 2018). The estimated probability that an encountered humpback whale within the Southern BC/Washington (including inland waters of the San Juan Islands) summer feeding area is part of a specific DPS are 69 percent for the Hawaii DPS - (not ESA-listed); 25 percent for Mexico DPS (threatened); and 6 percent for Central America DPS (endangered) (NOAA Fisheries 2021; Wade 2021). Therefore, it is possible that a humpback whale from either the Mexico or Central America DPS could be present in proximity to the proposed project area.

<u>Bocaccio, Puget Sound-Georgia Basin DPS</u>

The Puget Sound-Georgia basin DPS of bocaccio rockfish is listed as endangered by NOAA Fisheries April 13, 2011 (75 FR 22276). Bocaccio larvae are pelagic and generally occur in the upper 262 ft. (80 m) in the ocean, and adult bocaccio inhabit rocky habitats between 164 and 1,395 ft. (50 and 425 m) deep.

NOAA Fisheries designated critical habitat for bocaccio, which includes waters off Blakely Island within Rosario Strait where the proposed project would be located (79 FR 68041, 80 FR 7977; **Figure *8***). Critical habitat for the Puget Sound-Georgia Basin DPS bocaccio include (1) benthic habitats or sites deeper than 98 ft. (30 m) that possess or are adjacent to areas of complex bathymetry consisting of rock or highly rugged or corrugated habitat and (2) juvenile settlement habitats located in the nearshore with substrates such as sand, rock, and/or cobble that support kelp (79 FR 68041). Bocaccio have been documented in the San Juan Islands, which have rocky shorelines with extensive submerged aquatic vegetation and floating kelp beds necessary for juvenile settlement. Since the proposed project area lies within the bocaccio designated critical habitat, it is possible that bocaccio will be present in the area.

Yelloweye Rockfish, Puget Sound-Georgia Basin DPS

The Puget Sound-Georgia Basin DPS (Coastal Recovery Unit) of yelloweye rockfish is listed as threatened by NOAA Fisheries on April 11, 2011 (82 FR 7711). Adult yelloweye rockfish remain near the seabed and have relatively small home ranges. Like bocaccio, they occupy habitats between 98 and 1,395 ft. (30 and 425 m) deep, within and adjacent to areas where rocky habitats are very rough and highly corrugated. The description of designated critical habitat for yelloweye rockfish in the Puget Sound-Georgia Basin is like that for bocaccio (79 FR 68041) and includes nearshore areas off Blakely Island in Rosario Strait (**Figure 8**). Like bocaccio, the proposed project area lies within yelloweye rockfish designated critical habitat. Therefore, it is possible that yelloweye rockfish will be present in the proposed project area.

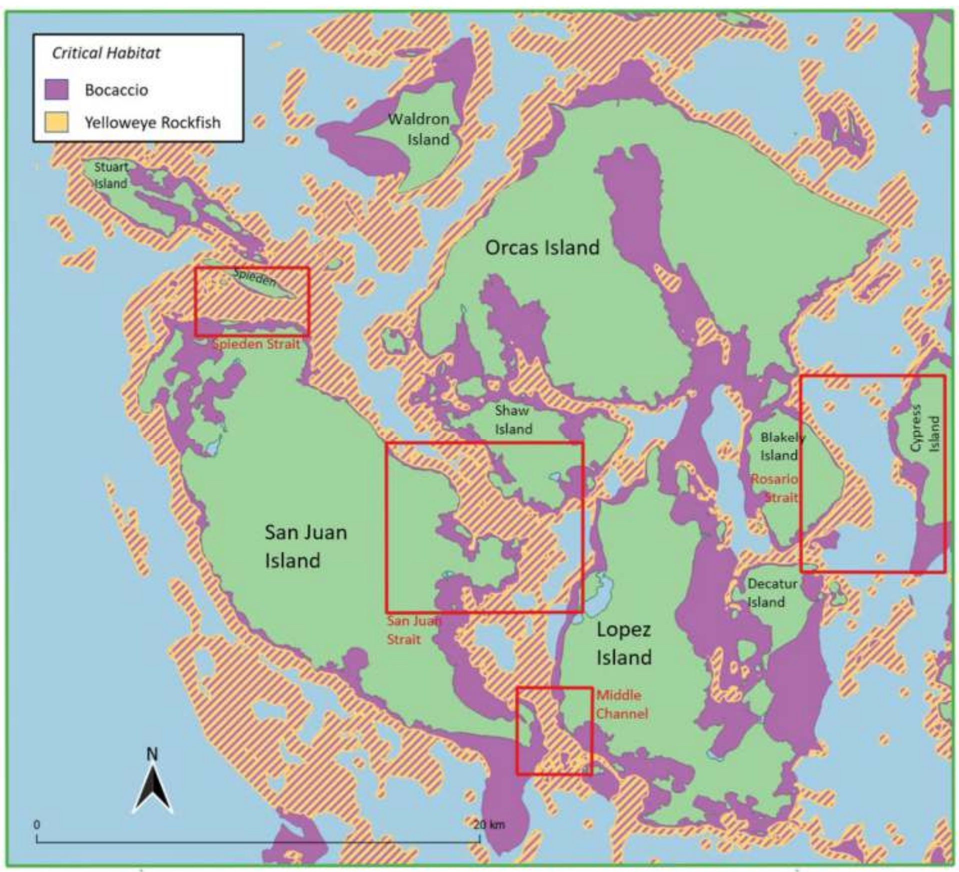

Figure 8: Critical habitat map for endangered bocaccio and threatened yelloweye rockfish. The red boxes delineate channels examined for tidal resources.

Chinook Salmon, Puget Sound ESU

Puget Sound ESU chinook salmon are listed as threatened by NOAA Fisheries on May 24, 1999 (79 FR 20802). The Puget Sound Chinook salmon ESU includes naturally spawned Chinook salmon from rivers and streams flowing into Puget Sound from eastward of the Elwha River (70 FR 37160), including rivers and streams flowing into the Strait of Georgia (north of Rosario Strait) in WA.

Puget Sound Chinook salmon run timings are in summer, fall, and spring. The Puget Sound Chinook salmon populations closest to the San Juan Islands spawn in the Nooksack River, Skagit River, and Dungeness River. Limited information exists about Chinook salmon habitat use of marine waters. Critical habitat includes all nearshore marine areas of the Strait of Georgia, Puget Sound, Hood Canal, and the Strait of Juan de Fuca from the line of extreme high tide out to a depth of 30 m (98.4 ft.; 70 FR 52629). Nearshore waters off eastern Blakely Island within Rosario Strait include chinook salmon designated critical habitat (**Figure 9**). Juvenile Chinook could occupy the nearshore, while subadult and maturing fish tend to occupy deeper water. The location of the proposed project may overlap with designated critical habitat for the Puget Sound ESU chinook salmon.

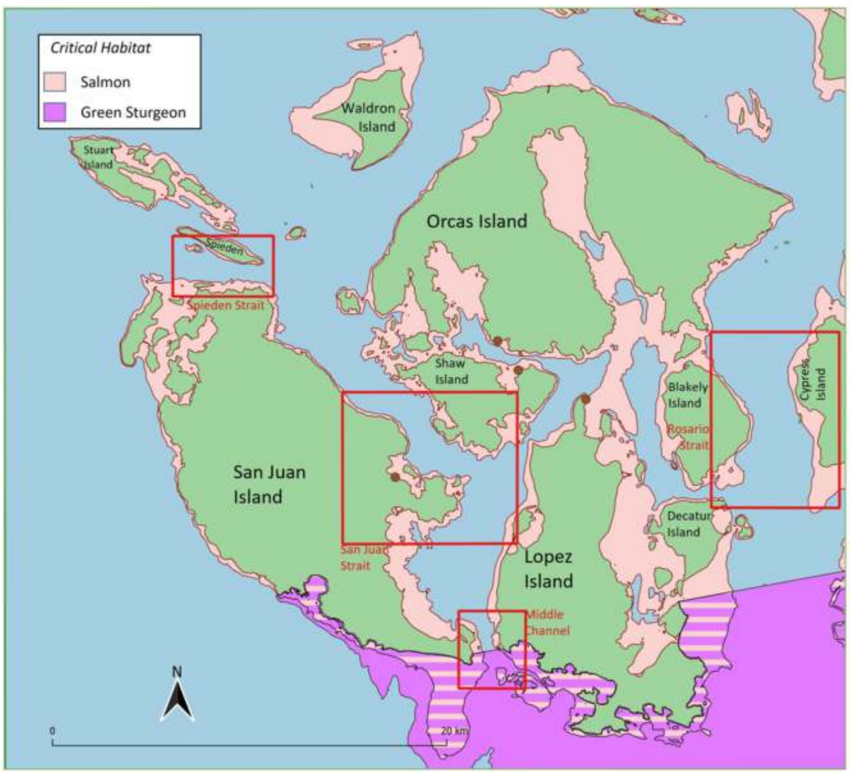

Figure 9: Critical habitat for threatened chinook salmon and green sturgeon around the San Juan Islands. (The red boxes delineate channels examined for tidal resources).

Steelhead, Puget Sound DPS

The Puget Sound DPS of steelhead was listed as threatened by NOAA Fisheries on May 11, 2007 (updated April 14, 2014. Their habitat includes all naturally spawned anadromous populations from streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, WA, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive) (79 FR 20802). Steelhead only ephemerally use the nearshore marine waters, unlike most other Pacific salmonids (e.g., Puget Sound Chinook). The species' lengthy freshwater rearing period results in large smolts that are prepared to move rapidly through estuaries and nearshore waters to forage on larger prey in offshore marine areas. Critical habitat for the Puget Sound steelhead DPS has been designated by NOAA Fisheries (81 FR 9251) but does not overlap with the proposed project area. However, there is designated critical habitat in the greater region, and therefore steelhead from the Puget Sound DPS may be present in the area.

Green Sturgeon, Southern DPS

The Southern DPS of green sturgeon is listed as threatened by NOAA Fisheries on April 7, 2006 (71 FR 17757). Green sturgeon is distributed in bays and estuaries in Washington, Oregon, and California during summer and fall. They typically occupy depths of 66 to 230 ft. (20 to 70 m) while in marine habitats (Erickson and Hightower 2007; Huff et al. 2011). Key elements needed for green sturgeon success in nearshore coastal marine areas include migratory corridors between estuarine and marine habitats, and nearshore marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants.

Critical habitat for the Southern DPS of green sturgeon was designated by NOAA Fisheries on October 9, 2009 (74 FR 52299) and includes areas south of San Juan, Lopez, and Decatur Islands (**Figure 9**). The proposed project area is not in designated critical habitat; however, given the proximity to the northern border of the designated critical habitat, there is the possibility that Southern DPS green sturgeon may be present in the proposed project area.

Bull Trout

The Coterminous U.S. DPS (Coastal Recovery Unit) of bull trout is listed as threatened by the USFWS on June 10, 1998 (64 FR 58910). This DPS encompasses all Pacific Coast drainages within the U.S. north of the Columbia River in Washington, including those flowing into Puget Sound. Puget Sound anadromous bull trout enter marine waters in early spring, with residence time in saltwater averaging two (2) months and not exceeding four (4) months (Goetz 2016). The Coastal-Puget Sound DPS is significant to the species because it currently contains the only anadromous forms of bull trout in the coterminous United States (USFWS 2004). Coastal-Puget Sound DPS anadromous adult and subadult bull trout may use the marine waters of Salish Sea for foraging and overwintering; however, the extent is poorly understood.

The Coterminous U.S. DPS of bull trout has designated critical habitat, some of it along the southern portion of the Strait of Juan de Fuca (75 FR 63898). Critical habitat for bull trout does not include the San Juan Islands, Rosario Strait or waters surrounding Blakely Island where the proposed project would be located. Therefore, it is unlikely that bull trout would be present within the proposed project area.

Marbled Murrelet

The USFWS has listed the marbled murrelet as threatened in Washington, Oregon, and California on October 1, 1992 (57 FR 45328). Marbled murrelets are small diving seabirds that spend most of their life in the marine environment but come inland to nest in forest stands with late-successional and old-growth characteristics. Most of their biological and physical interactions occur at sea, usually within 1.2 mi. (2 km) of the shoreline (USFWS 1997). In Washington, the current and historical marine distribution of marbled murrelets includes the southern Salish Sea (i.e., Puget Sound and the Strait of Juan de Fuca) and the outer coast (Desimone 2016). However, there is no appropriate nesting habitat in or near the proposed project area. In the San Juan Islands, Speich and Wahl (1995) found the highest seasonal density was in the summer and fall periods. Murrelets could be present in the proposed project area, but due to the high level of human activity and lack of nearby old growth forests, it is unlikely they would utilize habitat around the project area.

The USFWS originally designated critical habitat for the marbled murrelet on May 24, 1996 (61 FR 26256), revising it on October 5, 2011 (76 FR 61599) (confirmed on August 4, 2016 [81 FR 51348]). There is no designated critical habitat for the marbled murrelet within or near the proposed project area.

Sunflower Sea Star

The sunflower sea star is a large sea star, iconic of the northeast Pacific Ocean. On March 16, 2023, NOAA Fisheries proposed to list the sunflower sea star as a threatened species throughout its range (88 FR 16212). It has also been declared a critically endangered species by the International Union for Conservation of Nature (IUCN) (Gravem et al. 2020). It is among the largest sea stars in the world, with a maximum arm span of 3.3 ft. (1 m) and 16 to 24 limbs. Its distribution ranges from California to Alaska, but it is no longer observed in Oregon and California. However, it is present in low numbers in Puget Sound and Alaska. It exists on many different types of marine habitats, including mud, sand, shell, gravel, rocky bottoms, kelp forest, and lower intertidal, at depths from 0 to 1,427 ft. (0 to 435 m). NOAA Fisheries does not propose to designate critical habitat because it is not currently determinable (88 FR 16212).

Displacement of Animals from Critical Habitats

The proposed project location within Rosario Strait overlaps with designated critical habitat for the following species: killer whale (Southern Resident DPS); bocaccio (Puget Sound-Georgia Basin DPS); yelloweye rockfish (Puget Sound-Georgia Basin DPS); and chinook salmon (Puget Sound ESU).

The presence of one or more floating tidal turbines may displace marine animals from their critical habitat. This effect could occur from the presence of the device itself, anchors in the seabed, or mooring lines in the water column. Little research or insight has been gathered regarding this potential interaction, and the current thinking is that small numbers of devices (e.g., one to four) are unlikely to cause this effect (Copping 2020). No monitoring or informed modeling is possible at this time; however, as arrays are deployed in the future, research and monitoring will be needed to determine whether displacement or barrier effects are likely to occur.

C) Essential Fish Habitat

Essential fish habitat (EFH) is defined by the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (MSA) as "waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Within the project location, EFH has been identified for the following:

- Pacific Coast Groundfish (all life stages)
- Coastal Pelagic Species [CPS] (all life stages): finfish, krill (*Thysanoessa Spinifera*), krill (*Euphausia pacifica*), and other krill species.

Pacific Coast Groundfish

The Pacific Coast Groundfish fishery management plan (FMP) includes species inhabiting the bottom of the water column from Washington to southern California, including the Strait Juan de Fuca (PFMC 2020). EFH for Pacific Coast groundfish includes all waters and substrate at depths less than or equal to 11,483 ft. (3,500 m) to the mean higher high-water level. In Washington, Habitat Areas of Particular Concern (HAPCs) for the Pacific Coast groundfish are all waters and the sea bottom in state waters from the 3 nm boundary of the territorial sea, shoreward to the mean higher high-water level.

There are four groups of groundfish with species that potentially inhabit San Juan Islands waters based on their occurrence in Puget Sound: flatfish; rockfish; roundfish; and sharks, skates, and chimaeras. Common flatfish species encountered around San Juan Islands are dover sole (*Microstomus pacificus*), starry flounder (*Platichthys stellatus*), sand sole (*Psettichthys melanostictus*), and English sole (*Parophrys vetulus*). Rockfishes inhabiting the areas around the San Juan Islands are bocaccio, yelloweye rockfish, canary rockfish, and the brown rockfish (*S. auriculatus*) that are common in waters less than 174 ft. (53 m) deep. Roundfish include lingcod (*Ophiodon elongatus*) and Pacific cod (*Gadus macrocephalus*). In Puget Sound, lingcod inhabits intertidal areas to depths of 1,558 ft. (475 m).

Coastal Pelagic Species

CPS finfish are pelagic, generally occurring and harvested above the thermocline in the upper mixed layer. CPS finfish include the Pacific sardine (*Sardinops sagax*), Pacific (chub) mackerel (*Scomber japonicus*), Northern anchovy (*Engraulis mordax*, central and northern populations), and Jack mackerel (*Trachurus symmetricus*). Other CPS include market squid (*Doryteuthis opalescens*) and krill (*Euphausiid species*).

The east-west geographic boundary of EFH for CPS finfish and market squid is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington, offshore to the limits of the Exclusive Economic Zone (EEZ), and above the thermocline where sea surface temperatures range between 10 and 26°Celsius (C; 50 and 78.8°Fahrenheit [F]). The northern boundary is defined as the position of the 10°C (50°F) isotherm. The EFH designation for all species of krill extends the length of the West Coast, from the shoreline to the 1,000-fathom isobath, and to a depth of 1,312 ft. (400 m).

Habitat Areas of Particular Concern

No HAPCs were identified within, or in proximity to, the proposed project area. Additionally, there is no seagrass located within the proposed project area.

D) Marine Users

Ferry traffic

The Washington State Department of Transportation (WSDOT) passenger ferry system has routes from Anacortes on Fidalgo Island to Lopez Island, Shaw Island to Orcas Island, and to Friday Harbor on San Juan Island. These routes run south of Blakely Island through Rosario Strait, but do not cross through the location of the proposed project (**Figure *10***). Blakely Island itself does not have a WSDOT ferry terminal or public ferry service. Therefore, the proposed tidal project is not anticipated to have any impact on the WSDOT passenger ferry system.

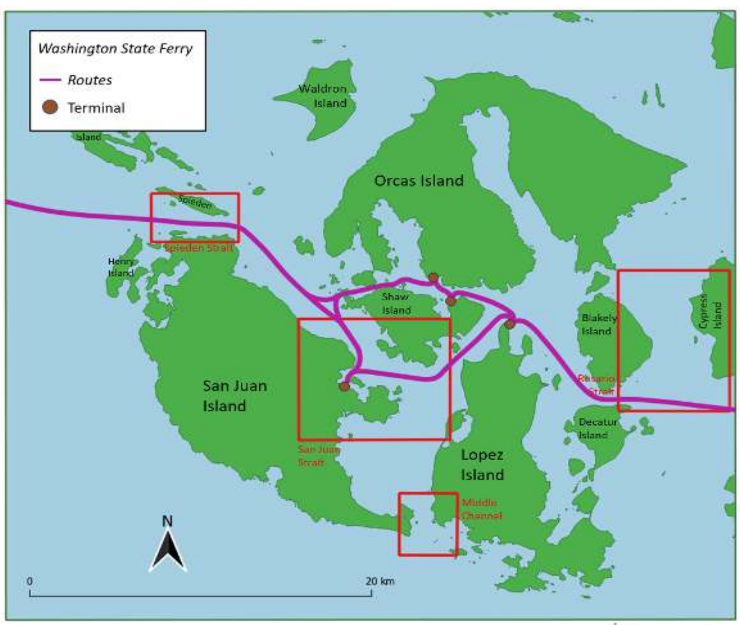

Figure 10: WSDOT ferry route from Anacortes (Fidalgo Island, not pictured) to terminals on Lopez, Shaw, Orcas Islands, and Friday Harbor on San Juan Island.

Recreation

Rosario Strait is included in Marine Area 7, which consists of waters south of the Canadian border containing the San Juan Islands, Haro Strait, Rosario Strait, Bellingham Bay, the southern Strait of Georgia, and the northeastern portion of the Strait of Juan de Fuca (WDFW 2023). The area is popular with recreationists and is renowned for SCUBA and freediving due to the biodiversity of the area (WDFW 2023). Recreational boaters commonly traverse and use Rosario Strait, due to its scenic views and access to various parks and beaches within the San Juan Islands.

Recreational fishing is also popular within Marine Area 7**.** The straits and bays of the San Juan Islands are recognized for having numerous scenic locations to fish for Chinook salmon and baitfish, due to its location at the convergence of several large bodies of water (WDFW 2023). Salmon fishing typically opens in July, coinciding with sockeye bound for the Fraser and Skagit rivers, but varies by year. Coho salmon are found in late-summer and early-fall around the exterior of the San Juan Islands and in Rosario Strait, while during odd-numbered years pink salmon are abundant from mid-July into early-September and are typically found in the same locations as coho (WDFW 2023).

Other common species recreationally fished in Rosario Strait include trout, steelhead, sturgeon, mackerel, herring, anchovy, sardine, sand lance, smelt, Pacific halibut, and bottom fish (e.g., lingcod, surfperch, Pacific cod, cabezon, and wolf-eel) (Washington Fishing 2023). Many of these species have year-round seasons, except for Pacific halibut, salmon species, and bottomfish (Washington Fishing 2023).

