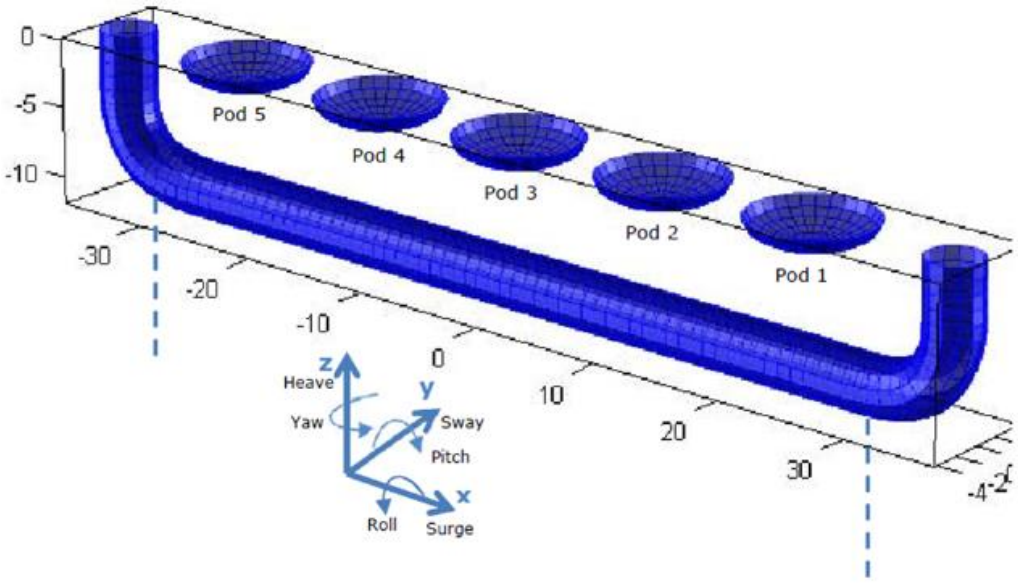
DEHLSEN ASSOCIATES, LLC



WAMIT mesh with WaveDyn model coordinate system for Centipod WEC mid-fidelity model

Numerical Modeling and Experimental Validation of Extreme Conditions Response for the Centipod WEC

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Project Overview

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

"Numerical Modeling and Experimental Validation of Extreme Conditions Response for the Centipod WEC"

Dehlsen Associates, LLC, plans to advance the design of the Centipod wave energy converter (WEC) by reducing extreme condition loads, while also improving the understanding of design tool suitability as pertains to Extreme Condition Modeling for the broader industry.

The Challenge: Extreme condition loads must be reduced in relation to operational loads, allowing for lighter more affordable structures and thus economic viability.

Project Overview

Partners:

DNV GL – Mid-fidelity numerical modelling

NREL, **Sandia National Labs** – High-fidelity modeling

Naval Surface Warfare Center Carderock Division (NSWCCD) – Wave basin testing

Program Strategic Priorities

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

Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- **Conduct R&D for innovative MHK 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

Project Strategic Alignment

Technology Maturity

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

The Impact

- **WEC closer to economic viability:** Ultimate loads reduced by 42%, leading to a 16% reduction in structural capital cost
- **WEC design significantly progressed:** At the conclusion of this project, the load mitigation approach will be selected for this WEC and a final set of load cases will be set completing development of the structure
- **Improved industry-wide understanding of design tools:** Comparison of analysis with mid-fidelity, high-fidelity, and model-scale physical tests, giving evidence on suitability of tools
- **Potential cross-platform load shedding methods:** Mechanical load reduction strategy employed on Centipod may be applied to other WECs

Technical Approach

The approach for this project will follow the process below:

1) Establish baseline load case through usage of a mid-fidelity numerical model and a full sea approach for selection of sea states
2) Model and run load mitigation strategies using a contour approach for selection of sea states, down-selecting to a single load mitigation strategy
3) Run result through full sea state approach

