An abstract in response to the Alaska Energy Authority's RFA for the

Emerging Energy Technology Fund Grant Program

AEA-12-047

Marine Hydrokinetic Plant Development

For Southeast Alaska

by

Archipelago Marine Energy

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Ben Haight, owner - operator

$ 521,000 grant funds requested

$ 176,000 match committed

= $ 697,000 total project costs

Previously submitted in response to the RFA solicited by AEA in 2011 (AEA 11-027) with the same title

Sent via USPS Express Mail on 7 March 2012

Project Summary

Description - This project 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 "Energy Production", and to a lesser extent, "Storage, Distribution and Controls".

The project will include the development of a power plant that 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.

Eligibility - MHK has received relatively little attention compared to other renewable energy resources, yet represents a vast and predictably reliable energy supply. This technology is in its infancy with commercialization only lightly applied in other parts of the world.

The MHK plant developed by this project will begin by drawing upon, improving and adapting the existing technology present. It will develop a plant using optimal components that minimize impacts to fish populations and minimize debris interference per this marine environment. The Pre-deployment will be an enhanced engineering effort with a high level of attention toward research and development.

Our mission is to provide a Pre-deployment effort completing the tasks associated with Technology Readiness Levels (TRL) 1 through 5; and to fabricate, test, and deploy a model scale plant per TRL 6. The goal is to subsequently proceed by placing a commercial plant into operation within a five year time frame.

Innovation – 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 plants will be positioned on floating structures, 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 the Western region of Alaska. The scheme is intended to lead to a high penetration type system due to the predictability of tides and production from MHK plants. This plant will also be designed to integrate with larger grids that employ hydroelectric plants for all or most of their energy production.

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 arrangement has not yet been established, but a partnership is also anticipated with the Alaska Center for Energy and Power. The match will be exclusively provided by the project manager in the form of donated time. There is presently no outside support but as the project progresses beyond the scope of this grant application through higher TRL tasks, additional finances will be sought. 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.

Technology Validation and Research Methodology

Objectives – The primary objective of this project is to develop a MHK plant that is particularly suitable 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.

The challenge will be to fabricate a plant that will produce energy competitively with the current local energy sources. As part of this project, the manufacturing and installation costs, as well as the operation and maintenance costs, will be projected for use in future project analysis to determine economic advantages. This will be incorporated into a commercialization plan as it is developed and refined.

Methodology – 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.

Schedule & Budget

Schedule – (total duration: 30 to 32 months)

Pre-deployment: (duration: twelve to fourteen months)

- *Project Development* - Agreements, report development, strategy & management plan: (one month).
- *System Design* – Site evaluations, technical research and concept analysis, plant design, and identification of implementation conditions: (eight months).

- *Project Financing* – Implement cost analysis, O&M cost analysis, and development costs: (one month).
- *Energy Purchase/Sales* – Development of agreement with utility to accept energy: (one month simultaneous with system design).
- *Site Control* – Assess site for demonstration project, and assess potential sites for commercial projects. Obtain letters of interest from utilities and communities: (two months simultaneous with system design).
- *Permits* – Obtain special permitting for demonstration project, and define/initiate permitting for planned commercial sites (three months simultaneous with system design and project financing).
- *Technology Validation and Research Plan* – Final goals and objectives, define physical and economic variables, define analytical evaluation and test methods, define study/test plan, identify test apparatus, identify schedule, and define deliverable product: (two months beginning when System Design task is completed).
- *Commercialization Plan* – Define markets and customers, develop a marketing plan, define the ongoing development strategy, analyze competition, perform a risk analysis, and project gross and net revenues: (three months beginning when System Design task is completed).

Deployment and Research: (duration: ~ sixteen months)

- *Prototype Deployment* – Model fabrication and deployment for demonstration: (ten months).
- *Technology Validation and Research Plan* – Performance monitoring, environmental monitoring, and plant improvements: (six months).
- *Commercialization Plan* – Update with more specificity: (one month during operation of prototype).
- *Project Costs and Financing Plan* – Update implementation and O&M costs: (ongoing through the duration of this activity).
- *Permitting* – Update permits and maintain status reports to permitting agencies: (ongoing through the duration of this activity)

Post-Deployment: (duration: ~ two months)

- *Analysis and Recommendations* – Report results, performance, reliability, challenges, environmental effects, and future deployment strategy: (two months beginning one month before completion of prototype demonstration).
- *Commercialization Plan* – Complete ongoing plan: (one month at the end of the prototype demonstration).
- *Permitting* – Finalize demonstration permitting and implement commercialization permitting as appropriate: (two months after completion of prototype demonstration).
- *Decommissioning* – Dispose of equipment and materials as appropriate: (two months after completion of prototype demonstration).

Budget –

Milestone or Task	Anticipated Completion Date	EET Fund Grant Funds	Grantee Matching Funds	Source of Matching Funds	Totals
Pre-Deployment	1-Sep-13	$ 177,000	$ 106,000	AME*	$ 283,000
Deployment	1-Feb-15	$ 311,000	$ 57,000	AME*	$ 368,000
Post-Deployment	1-Apr-15	$ 33,000	$ 13,000	AME*	$ 46,000
Total	1-Apr-15	$ 521,000	$ 176,000		$ 697,000
			25.3%		

* Archipelago Marine Energy

Matching Contribution: Only Archipelago Marine Energy will provide matching resources. The matching resource will be an "in-kind" contribution of approximately 25 percent of Mr. Haight's effort on the project. For his time on this project, Mr. Haight offers to charge at a submarket hourly rate. He is very committed to applying this technology locally.

Team Qualifications

Team Members – Ben Haight, PE, Archipelago Marine Energy, will be the grantee, project manager and principle investigator with assistance from staff at Haight & Associates, Inc, PND, Inc, Coastwise Corp, and Tongass Energy Consultants; all of which are Alaska businesses, hiring Alaskans.

Mr. Haight has lived in Southeast Alaska, working as an electrical engineer since 1975. He is familiar with many facilities and communities throughout Southeast Alaska from his 31 years experience as a consultant. Many of his projects have involved marine facilities (harbors & docks) and utility systems.

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

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

Amy Daugherty of Tongass Energy Consultants will assist with acquisition of permits and determination of permits required for commercialization, as well as assist with marketing and community involvement.

Robert Elliott, PE, retired mechanical engineer, will review the technical development and analysis, as well as economic viability.

Commercialization

Potential Market - The target market for the MHK plant is our coastal Alaska communities. However, other coastal region communities throughout the world are also potential customers.

The Southeast communities with the greatest needs are the smaller ones that produce electricity and heat entirely with fossil fuels. This project will focus on serving those communities, particularly when a good tidal flow is reasonably close by. The MHK plant will also be developed for application where it can supplement existing renewable energy resources, such as land-based hydroelectric plants.

Regardless of the plant location, it will have to integrate with the existing community power resources in a manner similar to that used with wind turbines. 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.

Potential Market Size - Southeast Alaska is blessed with many waterways between hundreds of islands. Studies by the Electric Power Research Institute (EPRI) indicate tidal generating potential exceeding 4,000 MW. Although much of this capacity is not accessible or economically feasible, a significant amount is for most of the communities in Southeast Alaska.

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.

Potential Public Benefit- 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. 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.