Commercial Fishing

There is commercial fishing occurring within the Salish Sea region. Currently, there is no specific data to present on commercial fishing intensity in Rosario Strait where the deployment is proposed. However, OPALCO is committed to thorough consultations with Tribal and commercial fishers in the area to avoid conflicting uses to the greatest extent possible. More information on this topic will follow as the project progresses.

1.3 Tidal Turbine Technology

Tidal energy is harnessed from the motion of tides turning turbines installed in the water column to convert into electricity. Unlike the variability in solar and wind conditions, tidal currents are a reliable and predictable form of energy potential. Areas with high tidal ranges and strong currents present the best potential for capturing tidal energy. As the industry is in its early stages, research is ongoing to develop technologies and optimize power output to make tidal a viable energy alternative.

There are a variety of tidal turbine designs on the market today. Tidal turbines are like wind turbines, with blades that turn a rotor to power a generator. They may be floating or installed on the seafloor, a single device or in an array. Designs include axial-flow turbines that operate in parallel with the current, crossflow turbines mounted atop a generator deployed on the seabed or at the surface. An example of an axial-flow, floating stream turbine that has been identified as a potential viable option for Rosario Strait deployment is the Orbital Marine O2.

1.3.1 Orbital Marine O2

The Orbital Marine O2 (**Figure 11**) is a floating tidal turbine with a 245-foot-long (75 m) hull and twin rotors suspended underneath. The device is 165 ft. (50.3 m) wide including the span of the blades underwater, with a main tube width of 13 ft. (4 m). The rotor blades are 65 ft. (19.8 m) in diameter, spinning at an average of 8.5 rotations per minute (rpm). This translates to an average rotor tip speed of 29 ft./s (8.8 m/s). The rpm and tip speed will increase or decrease with the speed of the tidal currents flowing past the device.

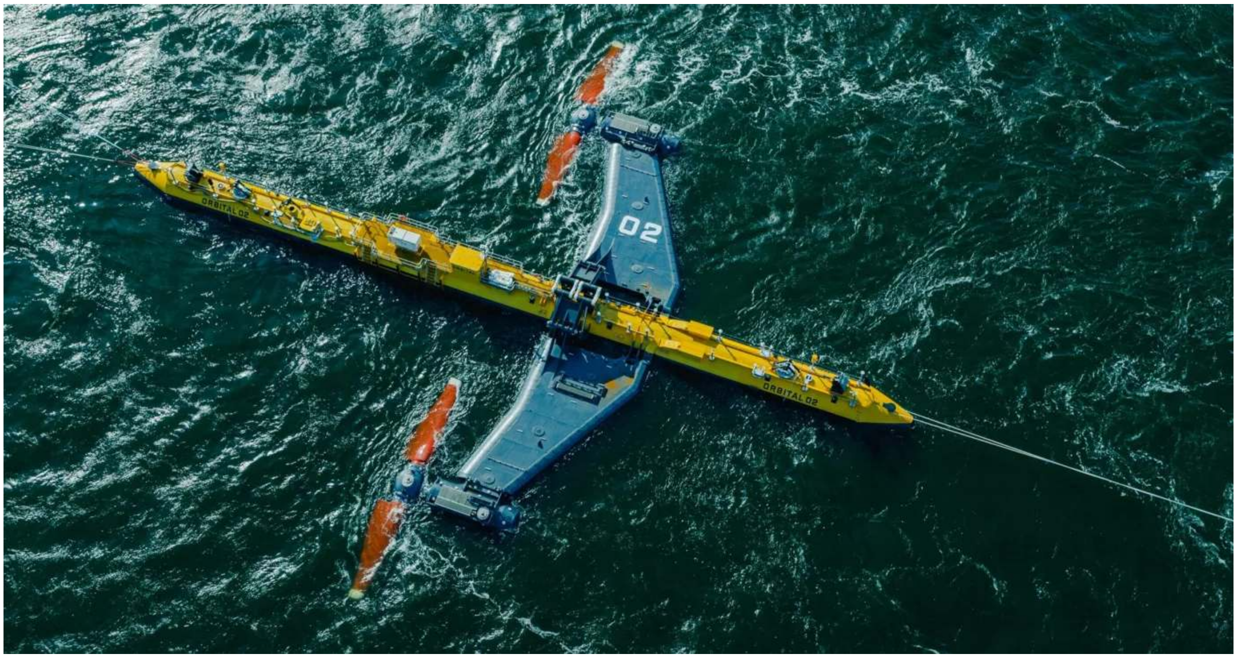

Figure 11: Orbital Marine O2 Floating Tidal Turbine

When operating, the turbines sit approximately 90 ft. (27.4 m) deep in the water column. Due to the wing-like design of the turbine placement on the device, the exact positioning of the turbines can be adjusted up and down to optimize output, as well as be fully lifted out of the water for maintenance without removing the device from service.

The device is anchored to the seafloor with mooring lines. Floating approximately 5 ft. (1.5 m) above the waterline and 7.5 ft. (2.3 m) below, the unit houses two turbines with a combined annual output of roughly 2 Megawatts (MW) and approximately 5 gigawatt hours. As of writing this report, this technology has been deployed for over 27 months in the Orkney Islands, Scotland, and connected to the European Marine Energy Centre grid via subsea cable where it generates enough electricity for approximately 2,000 homes.

The goal of investigating this tidal turbine technology is the potential it could emulate the current deployment of the Orkney Islands in the San Juan Islands. The marine conditions are similar and there are pre-constructed subsea cable conduits available on the north and south shores of nearby Blakely Island to connect to OPALCO's grid. The output would benefit a growing island community that seeks to strengthen its energy independence and improve livelihoods by divesting from the singular power cable currently supplying the archipelago from mainland Washington State.

2. Tribal Engagement

In the state of Washington, tribal nations have legal co-management of all natural resources which support their livelihoods and cultural heritage, decided by the landmark Boldt decision in 1975 and subsequent decisions (United States versus Washington 1975; United States versus Washington 1995), with special significance for salmon and shellfish. The San Juan Islands is home to the Lummi and Samish Tribes, with traditional territories that stretch over a wide region of the Salish Sea in northwest Washington, from the top of the Cascades Mountains to the far western shores of the San Juan Islands. In western Washington, many tribes have treaties reserving their right to fish in U&A fishing areas that often extend well beyond the geographical range of their tribal lands, including the federally recognized Lummi, Nooksack, Swinomish, Upper Skagit, Sauk-Suiattle, Stillaguamish, Tulalip, Muckleshoot, Puyallup, Nisqually, Squaxin Island, Skokomish, Suquamish, Port Gamble S'Klallam, Jamestown S'Klallam, Lower Elwha Klallam, Makah, Quileute, Quinault, and Hoh Tribal Nations (Pacific Fishery Management Council 2021b).

Since early 2022, the OPALCO team has been actively engaging with the tribal nations who primarily reside in the San Juan Islands (Lummi Nation and Samish Nation), as well as the tribal nations whose traditional territories and U&A fishing areas are in vicinity of the proposed project area including the Swinomish Indian Tribe, Tulalip Tribes, and Suquamish Indian Tribe. The OPALCO team has been actively working to share information about the proposed project, including location and technology, to establish trust and seek meaningful engagement on the proposed project early in the process. To date, there have been eight meetings with tribal representatives from these five tribal nations. **Table 2** includes a detailed summary of the meetings OPALCO has participated in with the tribal nations. The tribal representatives that have participated in our meetings have been actively sharing the project details with the tribal fishing community and tribal governments to solicit feedback on the types of fishing done in this vicinity and the methods used to identify any possible constraints. These early discussions have been positive, and we are optimistic that any impacts to tribal fishing/natural resources can be avoided, minimized, or mitigated through these meaningful engagement efforts.

In addition to meeting with the tribal nations to understand their access and use of natural resources in vicinity of the proposed project, we have been actively engaging with the Tribal Historic Preservation Officers (THPO) and cultural departments from each of these five tribal nations. Based on feedback received from the THPOs and the fact that the proposed project anticipates tying into existing infrastructure (e.g., submarine cable conduit and existing electrical grid) no impacts to tribal cultural resources or access are anticipated. Additional cultural resources studies and surveys are anticipated to occur as part of the permitting phase and to support compliance with Section 106 of the National Historic Preservation Act (NHPA). The THPO's will be actively engaged throughout the process and have agreed to provide input on the delineation of the Area of Potential Effects (APE), as well as the identification and inventory methods that will be used to determine if significant tribal cultural resources are present within the APE. Preliminary desktop review and tribal review of the nearshore and upland areas in the vicinity of the proposed project indicates that there are no previously recorded tribal cultural resources (i.e., archaeological sites, traditional cultural places, buildings/structures of tribal importance). Based on the early engagement with the THPOs, our understanding is that impacts to tribal cultural resources will be avoided by the proposed project.

Table 2: Tribal Engagement Summary

Tribal Nation	Meeting Dates
Lummi Nation	**July 17, 2022:** Letter sent to the tribal chairperson William Jones, Jr. via certified mail and included the brochure. Also emailed PDF of the signed letter and attached the brochure. **August 26, 2022:** Emailed copies of the letter/brochure to the Natural Resources Department Director (Merle Jefferson) and Cultural Resources Department Director (Lena Tso). **September 7, 2022:** OPALCO received a response from Lena Tso agreeing to participate in a meeting. **September 23, 2022:** OPALCO meeting with Lena Tso and Tamela Smart from the Cultural Resources Department (Merle Jefferson was not able to attend and canceled the day of the meeting). **October 5, 2022:** Attempted to reschedule meeting with Merle Jefferson, Natural Resources Director. **December 5, 2022:** Attempted to reschedule meeting with Merle Jefferson, Natural Resources Director. **March 14, 2023:** Attempted to reschedule meeting with Merle Jefferson, Natural Resources Director.
Samish Nation	**July 17, 2022:** Letter sent to the tribal chairperson Tom Wooten via certified mail and included the brochure. Also emailed PDF of the signed letter and attached the brochure. **August 26, 2022:** Emailed copies of the letter/brochure to the Natural Resources Department Director (Todd Woodard) and Cultural Resources Department Director (Jackie Ferry). **October 13, 2022:** Sent follow-up emails with brochure and newly completed figures since no response had been received to date. **October 27, 2022:** Received response from Todd Woodard Natural Resources Department Director confirming meeting date/time. **November 29, 2022:** OPALCO met with Tribal Councilmember Gary Hatch, Cultural Resources Department Director Jackie Ferry, and Natural Resources Department Director Todd Woodard and provided project overview and requested feedback.
Suquamish Indian Tribe	**July 17, 2022:** Letter sent to the tribal chairperson Leonard Forsman via certified mail and included the brochure. Also emailed PDF of the signed letter and attached the brochure. **August 26, 2022:** Emailed copies of the letter/brochure to the Natural Resources Department Director (Alison O'Sullivan) and Cultural Resources Department Director (Dennis Lewarch). **October 13, 2022:** Sent follow-up emails with brochure and newly completed figures since no response had been received to date.
Swinomish Indian Tribe	**July 17, 2022:** Letter sent to the tribal chairperson Steve Edwards via certified mail and included the brochure. Also emailed PDF of the signed letter and attached the brochure. **August 26, 2022:** Emailed copies of the letter/brochure to Amy Trainer, Environmental Policy Director. **August 29, 2022:** OPALCO received a response from Amy Trainer agreeing to participate in a meeting. **September 9, 2022:** OPALCO meeting with Amy Trainer with the Swinomish Indian Tribe. **September 22, 2022:** Supplemental meeting materials sent to Amy Trainer with the Swinomish Indian Tribe. **October 12, 2022:** Supplemental maps sent to Amy Trainer showing the proposed location of the project and the existing conduit. **March 6, 2023:** Meeting with Heather Spore who transitioned to OPALCO's point of contact (from Amy Trainer). **March 22, 2023:** OPALCO Cooperative Workshop on Tidal Energy; Amy Trainer and Heather Spore were in attendance. **May 25, 2023:** Emailed Heather Spore following up on action item to schedule briefing to Swinomish Tribal Senate.

Tulalip Tribes	**July 17, 2022:** Letter sent to the tribal chairperson Teri Gobin via certified mail and included the brochure. Also emailed PDF of the signed letter and attached the brochure. **August 26, 2022:** Emailed copies of the letter/brochure to the Natural Resources Department (Kurt Nelson, Darly Williams) and Cultural Resources Department Director (Richard Young). **October 13, 2022:** Sent follow-up emails with brochure and newly completed figures since no response had been received to date. **March 22, 2023:** Follow-up emails to Natural Resources Department (Kurt Nelson, Darly Williams) and Cultural Resources Department Director (Richard Young) to schedule a meeting. **May 25, 2023**: Emailed Richard Young, Daryl Williams, and Kurt Nelson requesting meeting; received response with several options for dates. **June 16, 2023:** Met with Daryl Williams and Kurt Nelson from the Natural Resources Department to provide an overview on the proposed project. Richard Young was unable to attend.

3. Regulatory Engagement

3.1 Agencies Engaged

Consultation with federal, state, and local agencies along with stakeholders is a critical component of any authorization process and generally involves analyzing a proposed project to determine the potential effects. Multiple federal, state, and local agencies are involved with approving the deployment of a tidal energy device in WA. To compound the complexity of the approval process, many agency staff expressed that they anticipate extended timelines in permitting process due to workload increases associated with the influx of funding from both the Infrastructure Investment and Jobs Act and the Inflation Reduction Act.

Upon engaging tribal representatives (Section 2), the OPALCO team then engaged the following state and federal agencies to discuss regulations and authorizations that would be applicable to a tidal energy deployment in Rosario Strait:

- NOAA Fisheries (also referred to as "NMFS")
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Army Corps of Engineers (USACE)*
- U.S. Coast Guard (USCG)
- Federal Energy Regulatory Commission (FERC)
- Washington Department of Ecology (Ecology)
- Washington Department of Natural Resources (DNR)*
- Washington Department of Fish and Wildlife (WDFW)*

* Denotes email engagement only.

Meeting minutes are provided in **Attachment 1**.

3.1 NEPA Review

The National Environmental Policy Act (NEPA; 1969) identified environmental protection as a major national policy objective. The NEPA requires all federal agencies involved in the permitting of activities affecting the environment to evaluate environmental impacts and the significance of these impacts. The NEPA process is to be used to identify and assess the reasonable alternatives to proposed actions, and federal agencies are to use all practical means to restore and enhance the quality of the human environment and to avoid or minimize any possible adverse effects of their actions upon the quality of the human environment. Depending on the project type, scale, and location, more than one federal agency may be involved in authorizing tidal energy activities.

If OPALCO receives federal funding to deploy tidal turbine devices in Rosario Strait, NEPA would need to be completed by that funding agency (e.g., U.S. Department of Energy). In addition to the federal funding agent's requirements, FERC would also be responsible for issuing a license to authorize the operation of a tidal energy device under the Energy Policy Act (2005). Licensing would be either as a standard full license or a pilot license. A pilot license is a good option for short-term projects (i.e., up to 10 years, or pilot projects) to test technology and site conditions. A full license is valid for up to 40 years and the application process requires greater effort from the project's proponent than the pilot license.

In applying for a license, the review process will consider the effects of the full build-out of the project, even if construction and installation occurs in phases. This is due to the NEPA requirements. FERC would act as the lead agency for NEPA review, or co-lead in coordination with the federal funding agent.

NEPA requires federal agencies to prepare an analysis for federal actions that have the potential to significantly affect the quality of the human environment, including both natural and cultural resources. Environmental Assessments (EA) are developed to determine whether an action may cause significant environmental effects. If the action is determined not to have significant impacts, then the federal agency issues a Finding of No Significant Impact (FONSI). If the action is determined to have significant impacts, then the federal agency will prepare an Environmental Impact Statement (EIS). An EA could take up to 18 months to complete, while an EIS could take 18+ months. When a project requires a NEPA review, this must be completed first before permitting within the Salish Sea can proceed.

As part of the NEPA process, NOAA Fisheries and USFWS (i.e., "the Services") review projects either as a "*formal*" consultation or an "*informal*" consultation under the ESA. This project is likely to trigger a formal ESA consultation, with the Services having up to 135 days to complete their review. There is no designated time limit for an informal consultation, but it is typically a shorter review period than a formal consultation.

Washington State Department of Archaeology and Historic Preservation serves as the State Historic Preservation Office. The NHPA was enacted and amended to require the federal government to accelerate its historic preservation programs and to encourage such efforts on state, local, and private levels. Compliance with the NHPA may be coupled with the NEPA compliance where a federal action such as FERC licensing affects a historical or cultural resource. The federal lead is bound by the provisions of the NHPA, which requires it consider the effect of the action on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places, and to give the Advisory Council on Historic Preservation.

3.2 Applicable Permit Process

A State Environmental Policy Act (SEPA) EIS may be required to obtain project approval. The SEPA process requires a governmental agency to consider the environmental impacts of a proposal before making decisions and helps agencies identify those impacts. The lead agency, likely to be San Juan County, would use this process to describe the probable significant adverse environmental impacts related to the project, investigate reasonable alternatives to project actions to minimize impacts, and discuss possible mitigation measures to offset the impacts. Local, state, and federal agencies, as well as tribes, participate in the EIS analysis. Additionally, the project will be subject to a public comment period.

Both formal and informal consultation with federal, state, tribal, and local agencies, as well as external stakeholders such as the fishing community, are critical to permitting in WA. Consultation generally involves analysis of a proposed project to determine any potential effects and develop effective monitoring, mitigation, and adaptive management measures necessary to prevent, minimize, and/or mitigate project impacts to the environment. It is during this consultation period that groups, such as the tribes, can voice their concerns and identify potential mitigation measures to include in the project planning. Early consultation with the tribal community is highly recommended ahead of submittal to the agencies.

Permitting of an aquatic project in WA is a well-established process through submittal of a Joint Aquatic Resources Permit Application (JARPA; **Table 3**). The JARPA is efficient as it initiates several related permitting processes through one application that is submitted to U.S. Army Corps of Engineers (USACE), Ecology, and DNR. WDFW receives the same information included in the JARPA, but through a separate online portal. In addition to the main JARPA application, an Attachment E would also be required for this project. This attachment is only submitted to DNR for an aquatic use authorization (e.g., right-of-entry, lease, or easement). Permitting in WA may take up to 12 months to complete, although this is variable based on agency managers' workloads. This process would occur after the NEPA review.

As part of the JARPA process, Ecology is responsible for issuing a federal consistency determination under the Coastal Zone Management Act (CZMA). This occurs after all relevant regulatory approvals are received, and Ecology may take up to one year to issue their determination. The Washington State Ocean Resource Management Act (ORMA) is also under Ecology's jurisdiction, which primarily addresses fossil fuel related projects; however, it can be more broadly applied. If triggered, Ecology will further assess the project under WA's Marine Spatial Plan legislature. Approvals are wrapped into the CZMA federal consistency provision process; ORMA does not have its own permit.

DNR would finalize their Aquatic Use Authorization after all environmental permits have been obtained for a project. This can be processed concurrently with Ecology's CZMA federal consistency determination. The final easement is granted after Ecology's determination has been issued. DNR may take up to 12 months to complete this authorization, so coordination with DNR is a high priority. Due to the timing of DNR's authorization (i.e., after all other state and federal permits/approvals have been received), it is essential that OPALCO work with DNR throughout the permitting process to streamline their project authorization. With all permits acquired, DNR would issue its authorization, unless DNR and OPALCO cannot reach an agreement on the easement terms.

