DE-EE0007347 – Reduction of System Cost Characteristics Through Innovative Solutions to Installation, Operations and Maintenance

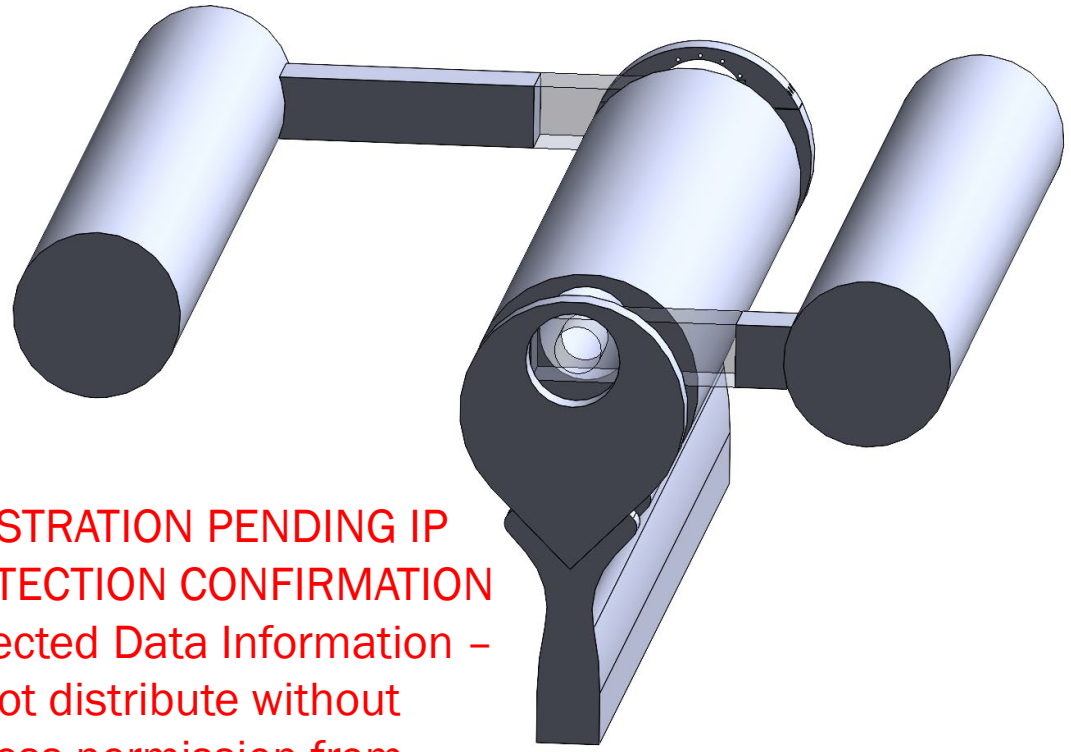

ILLUSTRATION PENDING IP PROTECTION CONFIRMATION
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Project Overview

Project Summary

This Project will demonstrate the C-Power SeaRAY wave energy converter (WEC) technology in its largest practical form over an extended period in an open-ocean environment; validating the performance, reliability, availability, and environmental impact of the design, including power output, availability, reliability, installation, operations, and maintenance (IO&M) costs. The goal is to minimize IO&M costs based on operational and research data and to implement and test innovative IO&M-centric design improvements, while also identifying optimization strategies to augment efforts to support wave energy commercialization and industry decarbonizations efforts.

Intended Outcomes

- Fabrication-ready design of novel, standards compliant SeaRAY k20 WEC with advanced hull structure and modular power-takeoff
- Validated performance and logistics capabilities to demonstrate commercial readiness
  - Delivery of ultra-reliable available power through multiple onboard power sources
  - Relevance for Powering the Blue Economy (PBE) applications with higher loads and for applications in lower resource environments and deeper water
  - Optimized handling and transport
- Performance analysis for next-generation WEC improvement

Project Information

Principal Investigator

- Michael Ondusko

Project Partners/Subs

- Harris Thermal - hull
- Borg-Warner (Cascadia Motion) – PTO/PE
- JBJ Techniques, Ltd - PTO
- SKF - PTO

