U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Survivability Enhancement Of A Multi-Mode Point Absorber

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Project Overview

Survivability Enhancement Of A Multi-Mode Point Absorber:

This project will reduce the cost of survivability (structural overdesign) for Oscilla Power's high performance Triton wave energy converter (WEC); resulting in reduced project risk and lower levelized cost of energy (LCOE).

Challenges:

1) Structural overdesign is an expensive approach to survivability in high performance WECs.
2) Innovative design solutions offer promise, but extensive use of validated numerical models is required to provide confidence in their effectiveness.

Partners: Glosten, DNV·GL, OSU, NREL National Renewable Energy Laboratory, Sandia National Laboratories

Increase MHK deployment in opportune markets

Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- **Conduct R&D for innovative MHK systems & components**
- Develop tools to optimize device and array performance and reliability
- Develop and apply quantitative metrics to advance MHK technologies

Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- Support research focused on retiring or mitigating environmental risks and reducing costs
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

Market Development

- Support project demonstrations to reduce risk and build investor confidence
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain and communicate our national strategy
- Support development of standards
- Expand MHK technical and research community

Crosscutting Approaches

- Enable access to testing facilities that help accelerate the pace of technology development
- Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets
- Exchange of data information and expertise

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The Impact

Target/Metric: *Peak structural load*

- The project will reduce WEC costs by reducing the requirement for structural overdesign to deal with extreme events.

Potential Impact: *Reducing LCOE to enable commercial viability*

- Significant cost reduction is required for commercial adoption for the Triton and potentially for other WECs.

Project Endpoint: *Improved WEC design validated at 1:30 scale*

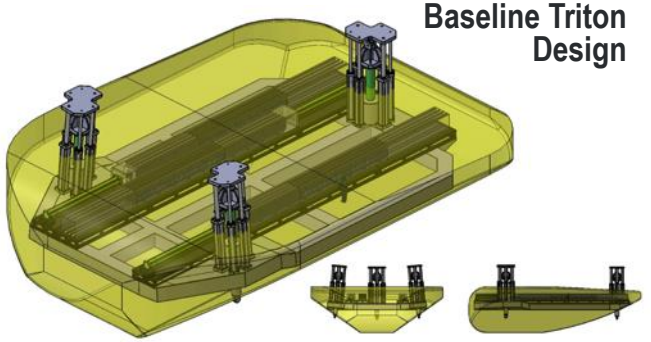
- Ideally, these improvements will be integrated into the the design phase of our community-scale project in Hawaii.

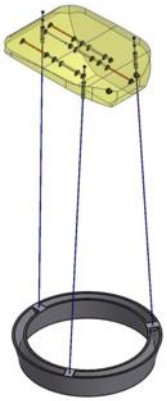
Technical Approach

Technical Approach

- Define baseline design, develop metrics to allow progress measure
- Develop capability to test physical heave plate models.
- Identify innovative survival strategies and associated costs
- Develop validated (by physical modeling and computational fluid dynamics) numerical models at increasing fidelity
- Use third-party experts to aid with Failure Modes and Effects Analysis as well as concept evaluation and down-selection
- Numerically evaluate survival strategies, focusing on impacts on performance and cost
- Demonstrate performance of selected strategy in 1:30 physical models