Table 3: Summary of applicable permits and regulatory agencies

Regulatory Agency	Permit, Approval, or Consultation	Description
FEDERAL		
USACE	NWP #6 Marine Survey Activities	Permits would be initiated through a JARPA.
	NWP #57 Utility Line Activities	Construction of utility lines and associated facilities provided the activity does not result in the loss of greater than 1/2-acre of waters of the United States for the complete project. Permits initiated through a JARPA.
	Authorization under Section 10 of the River and Harbors Act of 1899 (RHA)	Permits are required for the construction of artificial islands, installations, and other devices on the seabed, to the seaward limit of the OCS, pursuant to Section 4(f) of the CWA, as amended (see 33 CFR 320.2(b).). Permit initiated through a JARPA.
	Dredge and Fill Authorization under Section 404 of the Clean Water Act (CWA)	Discharge of dredged or fill materials in navigable waters of the US, including marine waters. Permit initiated through a JARPA.
NOAA Fisheries	ESA Consultation / EFH Assessment	Potential to cause harm to threatened and endangered species and/or affect EFH and EFH species. Requires a detailed biological assessment (BA) of potential impacts to ESA-listed species. NOAA Fisheries would be consulted for anadromous and marine species. An EFH assessment would identify potential impacts to fish species within the 200 nm of the shoreline. The EFH assessment would be an appendix to the BA.
USFWS	ESA Consultation	Detailed BA of potential impacts to ESA-listed species. USFWS would be consulted for avian, as well as marine and terrestrial species.
FERC	NEPA Review	NEPA directs federal agencies, when planning projects or issuing permits, to conduct environmental reviews to consider the potential impacts on the environment by the proposed action(s). The environmental review under NEPA can involve three different levels of analysis: 1. Categorical Exclusion determination (CATEX): A detailed environmental analysis is not required for a proposed activity. 2. EA/Finding of No Significant Impact (FONSI): When a CATEX does not apply, then prepare an EA. The EA determines whether an action could potentially cause significant environmental effects. Upon review, if there are no anticipated significant impacts, a FONSI would be issued. 3. EIS: Required when an action is determined to significantly affect the quality of the human environment. The regulatory requirements for an EIS are more detailed and rigorous than the requirements for an EA.
	Pilot License	A pilot license is a good option for short-term projects to test technology and site conditions. Typically, this license is valid for up to 10 years.
	Full License	A full license is valid for up to 40 years for long-term deployments. Typically requires greater effort from the project's proponent than a pilot license.
USCG	Local Notice to Mariners	Email notification of activity

STATE		
DNR	Aquatic Lands Right-to-Entry Approval	Required to conduct studies that would affect the seabed in WA State waters.
	Aquatic Use Authorization	Required for placing permanent improvements on submerged lands of the State. Submit a JARPA & Attachment E for each authorization.
Ecology	Coastal Zone Management (CZM) Consistency Determination	Regulatory authority to review federal actions for consistency with the Coastal Zone Management Program, out to 3 nm. Completion of a CZM Consistency form.
	Section 401 of CWA – Water Quality Certificate (WQC)	Regulatory authority to review Federal actions in or affecting the quality of waters of the State. Required before USACE will issue Section 404/Section 10 permits. Permit initiated through a JARPA.
	Section 402 of CWA – National Pollutant Discharge Elimination System (NPDES) 1200-C Construction Stormwater General Permit	Section 402 of the CWA prohibits the discharge of pollutants into waters of the US without a NPDES permit issued by the EPA. Submit engineering designs via an online application through Ecology's *Secure Access Washington* website.
DAHP	Section 106 of NHPA (1966)	Federal and state agencies must consider the effects of the project's undertakings on historic and cultural resources and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings. Reviewed as part of the JARPA submittal, which may include a cultural report.
WDFW	Hydraulic Project Approval (HPA)	Work that uses, diverts, obstructs, or changes the natural flow or bed of state waters. This is part of the JARPA submittal, via the online WDFW APPS system.
LOCAL		
County	SEPA Review	Each marine project in WA requires a determination of significance under SEPA. Typically, this submittal is in the form of either a SEPA Checklist or more complex, SEPA EIS.
	Shoreline Master Program (SMP) or Conditional Use Permit	Construction activities that may affect the shoreline environment. Submitted using a local municipality permit application.
	Critical Areas Ordinance (CAO) Review	To protect critical areas including wetlands, fish and wildlife habitat conservation areas, a local municipality may require either a Critical Area report or checklist completed.
	Utility ROW Permit	Required for works within a public right-of-way. Submitted using a local municipality permit application.
Tribes	Consultation	Regional Tribes are consulted both by the USACE and WDFW during their respective permit reviews.

3.3 Agency Feedback

Overall, agency representatives expressed unfamiliarity with a project like this, but did not believe there were any critical obstacles that would preclude successful permitting of the effort. This section serves to highlight specific feedback from some of the agencies (**Table 4**).

Table 4: Agency Meetings Summary

Agency	Meeting Dates
USFWS	**Oct 26, 2022:** Email sent to Ryan McReynolds (USFWS Consultation & Conservation Planning Division) requesting a meeting to discuss the project. **Oct 27, 2022:** Received reply from Ryan McReynolds agreeing to have a meeting. **Nov 2, 2022:** Met with Ryan McReynolds and fish biologist Mitch Dennis. **Nov 2, 2022:** Received follow-up email from Ryan McReynolds with written materials for the OPALCO team to review, to assist with preparing for the permitting process.
Ecology	**Oct 13, 2022:** Email sent to Loree Randall (Coastal Zone Management Policy Lead) requesting a meeting to discuss the project. **Oct 14, 2022:** Received reply from Loree Randall agreeing to have a meeting. **Oct 20, 2022:** Sent follow-up email with options for dates & times for the meeting. **Oct 31, 2022:** Meeting confirmed for Nov 4. **Nov 4, 2022:** Met with Loree Randall, Teressa Pucylowski (Coastal Zone Management Federal Consistency), Casey Dennehy (Marine Policy Analyst), Meg Bommarito (Northwest Office Regional Planner, SEPA Specialist), Chad Yunge (Senior Shoreline Planner), and Brittany Flittner (Spill Prevention Specialist). **Nov 4, 2022:** Follow-up/thank-you emails exchanged.
U.S. Coast Guard	**Oct 25, 2022:** Email sent to Tim Westcott (USCG District 13) requesting a meeting to discuss the project. **Oct 25, 2022:** Received reply from Tim Westcott agreeing to the meeting and including other members. **Dec 8, 2022:** Received email from Robert Nakama (USCG Sector Puget Sound) requesting to be brought into the meeting. **Dec 14, 2022:** Met with Tim Westcott, Robert Nakama, and Peter McAndrew (Waterways Management Specialist).
NOAA Fisheries	**Nov 22, 2022:** Email sent to Mary Bhuthimethee (Fish Biologist, North Puget Sound Branch) requesting a meeting to discuss the project. **Dec 7, 2022:** Follow-up email to schedule the meeting. **Jan 5, 2023:** Follow-up email to schedule the meeting. **Jan 25, 2023:** Follow-up email to schedule the meeting. **Feb 8, 2023:** Meeting confirmed for Feb 14. **Feb 14, 2023:** Met with Mary Bhuthimethee and Don Hubner (Oregon/Washington Coastal Office).
DNR	**Oct 13, 2022:** Email sent to Gabe Harder (Aquatic Lands Manager) requesting a meeting to discuss the project. **Oct 20, 2022:** Reply from Gabe Harder handing off the project to another contact at DNR. Instructed to hold until we receive a meeting invitation from them. **Oct 21, 2022:** Email sent to Gabe confirming receipt of the message and standing by. No further message was received.
WDFW	**Oct 13, 2022:** Email sent to Marcus Reaves (Habitat Biologist) requesting a meeting to discuss the project.
USACE	**Nov 21, 2022:** Email sent to Jen Casper (Project Manager) requesting a meeting to discuss the project

USFWS

It was advised by USFWS that the project does not need to reach net-zero wildlife impacts to be authorized. Consultation with the Services will be required to reach a satisfactory compromise that will allow the installation to proceed.

Ecology

A formal SEPA and/or NEPA review is likely. An EIS may be required, which is a lengthy process, and the project proponent should prepare accordingly. The Cooke Aquaculture net pen failure in 2017 occurred near the proposed deployment site of the tidal turbine. Due to the resulting impacts of this emergency, Ecology would pay particular attention to this project's strategy for managing biofouling that may occur on deployed infrastructure. There would be specific emphasis placed on managing SRKW and deterring them from turbine blades.

USCG

The device would require safety lighting and an automatic identification system to broadcast its location. Charts would need to be updated with USCG and NOAA. This project would require several contingency plans to manage for changes in navigation, vessel traffic, and recovery of device components in the event of anchor/tether breakage. Security measures should be considered for keeping boaters away from the device, such as cameras and speakers for communication.

NOAA Fisheries

Entrainment concerns were a primary point of discussion in this meeting. A formal consultation with the Services would likely be required, as the effects of the project may adversely affect ESA-listed species. An incidental harassment authorization may also be issued.

The Marine Mammal Protection Act (MMPA) was also discussed. For example, if seals and/or sea lions may be able to haul out onto the device and require interventive measures, this may constitute harassment and require authorization.

4. Economic Analysis

To assess the technical and economic feasibility of tidal power, working in combination with multiple other distributed energy resources (DERs), Argonne employed an optimization model to evaluate several economic benefits associated with varying scales of tidal power of between 2.4 and 9.6 MW and other DERs. In addition to existing photovoltaic and battery energy storage system (BESS) resources located on Decatur Island, Argonne also evaluated the addition of a BESS on southern Orcas Island with power and energy capacities ranging from 1 to 4 MW and 2 to 4 hours in storage duration. The placement of the energy assets considered in this evaluation, along with the portions of OPALCO's transmission and distribution system capable of islanding during outages, are illustrated in **Figure 12**.

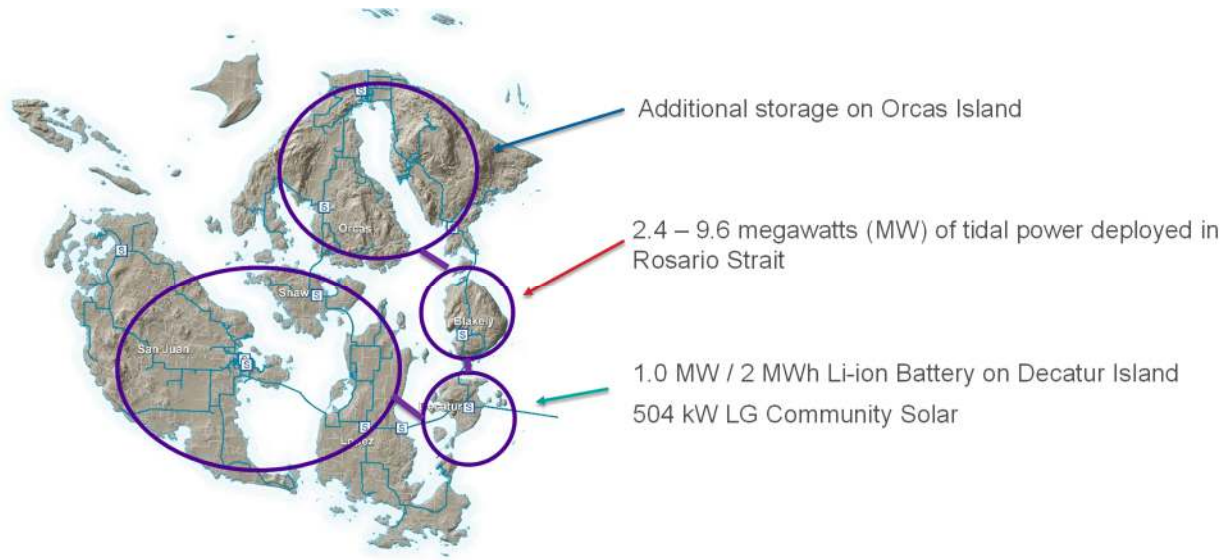

Figure 12. Four-zone OPALCO System and Placement of Tidal and Energy Assets

The OPALCO team performed a comprehensive resource scheduling simulation spanning an entire year. This simulation aimed to evaluate the impact and value of the Decatur Island Microgrid and new tidal power and BESS options on southern Orcas Island. To capture the unique characteristics of the OPALCO power system, such as network topology and the definition of various charges that are not typically well captured in traditional production cost simulation models, the project team developed the Energy Storage Microgrid Optimization (ESMO) model (**Figure 13**). The ESMO model is a least-cost linear programming model that determines the optimal hourly scheduling of resources in a system while ensuring the total cost is minimized. The least-cost objective function considers the following charges: load shaping charge, demand charges, transmission charges, and miscellaneous charges. In addition to these charges that directly affect the bill paid by OPALCO to PNGC Power, the research team also evaluated the benefits of deferring investment in a submarine cable linking the San Juan Islands to the mainland, and the benefits of outage mitigation to OPALCO customers.

Economic results were prepared for 15 scenarios (**Table 5**). Present value (PV) costs are compared to PV economic benefits to determine the net benefits and benefit-cost ratios (BCRs) for each scenario. Under each scenario, the evaluation is performed first from the perspective of the utility in isolation and second from the perspective of the utility plus the customers it serves. Including the customer perspective improves the economic performance of each scenario by removing the costs of payments to members who bought shares in community solar and by including the benefits of improved reliability.

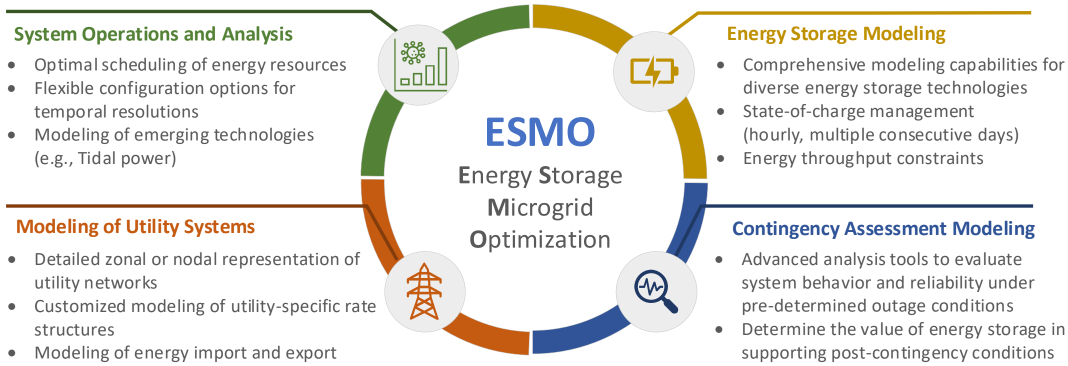

Figure 13. Overview of the ESMO model.

Table 5: Descriptions of Microgrid Scenarios

Scenario	Scenario Description
1	no DERs
2	Tidal power in isolation
3	Tidal power plus local storage on Orcas Island
4	Scenario 3 plus Decatur PV and BESS
5	Scenario 4 with 2X tidal power
6	Scenario 4 with 3X tidal power
7	Scenario 4 with 4X tidal power
8	Scenario 4 with 2x Orcas storage capacity
9	Scenario 4 with 3x Orcas storage capacity
10	Scenario 4 with 4x Orcas storage capacity
11	Scenario 4 with 1x Orcas storage capacity @ 4 hr.
12	Scenario 4 with 2x Orcas storage capacity @ 4 hr.
13	Scenario 4 with 3x Orcas storage capacity @ 4 hr.
14	Scenario 4 with 4x Orcas storage capacity @ 4 hr.
15	Scenario 4 but no assets are designated network resources

The annual benefits of each of the services provided by the microgrid assets under each scenario are presented in **Table 6** and **Figure 14**. Scenario 1 was used only to validate the model, thus, there are no benefits or costs defined under that scenario. Scenario 15 changes how the DERs are recognized by the Bonneville Power Administration, enabling them to be used to reduce transmission charges.

The scenarios yield roughly $458.2 thousand to $1.4 million in annual benefits. Demand and transmission charge reductions of up to $542.4 thousand and $110.9 thousand, respectively, were achieved, and are largely driven using BESSs discharging during peak load hours. Transmission deferral ($142.7 to $506.5 thousand), base customer charge ($184.9 to $194.0 thousand), and load shaping charge reductions of $166.6 to $715.1 thousand were driven mostly by tidal energy production.

Table 6: Annualized Benefits by Service by Scenario

Scenario ID	Transmission Deferral	Base Customer Charge	HLH Load Shaping Charge	LLH Load Shaping Charge	Demand Charge	Transmission Charge	Misc. Charge	Outage Mitigation
1	$-	$-	$-	$-	$-	$-	$-	$-
2	$142,692	$184,886	$106,580	$71,005	$(53,534)	$4,840	$1,712	$24,716
3	$170,605	$184,886	$96,630	$78,007	$79,846	$4,434	$1,695	$25,806
4	$189,479	$193,980	$98,614	$83,648	$152,843	$4,524	$1,779	$34,696
5	$271,385	$192,209	$205,474	$154,421	$96,709	$9,366	$3,491	$39,405
6	$377,811	$192,209	$312,427	$225,109	$39,159	$14,208	$5,203	$48,068
7	$506,503	$192,209	$419,057	$296,074	$(27,901)	$19,048	$6,914	$38,998
8	$216,983	$192,209	$90,569	$89,101	$257,132	$4,131	$1,763	$45,343
9	$244,284	$190,438	$83,548	$93,659	$345,237	$3,744	$1,747	$67,735
10	$271,385	$188,667	$77,561	$97,386	$415,103	$3,357	$1,730	$73,284
11	$189,479	$190,438	$89,385	$90,226	$182,224	$4,107	$1,763	$42,200
12	$216,983	$186,896	$73,753	$101,125	$317,894	$3,336	$1,730	$57,196
13	$244,284	$183,354	$60,393	$110,219	$438,218	$2,487	$1,697	$74,277
14	$271,385	$179,812	$50,122	$116,516	$542,399	$1,756	$1,665	$86,013
15	$189,479	$192,209	$99,405	$82,969	$152,204	$110,928	$1,779	$34,695

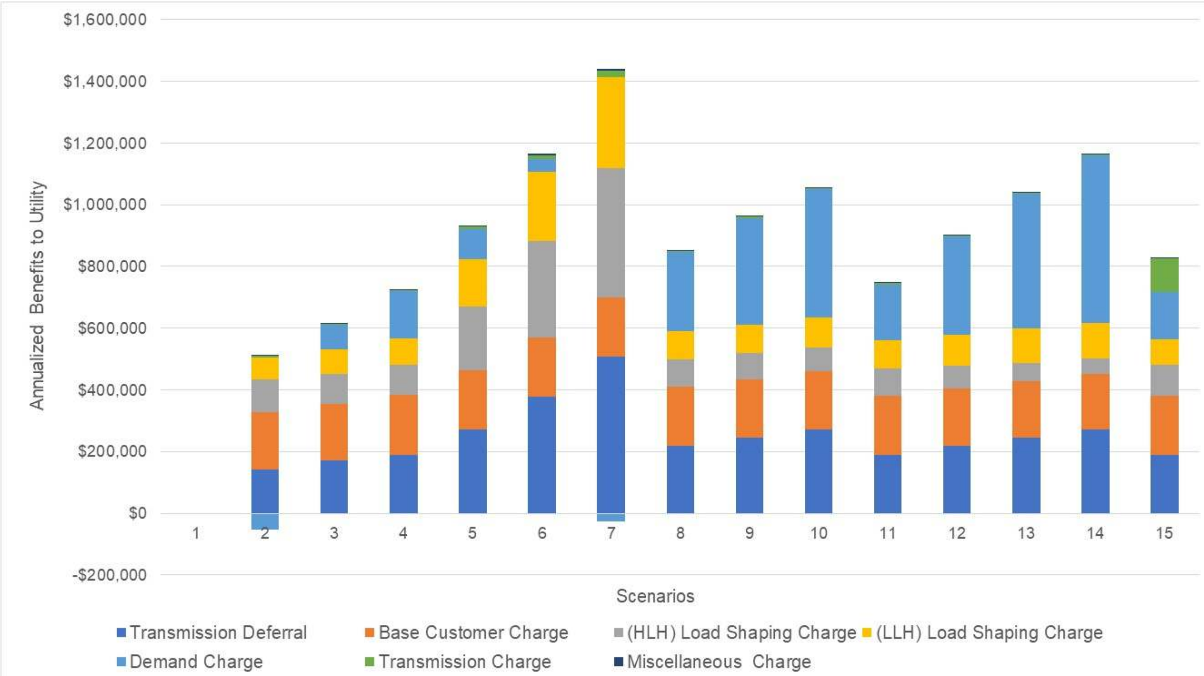

Figure 14. Annualized Benefits to OPALCO

The results of the benefit-cost analysis from a utility perspective are presented in **Table 7**. For this analysis, the OPALCO team used the BCR and net benefits financial metrics. The BCR was calculated by dividing discounted revenue or benefits of the project by discounted costs. A BCR of more than 1.0 demonstrates a positive return on investment. A BCR of 1.2 would indicate that for every dollar invested in the project, a return of $1.20 could be achieved. Net benefits are calculated by subtracting PV costs from PV benefits. BCRs presented in **Table 7** vary from 0.22 to 0.45, with lifetime net benefits ranging from -$144.4 million to -$38.3 million. While none of the BCRs exceed 1.0, the results of the analysis are useful in that they define the grant level for tidal power required to break even is $44.1 million. Further, the analysis demonstrates that additional investments in storage on Orcas Island could yield positive net returns of approximately $3 million in PV terms.

Table 7: Benefit-Cost Analysis Results – Utility Perspective

Scenario	PV Benefits	PV Costs	BCR	Net Benefits
1	$-	$-	-	$-
2	$13,054,594	$57,184,282	0.23	$(44,129,688)
3	$17,554,111	$58,760,677	0.30	$(41,206,566)
4	$20,653,054	$62,575,829	0.33	$(41,922,775)
5	$26,584,765	$101,299,469	0.26	$(74,714,704)
6	$33,225,435	$143,939,067	0.23	$(110,713,632)
7	$40,228,235	$184,620,686	0.22	$(144,392,451)
8	$24,272,180	$64,152,224	0.38	$(39,880,045)
9	$27,428,200	$65,728,620	0.42	$(38,300,420)
10	$30,064,648	$68,939,836	0.44	$(38,875,188)
11	$21,301,394	$63,689,973	0.33	$(42,388,579)
12	$25,691,895	$65,266,369	0.39	$(39,574,474)
13	$29,650,484	$67,956,908	0.44	$(38,306,424)
14	$33,155,064	$73,437,706	0.45	$(40,282,642)
15	$23,619,287	$62,575,829	0.38	$(38,956,542)

The results of the benefit-cost analysis from a utility plus customer perspective produced BCRs that varied from 0.23 to 0.49, and net benefits that ranged from -$142.1 million to $-35.0 million. Note that when capturing all customer benefits, including outage mitigation, the funding gap for tidal power is close to $43.4 million. BESS investments drive positive outcomes through the benefits associated with enhanced outage mitigation, which reaches as high as $86.0 thousand annually under Scenario 14.

