**Cover Page** (not part of page limit)

Project Title

**DEPLOYING AND OPERATING A PILOT-SCALE ARRAY OF THE ATMOCEAN WAVE ENERGY/SEQUESTRATION TECHNOLOGY (WEST™) IN YAKUTAT.**

Applicant contact information

**PHILIP W. KITHIL, dba ATMOCEAN-ALASKA. 505-310-2294, atmocean.kithil@gmail.com.**

**Local Alaska address: 668 Totem Ave, Yakutat, AK 99689.**

Partners

**ATMOCEAN, INC. (WEST technology source); Scott Chadwick Owner/operator of YakutatCharter.com and the charter and research vessel *Sea Wolf* (Yakutat-based Manager); Reytek Corporation (WEST design & production); Northwest National Marine Renewable Energy Center (NNMREC) (2012 test site to be used by Atmocean).**

Total project cost; **$408,345** Grant funds requested; **$408,345** Match committed **$0** (sec. 4.5)

Previous project/application title(s) and/or number(s) for grants from the Renewable Energy Fund or Denali Commission Emerging Energy Technology Grant program **Wave Energy / Sequestration Technology (submittal to Round V)**

Previous Project title(s) for abstracts submitted to the Emerging Energy Technology Fund, if applicable. **NONE**

**Abstract** (minimum of two pages and a maximum of four pages)

**1. Project Summary**

a. **Project Description**:

Consistent with Yakutat City/Borough Resolution #12-190, as well as recent comments by Senator Murkowski (http://juneauempire.com/state/2012-02-24/murkowski-energy-top-concern and minute 4 at http://www.ustream.tv/recorded/17542054), this project will deploy a functioning, full-scale mini-array of Atmocean's patents-pending Wave Energy/Sequestration Technology (WEST™) in the Pacific Ocean offshore Cannon Beach near Yakutat. Electrical output of the WEST array will be connected to the adjacent Yakutat Electric connection point (as/when available). The array will consist of 10 hydraulically-connected units. A seafloor hydraulic transmission line will be installed to connect the array hydraulic output to a shore-based conversion station (Pelton motor connected to an electrical generator). To undertake this effort, by September 2012 we will have completed the following developmental activities, at a cost of about $200,000:

1) CAD designs for full scale components (March 2012).
2) Hydraulic modeling by Sandia Labs to guide selection of hose diameters, pressures, and expected flow rates for various wave conditions, and Pelton motor sizing. (March 2012).
3) Three month sea trial of 3-pump WEST array at Northwest National Marine Renewable Energy Center (NNMREC) site - Newport, OR.
4) Moorings design by NNMREC/ OSU affiliate.

b. **Project Eligibility**:

By demonstrating the deployment and functioning of this mini-array of WEST devices offshore of Cannon Beach, Yakutat, this project will reach TRL 8: "Full-scale, similar (prototypical) system, demonstrated in relevant environment." By owning and operating the WEST mini-array, and obtaining required permits, applicant (a registered Alaska small business) believes this project conforms to **3 AAC 107.710 "**(A) own, operate, and maintain the emerging energy technology project…; (B) own, lease, or otherwise have adequate legal access to the site upon which the project is located; and (C) provide adequate demonstration of the technology."

c. **Project Innovation**:

This project will demonstrate, for the first time, a working wave energy system in Alaska. Performance and cost data will be obtained to assess the feasibility of wave energy for this and other Alaska locations. Specifically: 1) Can wave energy replace diesel electricity and reduce electricity costs for residents living off the grid in remote coastal communities? 2) What will be the likely savings per kWh? 3) What is the expected payback period? 4) What level of wave energy is available, and can this be estimated from distant NOAA buoys?

d. **Priority**:

This project achieves AIDEA "priority considerations" by benefitting "1. Alaska residents, associations, organizations, or institutions; and by showcasing "4. Projects with potential for widespread deployment in the state."

**2. Technology Validation and Research Methodology** (sec. 4.7)

a. **Objectives**:

The objective is to deploy the Atmocean WEST mini-array; and to acquire operational data from the mini-array which demonstrates a correlation of the mini-array output (hydraulic pressure and flow driving a Pelton motor connected to an electrical generator), to wave data obtained from the nearest NOAA national data buoy

center (NDBC) recording buoys (#46083 Fairweather Grounds 92 nm SSE of Yakutat, and #46082 Cape Suckling 86nm SW of Cordova). By demonstrating this correlation, commercial deployment of wave energy in Alaskan remote coastal communities will be expedited, as multi-year measurements of inherent wave energy will be shown as unnecessary. Expedited commercialization will generate substantial savings for these communities – avoiding the opportunity costs inherent to lengthy wave energy studies.

It should be noted, in commercial applications, Atmocean WEST will be configured as a hybrid system with wave electricity replacing some, but not all, of diesel electricity. Diesel will remain in place for peak and backup requirements. Therefore, new long-term studies capturing data on local wave energy are unnecessary. Multi-year approximations of the wave resource, based on the existing NOAA data buoys, provide suitable information at much lower cost for system planning purposes, than new studies (as waves are mainly driven by distant weather patterns, next year will be different than last year, anyway!).

