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Project Title: Demonstrating Tidal Energy in Southeast Alaska

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Project Partners: Alaska Center for Energy and Power, Southeast Conference, Tlingit & Haida Central Council, Juneau Economic Development Council, Renewable Energy Alaska Project, Inside Passage Electric Cooperative, Alaska Electric Light & Power Company, Alaska Power and Telephone Company, Southeast Alaska Conservation Council, Alaska Experimental Program to Stimulate Competitive Research, Northwest National Marine Renewable Energy Center, School of Fisheries and Ocean Sciences at the University of Alaska.

Grant Funds Requested	Match Committed	Total Project Cost
$750,000.00	$229,800.00	$979,800.00

Abstract

1. Project Summary

Project Description: In this project, Archipelago Marine Energy (AME) will develop and deploy a particular type of marine hydrokinetic (MHK) powered generation plant that is specifically designed for use in tidal waters near and for Alaska's coastal communities. Categorically, it will encompass "Testing emerging energy technologies" and span the Technology Readiness Levels (TRL) 1-5, and to fabricate, test, and deploy a model scale plant per TRL 6.

The small-scale power plant developed during this project will harness energy from open channel tidal flow. It will be positioned in marine channels and inlets near communities or transmission lines supporting small grids. The plant will involve development of a turbine, supporting float and anchoring system, debris guard, generator, transmission cables, converter and inverter, and controls (Appendix A).

Integration and use of this plant throughout Southeast Alaska will bring some economic relief to our small communities by reducing the cost of electrical energy and reducing harmful environmental impacts caused by traditional energy production. The predictability of the tides, based on the lunar cycle, makes integration with local energy grids less problematic than other renewables (e.g., wind, solar). At a broader level, MHK development in Southeast Alaska represents an opportunity to pioneer a global renewable energy industry, reinforce Alaska's legacy of energy leadership, and bolster climate change mitigation and adaptation efforts.

Project Innovation: Coastal communities in rural Alaska face steep and volatile energy costs as they depend heavily on diesel fuel for heating and electricity year-round. Burning diesel emits harmful greenhouse gases and meeting today's energy needs in rural Alaska requires an innovative approach. The intent of this project is to develop a locally existing renewable energy resource - the tides - for the benefit of Alaska communities utilizing optimally feasible technologies.

The innovative features of this project will include evaluating and developing turbine blade technology, turbine ducting, debris and wildlife avoidance mechanisms, support vessel characteristics, electrical generation, transmission characteristics, and control criteria.

The MHK plant will be positioned on a floating structure, thus eliminating the need for deep water diving equipment and expertise. The plant will house the generator and controls above water and transmit power to shore underwater utilizing direct current transmission. Mechanisms to lower and raise the turbine, and any associated underwater equipment, to the surface for on-site repairs, cleaning, or adjustment will be evaluated and incorporated to improve component maintenance.

This plant will be designed to integrate with off-grid type systems employing diesel driven generation in a manner similar to that used for wind turbines in Western Alaska. The scheme is intended to lead to a high penetration type system due to the predictability of tides and production from MHK plants. With the small communities, the intent is to implement high-penetration systems; while for the communities already endowed with land-based hydroelectric plants, the integration will be low penetration.

Project Site and Demonstration Environment: Alaska's extensive coastline is home to over 90% of U.S. tidal resources. In Southeast Alaska, where tidal ranges regularly range from 15 to 25 feet, we have identified several sites with potential for MHK (Appendix B). Of these, we have selected Juneau's Gastineau Channel for the development and demonstration of the MHK plant.

Gastineau Channel has oceanography that is typical of the archipelago seascape of Southeast Alaskan, with a broad tidal range and local coastal community. For the purpose of this project, the Channel also provides proximity to local infrastructure which will make the demonstration site easily accessible for monitoring and maintenance of the MHK plant over the course of this

project. We have already discussed a partnership with Alaska Electric Light & Power Company, the local power utility, to demonstrate the sea-to-land transmission can be conducted efficiently.

We anticipate that the MHK plant deployed in Gastineau Channel will experience marine conditions similar to those at other prospective commercial sites. The scheduled monitoring of the plant will provide data that can feed back into our design. Such feedback is critical to our plans to deploy a network of state-of-the-art MHK plants in the unique marine environment of Southeast Alaska.

Priority: This project supports several facets of prioritization defined in AS 42.45.375. The project team is composed of companies and individuals who are residents of the State of Alaska. A formal partnership is currently being established the Alaska Center for Energy and Power, an institution of the University of Alaska. Matching funds are provided to this project in the form of donated time and engineering equipment from the electrical engineering firm, Haight & Associates. This project has a strong potential for applications to serve many communities along the coastline of Alaska. The fabrication of the plants will occur in Alaska employing local citizens, and they will be deployed in Alaskan waters.