The OPALCO team evaluated the sensitivity of the results with respect to changes in several key assumptions and parameters. Results were sensitive to several alternative assumptions. Varying energy price inflation, meaning the price paid by OPALCO to PNGC Power, had a larger effect than that of varying the discount rate, with impacts reaching -$7.7 million (2% price inflation) to $10.4 million (4% price inflation) when compared to a 3% price inflation baseline. These findings suggested the microgrid assets would form somewhat of a hedge against future price inflation, with economic performance improving significantly under higher rates of inflation.

Scenario 4 reached a breakeven point when annual energy price inflation reaches 7.5%. Increasing the clean energy investment credit authorized under the Inflation Reduction Act of 2022 from 30% to 40% by adding in the bonus for meeting domestic content requirements on the Orcas Island BESS and tidal power would improve the economic performance of the microgrid by $4.3 to $11.9 million in total PV terms. Each of these results are from a utility perspective. Setting the BESSs state-of-charge to 80% in advance of reliability events adds $1 to $4.4 million in additional outage mitigation benefits over the life of the units to customers. Note that scenarios where the duration of energy storage is doubled yield significantly higher outage mitigation benefits.

For the full 'San Juan Islands Microgrid—preliminary Economic Assessment', please see **Attachment 2: Economic Analysis**.

5. Conclusion

This report presents a summary of information related to the deployment and operation of floating tidal technology in the Salish Sea, specifically off the eastern shore of Blakely Island within Rosario Strait.

Rosario Strait has favorable conditions for a tidal energy project. It has a maximum current speed that exceeds 6.56 ft./s (2 m/s) and current magnitude that exceeds 8.20 ft./s (2.5 m/s) during both peak flood and ebb. During spring and neap ebb, Rosario Strait has a maximum tidal energy at spring tide of 10.3 ft./s (3.14 m/s), and minimum tidal energy at neap tide of 5.91 ft./s (1.80 m/s).

Multiple species listed under the ESA occur in or near the proposed project area, as well as critical areas for several species. These factors do not preclude successful permitting of this project; however, meaningful consultation must occur with the appropriate regulatory agencies (namely, the Services) to obtain authorization to proceed. Overall, agency representatives expressed unfamiliarity with a project like this, but did not believe there were any significant obstacles that would preclude successful permitting of the effort.

With regards to engaging to tribal nations over the region, the OPALCO team has been actively working to share information about the proposed project, including location and technology, to establish trust and seek meaningful engagement on the proposed project early in the process. These early discussions were positive, and we are optimistic that any impacts to tribal fishing/natural resources can be avoided, minimized, or mitigated through these meaningful engagement efforts. OPALCO continues to share information with these nations as the project evolves.

The OPALCO team performed a comprehensive resource scheduling simulation spanning an entire year under 15 different scenarios. This simulation aimed to evaluate the impact and value of the Decatur Island Microgrid and new tidal power and BESS options on southern Orcas Island. The results showed varying investment returns, based on the effectiveness of grant funding.

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Attachment 1
Agency Meeting Minutes

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OPALCO TIDAL ENERGY PROJECT STAKEHOLDER ENGAGEMENT

U.S. Fish & Wildlife Service (USFWS)

Meeting Summary

DATE: Wednesday, Nov. 2, 2022 **TIME**: 1:00 PM PST

ATTENDEES

Name	Agency/Group	Email Address
Ryan McReynolds	USFWS	ryan_mcreynolds@fws.gov
Mitch Dennis	USFWS	mitchell_dennis@fws.gov
Russell Guerry	OPALCO	rguerry@opalco.com
Stacy Bumback	Environmental Science Associates	SBumback@esassoc.com
Cameron Fisher	48 NORTH	cfisher@48northsolutions.com
Celeste Barnes	48 NORTH	cbarnes@48northsolutions.com

MEETING SUMMARY

48 NORTH organized a meeting with Ryan McReynolds from the U.S. Fish & Wildlife (USFWS) Consultation & Conservation Planning Division, and Mitch Dennis, USFWS Fish Biologist, to discuss potential considerations in deploying a tidal energy turbine pilot project in Rosario Strait, Washington.

HIGHLIGHTS INCLUDE

There is limited, if any, consultation experience among the agency for a tidal energy project like this. The most relatable project may be the Sequim Bay tidal energy deployment by the Navy, but the technology is different from the Orbital O2 proposed by OPALCO. A regional collaboration of regulators would be likely to occur (federal nexus permitting) to ensure Endangered Species Act (ESA) compliance.

NOTES

- Merits of the proposal, from USFWS perspective, include:
  - Alternative energy generation
  - Phased implementation
  - Pilot project could produce early data outputs on wildlife interactions with tidal energy turbines
- They recommend leveraging any studies/papers/data produced from Orbital O2 deployment in Orkney Islands to support local deployment.
- There exists a moderate-high potential for presence of diving marbled murrelets (listed as threatened under the ESA) in the stretch of Rosario Strait targeted for deployment, according to Mitch Dennis. This may raise questions about "take" (harm/harassment of protected species).
  - Concerns regarding entrainment force associated with the rotor size, RPM, and tip-speed ratio.
- Anchor lines present potential hazards (e.g., entanglement risk)
  - Mitch asks if there would be regular dives required for maintenance/monitoring
- Monitoring capability for wildlife interactions with tidal energy turbines is unclear at this stage to the agency (e.g., emergency shutdown at detection)
  - It was suggested that wildlife observers, even ahead of deployment, monitor for activity in the area.

    - The project does not need to reach net zero wildlife impacts, but design consultation with USFWS and NOAA Fisheries will be needed in order to reach a satisfactory compromise.
- Ryan McReynolds suggested an agency roundtable ahead of permit application submittal to solicit more feedback.
- Ryan may allow the OPALCO team to review a letter, for reference, that was written by USFWS for the Navy regarding their deployment of tidal energy technology in Sequim Bay

OPALCO TIDAL ENERGY PROJECT STAKEHOLDER ENGAGEMENT

Washington State Department of Ecology ("Ecology")

Meeting Summary

DATE: Friday, Dec. 4, 2022 **TIME**: 9:00 AM PST

ATTENDEES

Name	Agency/Group	Email Address
Loreé Randall	WA Department of Ecology	Lora461@ecy.wa.gov
Teressa Pucylowski	WA Department of Ecology	teressa.pucylowski@ecy.wa.gov
Casey Dennehy	WA Department of Ecology	casey.dennehy@ecy.wa.gov
Meg Bommarito	WA Department of Ecology	meg.bommarito@ecy.wa.gov
Chad Yunge	WA Department of Ecology	chad.yunge@ecy.wa.gov
Brittany Flittner	WA Department of Ecology	Brittany.Flittner@ecy.wa.gov
Russell Guerry	OPALCO	RGuerry@opalco.com
Stacy Bumback	Environmental Science Associates	sbumback@esassoc.com
Cameron Fisher	48 NORTH	cfisher@48northsolutions.com
Celeste Barnes	48 NORTH	cbarnes@48northsolutions.com

MEETING SUMMARY

48 NORTH organized a meeting with contacts at the Washington State Department of Ecology ("Ecology") to discuss potential considerations in deploying a tidal energy turbine pilot project in Rosario Strait, Washington.

Loreé Randall - Section 401 Clean Water Act/Coastal Zone Management Federal Consistency Policy Lead

Teressa Pucylowski – Coastal Zone Management Federal Consistency

Casey Dennehy – Marine Policy Analyst

Meg Bommarito – Northwest Office Regional Planner, SEPA Specialist

Chad Yunge – Senior Shoreline Planner

Brittany Flittner – Project Specialist: Spill Prevention, Preparedness, and Response Program

HIGHLIGHTS INCLUDE

- Ecology appreciated the early engagement in regards to exploring the deployment of a tidal energy project in the waters of San Juan County. As some questions remain unanswered at this early stage, Ecology would like continued communication as the project progresses.

NOTES

- Ecology's target would be no additional shoreline alterations as part of this project.
- Requiring a formal SEPA/NEPA review is a possibility
  - Environmental Impact Statement would be required
  - Can expect this to be a lengthy process

- After the net pen catastrophe in 2017 off of Cypress Island, Ecology will pay particular attention to a project's strategy for managing biofouling.
- Consider the visibility of the turbine for vessel traffic (e.g., flashing lights on the structure at the water's surface).
- Manage for risks due to changes in navigation (Tribes, WA State Ferries, fisheries, tugs, etc.)
- Develop best management practices for potential collisions with vessels that may lose propulsion/control of steering (e.g., response capabilities and remote shut down time)
- Specific emphasis on managing for southern resident killer whales and deterring them from the turbine blades.

OPALCO TIDAL ENERGY PROJECT STAKEHOLDER ENGAGEMENT

U.S. Coast Guard (USCG)

Meeting Summary

DATE: Wednesday, Dec. 14, 2022 **TIME**: 10:00 AM PST

ATTENDEES

Name	Agency/Group	Email Address
Tim Westcott	USCG	Timothy.L.Westcott@uscg.mil
Rob Nakama	USCG	Robert.Nakama@uscg.mil
Peter McAndrew	USCG	Peter.J.McAndrew@uscg.mil
Russell Guerry	OPALCO	rguerry@opalco.com
Cameron Fisher	48 NORTH	cfisher@48northsolutions.com
Celeste Barnes	48 NORTH	cbarnes@48northsolutions.com

MEETING SUMMARY

48 NORTH organized a meeting with Tim Westcott, from the 13th District Waterways Management Division of U.S. Coast Guard (USCG), Rob Nakama and Peter McAndrew, Waterways Management Specialists from Sector Puget Sound USCG, to discuss potential considerations in deploying a tidal energy turbine pilot project in Rosario Strait, Washington.

NOTES

- Tim advises:
  - the Orbital O2 will require safety lighting and a physical AIS mounted on the device
    - will be marked as a structure, not a vessel, so as not to confuse other boaters
    - up to 6 flashing amber lights + radar cross-section
  - there needs to be a contingency plan in the event that tethers anchoring the device break free or if the orientation is disrupted[1]
  - there needs to be a recovery plan for all components
  - consider cameras, loud speakers to communicate with boaters who may try to tie up to buoys or the device, contingency plan for illegal contact with the device
- Tim recalls the SnoPUD tidal project that was nixed due to fish and orca concerns, entrainment and harm concerns
  - Russell describes the device's low RPM and the successful deployment of the O2 in Orkney Islands (Scotland)
- DOE, FERC, and USACE were identified as key regulatory agencies for this effort
- Rob mentions the shipping channel in vicinity of proposed deployment location in Rosario Strait
  - Identified as Buoy 11; deployment would target west of that buoy and remain outside the shipping channel
- Deployment was discussed, earliest this would occur is 2026
  - Would likely take ~6 months to place supporting infrastructure first, then tow in the O2 and connect up
  - 20 years is the lifetime expectancy of O2 device

[1] Was identified as a very important consideration, given potential live voltage/fiber connections

OPALCO TIDAL ENERGY PROJECT STAKEHOLDER ENGAGEMENT

National Marine Fisheries Service (NMFS; NOAA Fisheries)

Meeting Summary

DATE: Tuesday, Feb. 14, 2023 **TIME**: 11:00 AM PST

ATTENDEES

Name	Agency/Group	Email Address
Don Hubner	NMFS	donald.hubner@noaa.gov
Mary Bhuthimethee	NMFS	mary.bhuthimethee@noaa.gov
Russell Guerry	OPALCO	rguerry@opalco.com
Cameron Fisher	48 NORTH	cfisher@48northsolutions.com
Celeste Barnes	48 NORTH	cbarnes@48northsolutions.com

MEETING SUMMARY

48 NORTH organized a meeting with Don Hubner and Mary Bhuthimethee, Fish Biologists from the National Marine Fisheries Service (NMFS) North Puget Sound Branch of the Oregon/Washington Coastal Office, to discuss potential considerations in deploying a tidal energy turbine pilot project in the San Juan Islands.

NOTES

- ESA species to consider: orca, rockfish, salmon (juveniles along the shore)
- Don identified the Rosario Strait site would be within SRKW critical habitat (CH) and rockfish CH
  - outside of nearshore rockfish CH, but there may be deepwater rockfish CH
- Don and Mary expressed entrainment concerns, ask about possible protections to reduce entrainment impact of the rotors
  - Mary mentioned juvenile rockfish that are carried in the current
- Mary asks if the speed of the turbines can affect natural current patterns, therefore affecting plankton and redistributing trophic pressures
- Don asks if floating marine debris presents risk to the device
- Mary asks if marine mammals (e.g., seals, sea lions) might be able to haul out onto the device
  - Does marine mammal protection act (MMPA) come into play
  - Does this constitute a take (e.g., harassment), therefore authorization would be required?
- Don suggests an incidental harassment authorization, as it is unlikely that there is justification for a "not likely to adversely affect" effects determination for ESA
  - A formal consultation with NMFS and USFWS will be required
  - Quantifying "take" will be challenging

OPALCO TIDAL ENERGY PROJECT STAKEHOLDER ENGAGEMENT

Federal Energy Regulatory Commission

Meeting Summary

DATE: Monday, Mar. 27, 2023 **TIME**: 11:00 AM PST

ATTENDEES

Name	Agency/Group	Email Address
John Matkowski	FERC	john.matkowski@ferc.gov
David Turner	FERC	David.turner@ferc.gov
Stephen Bowler	FERC	Stephen.bowler@ferc.gov
Russell Guerry	OPALCO	rguerry@opalco.com
Cameron Fisher	48 NORTH	cfisher@48northsolutions.com
Celeste Barnes	48 NORTH	cbarnes@48northsolutions.com

MEETING SUMMARY

48 NORTH organized a meeting with John Matkowski and David Turner from FERC Northwest, and Stephen Bowler from FERC Southwest, to discuss potential considerations of OPALCO's tidal energy turbine pilot project.

NOTES

- David explains pilot license or standard full license, and suggests pursuing a prelim permit
  - Pilot license is a good choice for short-term projects (~10 years) for pilot projects/to test technology and site
  - Full license is ~40 years (but the first original license can be <30 years by request)
  - Heavier lift for a full license than pilot
  - The license considers the effects for the full build-out of the project (although the installation can be in phases) because of NEPA requirements
  - Historically, FERC has experienced that NMFS scrutinizes full licenses more carefully than pilot re: species impacts
- A previous project in Admiralty Inlet was under a pilot license, and the pitfalls it faced were to do with orcas, navigation concerns, and telecom issues
  - Review past projects for info – Admiralty, PacWave
  - Noise impacts to orcas a concern
- DOE will likely use the FERC NEPA to justify their funding decision
- A monitoring plan will be required for the pilot license
  - Biofouling is a concern to consider (look into Clean Currents Canada)
- John asks to be the main point of contact for ongoing FERC engagement

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Attachment 2
Economic Analysis

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ANL-23/67

Rosario Strait Tidal Energy plus Energy Storage — Preliminary Economic Assessment

Energy Systems and Infrastructure Analysis Division

ANL-23/67

Rosario Strait Tidal Energy plus Energy Storage — Preliminary Economic Assessment

prepared by
Patrick Balducci and Jonghwan Kwon
Energy Systems and Infrastructure Analysis Division, Argonne National Laboratory

Vivian Nwadiaru
University of Massachusetts Amherst

Russell Guerry and Travis Neal
Orcas Power and Light Co-op

Brian Polagye
University of Washington

January 2024

CONTENTS

FIGURES

TABLES

LIST OF ACRONYMS

aHLH	average heavy load hours
AHWM	Above High Water Mark
BCA	benefit-cost analysis
BCR	benefit-cost ratio
BESS	battery energy storage system
BPA	Bonneville Power Administration
C&I	commercial and industrial
CDQ	contract demand quantity
CSP	customer system peak
DER	distributed energy resources
DNR	Designated Network Resource
ESMO	Energy Storage Microgrid Optimization
HLH	heavy load hours
IRA	Inflation Reduction Act of 2022
LDD	low density discount
LFP	lithium iron phosphate
LLH	light load hours
MW	megawatt
O&M	Operations and maintenance
OPALCO	Orcas Power and Light Co-op
ORLR	operating reserve loss rate
PNNL	Pacific Northwest National Laboratory
PV	photovoltaic or present value
SDD	short duration discount
SOC	state-of-charge
TOCA	tier one cost allocator
TSP	transmission system peak

ACKNOWLEDGMENTS

We are grateful to Imre Gyuk, Mo Kamaludeen, and Eric Hsieh of the U.S. Department of Energy, Office of Electricity's Energy Storage Division. Without their organization's financial support and their leadership, this project would not have been possible. We also wish to acknowledge Zhaoqing Yang and Taiping Wang of the Pacific Northwest National Laboratory for providing estimates of tidal currents from simulations of currents throughout the San Juan Islands.

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EXECUTIVE SUMMARY

The Orcas Power and Light Co-op (OPALCO) is a non-profit utility that provides energy services to approximately 11,700 customers across 20 islands in San Juan County, Washington. OPALCO is developing a diverse set of local renewable energy resources to reduce dependence on mainland Washington State for energy and to reduce the regional need for fossil-fueled power. OPALCO's load doubles in winter but solar production is roughly 20% of levels reached in summer periods. Tidal energy is strong year-round, night and day, and is predictable, requiring much less storage to firm it. To assess the technical and economic feasibility of tidal power, working in combination with multiple other distributed energy resources (DERs), Argonne National Laboratory (Argonne) employed an optimization model to evaluate several economic benefits associated with varying scales of tidal power of between 2.4 and 9.6 megawatts (MW) and other DERs. In addition to existing photovoltaic (PV) and battery energy storage system (BESS) resources located on Decatur Island, Argonne also evaluated the addition of a BESS on southern Orcas Island with power and energy capacities ranging from 1-4 MW and 2-4 hours in storage duration. The placement of the energy assets considered in this evaluation, along with the portions of OPALCO's transmission and distribution system capable of islanding during outages, are illustrated in Figure ES-1.

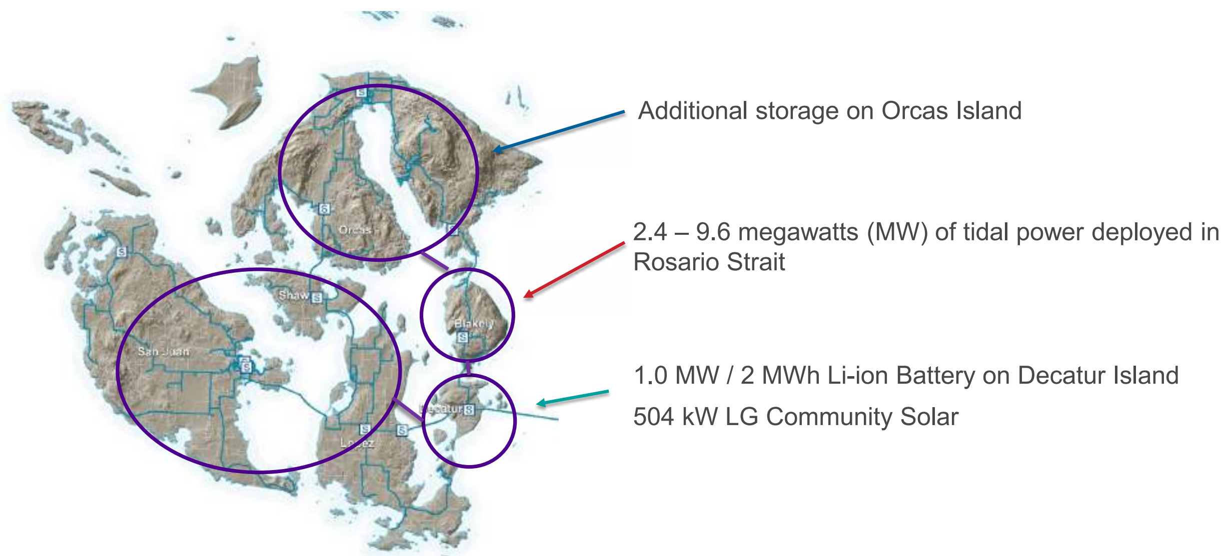

FIGURE ES-1 Four-zone OPALCO System and Placement of Tidal and Energy Assets

In this study, the project team performed a comprehensive resource scheduling simulation spanning an entire year. This simulation aimed to evaluate the impact and value of the Decatur Island Microgrid and new tidal power and BESS options on southern Orcas Island. In order to capture the unique characteristics of the OPALCO power system, such as network topology and the definition of various charges that are not typically well captured in traditional production cost simulation models, the project team developed the Energy Storage Microgrid Optimization (ESMO) model. The ESMO model is a least-cost linear programming model that determines the optimal hourly scheduling of resources in a system while ensuring the total cost is minimized. The least-cost objective function considers the following charges: load shaping charge, demand charges, transmission charges, and miscellaneous charges. In addition to these charges that directly affect the bill paid by OPALCO to PNGC Power, the research team also evaluated the benefits of deferring investment in a submarine cable linking the San Juan Islands to mainland Washington State, and the benefits of outage mitigation to OPALCO customers.

