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U.S. Ocean Current Marine Energy Test Facility Feasibility Assessment

A Concept Paper in response to:
DE-FOA-0002793 (Marine Energy Systems Innovation at Sea)
Topic 3: Ocean Current Test Facility Feasibility Assessment

Proposed Team Members:
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City of Lake Worth Beach, Florida
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IDOM Incorporated
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Technology Description

Energy found in the ocean's waves, water currents, and gradients (e.g., salinity or temperature) can be transformed into electricity for many coastal areas to attain energy independence. However, to be useful at community scales, marine energy resources must be abundant and predictable. To be compatible with electric utilities as a baseload carbon-free power generation source, marine resources should also be continuously present (i.e., dispatchable, or available on demand). Only western boundary ocean currents like the Florida Current can boast all these features for the U.S. In this section of the Gulf Stream, the Bahamian Shelf constrains the east-west movement of the current's 30,000,000 cubic meter per second "core" so that turbines could be placed in large areas that will always be exposed to the current. Here the Gulf Stream is also found close to shore (less than 20 nm in places) and near population centers that can immediately benefit from its massive energy capacity. The challenge lies in developing ocean current energy technologies with adequate efficiencies, reliability, safety, and economics.

For this reason, intrepid inventors, entrepreneurs, and engineers have begun to propose, build, and demonstrate technologies to harness ocean currents. The Southeast National Marine Renewable Energy Center (SNMREC), designated at Florida Atlantic University (FAU) by the U.S. Department of Energy (DOE) in 2010, has been working closely with these marine energy technology developers, regulators, policy makers, resource managers, utilities, communities, and other stakeholders to accelerate the new industry sector's establishment in southeast Florida. Throughout its history, SNMREC has helped evaluate new concepts, measured the Florida Current to inform turbine designs, evaluated environmental conditions and risk to marine life, developed desktop models to predict turbine performance, as well as built and demonstrated small-scale turbines onshore and offshore. Like tidal and wave systems around the world, the next step for many of these companies is to build full-scale equipment that requires real-world testing to simulate how they would be installed commercially.

SNMREC's long term vision is to help establish a "blue energy" innovation industry cluster in southeast Florida which addresses all aspects of utility-scale ocean current energy project development. The focus is not only on turbine developers, but the entire value and supply chain needed to establish commercial projects (e.g., undersea cables, electric transmission components, marine services). A legitimate utility-scale commercial electricity generation project cannot succeed without first demonstrating that all project aspects can be economically and safely integrated. Therefore, it is essential that the ocean current industry in the U.S. have access to an offshore, grid-connected test and evaluation capability. This proposal aims to begin addressing this need by conducting a preliminary feasibility assessment for an offshore ocean current test facility. Recognizing an imminent need for a grid-connected offshore test facility, and with lessons learned from other wave and tidal test centers around the world, SNMREC has developed a strategy to reduce risk, costs, and delays while also efficiently navigating regulatory requirements and meeting industry timelines. The tenets for this strategy are:

- Establishing a grid connection first
- Serving a wide variety of marine energy technology scales
- Building offshore in phases to manage risks and costs more effectively
- Integrating regional economic development opportunities and capabilities
- Engaging with stakeholders early and often

A preliminary conceptual offshore test facility is shown in Figure 1. A grid connection would interconnect zones that represent both technology maturity needs as well as increasing complexity and risk. A "Powering the Blue Economy Demonstration Zone" (Phase 1) would be first developed to establish a nearshore grid and data connection for testing and evaluation of small-scale marine energy systems and integration with at-sea marine energy users (30-100 m. depth). The second phase would involve extending the Phase 1 grid connection to a "Scaled Marine Turbine Evaluation Zone" (Phase 2) located in the westernmost Florida Current core (200-300 m. depth). Here, half to full-scale turbines would be moored and grid-connected for testing and evaluation of single system performance, power quality, reliability, and environmental effects. The final phase would be to leverage the previous subsea cable right-of-way and place larger cables to the core of the Florida Current approximately 15-20 nm offshore Palm Beach County, Florida to evaluate arrays of turbines in the "Full Scale Marine Turbine/Array Evaluation Zone" (Phase 3, 300-500 m. depth). Performance evaluation requires real-time measurement of the current as well as the environment, and therefore the zones would be located within an "Instrumented Evaluation Area" with real-time access to measurements.

