EE0008952 – MARMOK- Oscillating Water Column (OWC)

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*IDOM Inc.*

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July 20th 2022
## Project Overview

### Project Summary

The aim of this project is to advance towards the future commercial viability of the floating Oscillating Water Column (OWC) technology through the development of a commercial size wave energy converter (WEC) specifically suited to PACWAVE-South site conditions. This spar type WEC design is based on a previous low power prototype deployed and tested offshore for 2+years and it incorporates several innovations to contribute to the LCOE reduction potential of the technology. It is a grid connected prototype in which applicable IEC/IEEE standards have been followed. A technology commercialization plan has also been developed identifying potential markets for each of the development stages.

### Intended Outcomes

- Detailed design of a commercial size wave energy converter suited to PacWave-South site. It is a grid connected prototype capable of ensuring device survivability and operability & maintainability over a two-years operational life.
- Technology Commercialization Plan, identifying the targets markets, product development plans and the overarching commercialization strategy for the proposed technology.

### Project Information

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<th>Principal Investigator(s)</th>
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<td>• Borja de Miguel Para</td>
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<th>Project Partners/Subs</th>
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<tr>
<td>• NREL</td>
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<td>• Sandia</td>
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### Project Status

Sunsetting

### Project Duration

- May 1<sup>st</sup> 2020
- October 31<sup>st</sup> 2022

**Total Costed (FY19–FY21)**

$1,053K
Project Objectives: Relevance

Relevance to Program Goals, Challenges & Activities:

**Challenges**
- Difficult engineering to convert marine energy

**Approaches and Activities**
- Foundational R&D
  - Drive innovation in components, controls, materials, manufacturing, and systems
  - Develop numerical and experimental tools and methodologies to understand fluid-structure interactions
  - Improve MHK resource assessments and characterizations to optimize devices and arrays and understand extreme conditions
  - Develop and apply quantitative metrics to identify and advance technologies with high ultimate techno-economic potential

**Conducted tasks**
- • Improved Air Turbine
- • Shared mooring system
- • Advance Control Strategies analysis (Model Predictive Control)
- • Grid connected design
- • Numerical models validation through laboratory testing campaign
- • Extended PacWave-South resource assessment (Sandia) to optimize system design
- • LCOE, peak to avg. mechanical power and capture width ratio calculation
Relevance to Program Goals, Challenges & Activities:

**Challenges**
- Installation and operation of reliable systems

**Approaches and Activities**
- Technology-specific system design and validation
  - Validate performance and reliability systems through in-water tests of industry designed prototypes
  - Improve methods for safe, cost-efficient installation, grid integration, operations, maintenance, and decommissioning
  - Evaluate current and potential future needs for O&M infrastructure
  - Support the development and adoption of international standards for device performance and insurance certification

**Conducted tasks**
- Design suited to PacWave-South conditions (average and survival)
- Main O&M operations analyzed and derived requirements integrated into the design
- IEC TS 62600 standards applied
  - 2 – Structural design
  - 10 – Mooring design
  - 103 – Tank testing
Project Objectives: Relevance

Relevance to Program Goals, Challenges & Activities:

Challenges

- Lack of available, accessible technology/market information and data
- Data access, analytics, and workforce development

Approaches and Activities

- Leverage expertise, technologies, data, methods, and best practices from international marine energy sector and other offshore industries
- Assess potential market opportunities, including relevant maritime markets
- Aggregate, analyze, and disseminate data on performance and technology advances
- Support development of educational resources, such as curricula and training, to support an evolving workforce

Conducted tasks

- Development based on previous experience on a low power prototype deployed and tested offshore in BiMEP test site (Spain)
- Potential niche market opportunities analyzed such as Isolated power systems, Offshore Oil & Gas and Aquaculture
Project Objectives: Approach

The technology:

Spar type OWC ➔ technology with outstanding simplicity and survivability (a single moving part, not submerged).

Mooring system ➔ designed to minimize its influence on power performance and reduce cost when array deployments.