Economic results were prepared for 15 scenarios defined in Table ES-1. Present value (PV) costs are compared to PV economic benefits to determine the net benefits and benefit-cost ratios (BCRs) of each scenario. Under each scenario, the evaluation is performed first from the perspective of the utility in isolation and second from the perspective of the utility plus the customers it serves. Including the customer perspective improves the economic performance of each scenario by removing the costs of payments to members who bought shares in community solar and by including the benefits of improved reliability.

TABLE ES-1 Descriptions of Microgrid Scenarios

Scenario	Scenario Description
1	no DERs
2	Tidal power in isolation
3	Tidal power plus local storage on Orcas Island
4	Scenario 3 plus Decatur PV and BESS
5	Scenario 4 with 2X tidal power
6	Scenario 4 with 3X tidal power
7	Scenario 4 with 4X tidal power
8	Scenario 4 with 2x Orcas storage capacity
9	Scenario 4 with 3x Orcas storage capacity
10	Scenario 4 with 4x Orcas storage capacity
11	Scenario 4 with 1x Orcas storage capacity @ 4 hr.
12	Scenario 4 with 2x Orcas storage capacity @ 4 hr.
13	Scenario 4 with 3x Orcas storage capacity @ 4 hr.
14	Scenario 4 with 4x Orcas storage capacity @ 4 hr.
15	Scenario 4 but no assets are designated network resources

The annual benefits of each of the services provided by the microgrid assets under each scenario are presented in Table ES-2 and Figure ES-2. Note that Scenario 1 was used only to validate the model. Thus, there are no benefits or costs defined under that scenario. Scenario 15 changes how the DERs are recognized by the Bonneville Power Administration, enabling them to be used to reduce transmission charges.

The scenarios yield roughly \$458.2 thousand to \$1.4 million in annual benefits. Demand and transmission charge reductions of up to \$542.4 thousand and \$110.9 thousand, respectively, were achieved, and are largely driven by the use of BESSs discharging during peak load hours. Transmission deferral (\$142.7-\$506.5 thousand), base customer charge (\$184.9-\$194.0 thousand), and load shaping charge reductions of \$166.6-\$715.1 thousand were driven mostly by tidal energy production.

TABLE ES-2 Annualized Benefits by Service by Scenario

Scenario ID	Transmission Deferral	Base Customer Charge	HLH Load Shaping Charge	LLH Load Shaping Charge	Demand Charge	Transmission Charge	Misc. Charge	Outage Mitigation
1	$-	$-	$-	$-	$-	$-	$-	$-
2	$142,692	$184,886	$106,580	$71,005	$(53,534)	$4,840	$1,712	$24,716
3	$170,605	$184,886	$96,630	$78,007	$79,846	$4,434	$1,695	$25,806
4	$189,479	$193,980	$98,614	$83,648	$152,843	$4,524	$1,779	$34,696
5	$271,385	$192,209	$205,474	$154,421	$96,709	$9,366	$3,491	$39,405
6	$377,811	$192,209	$312,427	$225,109	$39,159	$14,208	$5,203	$48,068
7	$506,503	$192,209	$419,057	$296,074	$(27,901)	$19,048	$6,914	$38,998
8	$216,983	$192,209	$90,569	$89,101	$257,132	$4,131	$1,763	$45,343
9	$244,284	$190,438	$83,548	$93,659	$345,237	$3,744	$1,747	$67,735
10	$271,385	$188,667	$77,561	$97,386	$415,103	$3,357	$1,730	$73,284
11	$189,479	$190,438	$89,385	$90,226	$182,224	$4,107	$1,763	$42,200
12	$216,983	$186,896	$73,753	$101,125	$317,894	$3,336	$1,730	$57,196
13	$244,284	$183,354	$60,393	$110,219	$438,218	$2,487	$1,697	$74,277
14	$271,385	$179,812	$50,122	$116,516	$542,399	$1,756	$1,665	$86,013
15	$189,479	$192,209	$99,405	$82,969	$152,204	$110,928	$1,779	$34,695

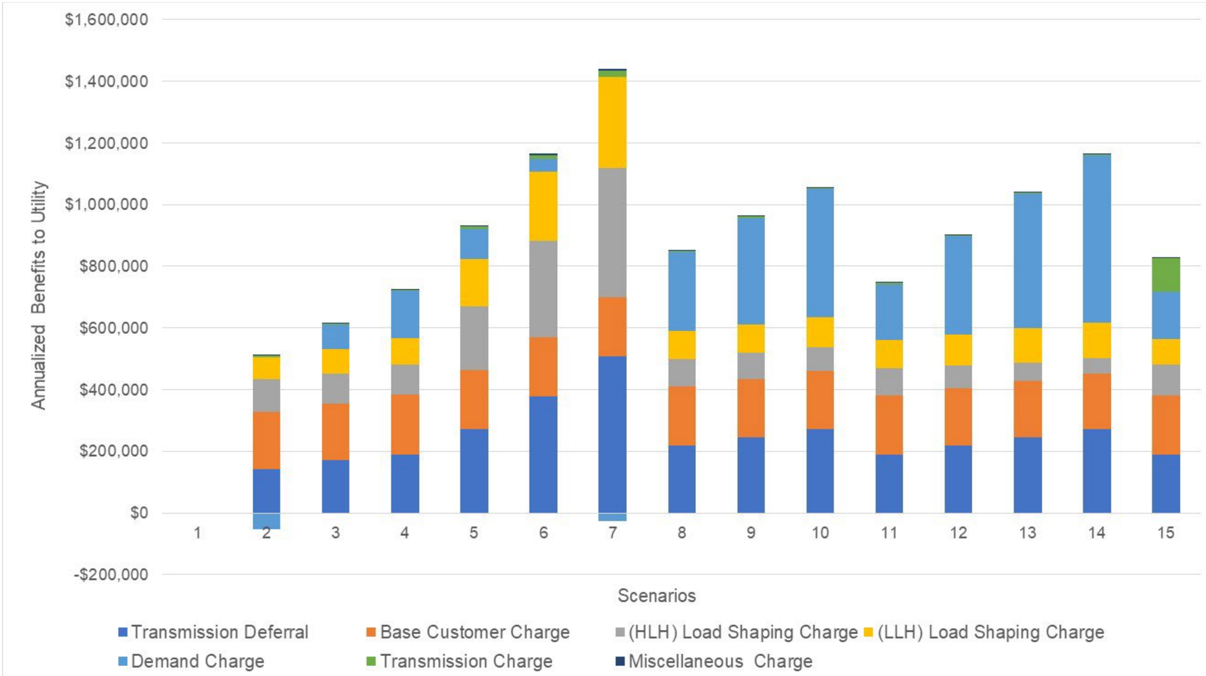

FIGURE ES-2 Annualized Benefits to OPALCO

The results of the benefit-cost analysis (BCA) from a utility perspective are presented in Table ES-3. For this analysis, we use the BCR and net benefits financial metrics. The BCR is calculated by dividing discounted revenue or benefits of the project by discounted costs. A BCR of more than 1.0 demonstrates a positive return on investment. A BCR of 1.2 would indicate that for every dollar invested in the project, a return of $1.20 could be achieved. Net benefits are calculated by subtracting PV costs from PV benefits. BCRs presented in Table ES-3 vary from 0.25 to 0.49, with lifetime net benefits ranging from -$123.6 million to -$33.1 million. While none of the BCRs exceed 1.0, the results of the analysis are very useful in that they define the grant level for tidal power required to break even at $38.9 million. Further, the analysis demonstrates that additional investments in storage on Orcas Island could yield positive net returns of approximately $3 million in PV terms.

TABLE ES-3 Benefit-Cost Analysis Results – Utility Perspective

Scenario	PV Benefits	PV Costs	BCR	Net Benefits
1	$-	$-	-	$-
2	$13,054,594	$51,983,452	0.25	$(38,928,858)
3	$17,554,111	$53,559,847	0.33	$(36,005,736)
4	$20,653,054	$57,374,999	0.36	$(36,721,945)
5	$26,584,765	$91,423,731	0.29	$(64,838,966)
6	$33,225,435	$128,336,577	0.26	$(95,111,142)
7	$40,228,235	$163,817,365	0.25	$(123,589,131)
8	$24,272,180	$58,951,394	0.41	$(34,679,214)
9	$27,428,200	$60,527,790	0.45	$(33,099,590)
10	$30,064,648	$63,739,006	0.47	$(33,674,358)
11	$21,301,394	$58,489,143	0.36	$(37,187,749)
12	$25,691,895	$60,065,539	0.43	$(34,373,644)
13	$29,650,484	$62,756,078	0.47	$(33,105,594)
14	$33,155,064	$68,236,876	0.49	$(35,081,812)
15	$23,619,287	$57,374,999	0.41	$(33,755,712)

The results of the BCA from a utility plus customer perspective produce BCRs that vary from .25 to .53, and net benefits that range from -$121.3 million to $-29.8 million. Note that when capturing all customer benefits, including outage mitigation, the funding gap for tidal power closes to $38.2 million. BESS investments drive positive outcomes through the benefits associated with enhanced outage mitigation, which reaches as high as $86.0 thousand annually in Scenario 14.

The research team evaluated the sensitivity of the results with respect to changes in a number of key assumptions and parameters. Results suggest that the findings are somewhat sensitive to several alternative assumptions. Varying energy price inflation, meaning the price paid by OPALCO to PNGC Power, has a larger effect than that of varying the discount rate, with impacts reaching -$7.7 million (2% price inflation) to $10.4 million (4% price inflation) when compared to a 3% price inflation baseline. These findings suggest that the microgrid assets would form somewhat of a hedge against future price inflation, with economic performance improving significantly under higher rates of inflation. Scenario 4 reaches a breakeven point when annual energy price inflation reaches 7.2%. Increasing the clean energy investment credit authorized under the Inflation Reduction Act of 2022 from 30% to 40% by adding in the bonus for meeting domestic content requirements on the Orcas Island BESS and tidal power would improve the economic performance of the microgrid by $4.3-$11.9 million in total PV terms. Each of these results are from a utility perspective. Setting the BESSs state of charge to 80% in advance of reliability events adds $1-$4.4 million in additional outage mitigation benefits over the life of the units to customers. Note that scenarios where the duration of energy storage is doubled yield significantly higher outage mitigation benefits.

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1 INTRODUCTION

The Orcas Power and Light Co-op (OPALCO) is developing a diverse set of local renewable energy resources to reduce dependence on mainland Washington State for energy and to reduce the regional need for fossil-fueled power. OPALCO's load doubles in winter but solar production is roughly 20% of levels reached in summer periods when island demand is lower. Tidal energy is strong year-round, night and day, and is predictable, requiring much less storage to firm it. To assess the technical and economic feasibility of tidal power, working in combination with multiple other distributed energy resources (DERs), Argonne National Laboratory (Argonne) employed an optimization model to evaluate several economic benefits associated with varying scales of tidal power of between 2.4 and 9.6 megawatts (MW) and other DERs. In addition to existing photovoltaic (PV) and battery energy storage system (BESS) resources located on Decatur Island, Argonne also evaluated the addition of a BESS on southern Orcas Island with power and energy capacities ranging from 1-4 MW and 2-4 hours in storage duration.

OPALCO is a non-profit utility that provides energy services to approximately 11,700 customers across 20 islands in San Juan County, Washington. A map of the San Juan Islands, including the Rosario Strait where the tidal power unit will be located and Decatur Island where the existing 1 MW / 2 megawatt-hour (MWh) BESS and PV system is located, is presented in Figure 1. The island network is located off the northwestern coast of Washington State.

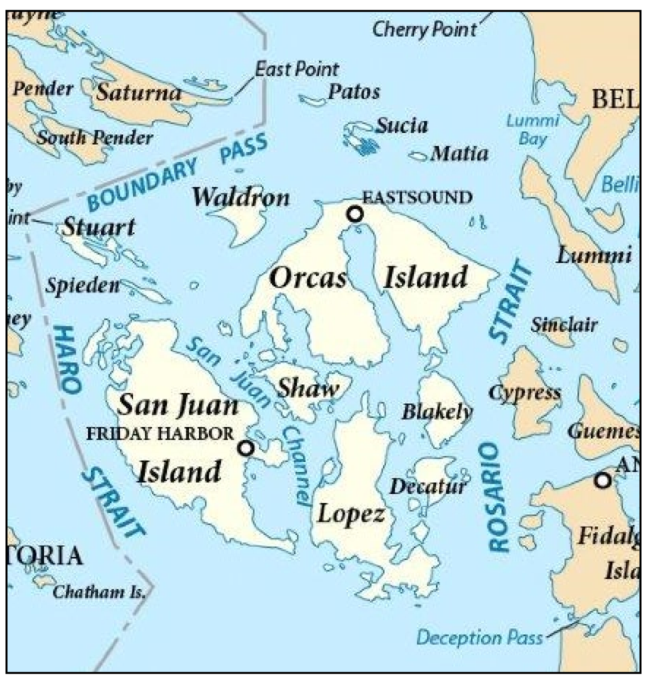

FIGURE 1 Map of the San Juan Islands, Washington

2 MODELED DISTRIBUTED ENERGY RESOURCES

This section presents an overview of the DERs modeled in this study. Modeled DERs include the community solar and BESS together forming the Decatur Island microgrid, plus tidal energy deployed in Rosario Strait at a location between Blakely and Cypress Islands, and a BESS to be deployed in the Olga District of southern Orcas Island.

2.1 COMMUNITY SOLAR ON DECATUR ISLAND

A community solar facility deployed on Decatur Island is a 504 kW DC array that produced 466 MWh of energy in 2022. Figure 2 presents an image of Decatur Island PV. The system includes 1,260 LG400 Watt monocrystalline modules supplied by Puget Sound Solar (Puget Sound Solar 2017). OPALCO customers can purchase shares in the community solar to receive energy credits that are allocated based on the number of shares purchased and used to defray energy costs on their monthly utility bill.

FIGURE 2 Decatur Island Community Solar

OPALCO provided hourly PV production data for the 2019 through 2022 time period. PV production values influence load shaping charges, demand charges, transmission charges, outage mitigation, and transmission submarine cable replacement deferral benefits using the methods outlined in the next section of this report. The research team used the 2022 hourly production values presented in Figure 3 for modeling purposes.

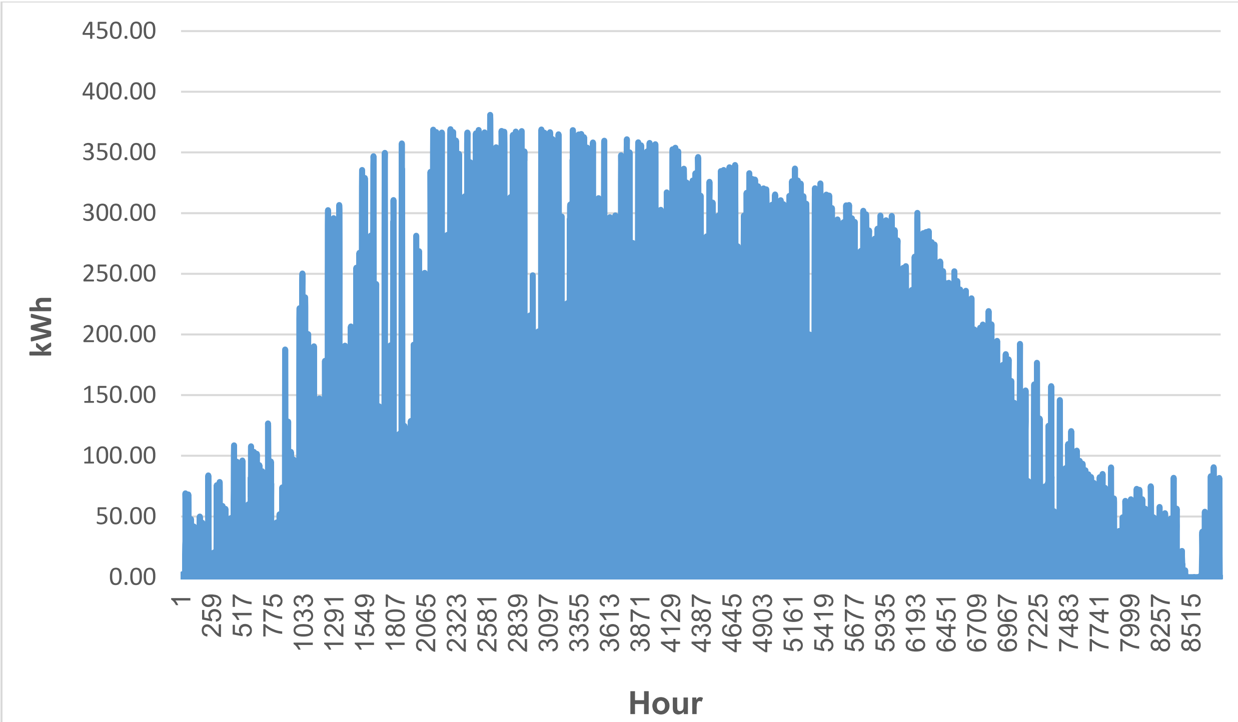

FIGURE 3 Hourly PV Production Data on Decatur Island in 2022

2.2 BATTERY ENERGY STORAGE SYSTEMS

The Decatur Island BESS is a 1 MW / 2 MWh lithium iron phosphate (LFP) battery. The BESS consists of a single container with 12 rack-mounted strings. Each string contains 24 cells in a series or a total of 264 cells. Pacific Northwest National Laboratory (PNNL) conducted extensive testing of the Decatur Island BESS but was unable to accurately account for ancillary systems (e.g., heating and control systems) and the resulting estimates of round-trip efficiency (RTE) (>95%) were, therefore, deemed unsuitable for this study and ultimately not used (Crawford et al. 2022). Instead, when modeling all BESSs considered in this study, we rely on industry average values for LFP presented in Viswanathan (2022) at 83%.

FIGURE 4 Decatur Island Energy Storage System

2.3 TIDAL ENERGY

OPALCO has developed site and cost information on tidal power, working with PNNL, Orbital Marine Power, and the University of Washington. Following an extensive review of potential sites conducted by PNNL (Copping et al. 2021), Rosario Strait was selected as the site for the tidal power unit (Figures 5a and 5b). Note that the maximum power capacity for the Orbital Marine Power tidal unit considered here is 2.4 MW. For this evaluation, we study the costs and benefits of up to four tidal power units with maximum combined power output levels of 9.6 MW.

FIGURE 5a Map of San Juan Islands

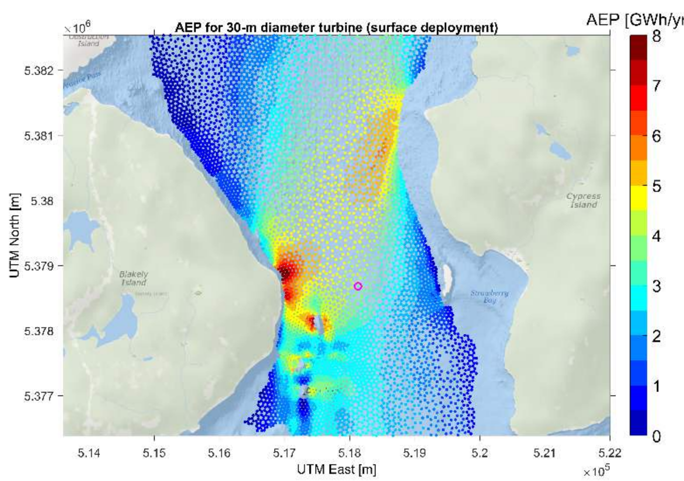

FIGURE 5b Tidal Flow Map of Rosario Strait

Tidal production data was estimated from a simulation of tidal currents throughout the San Juan Islands conducted by PNNL. The hourly values of the two-dimensional currents are converted to a scalar speed, U_o, as

$$U_o = (u^2 + v^2) \tag{1}$$

These hourly values of speed are then linearly interpolated to a 5-minute time basis. From this, electrical power output from the turbine, P, is calculated as

$$\mathrm{P} = \frac{1}{2}\rho\eta A U_o^3 \tag{2}$$

where ρ is the seawater density (1025 kg/m3), η is the "water-to-wire" turbine efficiency (0.39), and A is the turbine area (for a pair of 30 m diameter rotors). This time series is then modified by two constraints:

1. When currents are below the turbine cut-in speed (0.5 m/s), electrical power output is zero.
2. When electrical power output would otherwise exceed the turbine's rated power (2.4 MW), electrical power is capped at this value.

The 5-minute time series is then converted to hourly electrical generation (MWh) by calculating the average power, in MW, for each hour of the year and multiplying this by one hour. Using this approach, hourly tidal power production was prepared for 2022, as presented in Figure 6. Total energy production for the year was estimated at 5.7 gigawatt-hours or 2.4% of total OPALCO energy needs.

