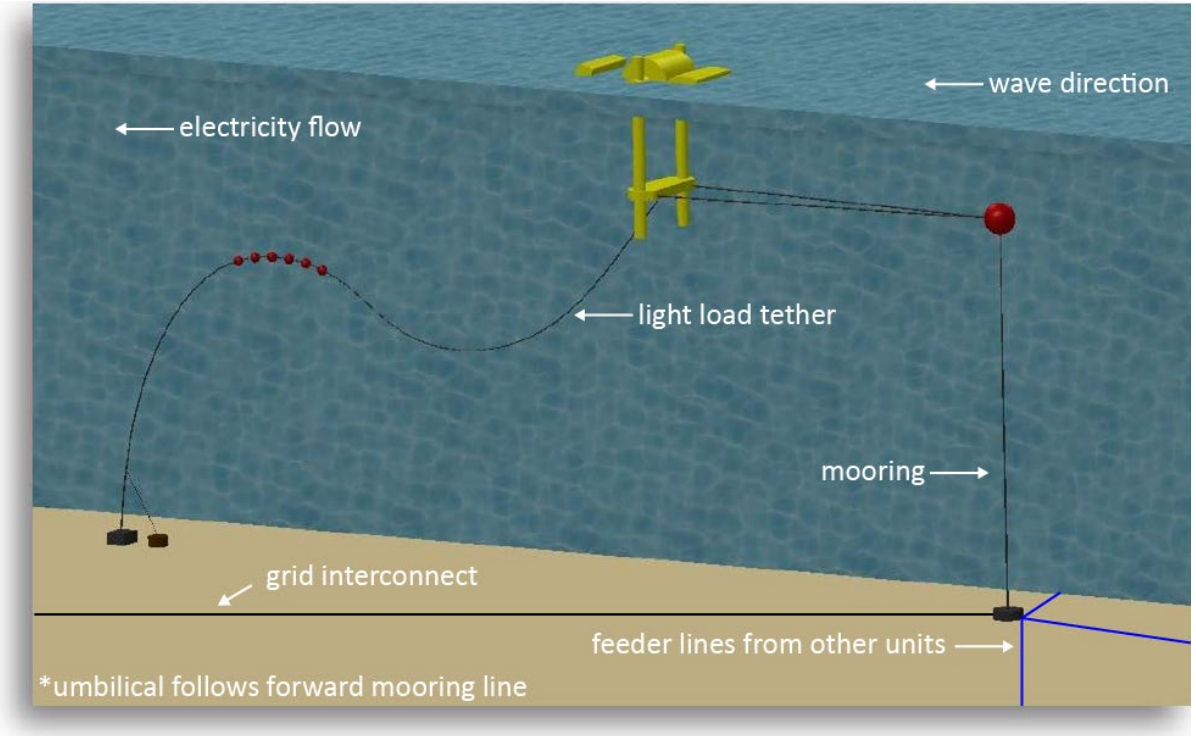
DE-EE0008954 – Optimization, Design, And Commercialization Planning Of Next-Generation Stingray H3 Wave Energy Converter



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Project Overview

Project Summary

The Project's goal is to develop a standards-compliant, fabrication-ready, next-generation design of C-Power's StingRAY wave energy converter (WEC). The H3 StingRAY – intended for applications with >50kw generation requirements – will be designed for grid-connection and at least two years of continuous testing and operation at the PacWave-South (PWS) test site. The H3 design is intended to deliver an innovative, high-performance, survivable, and reliable device that is acceptable to potential customers, regulators, and other stakeholders, while also demonstrating the StingRAY's path towards cost-competitive electricity generation.

Intended Outcomes

- Detailed design of StingRAY H3 WEC
  - Ready for fabrication, standards-compliant
- Post-Project, the H3 WEC is intended to be manufactured and deployed for a 2+ year demonstration at PacWave South
- Commercialization of the H3 WEC
  - Near-term commercialization targets remote offshore markets (e.g., diesel gen set replacement)
  - Lessons learned will support development of larger StingRAY for local microgrid and grid-scale markets

Project Information

Principal Investigator(s)

- Pukha Lenee-Bluhm

Project Partners/Subs

- GE Power Systems
- Cardinal Engineering
- Blue Frontier Engineering
- DNV
- National Renewable Energy Laboratory
- Sandia National Laboratory

Project Status

Sunsetting (ending Oct 2022)

Project Duration

- Project Start Date – February 1, 2020
- Project End Date – October 31, 2022

Total Costed (FY19–FY21)

- $1,340K

Project Objectives: Relevance

Relevance to Program Goals:

- StingRAY H3: system design and validation
  - Generating clean power at sea
  - Survivable, reliable, and cost-effective
- WPTO challenges addressed
  - Difficult engineering to convert marine energy
  - Installation and operation of reliable marine energy systems
- Intermediate and long-term outcomes supported by StingRAY H3 design
  - Utilization of internationally accepted standards and performance metrics
  - LCOE gains via cost reduction and performance improvement
  - Increase in private investment and commercial demonstration
  - Multi-year demonstration at PacWave South testing facility
  - Growth of Blue Economy
  - Deployment of grid-scale systems

Project Objectives: Approach

Approach:

