Passive Control for WECs (NASA CDOF)

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Project Overview

Point absorber with compressible surface

Rigid surface

Compressible surface

Pressure

Waterline
Passive Control for WECs: Demonstrated that a compressible point absorber, with optimized damping using passive power-take-off (PTO), can increase energy capture by broadening the bandwidth response, similar to an optimally controlled rigid-point absorber requiring a PTO generating reactive power. Eliminating the need for a reactive PTO would significantly reduce complexity and cost, and increase efficiency.

The Challenge: Wave energy converters (WEC) must be tuned to resonate with incident waves in order to capture energy over broad range of incident wave periods.

Partners: National Aeronautics and Space Administration (NASA) (Dr. Robert Haberman, Raytheon Integrated Defense Systems, review and QA/QC)
## 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
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**
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**Target/Performance Metric:** Achieve maximum theoretical limit of absorbed power over full range of incident wave periods

**Impact:** Identified and demonstrated strategy for WEC technology developers to reduce design complexity and cost

**Endpoint & Final Products:** (1) Demonstrated proof of concept; (2) SAND report with study details; (3) Paper submitted to peer-reviewed journal, *Renewable Energy*
WEC power absorption width as a function of angular frequency. the value for $\sigma$ denotes the ratio of the compressible air volume relative to the submerged volume of the point absorber.
Effects on conversion efficiency

Rigid-body: mostly **bi-directional** power flow $\rightarrow$ Efficiency is critical

Compressible-body: **unidirectional** power flow

Conversion efficiency of the PTO is less critical
Implement reactive control with passive PTO
Accomplishments and Progress

- Demonstrated value of compressible degree of freedom for reducing complexity and cost of tunable point absorbers, and for increasing energy absorption
- Successful transfer of NASA technology
Project Plan & Schedule

- Project original initiation date: October 1, 2014 (FY15 start)
- Project planned completion date: September 30, 2015
- Actual completion date: September 30, 2015 (on time and on budget)
## Project Budget

### Budget History

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Partners, Subcontractors, and Collaborators: Dr. Bob Haberman, Raytheon IDS (NASA Contractor), provided QA/QC of model formulation and peer review of SAND report.

Communications and Technology Transfer:
• One SAND report
• One conference presentation: METS 2015
• One peer-reviewed journal manuscript submitted, *Renewable Energy*
Next Steps and Future Research

FY17/Current research: N/A

Proposed future research: Validate numerical modeling approach with experimental measurements. May physically model CDOF at Navy’s Manuvering And Sea Keeping (MASK) basin in FY18 as part of Advanced WEC Dynamics and Control project to verify the dynamics of a compressible point absorber.