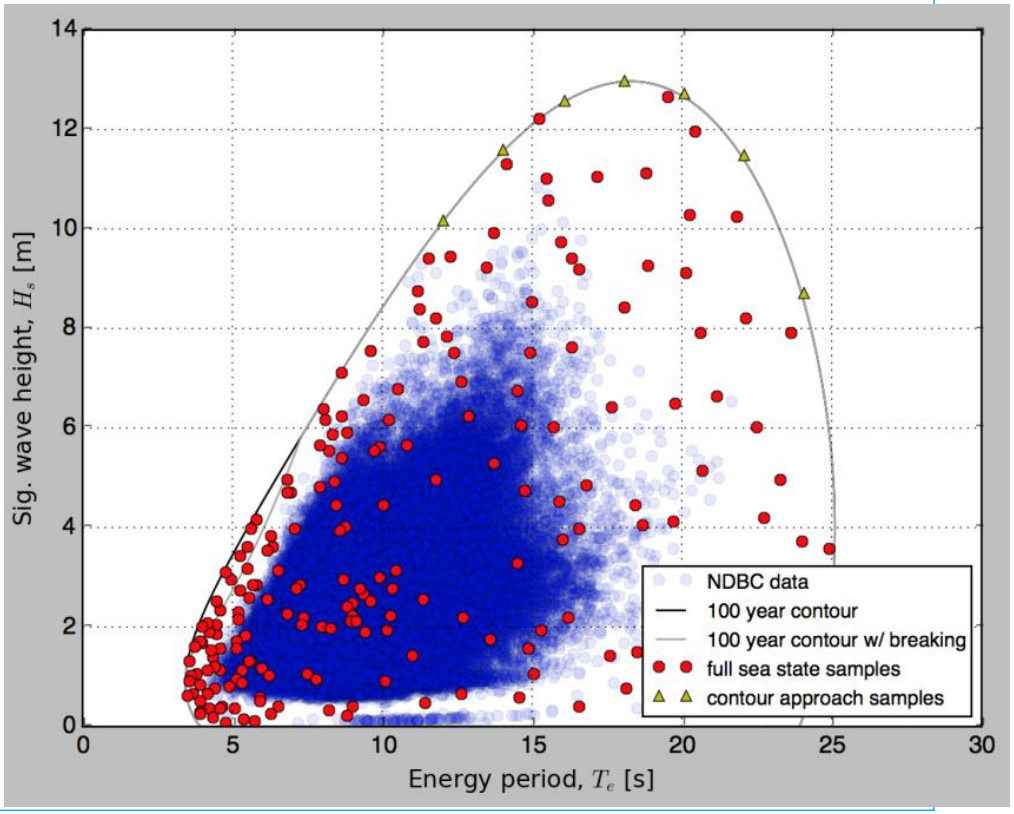

Figure: R.G. Coe, C. Michelen, A. Eckert-Gallup, Y. Yu and J. van Rij, "WDRT: A toolbox for design-response analysis of wave energy converters," METS, Washington, DC, 2016.

Technical Approach

4) Conduct high-fidelity modeling through usage of computational fluid dynamics (CFD) for selected cases
5) Complete wave basin testing of 1:30 scale model of WEC for selected cases
6) Refine and re-run numerical models based on parameters of tested WEC model
7) Define loads for studied cases and evaluate numerical model suitability for extreme load cases

Accomplishments and Progress

- Mid-fidelity model established and baseline loads computed
  - Data are collected that can form baseline load cases
- Assessment of load mitigation strategies underway
  - Computation of these cases will lead to a winning load mitigation strategy shortly

Project Plan & Schedule

- Project started in June 2016
- Project to be completed at the end of Dec 2017
  - Report covering the entire project to be completed and uploaded to MHK Data Repository
- Currently progressing as scheduled

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$0k	$0k	$0k	$0k	$8k	$2k

- No variance from original budget
- $9.998k spent as of 12/01/16 (DOE and Cost-share)
- $750k total project budget (DOE and Cost-share)

Research Integration & Collaboration

Partners, Subcontractors, and Collaborators:

National Renewable Energy Laboratory
Sandia National Laboratories
DNV GL
Navy Surface Warfare Center, Carderock

Communications and Technology Transfer:

- No publications to date
- Deliverables and reports to be submitted to MHK Data Repository
- Public report to be submitted in 2017

Next Steps and Future Research

FY17/Current research:

- Modeling load cases in CFD (in 2017)
- 1:30 scale model fabrication and wave basin test (in 2017)
- Numerical model validation (in 2017)
- 2017 work to culminate in confirmation of structural cost improvement

Proposed future research:

Next steps (outside of project scope) will include testing load mitigation methods on WEC system, demonstrating the benefit of this work on real, full-scale hardware.