- Leverage C-Power experience and expertise
  - Iterative improvement over previous generation StingRAY WEC
  - Novel device architecture optimizes energy conversion and eliminates end stops
  - Survivable, reliable, cost-effective
- Leverage 3rd party expertise where possible
  - Generator and electric plant design by GE Power Systems
  - Structural design by Cardinal Engineering (and auxiliary system design support)
- Risk reduction driven design
  - Numerical model driven approach to scale selection and optimization
  - Design guided by international standards (IEC 62600)
  - Iterative risk assessment
  - Model validation via scaled tank testing

Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- H3 WEC detailed design
  - Standards compliant
  - Ready for fabrication
- Plans for manufacturing, deployment, and operation
- Technology qualification plan
- Performance and cost calculations for future-targeted utility-scale H3 WEC

Outcomes:

- Project design leads to fabrication and assembly of H3 WEC
- Deployment and 2+ year demonstration at PacWave South
- Commercialization of H3 for near-term markets (e.g., diesel genset replacement)
- Development of larger H3 for remote village and utility-scale markets

Project Timeline

FY 2020

Project Management Plan utilizing procedures and processes in conjunction with a FMECA-based Risk Management Plan to address uncertainties in advance

Design basis comprehending Project objectives and environmental constraints

Model-driven scale selection, with DOE concurrence, resulting in rational development approach

FY 2021

Commercialization plan identifies multiple markets and staged development approach

Preliminary design completed

Preliminary design review, conducted with DOE participation, demonstrated progress towards Project objectives

Tank test conducted, providing observations and data for model validation

Manufacturing plan and design review, verifies and improves manufacturability

Final design will be standards-compliant and ready for fabrication

Final design review schedule allows time for revisions, if needed

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$1,800K	$452K	$2,252K

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$0K	$427K	$913K	$1,340K

- Personnel freeze enacted due to Covid-19, partially mitigated by engaging consultants
- Slow process in contracting designer for critical PMG and PE systems resulted in Project delays
  - Having GE engaged is a significant benefit for the Project, and for risk reduction overall
- First scale-model WEC used innovative 3D printed structure to save time/money, failed to function adequately
  - Redesign utilized standard aluminum fabrication successfully
- Budget overruns resulted from increased personnel and contractual costs, but C-Power remains absolutely committed to completing this Project
- Schedule delays led to approved Schedule Extension, and C-Power on-track to complete Project on schedule

End-User Engagement and Dissemination

- StingRAY H3 electrical power generation intended for:
  - **Short term: remote offshore loads** (avoids costly subsea cable runs)
  - Medium term: local microgrids
  - Long term: utility grid
- Project-targeted H3 WEC intended for remote offshore markets (e.g., at-sea diesel genset replacement)
  - Primarily offshore, upstream oil and gas operators and suppliers looking to decarbonize operations
  - Step towards future development of utility-scale H3 and fulfilling medium- and long-term goals
- C-Power engagement with oil & gas industry for co-development and commercialization objectives
  - Operators, including BP, Shell, Chevron, Murphy Oil, Equinor, Talos, and ExxonMobil
  - Tier 1 suppliers, including Subsea7, TechnipFMC, Baker Hughes, Saipem, Oceaneering, NOV, and Wood
- Dissemination has occurred through multiple industry conference presentations

Performance: Accomplishments and Progress

- Model-driven scale selection resulting in rational development approach
  - Simulation of over 700 unique configurations
  - Levelized cost of energy (LCOE) analysis performed to assess each
  - Optimal utility-scale characteristics identified
  - Smaller Project-targeted characteristics identified for near-term markets
    - Rational approach reduces risk for eventual utility-scale development
- Commercialization plan identifies multiple intended markets, and staged development strategy
- Preliminary design review demonstrated progress towards Project objectives
- Preliminary techno-economic metrics approach, or exceed, targets
  - Metrics include LCOE, capture width ratio, peak-to-average power
  - Project targets and estimates based on utility-scale H3

Performance: Accomplishments and Progress (cont.)

- Significant progress towards detailed designs of major systems, including:
  - Integration of GE-designed direct drive generator into Cardinal-designed structure
  - Single point mooring system allowing WEC to passively align with wave systems
- Successfully conducted scale-model tank test
  - Testing to validate WEC response in multiple wave conditions and WEC states
  - Demonstration of weathervaning (passive orientation with wave systems) and other key WEC response characteristics
  - Aluminum scale-model performed admirably after 3D printed version failures
- Codeveloped methods for transferring loads, from numerical models to spreadsheet calculations and Finite Element Models, for structural design
- Results from Project
  - Patent application for H3 WEC (pending)
  - Established relationships with multiple potential customers and partners

Future Work

- Project completion
  - Finalizing designs for all systems by mid-August 2022
  - Finalizing planning for manufacturing and operations by mid-August 2022
  - Final assessment of Project metrics by August 2022
  - Final revisions and reporting by October 2022
- Post-Project
  - Fabrication and assembly of H3 WEC
  - Deployment and 2+ year demonstration at PacWave South
  - Commercialization of H3 for near-term markets
    - Recruit customers and partners for co-development and sales
  - Development of larger H3 for remote village- and utility-scale markets

Q&A