



## Azura™ Demonstration at the Navy's Wave Energy Test Site

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**Azura Commercial Prototype Ocean Testing:** The project will build on the success of the half scale demonstration program to design, build and ocean test a commercial scale Azura device with a target levelized cost of energy (LCOE) of less than \$500/MWh.

## **The Challenge:**

- 1) Validate computer simulations with wave tank testing
- 2) Develop full scale hydrodynamic and structural design and LCOE estimates
- 3) Validate WEC-Sim modelling and LCOE estimates with ocean test data

## **Partners:**

**Energy Hydraulics Ltd** – Power take-off (PTO) design

**Sea Engineering** – Marine operations

**University of Hawaii/National Marine Renewable Energy Center (HNMREC)** – Data collection, analysis reporting

## 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

## Technology Maturity

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## The Impact

### Target

The objective of the project is to design, build, and conduct one year of ocean testing of a commercial scale (500kW to 1MW) Azura wave energy device with an LCOE less than \$500/MWh

### Potential Impacts

1. Advance understanding of innovative marine and hydrokinetic (MHK) technologies in the ocean environment
2. Demonstrate system durability in ocean
3. Validate numerical models to allow commercial scale design validation

### Final Product

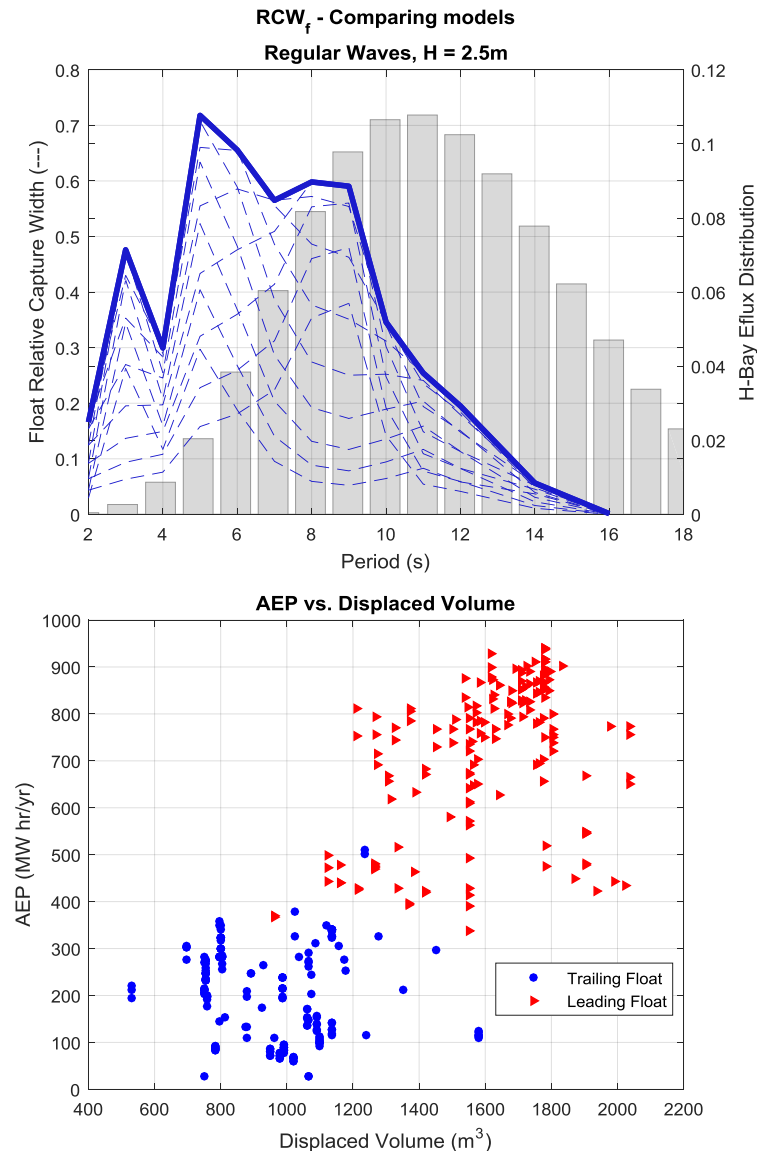
- 12 months of test data correlated with WEC-Sim
- Validation of commercial scale design