2. Technology Validation and Data Collection

Objectives: The primary objective of this project is to develop a MHK plant that is specifically designed for the Alaska marine environment, and is economically feasible for application in small off-grid communities as well as supplement the existing power sources for the larger coastal communities. The plant features will include the following:

- Floating vessel: This will allow it to be moved from the site to shore for major repairs and retrofits. Access to the equipment for maintenance will be easier if it doesn't require divers. Additionally, water flow at the surface is consistently stronger providing more power capacity.
- Modular design: The vessels will be designed to allow simple component exchanges thus permitting more consistent on-line operation. This is intended to minimize the cost of alternate power production. And, the size of the overall penetration to the community (off-grid) will match their demand and grid characteristics by providing the optimum number of turbine generators. The optimum size or sizes will be determined as a part of the evaluation with this project.
- Turbine design: The turbine will be designed with a vertical cross-flow axis. The blade design will be patterned after those developed for the Darrieus, Gorlov, and Kobold turbines to gain the best performance in low and high flow conditions. Enclosing the turbine inside a venturi type duct will be evaluated to assess the cost and benefit of increased water flow and power capacity. Debris and wildlife avoidance mechanism will be researched, developed, modified, evaluated and applied.
- Generator design: The generator will be an alternating current type directly connected to the shaft. It will be designed to operate at low rotational speeds without the mechanical advantage of gearboxes. By converting the ac output to direct current, the plant can be controlled to operate at rotational speeds that yield the most optimal output for the turbine design. This output will be transmitted to shore in its dc configuration where it will be reconverted to alternating current and synchronized to the community system.

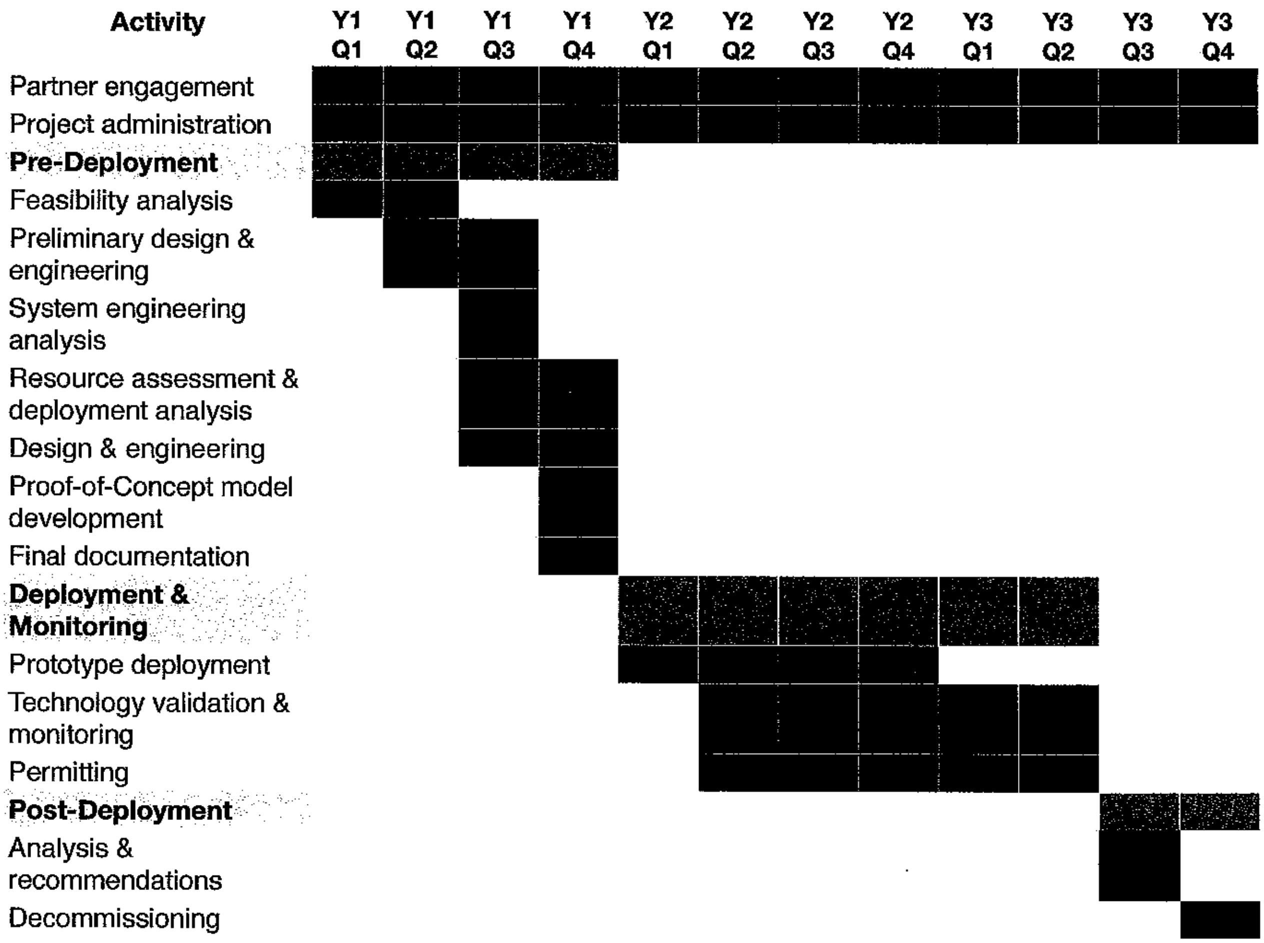
Data Collection: As system components are developed, their performance will be evaluated using the most appropriate test methods. In the pre-deployment phase, the required tests and their associated procedures will be defined. Anticipated tests will include those to define the performances of the turbine blades, the turbine as a whole, the generator, and the electrical transmission system.