Tidal production values influence load shaping charges, demand charges, transmission charges, outage mitigation, and transmission submarine cable replacement deferral benefits.

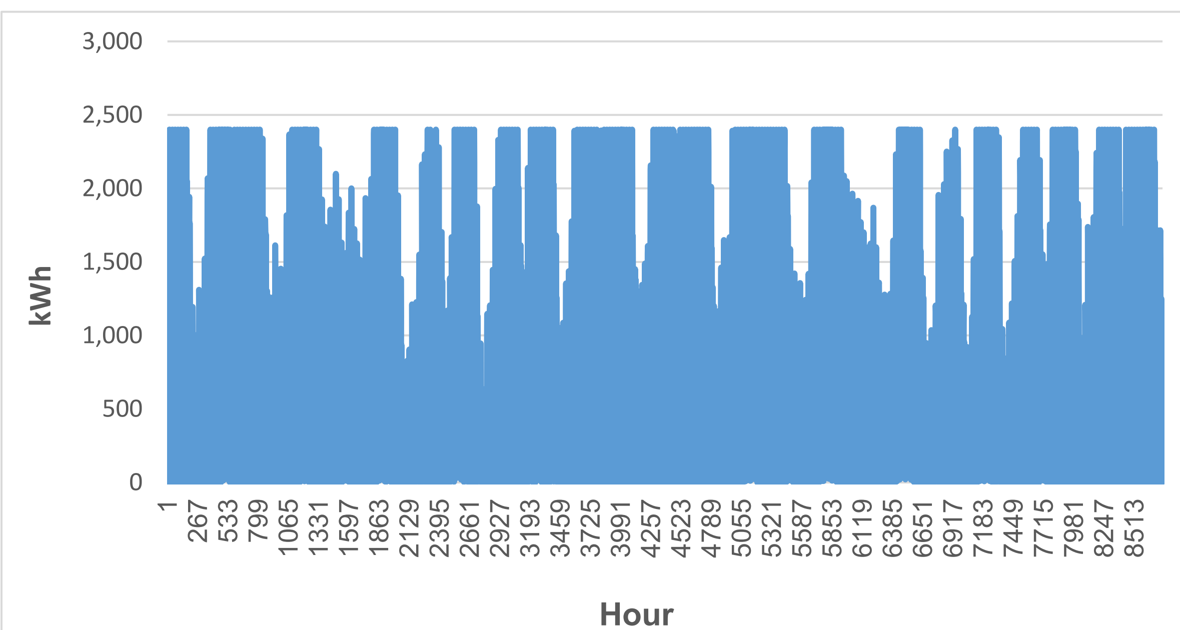

FIGURE 6 Modeled Hourly Tidal Production Data

3 ENERGY STORAGE VALUATION METHODOLOGY

Argonne began its assessment of tidal power, community solar, and BESS benefits by meeting with OPALCO and developing a list of use cases or services that could be offered by the DERs defined for this study. The following use cases were defined for further evaluation:

1. Customer base charge;
2. Load shaping charge reduction;
3. Demand charge reduction;
4. Transmission charge reduction;
5. Miscellaneous charge reduction;
6. Submarine transmission cable replacement deferral; and
7. Outage mitigation.

Each of these use cases are defined in the following sections along with the methodology used to estimate the associated value. The value of each use case by scenario is presented in Section 4.

Note that this section represents an update to a report on a project for which the principal investigator (PI) of this study also served as the PI (Mongird et al. 2018). Some of the text that describes the basis of each charge appears in both reports. With that noted, this study includes certain charges (e.g., spinning and supplemental reserves, regulation and frequency response, and miscellaneous charges) that were not considered in that previous study. Further, text and in some cases equations, have also been modified.

3.1 DIRECT OPALCO CHARGES

OPALCO pays its bill through the electric utility company PNGC Power, but its energy is delivered by the Bonneville Power Administration (BPA) and is, therefore, subject to BPA's rate structure. BPA offers a tiered tariff structure to its customers within which there are multiple levels, differentiated by a MW demand quantity, with each individually priced. The cutoff at which it crosses over from the lower level to the next is established to align with the current generation capabilities of BPA's system.

Tier 1 is the lower price level in BPA's structure and each energy customer is allocated a limited MW quantity that they may purchase at this rate. The reasoning behind the purchase cap is that Tier 1 is constrained by BPA's total current generation capability and the level of MW demand it can readily meet with available resources. Tier 2 rates, on the other hand, are established to cover any remaining customer demand beyond what is covered under Tier 1 and are higher as they are priced according to the cost of BPA obtaining more generation to meet the additional demand.

Tier 1, which accounts for almost all of the power OPALCO purchases, includes five separate charges:

1. the customer base charge;
2. the load shaping charge;
3. the demand charge;
4. transmission charges; and
5. a miscellaneous charge.

3.1.1 Base Charges

The customer base charge is not dependent on either OPALCO's monthly peak demand or the time at which it consumes energy, but rather is a pre-calculated amount based on a forecasted load. Each customer is assigned a tier one cost allocator (TOCA), which defines the portion of BPA generation costs that should be paid by OPALCO. In 2022, OPALCO's TOCA was 0.35 percent. The base charge is calculated at roughly $2 million per percentage point per month. At this rate, the charge to OPALCO would be roughly $700,000 per month. However, the base charge is adjusted downward by non-slice charges and low density discounts. These adjustments reduce the fixed customer base charge at $550,302 monthly or $6.6 million annually. During 2022, OPALCO consumed 241.8 gigawatt-hours of energy. Thus, the base charge can be calculated at 2.7 cents per kWh. Tidal and PV production would affect future year TOCAs and, therefore, the base charges allocated to OPALCO. Thus, the pure energy charge reduction attributed to tidal and PV generation was calculated at 2.7 cents per kWh.

3.1.2 Load Shaping and Demand Charge Reductions

Load shaping and demand charges are components of OPALCO's energy bill that fluctuate on a monthly basis and can appear as either a charge or a credit that is dependent upon whether OPALCO purchases more or less energy than the amount expected by BPA. The demand charge, on the other hand, is a fee OPALCO incurs that is tied to energy purchases during the utility's most load-intensive hour each month. The DERs have the potential to impact both of these charges and, therefore, it is important to understand how they are derived. To be able to accurately calculate the full benefits that the BESS can derive by mitigating these charges, it is necessary to first understand the structure of BPA's rates.

In this section, we will use three key load metrics: total retail load, Tier 1 customer system peak (CSP), and transmission system peak (TSP). Total retail load equals all energy consumed during a month (sometimes split between heavy load hours [HLH] and light load hours [LLH]) including energy consumed by storage (including battery charging) and renewable energy. Tidal power and PV can reduce the load through energy production and the BESSs can shift load from HLH to LLH to reduce cost. Total retail load is the sum of the metered load at the 335 Fidalgo #4 Out meter, 2387/8631 Fidalgo #5 out, and 4831 Decatur out meter. Tier 1 CSP is the customer's maximum load during HLHs each month as measured at the two meters on Fidalgo Island and the one on Decatur Island. This will include load from all customers and utility equipment, including solar and energy storage systems. The TSP adds DER energy production to the load measured at the Fidalgo Island meters and the Decatur Island meter during the peak BPA transmission hour each month, thus negating their effects. Tidal power production will also be added back into the metered load during the TSP. All are considered Designated Network Resources (DNRs) by BPA currently and load served by DNRs are included in the TSP. The threshold for defining a DNR is currently 200 kW but will be raised to 1 MW in 2028. Thus, PV production during the TSP hour could reduce transmission charges starting in 2028 while tidal power will not yield any savings because its nameplate capacity exceeds 1 MW. Batteries are also considered DNRs.

For the amount of power that OPALCO is unable to purchase at Tier 1 rates, it must pay at the higher, Tier 2 rates. This is incorporated into its bill from PNGC under what is called the Above High Water Mark (AHWM) Power Cost. This MWh quantity is set as a fixed amount based on a forecast of how much Tier 2 power BPA expects OPALCO to require. Like the customer base charge described previously, the DERs will not be able to affect the AHWM power cost, as the value is fixed and not dependent on OPALCO's time-of-use or peak energy usage. Nevertheless, the AHWM load that OPALCO makes the obligation to purchase is important, as it allows us to determine the Tier 1 amounts each month that the microgrid assets have the ability to impact.

3.1.2.1 Load Shaping Charge

Load shaping is a Tier 1 charge or credit OPALCO receives that is dependent on whether its actual retail load each month is greater or less than the amount BPA predicted it would purchase. Load shaping is split into two categories: HLH and LLH. A different charge/credit is determined for each that fluctuates depending on energy purchased during set hours.

HLHs include all hours between 6:00am and 10:00pm, Monday through Saturday. LLHs include all other hours on those same days as well as all hours on Sundays and holidays. Those holidays include New Year's Day, Memorial Day, Independence Day, Labor Day, and Christmas Day, which in 2022 fell on January 1, May 30, July 4, September 5, November 24, and December 25 in that order. If OPALCO's power purchases are less than expected, they receive a credit on their bill. Conversely, if they purchase more power than expected, they must pay an additional charge.

For HLHs, the load shaping charge/credit for each month in 2022 is determined by the following formula:

$$\begin{aligned} &\mathit{HLH\ Load\ Shaping\ Charge} \\ &\quad = [(\mathit{Total\ HLH\ retail\ load\ in\ MWh} \\ &\quad - \mathit{AHWM\ Obligation\ HLH\ in\ MWh}) - \mathit{OPALCO\ HLH\ System\ Shaped\ Load}] \\ &\quad \times\ \mathit{HLH\ Load\ Shaping\ Rate\ per\ MWh} \end{aligned} \tag{3a}$$

For LLH it is:

$$
\begin{aligned}
&\mathit{LLH\ Load\ Shaping\ Charge} \\
&\qquad = [(\mathit{Total\ LLH\ retail\ load\ in\ MWh} \\
&\qquad - \mathit{AHWM\ Obligation\ LLH\ in\ MWh}) - \mathit{OPALCO\ LLH\ System\ Shaped\ Load}] \\
&\qquad \times\ \mathit{LLH\ Load\ Shaping\ Rate\ per\ MWh}
\end{aligned} \tag{3b}
$$

Where:

Total HLH (LLH) retail load is the MWh quantity that OPALCO purchases each month; *HLH (LLH) system shaped load* is BPA's forecast of OPALCO's MWh total retail load for that month; and *HLH (LLH) load shaping rate* is the mills/kWh rate that BPA charges for these bill components.

Note the two differing values that are subtracted from the total retail load for the respective hours. These values are the AHWM obligations that OPALCO has agreed to pay each month that cannot be charged at the lower Tier 1 rates. By subtracting them from total retail load we are left with the HLH Tier 1 load and LLH Tier 1 load, respectively. OPALCO's monthly AHWM obligations are presented in Table 1.

TABLE 1 OPALCO 2022 AHWM Obligation

Month	HLH (MWh)	LLH (MWh)
January	570.40	490.54
February	547.58	410.69
March	616.03	443.49
April	593.22	433.50
May	570.40	490.54
June	593.22	433.50
July	570.40	490.54
August	616.03	444.91
September	570.40	456.32
October	624.83	492.66
November	600.80	482.14
December	624.83	492.66

The second component of the equations above, the system shaped load, is the total monthly amount of energy BPA expects OPALCO to purchase during the indicated hours across the entire month. These values are predetermined for OPALCO for each month of 2022 for both HLH and LLH, and are provided in Table 2.

TABLE 2 OPALCO 2022 System Shaped Load by Month (MWh)

Month	HLH (MWh)	LLH (MWh)
January	9,287.16	7,038.17
February	8,219.28	5,930.24
March	10,373.84	6,517.83
April	8,081.37	5,032.76
May	12,243.72	5,926.00
June	13,845.15	5,569.58
July	12,277.45	6,155.96
August	11,996.97	5,817.50
September	10,506.40	5,956.03
October	10,230.07	5,720.05
November	12,391.65	7,801.78
December	11,291.61	8,473.72

The difference between the Tier 1 loads and the system shaped loads, as shown in the equation, gives the deviation in energy consumption for which OPALCO will be additionally charged or rewarded. This deviation is charged/credited at the appropriate load shaping rate shown in Table 3. The sum of the HLH and LLH load shaping charges/credits is the total load shaping charge/credit for the month.

TABLE 3 HLH and LLH Load Shaping Rates Set by BPA for 2022 (mills/kWh)

Month	HLH Rate	LLH Rate
January	34.29	25.85
February	34.79	28.29
March	27.57	28.44
April	20.71	25.66
May	16.28	16.30
June	17.15	10.62
July	36.83	21.36
August	35.87	26.85
September	28.15	28.95
October	29.92	28.27
November	31.71	29.14
December	38.76	32.05

OPALCO also qualified for a low density discount (LDD) from BPA of 5.61 percent on its Tier 1 charges in 2022. This discount is given to qualified BPA customers who meet a list of criteria including: low kWh/investment and low consumers/mile of line ratios. During months in which OPALCO purchases more energy from BPA than expected, this discount is applied to the cost it faces. In months in which OPALCO purchases less energy than expected, this discount works against it and any credit it receives is 5.61 percent smaller.

The potential monetary savings that can be gained through the usage of the BESSs is through the shifting of energy consumption away from the pricier HLHs and towards the LLHs. As shown in Table 3, the LLH load shaping rate is generally lower each month. By charging up the BESSs during these hours and discharging during HLH, the price differential generates the potential for benefits. These benefits, however, are typically low for BESS operations due to the cost associated with RTE losses.

3.1.2.2 Demand Charge

The second Tier 1 charge that the DERs have the potential to impact is the demand charge paid by OPALCO. Demand charges are fees incurred by a customer proportional to the highest MWh load it consumes each month. This charge can be reduced by shaving peak loads throughout the month. Demand charges will be reduced as production from the tidal energy and community solar drive down metered load during peak hours. This service can also be provided by the BESSs discharging energy when a specific load threshold is surpassed, thereby reducing peaks. These peak-reducing activities can amount to substantial savings for OPALCO.

The demand charge is determined by three factors: (1) OPALCO's Tier 1 (T1) CSP, (2) OPALCO's Tier 1 average HLH load, and (3) OPALCO's contract demand quantity (CDQ). These three components come together in the following equation each month:

$$
\begin{aligned}
Demand\ Charge &= \Big[\big((T1\ CSP - AHWM\ Obligation\ at\ T1\ CSP) \\
&\quad - (average\ HLH\ load - AHWM\ Obligation\ at\ T1\ CSP) - \ CDQ\big)\Big] \times\ 1{,}000 \\
&\quad \times\ Demand\ Charge\ Rate
\end{aligned} \tag{4}
$$

Where,

T1 CSP is OPALCO's peak hourly load for the given month; the AHWM Obligation at T1 CSP is a static obligation; *average HLH load* is the average load across all HLH hours for the month; and *CDQ* is the CDQ set by BPA that is preset for each month.

The AHWM Obligation at T1 CSP, which should not be confused with the AHWM obligation referenced in the load shaping section, was 1.43 MW in January through September of 2022 and 1.502 in October through December 2022.

OPALCO's CDQs in MW are shown for each month in Table 4.

TABLE 4 OPALCO Contract Demand Quantities (MW)

Month	OPALCO CDQ (MW)
January	10.557
February	9.877
March	9.049
April	8.336
May	5.661
June	2.964
July	3.04
August	1.537
September	3.725
October	8.608
November	11.397
December	5.808

As before, note the 1.43 or 1.502 that is subtracted from both the T1 CSP and the average HLH (aHLH) in the equation. By subtracting these Tier 2 amounts from the total load, we are ensuring that only the portion of the total retail load that applies to Tier 1 rates is being used in the equation. CDQs are set independently and only for Tier 1 equations, therefore they do not require any adjustment and are already Tier 1 amounts. The resulting value is charged at the appropriate demand charge rate for the given month, provided below in Table 5.

TABLE 5 BPA Demand Charge Rate for 2022

Month	Rate ($/kW)
January	11.31
February	11.47
March	9.09
April	6.83
May	5.36
June	5.65
July	12.14
August	11.83
September	9.29
October	9.87
November	10.46
December	12.78

The demand charge is also subject to the same LDD discount that applied to the load shaping charge. Therefore, this final calculated value benefits from a 5.61 percent reduction each month.

3.1.3 Transmission Charge Reduction

OPALCO incurs a variety of transmission charges that are calculated using three methods as outlined below:

1. OPALCO pays a transmission service charge each month of \$2.103/kW along with a scheduling, system control and dispatch charge of \$0.389/kW. These rates are applied to the TSP, which is measured during BPA's peak transmission hour in that same month. Unlike the peak loads defined in the previous sections, transmission system peak would add back in any production from the DERs as they are defined as DNRs. Network load as used in determining the transmission charges includes any load served by DNRs. Historically, the OPALCO bill has netted out the effects of solar and BESS operations. During this study, the research team made a strong case that batteries should not be treated as DNRs under the current tariff and while PNGC Power agreed, BPA did not. With that noted, PNGC did agree that energy produced by the DERs should be subjected to a short duration discount (SDD). The SDD is calculated by taking the product of the transmission service charge and the lesser of the energy produced by DERs during the TSP and the aHLH production by DERs multiplied by 0.4. While all DERs are DNRs currently, PV may not be a DNR beginning in 2028. Peak transmission loads were reached in the hours identified in Table 6. Hour 1 occurs between 12am and 1am.

TABLE 6 BPA Transmission Peak Days/Hours in 2022

Month	Day	Hour
January	1/31/2022	HE19
February	2/1/2022	HE19
March	3/7/2022	HE7
April	4/1/2022	HE7
May	5/9/2022	HE21
June	6/27/2022	HE20
July	7/11/2022	HE20
August	8/2/2022	HE17
September	9/6/2022	HE19
October	10/31/2022	HE19
November	11/22/2022	HE18
December	12/22/2022	HE18

2. Spinning and supplemental reserve charges are calculated using the equations below.

$$Spinning\ and\ Supplemental\ Reserves = Trasmission\ Reserve\ Determinant\ in\ MW\ x\ \$18.27 \quad (5)$$

$$\begin{aligned} &Transmission\ Reserve\ Determinant \quad (5a) \\ &= \big[\big((Total\ Retail\ Load\ in\ kWh)\ x\ (1 + Operating\ Reserve\ Loss\ Rate)\ x\ .03\big) \\ &- ((AHWM\ Supply\ x\ AHWM\ \%\ x\ 1{,}000) * (1 \\ &+ Operating\ Reserve\ Loss\ Rate)\ x\ .015\big] \end{aligned}$$

The operating reserve loss and AHWM supply by month are presented in Table 7.

TABLE 7 Operating Reserve Loss Rate (ORLR) and AHWM supply.

Month	ORLR	AHWM Supply
January	0.0195	7440
February	0.0195	6720
March	0.0195	7430
April	0.0195	7200
May	0.0195	7440
June	0.0231	7200
July	0.0231	7440
August	0.0231	7440
September	0.0195	7200
October	0.0195	7440
November	0.0195	7210
December	0.0195	7440

The AHWM % is 3.063%.

3. The remaining transmission charges, which include regulation and frequency response, peak dues, and WECC dues, are calculated by taking total retail load plus energy discharged from the BESSs and solar production in MWh and multiplying that by 55 cents/MWh.

Once again, there are no current benefits to PV and tidal energy production in terms of reducing these charges. However, benefits will begin to accrue to PV energy production beginning in 2028.

3.1.4 Miscellaneous Charges and Credits

OPALCO incurs miscellaneous charges and credits. One such charge is called the Additional Marginal Contribution (Part A) charge. It is calculated using the following equation:

$$\begin{aligned} &Additional\ Marginal\ Contribution\ (Part\ A) \quad (6) \\ &= \big[\big((Total\ HLH\ retail\ load - AHWM\ HLH\ Obligation\ ) \\ &+\ (Total\ LLH\ retail\ load - AHWM\ LLH\ Obligation))\ x\ .25\big)\big] \end{aligned}$$

OPALCO's AHWM obligations (HLH and LLH) by month are presented in Table 8.

TABLE 8 OPALCO 2022 AHWM Obligation

Month	HLH (MWh)	LLH (MWh)
January	570.40	490.54
February	547.58	410.69
March	616.03	443.49
April	593.22	433.50
May	570.40	490.54
June	593.22	433.50
July	570.40	490.54
August	616.03	444.91
September	570.40	456.32
October	624.83	492.66
November	600.80	482.14
December	624.83	492.66

3.1.5 Transmission Submarine Cable Replacement Deferral

There is a BPA-owned submarine transmission cable that connects Fidalgo Island on mainland Washington near Anacortes with Decatur and Lopez Islands. This location of this cable, referred to as Cable 5, is presented in Figure 7. While the cable currently is under BPA ownership, we value its life extension under the assumption that its replacement could be paid for by OPALCO customers. Value is obtained by using the DERs to reduce peak loads, thereby reducing heat on the cable and acting as a reactor that compensates for the submarine cable's large capacitance. The analysis evaluates the value of extending the 40-year cable life over two rounds of investment.