## Technical Approach

1. Develop optimized hydrodynamic shape via iterative WEC-Sim analyses
2. Conduct wave tank testing to validate WEC-Sim analyses
3. Complete structural design and analyses
4. Fabricate commercial scale prototype
5. Deploy at U.S. Navy's Wave Energy Test Site (WETS) 80-meter site
6. Ocean test for one year
7. Correlate WEC-Sim models with ocean test data

## Design Process

- Run regular waves, ideal PTO, with wide range of damping values.
- Adjust power for PTO efficiency
- Calculate n Relative Capture Widths for the n damping values
- For each  $H_{m0}/T_e$  bin,  $AEP_{bin} = RCW_i * (Annual\ Energy\ Flux)$ ;  $RCW_i$  gives max AEP for bin
- Annual energy production (AEP) total =  $(AEP_{bin}\ matrix) * (occurrence\ matrix)$



## **2015 Accomplishments**

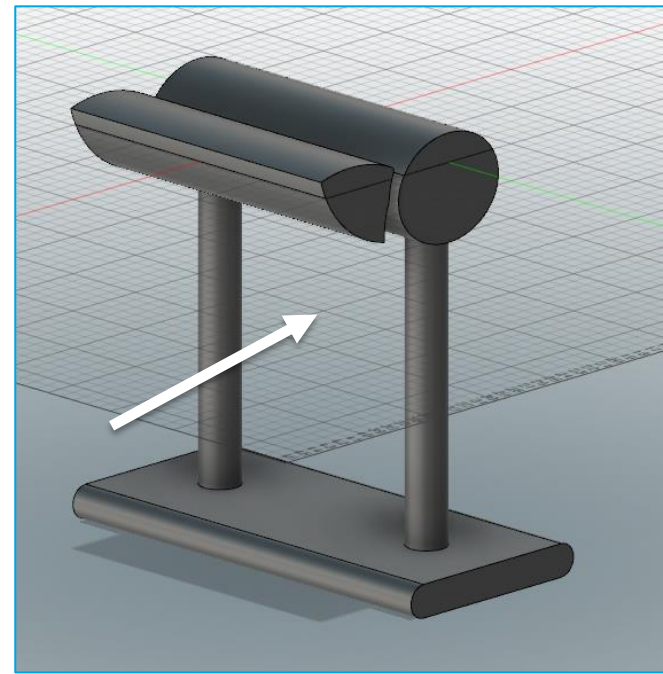
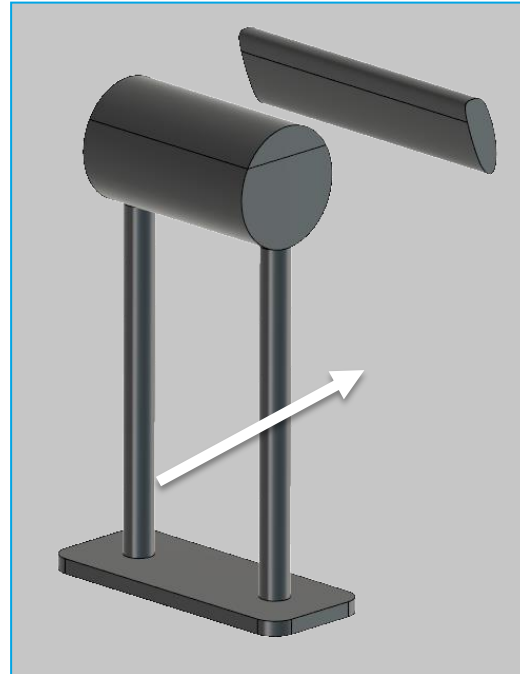
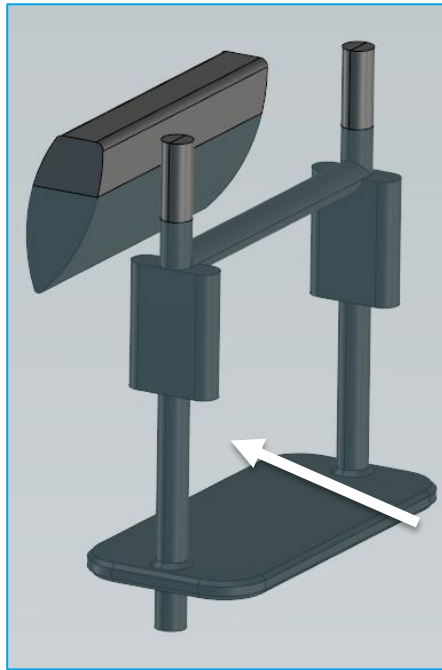
- Initiated design—July
- Completed approximately 500 design iterations and selected optimal design for wave tank testing—November
- Discovered WEC-Sim sign error—December