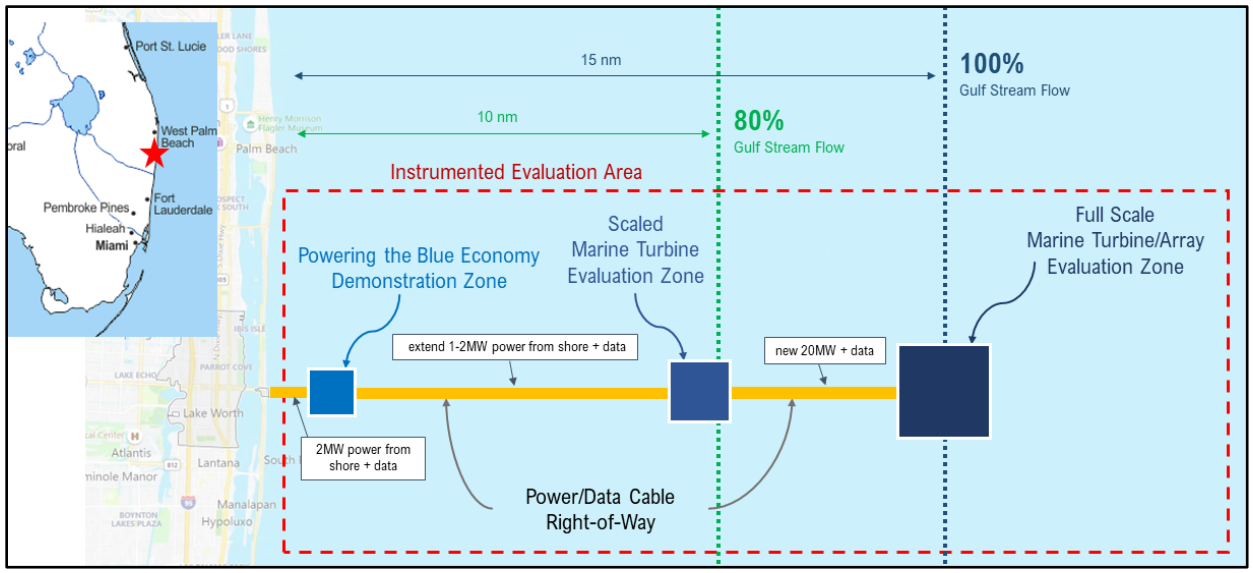

Figure 1 – U.S. ocean current energy offshore grid-connected test facility concept

The team will assess the feasibility of this concept providing the following deliverables, with the explicit deliverables required by the Funding Opportunity Announcement (FOA) included within:

1. **Requirements database** (Programmatic, Project, and Technical)
2. **Preliminary technical specification** (site/resource characterization, geotechnical survey needs, cable route/specification, shore landing/grid interconnection)
3. **Regulatory and permitting plan** (roadmap/timeline, turbine archetype approvals, user conflict and Marine Spatial Planning analyses)
4. **Project costs estimate and analysis** (facility design and construction, regulatory and NEPA, annual operating and maintenance projections, industry utilization analysis, Blue Energy Innovation Industry Cluster plan)
5. **Risk assessment** (regulatory, technical, economic)

The team's plan for addressing FOA deliverables is provided as a responsibilities matrix in Table 1 (proposed DOE national laboratory contributions are included).

Table 1 – Responsibility matrix for FOA-required deliverables (abbreviations for partners found in the Addendum). Role abbreviations: R=Responsible; A=Accountable; S=Supporting; I=Informed; C=Consulted.