Strategy:

Staged development path to reduce technical and financial risk
Project Objectives: Approach

Approach:

• Leverage previous deployment experience into this larger WEC
• Geometry optimization to maximize power output/cost ratio
• All subsystems design (Structure, Mooring, PTO...)
• Laboratory testing of a scaled prototype to validate numerical models
• Marine operations preliminary analysis to identify design requirements
• Third party manufacturability review feedback incorporated into the design
• Standards incorporation to the largest extent possible
• Risk management following NREL procedure covering a potential testing phase
• Technology commercialization plan and LCOE projections
• Support of partners (NREL, Sandia) on key subsystems (Geometry, PTO, array mooring system)
Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

• Detailed WEC design report including all subsystems
• CAD design drawings
• Laboratory testing campaign report
• Third party manufacturability review
• Risks register including a potential testing phase
• Performance metrics assessment for single device, small array and medium size array (LCOE, peak to avg. ratio, capture width)
• Technology commercialization plan

Outcomes:

• Completion of the design phase of the next technology development stage
• Ready to build WEC design to be deployed and grid connected at PacWave-South
• Reliable LCOE projections of the technology and identification of potential niche markets
Project Timeline

• Preliminary design

• Preliminary assessment of performance metrics & commercialization plan

Preliminary design review

• Final design
  – Testing campaign
  – Third party manufacturability review

• Technology commercialization
  – Performance metrics
  – Commercialization plan

Final design review

• Risk management

• National labs support
## Total Project Budget – Award Information

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<tr>
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<th>DOE</th>
<th>Cost-share</th>
<th>Total</th>
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<tr>
<td>Total</td>
<td>$1,640K</td>
<td>$420K (20%)</td>
<td>$2,060K</td>
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### FY19 – FY21 Actual Costs

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<tr>
<th></th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
<th>Total Actual Costs FY19–FY21</th>
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<tr>
<td></td>
<td>Costed</td>
<td>$145K</td>
<td>$908K</td>
<td>$1,053K</td>
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- Project will be completed with no additional budget required
- $400K of technical assistance budget for NREL and Sandia to support IDOM on this project
End-User Engagement and Dissemination

- Key stakeholders involved in the project
  - DOE providing feedback (monthly meetings) to reconduct project activities
  - NREL and Sandia supporting on the technology development
  - PacWave providing feedback during design reviews

- Dissemination activities
  - Conference presentations
    - ICOE2021 (Washington D.C/Virtual)
    - IEEE PES General Meeting 2022 (Denver)
    - ICOE 2022 (San Sebastian, Spain)
      - Technology (IDOM)
      - Air turbine (Sandia)
      - Mooring array (NREL)
  - MHK data repository
    - Data sets from the testing campaign
    - LCOE estimation for a MW deployment using SAM tool

- Diversity equity and inclusion
  - IDOM is fully committed with these aspects as gathered in the code of conduct of the company. This code is applied during whole lifecycle of the projects and in the daily basis works
Performance: Accomplishments and Progress

- WEC dimensions optimized to maximize power/cost ratio at PacWave-South site
- CFD model developed by Sandia to estimate drag losses and optimize geometry
- Detailed structural design developed covering all load cases along the lifecycle of the WEC; Ultimate and Fatigue limit states (ULS, FLS)
- Manufacturing drawings developed and reviewed by a third-party company
- Detailed mooring system design (ULS, FLS and Accidental limit state ALS)
- Umbilical cable routing designed to ensure survivability
Performance: Accomplishments and Progress

- Testing Campaign completed at OTRC (Texas University) (1/23 scale) to validate numerical models (power performance, structural and mooring design)
- PTO system design completed using a baseline turbine and off-the-shelf generator and power electronics (4x75kW turbines)
- SCIG and PMG generators compared through numerical models developed by NREL
- Improved air turbine developed with the support of Sandia and Penn State University
- Baseline control strategy defined (Torque as a function of rotational speed), and advance control strategy (Model Predictive) potential evaluated (15% improvement estimated)
- Control architecture, Instrumentation, DAQ and communications defined
Performance: Accomplishments and Progress

- Auxiliary systems design (bilge, ventilation...)
- Onboard electrical design completed
  - Power generation system
  - Auxiliary system
  - Transmission system (transmission voltage study developed)
- Main marine operations description to identify means required (piping, vessels, onboard crane...)
- Preliminary maintenance plan developed based on previous experience
- LCOE calculation based on a detailed cost breakdown of the single device and projection for larger deployments (4 WECs and 42 WECs array) for PacWave-South and CalWave sites
  - Mooring cost reduction potential estimated by NREL using MoorDyn
- Technology commercialization plan developed, and potential niche markets analyzed in more detail linked with this tech. characteristics
  - Isolated power systems (large potential, medium size deployments)
  - Offshore Oil & Gas (large potential, medium-large size deployments)
  - Aquaculture (medium potential, small deployments)
- Detailed case studies for Alaska and Canary Islands