Project Status

Ongoing

Project Duration

- Project Start Date – May 6, 2016
- Project End Date - September 30, 2022

Total Costed (FY19–FY21)

$1,951k

Project Objectives: Relevance

Relevance to Program Goals:

- WPTO challenges addressed
  - Difficult engineering to convert marine energy & Installation and operation of reliable marine energy systems
    - 20kW output WEC is an order of magnitude increase relative to its 2kW design basis
    - Despite relative size and output, WEC designed for optimized handling and logistics using commercially available equipment, including ocean shipping containers
    - Modular PTO design for optimized on-site final assembly and maintenance
    - Novel, cantilever float arms allow relaxed hull tolerances, reduced mass, and reduced risk of shaft binding
    - Initial implementation of mooring design that enables deep-water, reduced watch circle deployments
  - Limited Availability of Technology/Market Information
    - Market-driven design for PBE applications that require higher power levels and deployment in low resource locations
- Intermediate and long-term outcomes supported by SeaRAY k20
  - Utilization of internationally accepted standards (IEC 62600) and performance metrics
  - Increase in private investment and commercial utilization by providing more cost-effective solutions to marine industries' challenges
  - Decarbonization of commercial marine operations
  - Decrease total cost of ownership of low-power marine applications
  - Growth of Blue Economy

Project Objectives: Approach

Approach:

- Leverage C-Power experience and expertise
  - Maximize size/output of patent pending SeaRAY design, while maintaining operations and handling advantages of smaller systems
  - Combine market insights and relationships with internal technical expertise and experience to deliver ultra-reliable marine power system for PBE applications
- Customer- and risk-reduction driven design
  - Market discovery process conducted through direct customer and partner interaction
  - Numerical model driven approach to increase scale of current designs
  - Design guided by international standards (IEC 62600)
  - Iterative risk assessment
- Leverage 3rd party experience where possible
  - Utilize components and controls developed in electric vehicle and other industries
  - Structural design by Cardinal Engineering; mooring design by EOM

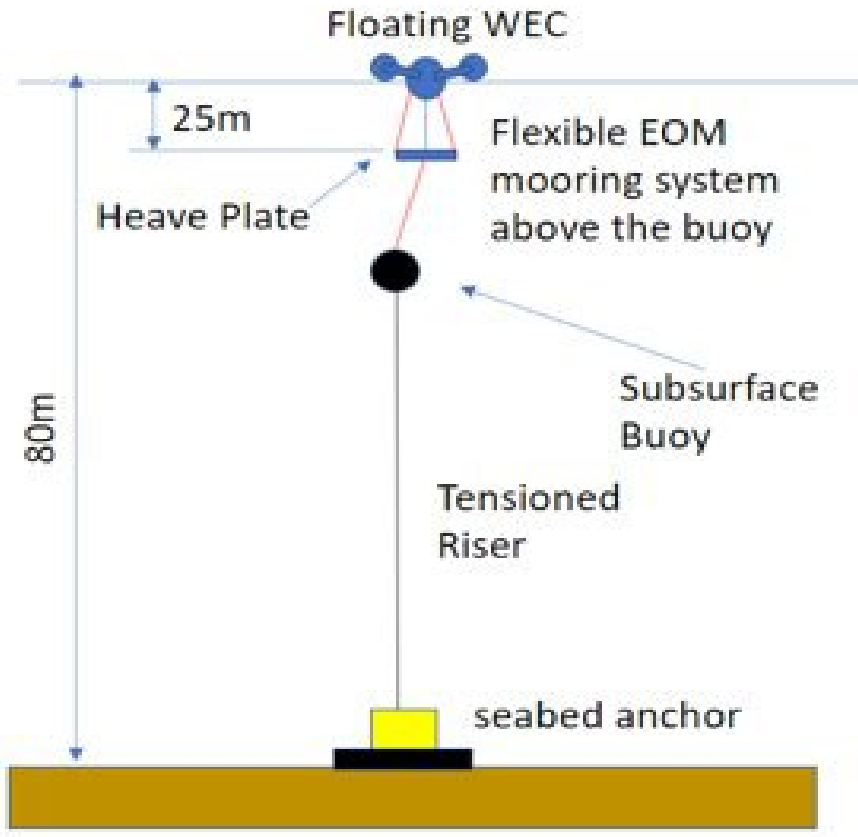
Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- SeaRAY k20 design and prototype with multiple power sources and deep-water capable mooring
- Marine cost-optimized IO&M procedures validated
- Total Cost of Ownership baseline for 10 to 20 kW applications to be established
- Leverage technology commercially developed for other industries e.g., heavy electric vehicles, machining, and material handling