Funding Opportunity Announcement Deliverable	Project Deliverable	R	A	S	I	C
1. Definition of complete system requirements	1	FAU	FAU	ALL	DOE	DOE
2. Estimated costs and schedule for facility design and construction	2,4	IDOM	FAU	FAU, LWB, 3U	DOE	Braid, EMEC
3. Scope of work and estimated costs including those necessary to ensure NEPA compliance, biological assessments, permitting activities, and environmental monitoring for both species of concern and physical oceanographic processes like energy transport	2,3,4	FAU	FAU	48N, IDOM, 3U, EMEC, LWB, Braid, NREL, PNNL, Sandia	DOE	DOE
4. Estimated annual operating and maintenance costs for the facility	2,4	IDOM	FAU	FAU, 3U, LWB	Braid, DOE	DOE, EMEC
5. Specific coordinates and resource characterization for proposed test location	2	FAU	FAU	48N, NREL, Sandia	DOE	3U, LWB
6. Report describing geotechnical surveys required, with associated estimated costs and number/depth of core samples that may need to be collected	2	3U	FAU	FAU, 48N	DOE	IDOM
7. Detailed risk assessment of ability to permit the facility	5	48N	FAU	FAU, PNNL	DOE	3U, LWB
8. Detailed permitting plan that identifies all federal, state and local permits and/or licenses required for test site construction and operation	3	48N	FAU	ALL	DOE	Regulators, Resource Managers
9. Detailed discussion of potential Marine Spatial Planning (MSP) issues concerning facility construction and operation	3	48N	FAU	FAU, 3U, LWB, PNNL	DOE	Stakeholders
10. Evaluation of ME industry utilization of the facility.	4	FAU	FAU	EMEC, Braid, NREL	DOE	ME Industry
11. Preliminary analysis of alternatives considered for achieving project objectives, including:	2,3,4,5	FAU	FAU	ALL	DOE	ALL
a. Technical design considerations and assumptions	2	IDOM	FAU	ALL	DOE	DOE
b. Facility floorplan sketches and preliminary plans for outdoor space available for developers to utilize for equipment storage	2	IDOM	FAU	FAU, LWB, Braid	DOE	EMEC
c. Ocean and terrestrial property boundaries to include subsea and terrestrial cable corridors.	2	FAU	FAU	3U, LWB, IDOM	DOE	EMEC
d. Specific coordinates and site conditions relevant to project design	2	FAU	FAU	3U, LWB, Sandia, NREL	DOE	48N, LWB
e. Description of nearby transportation capabilities, port facilities, utility substations, or other infrastructure as appropriate.	2,4	Braid	FAU	FAU, LWB, 3U	DOE	EMEC
f. Description of environmental monitoring plans and justifications for chosen instrumentation and methodologies.	3	48N	FAU	FAU, PNNL	DOE	EMEC

Addendum

Project Team

►*Florida Atlantic University (FAU)*

Southeast National Marine Renewable Energy Center (SNMREC)

SNMREC is one of three founding U.S. Marine Renewable Energy Centers, designated at FAU in 2010. Since 2007, when it was first established as a State of Florida Center of Excellence, more than $22M of state, federal, and industry funds have been invested to further the Center's goal of accelerating the responsible commercialization of marine renewables. SNMREC secured the nation's first offshore marine energy lease with the Bureau of Ocean Energy Management, conducted inshore and offshore scaled turbine performance tests, performed cutting-edge R&D, conducted over a decade of resource characterization campaigns, performed environmental assessments, influenced national policy and regulatory framework, and have trained more than 150 students for positions within the sector. With a robust industry, university, and National Laboratory partner network, FAU is strategically positioned to establish and operate an offshore marine energy test facility.

►*City of Lake Worth Beach, Florida (LWB)*

The City of Lake Worth Beach owns and operates a municipal electric utility providing service to its surrounding community (. The electric utility system extends from the beachfront area of the barrier island to inland locations (covering approximately twelve square miles) and is directly connected to the state-wide high voltage transmission system regulated by the Federal Energy Regulatory Commission. The City's electric system includes ownership and operation of sub-sea cables extending from the mainland to the barrier island beachfront area, and a significant system hardening and reliability project is currently underway. The City has been working collaboratively with SNMREC for nearly a decade, including sponsoring an independent study of the potential regional economic benefits of establishing a technology hub for ocean current energy. Electric utility leadership has led outreach efforts with fellow members in the Florida Municipal Power Agency who would be potential purchasers of future commercially available ocean current energy accessible through the City's interconnection to the state-wide grid.