The preparation for acquisition and presentation of data will begin during the TRL 1 & 2 effort. During the TRL 3 through 5 effort, testing will occur on some components, as well as those integrated to complete the primary equipment. With the TRL 6 work, a small prototype unit will be fabricated. It will be tested in real conditions in two manners: towing the unit behind a boat at varying specific speeds (allowing a collection of performance data) and anchoring the unit, connecting it to a grid, and collecting data over a longer period of time.

The tests will be developed into individual reports to be submitted to the Authority as the project progresses. A final report will also be submitted with the collection of all of the tests and summary of project results.

3. Project Schedule and Project Budget

Schedule:



Budget:

Task	Anticipated Completion Date	EETF Grant Funds	AME Matching Funds	Total
Pre-Deployment	Apr 1, 2014	$240,000.00	$154,800.00	$394,800.00
Deployment & Monitoring	Sep 1, 2016	$450,000.00	$60,000.00	$510,000.00
Post-Deployment	Nov 1, 2016	$60,000.00	$15,000.00	$75,000.00
Total		**$750,000.00**	**$229,800.00**	**$979,800.00**

Matching Contribution: While AME is currently pursuing other resources from federal and private sources, the only matching resources provided to this project will be an in-kind contribution in the form of time, equipment, and office space from AME. Mr. Haight, PE will devote approximately 25% of his effort to this project and offer 10% effort of a CAD Technician from Haight & Associates. In addition, AME supports this project by providing computers and professional modeling software (2 computers @ $2,000 each, 1 set of CAD @ $4,500 and 1 set of Revit @ $7,000). AME also receives office space and supplies for the duration of the project term ($15,000/year).

4. Project Team Qualifications

Ben Haight, PE is the Founder and Technical Manager of AME, and the Principal Investigator of this project. He will receive technical support throughout the project from staff at Haight & Associates, Inc, PND, Inc, Coastwise Corp, and Tongass Energy Consultants; all of which are Alaska businesses, hiring Alaskans.

Collin Daugherty, MA is the General Manager, Environmental Analyst for AME. As Co-investigator of this project, he will work closely with Mr. Haight on day to day operations and conduct partner engagement, community outreach, report writing, and plant maintenance.

Patrick Eberhardt, PE is a naval engineer with Coastwise Corporation. Mr. Eberhardt has extensive experience working with marine vessels in Alaska. He will assist with the design of support vessel.

PND Engineers Inc. is a civil engineering firm with offices in Alaska and will assist with design for the plant anchoring and flotation systems.

Amy Daugherty is a consultant with Tongass Energy Consultants and will assist with acquisition of permits and determination of permits required for plant development and commercialization. Ms. Daugherty will also assist with marketing and community involvement.

Robert Elliott, PE is a retired mechanical engineer and will review the technical development, analysis, and economic viability of the proposed MHK plants.

5. Discussion of Commercizlization of Funded Technology

The Southeast Alaskan communities with the greatest needs for renewable energy are generally smaller communities that depend entirely on fossil fuels for electricity and heating. These communities are currently at the mercy of petroleum distributors and the continual rapidly increasing cost of petroleum products occurring globally. This project will focus on serving those communities, particularly when a good tidal flow is reasonably close by.

By deploying and demonstrating the first marine hydrokinetic system designed specifically for Southeast Alaska's marine environment this project will showcase Alaska's capacity to capitalize on locally available renewable resources using Alaskan human resources. Over the next five years, this project will help set the stage for what will ultimately be Southeast Alaska's tidal energy network, a system of multiple MHK plants deployed throughout the region providing coastal communities dependable, zero-emission energy and clean tech jobs.

The commercial potential for this design is high: Some of Southeast's potential MHK sites could, after meeting local needs, generate enough clean energy to service foreign markets. While we are designing this for our region, it will likely suit other locations as well. Other countries, such as Scotland, Canada and Australia, have a demonstrated interest in MHK. Considering much of the world's population resides near coasts, work provided by this project can benefit distant populations as well.