Project information will consist of:

1) Photographs of the containerized Atmocean WEST mini-array arriving in Yakutat; unloading the container; assembling the WEST components; sequencing the subsystems for deployment; loading the subsystems on a deployment vessel; proceeding to the deployment site; and deploying the mini-array.
2) Hydraulic pressure and flow output produced by the mini-array for the duration of the project.
3) Significant wave height and dominant period recorded at the NDBC buoys during the project.
4) Adjustments to time-synchronize this data with the WEST data.
5) Calculations of expected hydraulic pressure and flow based on this data, and nominal kWh produced if the full energy contained in these waves had reached the WEST mini-array.
6) Actual measured pressure and flow exiting the end of the mini-array, driving a Pelton motor connected to an electrical generator, and measurement of the kWh;
7) A correlation of the NDBC data buoys nominal kWh to the mini-array actual kWh.b.

**Methodology**:
Given the following formula: [power (kW) = flow (liters/minute) x pressure (bar)/600]; the WEST pump volume of 0.0462 cubic meters; minimum functional wave height of 1.0 m and maximum functional wave height of 3.0 m; and from the hourly significant wave height and dominant period for the two NOAA buoys, we can calculate the nominal pumped volume per hour, and kW per hour if the mini-array were positioned adjacent the NOAA data buoys. By time-adjusting for the distance to Yakutat, it is possible to compare the nominal kWh output based on the wave data, against the mini-array kWh output.

This methodology avoids the cost and delay of acquiring and operating an onsite wave-measuring device such as the TRIAXYS quoted at over $100,000 cost, while arriving at a reasonable <u>estimate</u> of wave energy offshore Yakutat, compared to the WEST mini-array <u>actual</u> output.

Once this procedure is verified, it can be used to develop cost/payback feasibility studies for other Alaska locations, avoiding the high cost and delay inherent in deploying wave measuring systems.

**3. Summary of Project Schedule and Summary of Project Budget**

Below we quote our direct cost without profit margin or investor ROI. This is similar to the costs representing Atmocean's possible future role as an Independent Power Producer (IPP) in which we would earn a return on investment (ROI) based on direct and operational costs, including maintenance.

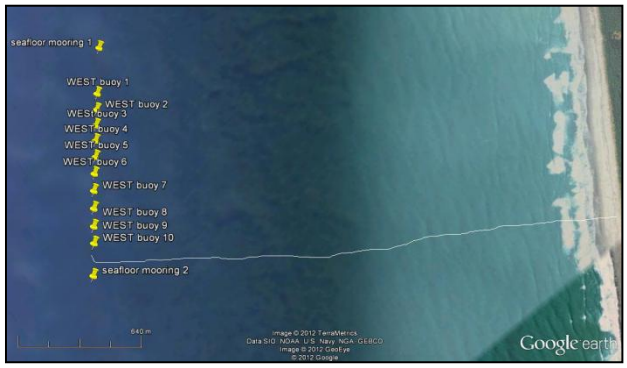
This quotation does not include spare parts or servicing, as the operational time frame is anticipated to be about one year at which time the mini-array will be retrieved.

With respect to matching or in-kind contributions, for-profit businesses provide products and services to customers by increasing direct costs to reflect gross profit margin which covers overhead expenses and provides return on investment (ROI). For technical products and services, a typical amount would be at least 100% of direct costs – in this case about $400,000.

We wish to advise the AIDEA that we have elected NOT to show this amount as in-kind contribution, rather to price our application net of any upcharge. Therefore, if AIDEA wishes to make our application comparable to other applications which INCLUDE overhead costs and ROI but then recategorize those upcharges as "matching funds", the $400,000 we exclude because our quote is "net", should in fact be restated as "matching funds". **In short, we do not use accounting artifacts for "matching funds".**

| Task | Start | Complete | Cost |
|---|---|---|---|
| Legal, permitting | Sep 2012 | May 2013 | $ 25,000 |
| Produce & ship WEST mini-array | Oct 2012 | Jan 2013 | $ 205,015 |
| Assemble, deploy, operate and retrieve WEST mini-array | Feb 2013 | May 2014 | $ 45,995 |
| Provide notice to mariners of subsea operations | May 2013 | May 2014 | $ 10,000 |
| Travel | Sep 2012 | May 2014 | $ 16,585 |
| Project management & staff costs | Sep 2012 | May 2014 | $ 47,750 |
| Insurance | Sep 2012 | May 2014 | $ 50,000 |
| Local rentals & site fees | Sep 2012 | May 2014 | $ 8,000 |
| | | Total Cost | $ 408,345 |

The project location is approximately 1.7 miles offshore Cannon Beach, with the mini-array occupying a line about 900' long. Moorings will extend about 600' beyond each end of the mini-array. Depth is about 40 meters. The environment is the Pacific Ocean. Marker buoys will be installed to notify local vessels of the undersea WEST system, and NOTAMS circulated to ocean users.