►*48 North Solutions, Inc. (48 NORTH, 48N)*

48 NORTH is an aquatic-focused environmental consulting firm, providing expertise and support in biological services, environmental planning, regulatory compliance, and stakeholder engagement. 48 NORTH manages documents prepared under the National Environmental Policy Act; conducts essential fish habitat evaluations pursuant to the Magnuson-Stevens Act to identify potential impacts of land use strategies on managed fisheries; develops biological assessments and marine mammal authorizations to identify risk and potential impacts on species listed under the Endangered Species and the Marine Mammal Protection Acts; and identifies mitigation and conservation measures. A regulatory leader in the marine energy sector, 48 NORTH is well-versed in permitting the deployment of infrastructure in the marine environment, with previous projects in marine energy, offshore wind, and subsea power and fiber cable installations.

►*IDOM Incorporated (IDOM)*

IDOM is an engineering company with more than 3500 employees which operates worldwide in all the fields of the engineering. Having performed more than 20,000 projects in more than 125 countries, it has proven capability to carry out large international projects where

multidisciplinary teams are required. IDOM has been involved in the design, build and construction of multimegawatt wind turbine test facilities, such as the Clemson Wind Energy Research Center and the Fraunhofer IWES Institute's Dynamic Nacelle Laboratory. In the offshore renewables sector, IDOM has developed a wave energy converter, the Harshlab 2.0 marine energy floating test laboratory, and in partnership with SNMREC ND the U.S. Department of Energy, is currently developing a Mobile Test Vessel to test scaled current energy turbines around the U.S. Its combination of conventional and offshore engineering capabilities uniquely positions IDOM for effective technical project management of an offshore marine energy test facility.

► *3U Technologies LLC (3U)*

3U was founded in 1998 and provides marine engineering, design, infrastructure consulting, and technical analysis, business consulting, and project management services to commercial and government clients. 3U provides mechanical, electrical and controls system engineering for underwater/offshore systems and manages the installation of submarine power and fiber optic cable networks, including the unique challenges of horizontal boring and burial of submarine marine cable shore approaches. 3U engineering experience includes medium voltage power and fiber optic equipment in the submarine environment, including high power dynamic umbilicals (4500 volts), powered telecommunications cable (8-12 KV) and undersea energy (36 KV / 25 MW). 3U personnel have 25 to 40 years of individual experience working offshore and are presently managing installation of the PacWave submarine power cable system for Oregon State University, which uniquely positions 3U to provide similar support for this project.

► *Braid Theory (Braid)*

Braid Theory, a vertically integrated advisory, has been launching and supporting blue economy entrepreneurs since 2016. It incorporates a hybrid model of services based on deep domain expertise, proven methodology, and rigor in evidence-based entrepreneurship, focused on key aspects of commercialization: building capability, capacity, and intellectual and working capital. Key to Braid Theory's process is connecting science- and engineering-led entrepreneurs with industry partners to develop blue economy clusters to build opportunities for market traction and growth. As the nation's only Blue Power Connector, designated by the Water Power Technologies Office at the U.S. Department of Energy, Braid Theory provides entrepreneur advisory services to wave energy innovators in DOE/NOAA's Ocean Observing and Waves to Water prizes.

► *European Marine Energy Center (EMEC)*

Established in 2003, EMEC is the longest established research centre of its kind in the world, providing developers of wave and tidal energy technologies with access to purpose-built, accredited, open-sea test facilities (35 technologies from 11 countries to date), and supporting the demonstration of other offshore innovative technologies (anchors, quick connectors, blue economy related initiatives, among others). EMEC's vision is to pioneer a low carbon future. The Centre has supported the development of +10 marine energy research, testing and demonstration centres around the world, providing guidance and support around their design and operation (most notably at the PacWave centre in Oregon). EMEC chairs the International Wave and Tidal Energy Research Sites (International WaTERS) network of marine energy test centres, which it convenes once annually to share lessons learned and coordinate efforts around open-sea testing globally.