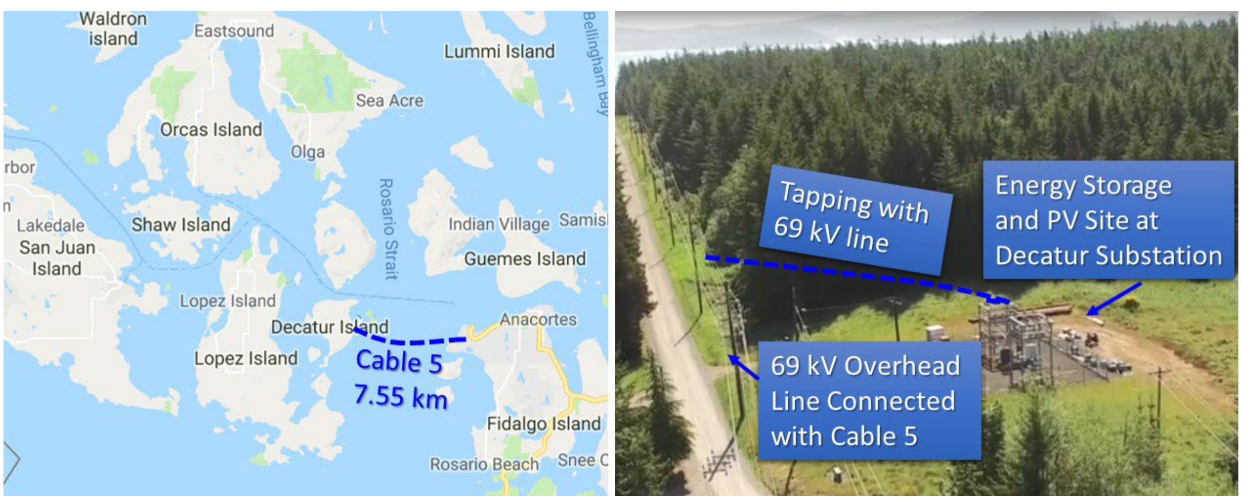

FIGURE 7 Cable 5 Location

The basis of the approach employed for this study is defined in detail in Mongird et al. (2018). In addition to employing the model described in that report, the scenarios defined in Table 9 were evaluated by forecasting load growth at 0.7% annually and additionally exploring how the added load would be accommodated through the DER additions.

TABLE 9 Deferral Periods and Value by Scenario

Scenario	Scenario Description	Deferral Period	Total Present Value	Annualized Value
1	no DERs	0		
2	Tidal power in isolation	5	2,116,805	119,503
3	Tidal power plus local storage on Orcas Island	6	2,530,878	142,879
4	Scenario 3 plus Decatur PV and BESS	7	2,941,907	166,083
5	Scenario 4 with 2X tidal power	10	4,156,959	234,678
6	Scenario 4 with 3X tidal power	14	5,735,761	323,808
7	Scenario 4 with 4X tidal power	19	7,644,868	431,585
8	Scenario 4 with 2x Orcas storage capacity	8	3,349,915	189,117
9	Scenario 4 with 3x Orcas storage capacity	9	3,754,925	211,981
10	Scenario 4 with 4x Orcas storage capacity	10	4,156,959	234,678
11	Scenario 4 with 1x Orcas storage capacity @ 4 hr.	7	2,941,907	166,083
12	Scenario 4 with 2x Orcas storage capacity @ 4 hr.	8	3,349,915	189,117
13	Scenario 4 with 3x Orcas storage capacity @ 4 hr.	9	3,754,925	211,981
14	Scenario 4 with 4x Orcas storage capacity @ 4 hr.	10	4,156,959	234,678
15	Scenario 4 but no assets are DNRs	7	2,941,907	166,083

3.1.6 Outage Mitigation

With the addition of tidal power and the BESS on southern Orcas Island in the Olga District, OPALCO could island a significant portion of its system spanning the Olga District to Decatur and Center Islands.

In the outage mitigation analysis, a four-zone system was employed, consisting of:

1. Olga substation and three lines (Orcas Island),
2. Blakely substation and two feeders (Blakely Island),
3. Decatur substation and two feeders (Decatur Island), and
4. All other islands, including San Juan, Shaw, and Lopez.

The placement of the energy assets considered in this evaluation, along with the portions of OPALCO's transmission and distribution system capable of islanding during outages, is illustrated in Figure 8. It is assumed that the addition of tidal power and an energy storage system would not provide outage mitigation benefits to any customers in the fourth zone identified above and highlighted in Figure 8.

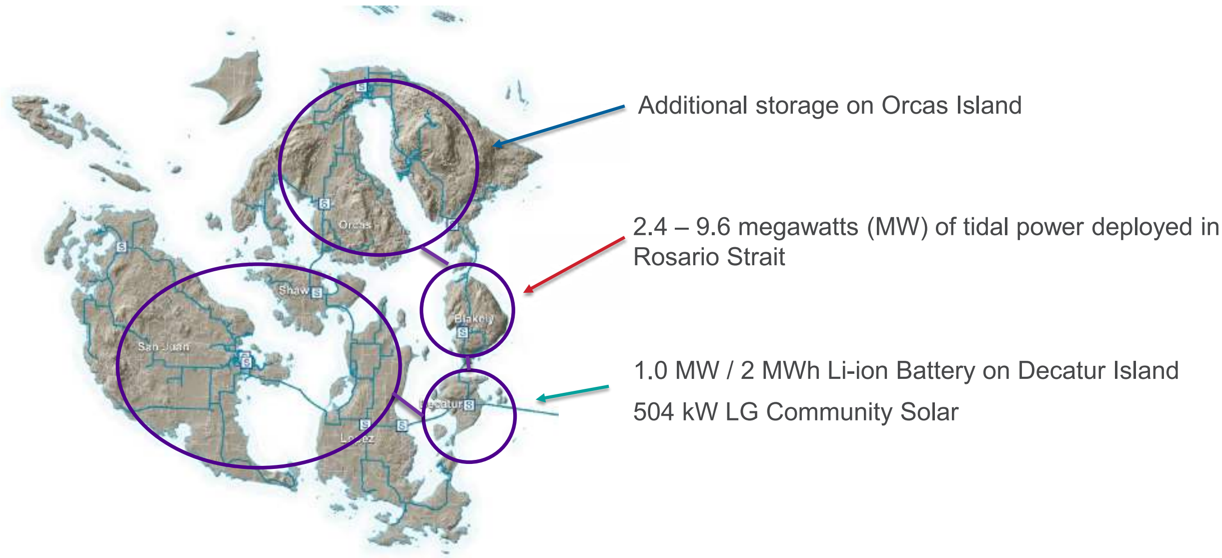

FIGURE 8 Four-zone OPALCO System and Placement of Tidal and Energy Assets

The feeders identified for potential islanding during outage mitigation are detailed in Table 10. These include three on Orcas Island, two on Blakely Island, and two on Decatur Island. Across these seven circuits, there are 2,326 customers, with 92% classified as residential customers, 5.9% as small commercial and industrial (C&I) customers, and 1.6% as large C&I customers. Customer classification accounts for differences in outage costs between residential, small C&I, and large C&I customers.

TABLE 10 Customer Counts by Class for All Feeders with Capacity for Islanding

		Customer Class		
Substation	Circuit	Residential	Small Commercial	Large Commercial
Olga	1	658	59	18
Olga	2	446	26	6
Olga	3	211	4	3
Blakely	1	271	12	0
Blakely	2	46	10	10
Decatur	1	140	11	0
Decatur	2	368	15	0

Outage data was collected for the 2019-2022 time period for any event affecting any of the seven circuits in isolation or in combination. Over this time period, there were 30 outages affecting 32,264 customers. Total hours of load interruption were 188.6, and the average outage duration was just over 6 hours. Total customer minutes of outages reached nearly 11 million over the 4-year timeframe.

For each outage event, we isolate the relevant zone or combination of zones based on the affected areas. For instance, in the case of an outage affecting only Decatur Island, we isolate Decatur and utilize the Li-ion battery and community solar on Decatur to mitigate the outage event. In scenarios covering both Blakely and Orcas Islands, we isolate these regions and employ tidal power and the BESS to address the outage.

The primary objective of the outage mitigation analysis is to systematically minimize both the financial impact and the inconvenience caused by power interruptions. This study takes into account interruption costs for three distinct customer classes: 1) medium and large C&I, 2) small C&I, and 3) residential customers within each region. The outage mitigation analysis is conducted using the Energy Storage Microgrid Optimization (ESMO) model, and is based on a two-stage simulation as shown in Figure 9.

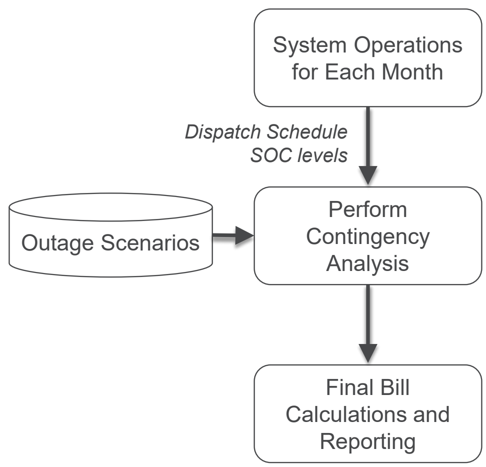

FIGURE 9 Two Stage Structure of Outage Mitigation Analysis

In the first stage, the ESMO model simulates steady-state system operations for each month of the year without considering contingencies. This stage provides hourly dispatch schedules and battery state-of-charge (SOC) levels for all resources in the system. The second stage involves ESMO conducting a contingency analysis for each outage event individually. This contingency analysis model is an optimization model that minimizes total interruption costs by determining the optimal resource utilization strategy. During an outage event, Tidal and PV resources can curtail their outputs only when needed, while energy storage resources can be operated optimally to mitigate the consequences of outage events as much as possible, contingent on the storage energy at the beginning of an outage event derived from the stage 1 outputs. It is important to note that the stage 1 simulations, based on steady-state analysis, are not aware of potential outages. Also, the stage 1 simulations do not incorporate N-1 contingencies explicitly. This means that the energy storage dispatch schedule is not optimized to minimize outage costs; rather, the contingency analysis model simulates how the system would behave when addressing predefined, historically obtained outage events. Also, due to the nature of the simplification made in the outage mitigation analysis, the annual load shedding amounts (in terms of MWh) do not reflect the actual reliability levels of the OPALCO system. Thus, the results should be used solely to compare the relative impact and value of additional tidal and other DERs in mitigating outages and reducing outage costs.

To monetize the value of outages, data from the Interruption Cost Estimate Calculator was utilized.[1] The interruption cost per unserved energy in terms of kWh for each customer class is applied in this study. These values, along with the customer energy consumption rates in percentage terms, are used to derive total outage costs per kWh in each region. The cost functions for each customer class are presented in Equation (7a)-(7c).

$$OC_{MLC\&I} = 52.7 * \alpha_{MLC\&I} * x \tag{7a}$$

$$OC_{SC\&I} = 189.2 * \alpha_{SC\&I} * x \tag{7b}$$

$$OC_{R} = 4.1 * \alpha_{R} * x \tag{7c}$$

Where:

$OC_{MLC\&I}$	Outage costs for medium and large C&I customers
$OC_{SC\&I}$	Outage costs for small C&I customers
OC_{R}	Outage costs for residential customers
$\alpha_{MLC\&I}$	Energy consumption rate for medium and large C&I customers (%)
$\alpha_{SC\&I}$	Energy consumption rate for small C&I customers (%)
α_{R}	Energy consumption rate for residential customers (%)
$x =$	Outage amount (kWh).

3.2 VALUATION MODELING APPROACH

In this study, the project team performed a comprehensive resource scheduling simulation spanning an entire year. This simulation aimed to evaluate the impact and value of the Decatur Island Microgrid and new tidal power and BESS options on southern Orcas Island. In order to capture the unique characteristics of the OPALCO power system, such as network topology and the definition of various charges that are not typically well captured in traditional production cost simulation models, the project team developed ESMO. Figure 10 shows an overview of the ESMO model. In this report, rather than describing all the model features and components in detail, we briefly provide the key characteristics of the ESMO model.

[1] The interruption cost calculator can be accessed at https://icecalculator.com.

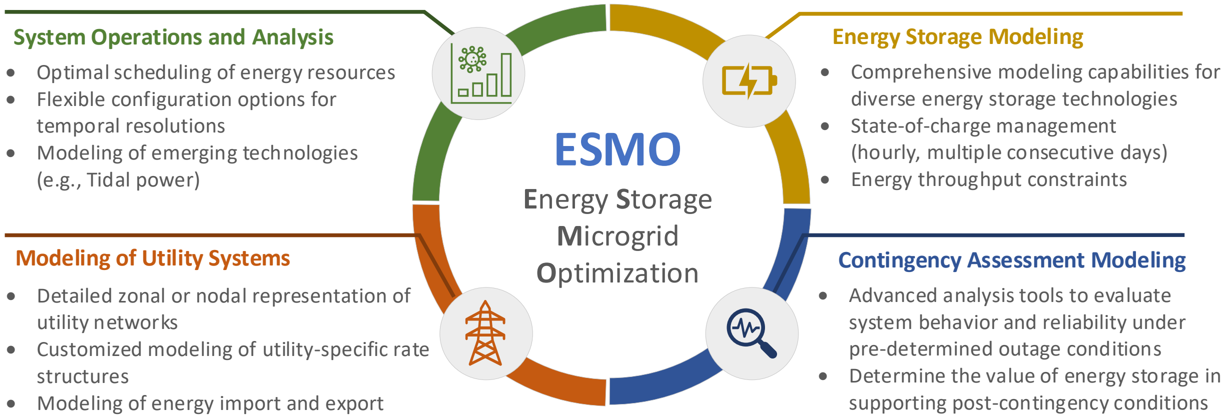

FIGURE 10 Overview of the Energy Storage Microgrid Optimization Model

The ESMO model is a least-cost linear programming model that determines the optimal hourly scheduling of resources in a system while ensuring the total cost (i.e., the summation of various charges described in Section 3.0) is minimized. The least-cost objective function includes the functions of the following charges:

- Load shaping charge,
- Demand charge,
- Transmission charge, and
- Miscellaneous charge.

These charges collectively contribute to the minimization of total system costs. The model accounts for constraints related to technology characteristics, electricity demand profiles, system requirements, and resource availability. The dispatch formulation incorporates constraints to ensure 1) load balance, 2) power flow and transmission limits, and 3) generator operating limits. The load balance constraints ensure that enough power is supplied to meet the demand in each region in each time interval. The power flows between regions are constrained by the transfer capability of transmission lines. A distinctive feature of the ESMO model lies in its detailed representation of the physical and operational constraints of energy storage resources. The model allows energy storage resources to provide all considered grid services. In addition, ESMO tracks and optimizes the SOC levels of energy storage resources through intertemporal constraints. Lastly, the total amount of energy an energy storage resource can be expected to store and deliver over a year is considered in ESMO by an energy throughput constraint. The energy throughput constraint is a proxy for capturing cycle life specifications of energy storage resources, particularly battery storage technologies. The ESMO model, with its nuanced consideration of these constraints and charges, provides a robust framework for evaluating the deployment and utilization of tidal power and energy storage resources within the OPALCO power system.

4 ECONOMIC RESULTS

4.1 INTRODUCTION

Here we evaluate the economic results of the assessment achieved using the ESMO model and approaches defined in the previous section. Value is reported for each service as presented for 15 scenarios defined in Table 11. The ESMO model defines the value of each service individually and when co-optimized. The co-optimized values are reported here. The bundling of services, or use of the microgrid to achieve multiple objectives over a period of time, improves overall economic performance. Present value (PV) costs are compared against the economic benefits to determine net benefits and benefit-cost ratios (BCRs) of each scenario. Under each scenario, the evaluation is performed first from the perspective of the utility in isolation and second from the perspective of the utility plus the customers it serves. Including the customer perspective improves the economic performance of each scenario by removing the costs of payments to members who bought shares in community solar and by including the benefits of improved reliability.

TABLE 11 Descriptions of Microgrid Scenarios

Scenario	Scenario Description
1	no DERs
2	Tidal power in isolation
3	Tidal power plus local storage on Orcas Island
4	Scenario 3 plus Decatur PV and BESS
5	Scenario 4 with 2X tidal power
6	Scenario 4 with 3X tidal power
7	Scenario 4 with 4X tidal power
8	Scenario 4 with 2x Orcas storage capacity
9	Scenario 4 with 3x Orcas storage capacity
10	Scenario 4 with 4x Orcas storage capacity
11	Scenario 4 with 1x Orcas storage capacity @ 4 hr.
12	Scenario 4 with 2x Orcas storage capacity @ 4 hr.
13	Scenario 4 with 3x Orcas storage capacity @ 4 hr.
14	Scenario 4 with 4x Orcas storage capacity @ 4 hr.
15	Scenario 4 but no assets are DNRs

4.2 SYSTEM COST AND FINANCIAL ASSUMPTIONS

This section outlines several cost and financial assumptions used to determine the PV costs of each scenario.

4.2.1 Decatur Solar

The cost of Decatur community solar was $986,239, but was paid for directly by OPALCO members (Baldwin and Wu 2022). Therefore, those costs have been excluded from the analysis. What was included, but only in the utility-focused analysis, is the cost of payments at $0.10 per kWh from OPALCO to those who purchase shares in community solar.

4.2.2 Battery Energy Storage Systems

The cost of the Decatur BESS, including permitting and installation, was $2.5 million (Baldwin and Wu 2022). A Washington Clean Energy Fund grant of $1 million minus a $95,000 contract provided to PNNL for testing the BESS was netted out of the BESS cost. When estimating the cost of the BESS modeled for Orcas Island, we accounted for future cost reductions (40%) predicted for Li-ion technologies between 2018 and 2027 plus a 30% clean energy investment credit authorized under the Inflation Reduction Act (IRA) of 2022 (Cole et al. 2021). The dual impacts of these measures reduce BESS costs to just over $1.0 million. It is further assumed that the Orcas Island BESS will be replaced in year 20 to ensure its economic life aligns with that of the tidal energy system. The analysis includes scenarios with 2x, 3x, and 4x purchases of storage on Orcas Island and also ones where the energy capacity of the units are doubled to 4 hours at a 73% higher expense (Viswanathan 2022).

4.2.3 Tidal Energy

Tidal energy costs by year for the first round of tidal energy investments are presented in Table 12. All costs presented in this section were supplied to the research team by OPALCO staff. Embedded in those cost estimates are $3.1 million in equipment purchases, including submarine cable, and $33.1 million in contracting expenses. Of the contracting expenses, $25.1 million would cover tidal energy deployment costs, including installation, $4 million would be dedicated to submarine cable/anchor installation, and the remaining funds would be used to cover all permitting, environmental, and mitigation expenses. Other costs, at under $4 million, would cover staff time, travel, supplies, and indirect charges. The costs presented in Table 12 were reduced by 30% to account for the clean energy investment credits authorized in the IRA of 2022.

TABLE 12 Budget by Period for Tidal Energy in Rosario Strait

Year	Cost ($Millions)
2024	$3.75
2025	$5.00
2026	$12.50
2027	$18.75
Total	$40.00

Annual operations and maintenance (O&M) costs were estimated by Orbital Marine Power and OPALCO at $304,000. An additional expense of $575,000 would be incurred during a refurbishment operation after 10 years of operation. The 2nd investment in tidal energy was estimated at $15.0 million. The 2nd investment was lower because tidal energy is projected to fall in cost over the next 20 years by 80% and because over $10 million in submarine cable investments and environmental, permitting, and mitigation costs could be avoided. Remaining ancillary costs not tied directly to the development and installation of the tidal power unit was inflated at 4% annually and we assume that the clean energy investment credits of the IRA will have expired before the 2nd investment in tidal power is made.

4.2.4 Key Cost and Financial Assumptions

Table 13 presents several key cost and financial assumptions used in this assessment. These cost and financial parameters were used to address the timing of investments, inflation costs, debt costs, taxes, insurance, and discounting of benefit and cost streams into PV terms. The basis of each assumption is also provided in Table 13. Note that the 4.77% discount rate represents the weighted cost of capital for OPALCO.

TABLE 13 Key Cost and Financial Parameters

Parameter	Assumption	Source
Discount Rate	4.77%	OPALCO
Local Inflation Rate	4.0%	OPALCO
BPA Cost Inflation Rate	3.0%	OPALCO
OPALCO Borrowing Rate	5.5%	OPALCO
Insurance Rate (Annual) as % of Capital Investment	0.271%	OPALCO
Property Tax Rate	0.345%	OPALCO
Clean Energy Investment Credit	30%	IRA
Tidal Development Period		Orbital Marine Power
Timing of Expenditures for Tidal Power		Orbital Marine Power
Year 1 Cost Share	9.4%	
Year 2 Cost Share	12.5%	
Year 3 Cost Share	31.3%	
Year 4 Cost Share	46.9%	

4.3 ECONOMIC RESULTS

The annual benefits of each of the services provided by the microgrid assets under each scenario are presented in Table 14. Note that Scenario 1 was used only to validate the model. Thus, there are no benefits or costs defined under that scenario.