Outcomes:

- Demonstrate upper power output limit of C-Power's SeaRAY design topology
- Demonstrate commercial appeal for potential customers and partners; initiate engagement in commercial pilots and co-development/co-sales opportunities
- Enable deployment opportunities for next-generation, non-shallow water applications with a flexible depth mooring design (concept shown right)



Project Timeline

FY 2016 - 2019

- Project Management Plan utilizing procedures and processes in conjunction with a FMECA-based Risk Management Plan to address uncertainties in advance
- Complete StingRAY H2 design informing both StingRAY H3 and SeaRAY k2 and k20 design
- GO issued on project
- Long-lead materials procured

FY 2020

- Project Revised to ensure targeted WEC was appropriately matched to available infrastructure to best leverage mutual investment
- Establish Constraints and Concepts for Revised Project

FY 2021

- Market outreach and investigation
- K20 Preliminary Design

FY 2022

- Final Design
- Procurement
- Fabrication and Deployment Planning
- Permitting
- Fabrication

FY 2023

- Fabrication
- V&V
- Deployment and Testing

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$4,150K	$2,105K	$6,255K

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$1,773K	$108K	$70K	$1,951K

- Project was paused in 2019 after the utility-scale WEC design was complete.
- The cost reduction and IO&M optimization aspects of the project were continued with the proposed focus of the demonstration revised to develop a 20kW PBE device, the SeaRAY k20.
- Project revisions were approved August 2021 and a new design was initiated to incorporate the project learnings.

End-User Engagement and Dissemination

- Customer engagement strategy
  - Early engagement - More 40 customers and partners directly engaged during Project to understand operational and logistical requirements for larger SeaRAY systems
  - Leading to integration and involvement - Multiple co-development and integration partners recruited to participate directly or indirectly in Project
- Project dissemination and technology transfer
  - Papers and Presentations – Offshore Technology Conference 2020,2021,2022, North Sea Decarbonization Conference, Subsea Tieback 2022, and others
  - Podcasts – “Through the Noise” and others
  - Development of PBE-appropriate deep-water mooring by EOM
  - Project use of PTO and redundant power supply technologies from automotive and other industries

Performance: Accomplishments and Progress

- Design and build of novel, purpose-built WEC with next-generation SeaRAY hull design and deep-water capable mooring
- Integration of improved logistics and operational opportunities
- Integration of novel PTO cartridge concept that enables faster maintenance and relaxed build tolerances reducing cost
- Upgraded design tool to size optimize the architecture in a family of WECs; this design represents the third iteration – a 20kW design following 500W and 2kW prototypes
- Integration of components from the EV industry which reduces the validation and verification time and effort as well as component mass
- Integration of a hydrogen fuel cell as an auxiliary power unit (reducing mass compared to original diesel genset concept) and using hydrogen storage tanks to achieve greater buoyancy which in turn allows for a less strenuous mass budget

Future Work

- Complete Preliminary Design
- Subcontracting of Suppliers;
- Generator selection with future improvement in conversion efficiency by x% if you can state target efficiency
- Preparation of test plan to accommodate SeaRAY test at WETS
- Continuation of permitting with Navy
- Fabrication, assembly, deployment, operations, maintenance, recovery, and final reporting

Q&A