## **2016 Accomplishments**

- Initiated redesign process with modified WEC-Sim code—January
- Completed approximately 450 design iterations and selected optimal design for wave tank testing—April 2016
- Completed Wave Tank Test Planning—May 2016
- Notified of second WEC-Sim sign error by NREL—June 17 2016
- Completed cooperative research and development agreement (CRADA) with Naval Facilities Engineering Command (NAVFAC)—June 2016
- Initiated second redesign process with modified WEC-Sim code—
- July 2016
- Completed approximately 360 design iterations—December 2016



# Accomplishments and Progress



Design Date	December 2015	May 2016	December 2016
Initial AEP	990 MWh	950 MWh	920 MWh
Revised AEP	390 MWh	N/A	N/A
Volume	1,370 m <sup>3</sup>	1,020 m <sup>3</sup>	1770 m <sup>3</sup>



- **Initial Start Date:** January 2015
- **Planned Completion Date:** 2020
- **Actual Completion Date:** N/A
- **Schedule Slips**
  - First WEC-Sim error (+6 months)
  - Second WEC-Sim error (+6 months)
- **Go/No-Go Decision Points:** Planned for Q1 2017 based on completion of third design iteration

## Budget History

FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
		\$377.939k	\$53.855k	\$529.939k	\$172.915k

- **Total Project Budget:** Federal: \$4,805k, Cost-share: \$4,312k
- **Variiances:** Budget Period 1 will be completed on budget
- **Expenditure:** 78.9% of BP1 as of September 30, 2016
- **Other Funding Sources:** None

## Partners, Subcontractors, and Collaborators:

**Energy Hydraulics Ltd**—PTO development

**Makai Engineering**—detailed design (BP2)

**Sea Engineering**—Marine construction and operations (BP2)

**UH/HNMREC**—Data collection, analysis, and reporting (BP2)

**NREL**—extreme event modelling (BP1), instrumentation and data acquisition system (BP2)

**NAVFAC**—WETS site management (BP2)

## Communications and Technology Transfer:

**Website:** [www.azurawave.com](http://www.azurawave.com)

## FY17/Current research:

1. **Wave Tank Testing** – to be completed Q1 2017 at Hinsdale
2. **Preliminary Structural Design** – to be complete to support LCOE model
3. **PTO Redesign** – revise PTO design based on third generation hydrodynamic design
4. **LCOE Modelling** – utilize
5. **Go/No Go Decision for BP2**
6. Complete Structural Design – to support detailed manufacturing estimate and updated LCOE model
7. **Order long lead materials** – to support fabrication in 2018

## Proposed future research:

**Advanced Controls** – award received under SPA-II FOA