Results from a utility perspective exclude the benefit of outage mitigation, and are presented in Figure 11. The scenarios yield roughly $458.2 thousand to $1.4 million in annual benefits. Demand and transmission charge reductions of up to $542.4 thousand and $110.9 thousand, respectively, were achieved, and are largely driven by the use of BESSs discharging during peak load hours. Transmission deferral ($142.7-$506.5 thousand), base customer charge ($184.9-$194.0 thousand), and load shaping charge reductions of $166.6-$715.1 thousand were driven mostly by tidal energy production.

The results of the benefit-cost analysis (BCA) from a utility perspective are presented in Table 15. For this analysis, we use the BCR and net benefits financial metrics. The BCR is calculated by dividing discounted revenue or benefits of the project by discounted total costs. A BCR of more than 1.0 demonstrates a positive return on investment. A BCR of 1.2 would indicate that for every dollar invested in the project, a return of $1.20 could be achieved. Net benefits are calculated by subtracting PV costs from PV benefits. BCRs presented in Table 15 vary from 0.25 to 0.49, with lifetime net benefits ranging from -$123.6 million to -$33.1 million. While none of the BCRs exceed 1.0, the results of the analysis are very useful in that they define the grant level for tidal power required to break even at $38.9 million. Further, the analysis demonstrates that additional investments in storage on Orcas Island could yield positive net returns of approximately $3 million in PV terms.

The results of the BCA from a utility and customer perspective combined are presented in Figure 12 and Table 16. These results differ from those calculated from OPALCO's perspective in that they include the value of outage mitigation and they exclude the lost revenue to OPALCO tied to the Decatur Island Community Solar project. BCRs vary from .25 to .53, and net benefits range from -$121.3 million to $-35.0 million. Note that when including all customer benefits, including outage mitigation, the funding gap for tidal power closes to $38.2 million. BESS investments drive positive outcomes through the benefits associated with enhanced outage mitigation, which reaches as high as $86.0 thousand annually in Scenario 14.

Reduction in interruption times were estimated for Blakely and Decatur Islands, and for the Olga District of Orcas Island. Annual interruption reductions, as measured in terms of customer outage times, under Scenario 4 reached 26.6%, 3.8%, and 1.4% for Blakely Island, Decatur Island, and the Olga District, respectively. The annual interruption reduction across the entire microgrid was estimated at 4% under Scenario 4, but reached as high as 9.1% under Scenario 14. An alternative case was considered where the BESS SOCs were maintained at 80% during periods at high risk for outages and under that scenario, the total microgrid-wide interruption reduction reached 9.5% under Scenario 4 and 25.8% under Scenario 14. The economic benefits, as measured in terms of the value of lost load to customers, of this case are presented in the sensitivity analysis section of this report.

TABLE 14 Annualized Benefits by Service by Scenario

Scenario ID	Transmission Deferral	Base Customer Charge	HLH Load Shaping Charge	LLH Load Shaping Charge	Demand Charge	Transmission Charge	Misc. Charge	Outage Mitigation
1	$-	$-	$-	$-	$-	$-	$-	$-
2	$142,692	$184,886	$106,580	$71,005	$(53,534)	$4,840	$1,712	$24,716
3	$170,605	$184,886	$96,630	$78,007	$79,846	$4,434	$1,695	$25,806
4	$189,479	$193,980	$98,614	$83,648	$152,843	$4,524	$1,779	$34,696
5	$271,385	$192,209	$205,474	$154,421	$96,709	$9,366	$3,491	$39,405
6	$377,811	$192,209	$312,427	$225,109	$39,159	$14,208	$5,203	$48,068
7	$506,503	$192,209	$419,057	$296,074	$(27,901)	$19,048	$6,914	$38,998
8	$216,983	$192,209	$90,569	$89,101	$257,132	$4,131	$1,763	$45,343
9	$244,284	$190,438	$83,548	$93,659	$345,237	$3,744	$1,747	$67,735
10	$271,385	$188,667	$77,561	$97,386	$415,103	$3,357	$1,730	$73,284
11	$189,479	$190,438	$89,385	$90,226	$182,224	$4,107	$1,763	$42,200
12	$216,983	$186,896	$73,753	$101,125	$317,894	$3,336	$1,730	$57,196
13	$244,284	$183,354	$60,393	$110,219	$438,218	$2,487	$1,697	$74,277
14	$271,385	$179,812	$50,122	$116,516	$542,399	$1,756	$1,665	$86,013
15	$189,479	$192,209	$99,405	$82,969	$152,204	$110,928	$1,779	$34,695

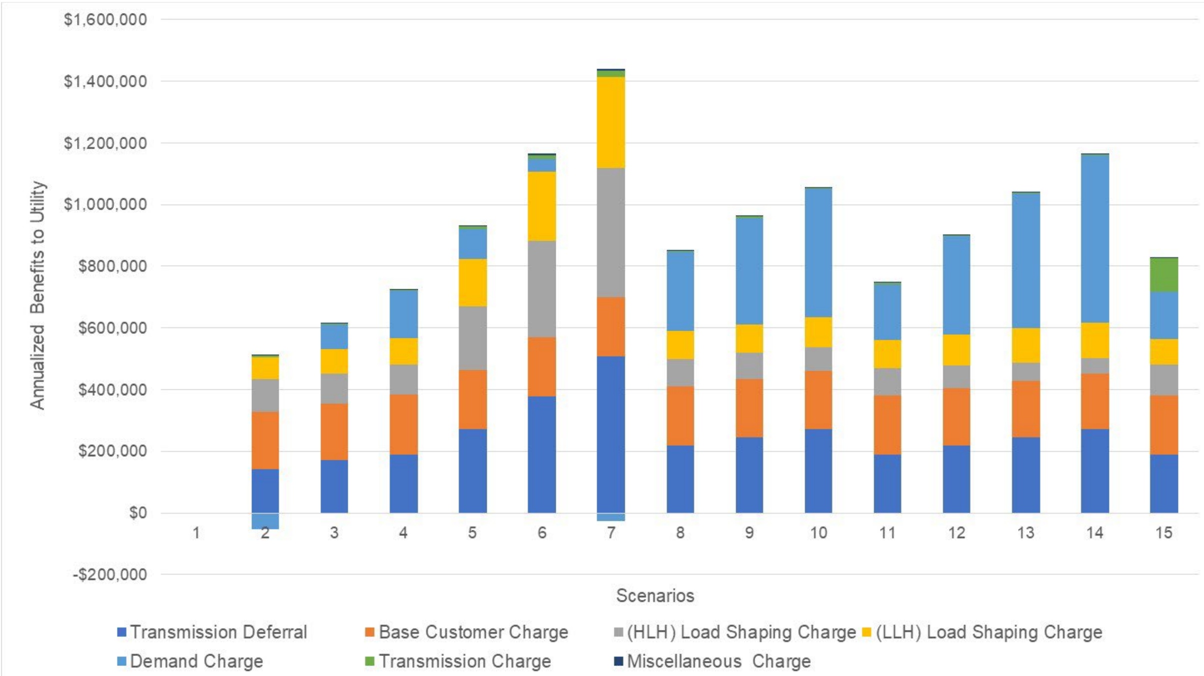

FIGURE 11 Annualized Benefits to OPALCO

TABLE 15 Benefit-Cost Analysis Results – Utility Perspective

Scenario	PV Benefits	PV Costs	BCR	Net Benefits
1	$-	$-	-	$-
2	$13,054,594	$51,983,452	0.25	$(38,928,858)
3	$17,554,111	$53,559,847	0.33	$(36,005,736)
4	$20,653,054	$57,374,999	0.36	$(36,721,945)
5	$26,584,765	$91,423,731	0.29	$(64,838,966)
6	$33,225,435	$128,336,577	0.26	$(95,111,142)
7	$40,228,235	$163,817,365	0.25	$(123,589,131)
8	$24,272,180	$58,951,394	0.41	$(34,679,214)
9	$27,428,200	$60,527,790	0.45	$(33,099,590)
10	$30,064,648	$63,739,006	0.47	$(33,674,358)
11	$21,301,394	$58,489,143	0.36	$(37,187,749)
12	$25,691,895	$60,065,539	0.43	$(34,373,644)
132	$29,650,484	$62,756,078	0.47	$(33,105,594)
14	$33,155,064	$68,236,876	0.49	$(35,081,812)
15	$23,619,287	$57,374,999	0.41	$(33,755,712)

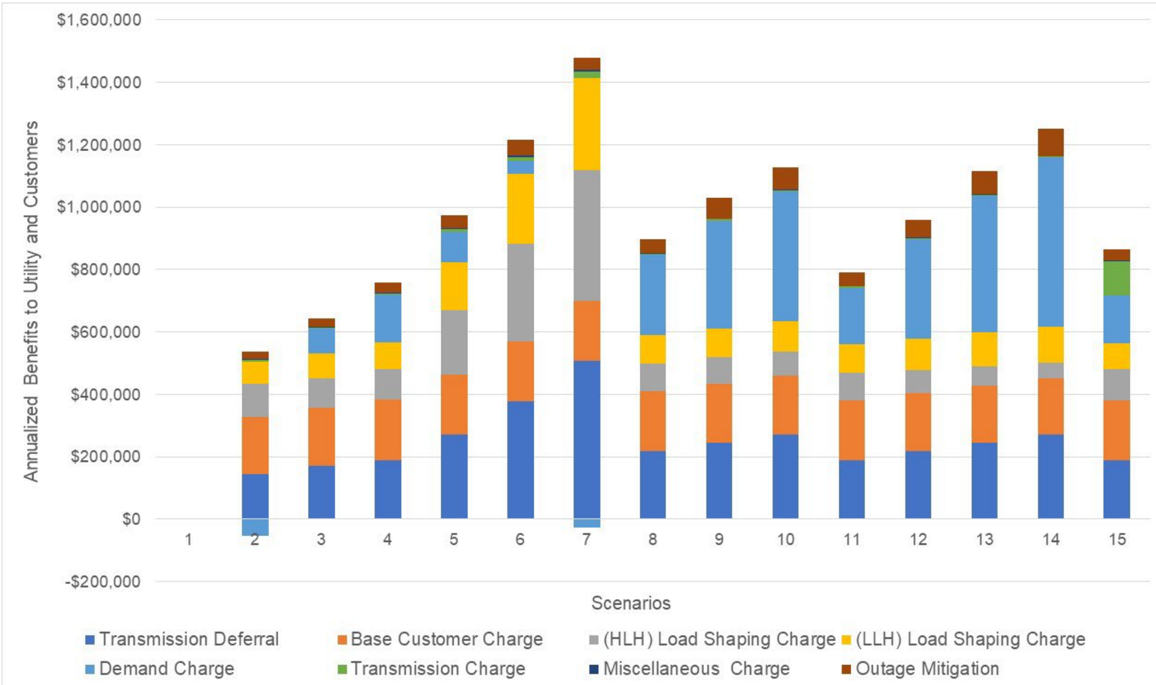

FIGURE 12 Annualized Benefits to OPALCO and Customers

TABLE 16 Benefit-Cost Analysis Results – Utility and Customer Perspectives

Scenario	PV Benefits	PV Costs	BCR	Net Benefits
1	$-	$-	-	$-
2	13,758,792.76	51,983,451.79	0.26	(38,224,659.03)
3	18,289,375.01	53,559,847.32	0.34	(35,270,472.30)
4	21,641,630.64	56,211,131.53	0.39	(34,569,500.89)
5	27,707,510.20	90,259,863.88	0.31	(62,552,353.68)
6	34,595,008.36	127,172,709.25	0.27	(92,577,700.89)
7	41,339,385.56	162,653,498.11	0.25	(121,314,112.55)
8	25,564,093.86	57,787,527.05	0.44	(32,223,433.20)
9	29,358,117.21	59,363,922.58	0.49	(30,005,805.37)
10	32,152,680.80	62,575,138.72	0.51	(30,422,457.91)
11	22,503,769.00	57,325,275.74	0.39	(34,821,506.74)
12	27,321,525.06	58,901,671.26	0.46	(31,580,146.21)
132	31,766,789.29	61,592,210.99	0.52	(29,825,421.70)
14	35,605,770.78	67,073,008.46	0.53	(31,467,237.68)
15	24,607,815.86	56,211,131.53	0.44	(31,603,315.67)

4.4 EVALUATION OF ALTERNATIVE SCENARIOS AND SENSITIVITY ANALYSIS

We evaluated the sensitivity of the results with respect to changes in a number of key assumptions and parameters. The following adjustments are considered:

- BPA energy price inflation is varied by +/- 1% from the 3% baseline
- Discount rate is varied +/- 1% from the 4.77% baseline
- Outage mitigation benefits are improved by bringing each BESS to an 80% SOC prior to reliability events, simulating the use of advanced predictive control methods
- Clean energy investment credits of the IRA are expanded to 40% by meeting all domestic content requirements.

The results of each sensitivity analysis are presented in Tables 17 (utility perspective) and 18 (utility plus customer perspective). The findings of this analysis suggest that the results are somewhat sensitive to all of these assumptions. Varying energy price inflation, meaning the price paid by OPALCO to PNGC Power, has a larger effect than that of varying the discount rate, with impacts reaching -$7.7 million (2% price inflation) to $10.4 million (4% price inflation) when evaluated from a utility perspective. These findings suggest that the microgrid assets would form somewhat of a hedge against future price inflation, with economic performance improving significantly under higher rates of inflation. Scenario 4 reaches a breakeven point with annual energy price inflation of 7.2%. Increasing the clean energy investment credit to 40% for the Orcas BESS and tidal power would improve the economic performance of the microgrid by $4.3-$11.9 million in total PV terms, and setting the BESSs SOC to 80% in advance of reliability events adds $1.0-$4.4 million in additional outage mitigation benefits to customers over the life of the units. Note that scenarios where the duration of energy storage is doubled yield significantly higher outage mitigation benefits.

TABLE 17 Results of Sensitivity Analysis from Utility Perspective

	Energy Price Inflation Rate		Discount Rate			
Scenario	2%	4%	3.77%	5.77%	80% BESS SOC	40% Clean Energy Inv. Credit
1	$-	$-	$-	$-	-	$-
2	$(2,683,948)	$3,605,786	$(2,197,617)	$1,778,177	-	$4,253,880
3	$(3,609,022)	$4,848,590	$(1,383,107)	$1,154,281	-	$4,401,231
4	$(3,710,958)	$4,973,194	$(1,152,647)	$916,394	-	$4,401,231
5	$(4,930,483)	$6,611,581	$(3,123,340)	$2,473,852	-	$6,894,240
6	$(6,295,765)	$8,445,789	$(5,504,640)	$4,380,429	-	$9,387,249
7	$(7,735,500)	$10,380,020	$(7,534,213)	$5,999,434	-	$11,880,258
8	$(4,455,029)	$5,972,826	$(518,026)	$431,339	-	$4,548,581
9	$(5,103,888)	$6,844,545	$21,969	$19,319	-	$4,695,932
10	$(5,645,926)	$7,572,753	$141,196	$(53,675)	-	$4,843,283
11	$(3,844,253)	$5,152,270	$(1,094,291)	$874,715	-	$4,505,373
12	$(4,746,914)	$6,364,963	$(302,056)	$268,012	-	$4,652,724
13	$(5,560,777)	$7,458,358	$327,809	$(210,010)	-	$4,904,217
14	$(6,281,297)	$8,426,351	$327,949	$(177,643)	-	$5,155,711
15	$(4,320,798)	$5,792,491	$(546,562)	$448,607	-	$4,401,231

TABLE 18 Results of Sensitivity Analysis from Utility Perspective plus Customer Perspective

	Energy Price Inflation Rate		Discount Rate			
Scenario	2%	4%	3.77%	5.77%	80% BESS SOC	40% Clean Energy Inv. Credit
1	$-	$-	$-	$-	$-	$-
2	$(2,828,727)	$3,800,292	$(2,053,729)	$1,667,122	$-	$4,253,880
3	$(3,760,188)	$5,051,676	$(1,232,872)	$1,038,327	$950,764	$4,401,231
4	$(3,973,741)	$5,302,101	$(986,218)	$788,975	$1,177,036	$4,401,231
5	$(5,220,850)	$6,977,546	$(2,929,497)	$2,325,275	$1,167,823	$6,894,240
6	$(6,636,879)	$8,879,930	$(5,260,363)	$4,192,925	$976,016	$9,387,249
7	$(8,023,483)	$10,742,783	$(7,342,739)	$5,852,685	$1,276,992	$11,880,258
8	$(4,780,176)	$6,385,517	$(289,617)	$256,083	$1,855,526	$4,548,581
9	$(5,560,205)	$7,433,458	$380,740	$(256,553)	$2,079,011	$4,695,932
10	$(6,134,751)	$8,205,339	$532,274	$(354,482)	$2,719,990	$4,843,283
11	$(4,150,991)	$5,540,230	$(884,177)	$713,580	$1,762,332	$4,505,373
12	$(5,141,494)	$6,870,934	$(4,642)	$39,497	$3,116,000	$4,652,724
13	$(6,055,414)	$8,098,753	$724,665	$(515,276)	$3,906,234	$4,904,217
14	$(6,844,686)	$9,159,111	$793,132	$(535,645)	$4,390,494	$5,155,711
15	$(4,583,571)	$6,121,385	$(380,143)	$321,196	$1,177,083	$4,401,231

5 CONCLUSIONS

OPALCO is developing a diverse set of local renewable energy resources to reduce dependence on mainland Washington State for energy and to reduce the regional need for fossil-fueled power. For this report, the research team at Argonne employed an optimization model to evaluate several economic benefits associated with varying scales of tidal power of between 2.4 and 9.6 MW and other DERs. In addition to existing PV and BESS resources located on Decatur Island, Argonne also evaluated the addition of a BESS on southern Orcas Island with power and energy capacities ranging from 1-4 MW and 2-4 hours in storage duration.

This report evaluates 15 scenarios differentiated based on microgrid asset configuration. The scenarios yield roughly $458.2 thousand to $1.4 million in annual benefits from a utility perspective. Annual demand and transmission charge reductions of up to $542.4 thousand and $110.9 thousand, respectively, were achieved, and are largely driven by the use of BESSs discharging during peak load hours. Transmission deferral ($142.7-$506.5 thousand), base customer charge ($184.9-$194.0 thousand), and load shaping charge reductions of $166.6-$715.1 thousand were driven mostly by tidal energy production.

The results of the BCA from a utility perspective produce BCRs that vary from 0.25 to 0.49, with lifetime net benefits ranging from -$123.6 million to -$33.1 million. Thus, no scenarios yield positive economic returns. Note that total energy production for a 1-year simulation was estimated at 5.7 gigawatt-hours or 2.4% of total OPALCO energy needs. While the benefits of 2.4 MW of tidal power to OPALCO are significant, estimated at $13.1 million in PV terms, they fall $38.9 million short of the breakeven point due in part to high initial capital costs that are estimated at $40 million minus a 30% ($12 million) clean energy investment credit. In addition, annual operating costs, including property taxes and insurance, would reach nearly $550 thousand in the first year of operation. The analysis also demonstrates that additional investments in storage on Orcas Island could yield positive net returns of approximately $3 million in PV terms.

With the addition of tidal power and a BESS on southern Orcas Island in the Olga District, OPALCO could island a significant portion of its system spanning the Olga District to Decatur and Center Islands. Outage data was collected for the 2019-2022 time period for events affecting any of the seven circuits where microgrid assets would be sited in isolation or in combination. Over this time period, there were 30 outages affecting 32,264 customers. Total hours of load interruption were 188.6, and the average outage duration was just over 6 hours. Total customer minutes of outages reached nearly 11 million over the 4-year timeframe. Argonne simulated the use of microgrid assets for reducing outage times and found that BESS investments primarily drove outage mitigation benefits reaching as high as $86.0 thousand annually under one scenario.

The research team evaluated the sensitivity of the results with respect to changes in a number of key assumptions and parameters. Results suggest that the results are somewhat sensitive to several alternative assumptions. Varying energy price inflation, meaning the price paid by OPALCO to PNGC Power, has a larger effect than that of varying the discount rate, with impacts reaching -$7.7 million (2% price inflation) to $10.4 million (4% price inflation) when compared to a 3% price inflation baseline. These findings suggest that the microgrid assets would form somewhat of a hedge against future price inflation, with economic performance improving significantly under higher rates of inflation. The baseline scenario (Scenario 4) reaches a breakeven point when annual energy price inflation reaches 7.2%. Increasing the clean energy investment credit authorized under the IRA of 2022 from 30% to 40% by adding in the bonus for meeting domestic content requirements on the Orcas BESS and tidal power would improve the economic performance of the microgrid by $4.3-$11.9 million in total PV terms, and setting the BESSs SOC to 80% in advance of reliability events adds $1.0-$4.4 million in additional outage mitigation benefits over the life of the units. Finally, scenarios where the duration of energy storage is doubled yield significantly higher outage mitigation benefits.

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