Baseline Triton Design





Heave Plate Test Jig

3D Printed Heave plates at 1:36 to 1:75 scales

Technical Approach

Key Issues

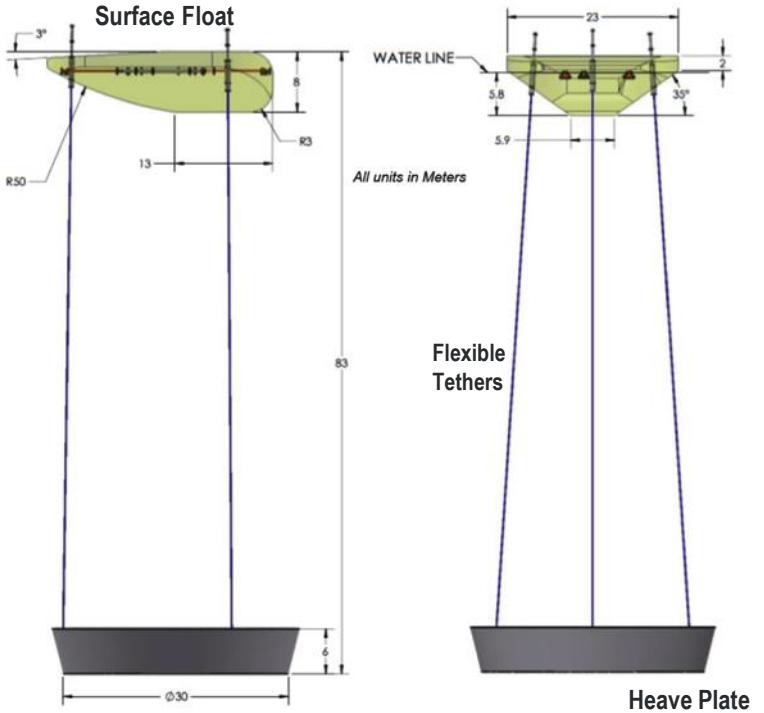
- A WEC's structural response in extreme waves is highly non-linear and thus very challenging to model numerically.
- Oscilla Power's high-performance Triton WEC is particularly complex to model due to the coupled nature of the multiple power-take-offs and heave plate geometry.
- Triton's flexible tether system must be designed to eliminate slack tether events.
- Accurate numerical representation is critical to enable alternate approaches to be evaluated time-effectively and to understand system fundamentals.

Unique Aspects of Approach

- Cost impact of survival strategies being evaluated as cost vs. sea state curves to aid comparison and connection to LCOE
- Design of Oscilla Power's unique heave plate requires and has enabled an improved fundamental understanding of heave plate hydrodynamics
- Combined numerical approach by Sandia is important to enable full exploration of performance across extreme wave contour
- Dynamic physical model tests will more accurately validate the survival approach and numerical models

Accomplishments and Progress

- Baseline system defined
  - Baseline performance metrics determined to allow quantification of project improvements
  - Identified baseline LCOE and CAPEX
  - Developed greater understanding of system for future reduction in LCOE
  - Rudimentary survival strategy developed
- Heave plate test facility created and used to derive coefficients and scale relationships
  - Enables improved numerical modeling and calculation of LCOE and system metrics
- Contracting complete with Sandia and NREL, and initial data parameter package substantially complete.



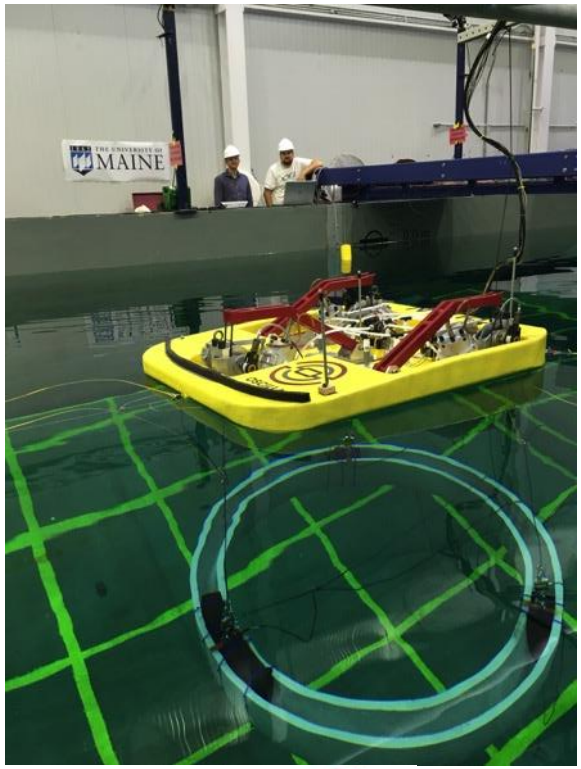
Tp (s)	4.9	6.3	7.7	9.2	10.6	12.0	13.4	14.8	16.2	17.6	19.0	20.4	21.8	23.2
Te (s)	4.2	5.4	6.6	7.8	9.0	10.3	11.5	12.7	13.9	15.1	16.3	17.5	18.7	19.9
Tz (s)	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5
Hs (m)														
0.25				11	11									
0.75	18	746	4750	9888	7377	3615	935	83						
1.25	23	2522	32766	56105	46882	23367	9277	3152	408	101				
1.75		924	48883	97821	102783	66488	31055	13728	3361	550				
2.25			31285	139968	143316	124428	50402	23224	7375	1816	258			
2.75			12375	98235	132000	147760	79172	28920	7347	1734	298			
3.25				39403	88748	116336	85619	34807	8556	1567	308	63	27	
3.75				10874	38001	69575	68247	31837	8811	1818	381			
4.25					11178	30067	40100	22913	6801	1128	307			
4.75					3866	8647	18707	15567	6384	1151	191			
5.25						2301	7660	8676	4612	1123				
5.75							1348	3700	2005	836				
6.25								1584	1182	329				
6.75									632	403				
7.25														
7.75														
8.25														