**4. Project Team Qualifications**

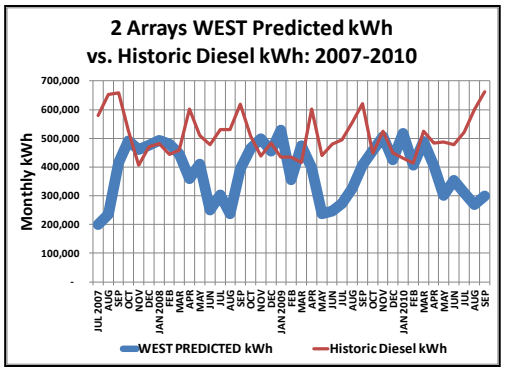
For this project, Atmocean Inc. has assembled a highly qualified project team with skills ranging from economic analysis, sales & marketing, entrepreneurship, marine operations, design/build of marine vessels, mechanical engineering, marine biology, physical oceanography, computer science, emergency medical care, and diving (this experience helpful but not required), and administration/permitting:

**Philip W. Kithil**, BA/MSBA Economics. Sole proprietor dba Atmocean-Alaska, CEO of Atmocean, Inc., and project leader for his EETF submittal. Founder of Atmocean, Inc., and inventor of the Atmocean WEST system. Serial entrepreneur with six startups since 1972. 13 patents in prior auto safety business.
**Scott Chadwick**, resident Operations Director in Yakutat for Atmocean-Alaska. Owner/operator of YakutatCharter.com. Marine based ocean charters and research vessel *Sea Wolf*. Former General Contractor. Diver/welder/Commercial Fishermen/Coast Guard 25 ton credentials.
**Philip Fullam**, BS, PE, MBA. Chief Engineer, Atmocean, Inc. and Reytek Corporation. Oversees design, build, deploy, and data acquisition mechatronics of the WEST system.
**Chris White**, BS, Marine Biology. Onsite assembly manager; ocean operations assistant. Emergency Medical Technician rating (EMT-I); Dive Master. Multi-lingual.

**Chris Ferguson**, BS, Physics & Electrical Engineering, minor in physical oceanography and marine renewable energy. Guided 2011 Atmocean seatrials at California Polytechnic State University Responsible for data analysis, assisting in mechanical assembly and ocean operations.
**Kathryn Lane**, office administration and permitting coordinator.
**Curt McGill**, CPA, Ricci & Company. Accounting and taxes.

**5. Discussion of Commercialization of Funded Technology**
This project will advance wave energy in Alaska by demonstrating a commercial WEST system.

Using wave data from NOAA #46083 for the period July 1, 2007 to September 30, 2010 (27,900 hours of valid data), we have calculated the hourly kWh generated by 100 Atmocean WEST units located offshore Yakutat, and how much diesel electricity would have been replaced by clean, renewable Atmocean WEST wave electricity:




Based on "Power House PCE" actual diesel cost per kWh (thanks to Scott Newlun), we show the diesel cost **saved** would have averaged $125 per hour, or nearly $1.1 million per year based on the diesel cost per gallon actually paid during this period. The savings will be correspondingly greater in future time periods when higher diesel costs are likely. If our mini-array were expanded from 10 pumps to 100 pumps, we estimate the WEST complete system, including first year sinking fund payment for operations, maintenance & support, would cost about $2.1 million. Based on financing estimates from Independence Bank, at 6% interest over 20 years, the monthly payment is about $49,000. The payback is 27 months, assuming $5/gallon future diesel price, and the cost of energy is about 14 cents/kWh. These amounts reflect an IPP business model, e.g. exclude Atmocean overhead and ROI.

The market for wave energy in Alaska, and particularly SE Alaska and the Aleutian chain is significant as every remote coastal village relying on diesel is paying upwards of 50 cents per kWh. A key factor in the WEST system is its scalability for smaller markets while retaining economic feasibility. Even a nominal 300 kW (25 WEST pumps) system can be produced and installed for not much more than 25 cents/kWh. In addition to these kWh savings, by adopting this proposal, AIDEA will accelerate wave energy deployment by at least a year since that is the normal data acquisition time of the wave measuring devices such as the TRIAXYS technology (actual deployments typically would proceed afterward). Unlike wind energy which requires significant time periods of onsite data collection, wave energy systems can utilize the wave height and period data from NOAA/NDBC data buoys which, though distant from the site, are representative of local conditions.

In the example of Yakutat, with the WEST system supplying about 76% of electricity on an annual basis as calculated and shown above, the annual savings of $1.1 million (more than 2x this grant request) illustrates the opportunity cost of not proceeding expeditiously. By funding this proposal, project payback is accelerated, and consumers benefit from lower electric bills sooner rather than later.

To accelerate the roll-out of marine renewable energy in Alaska, Atmocean has partnered with **Independence Bank, East Greenwich, RI**, to make available 100% financing of WEST projects.

**6. Signed Applicant Certification** (sec. 4.6)
"By signature on this application, I certify that we are complying and will comply with the amount of matching funds being offered."

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