Annual energy production (AEP)	2,406	MWh
Average Power	274.6	kW

Power Matrix

Project Plan & Schedule

- Project Start: April 1 2016
- Planned Completion: Sep 30 2017
- 18-month project without Go/No-Go decision points
- Oscilla Power's substantial efforts on the Wave Energy Prize has delayed progress on initial tasks
- Now that the Wave Energy Prize competition is complete, we are catching up and are striving to complete the project close to the original target date
- Project outputs will be disseminated through conference participation and/or research papers



WAVE ENERGY PRIZE
U.S. DEPARTMENT OF ENERGY

Official FINALIST TEAM

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$0k	$0k	$0k	$0k	$93.486k	$23.372k

- Other than aforementioned delays, the project plan has not changed since the project started.
- Approximately ~16% of the budget has been expended which is is commensurate with the current project progress.
- Our cost share on this project is supported by funding raised from investors.

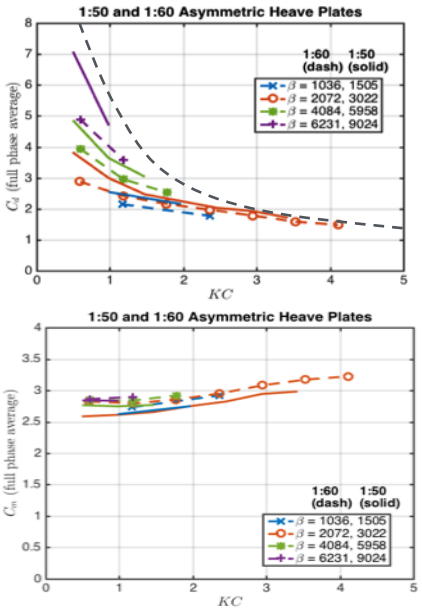
Research Integration & Collaboration

Partners, Subcontractors, and Collaborators:

Glosten
DNV-GL
Oregon State University
Sandia National Laboratories
National Renewable Energy Laboratory

Communications and Technology Transfer:

- Work completed on understanding the Heave Plate hydrodynamics has been presented at the International Conference on Ocean Energy conference.
- This has initiated extended dialogue on some of the challenges and helped identify possible future collaborations (University of Washington and University of Maine)



Next Steps and Future Research

FY17/Current research:

- Project completion is planned for Sept/Oct 2017.
- To mitigate initial lost time, numerical modeling and system engineering tasks will be parallelized where feasible from an execution perspective.

Proposed future research:

- Further refinement and dissemination to the industry through MHK Data Repository of the numerical approaches used in developing the numerical models used in this project can help other WEC developers
- Incorporation of the successful strategy into the Triton-C community scale WEC being demonstrated in Hawaii as part of a recent DOE (1418 Funding Opportunity Announcement) award