

# Water Power Technologies Office (WPTO) Marine and Hydrokinetic

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



## Controls Technology Overview

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Bill McShane –  
[william.mcshane@ee.doe.gov](mailto:william.mcshane@ee.doe.gov)  
Water Power Technologies Office

[water.energy.gov](http://water.energy.gov)

# Controls Session Overview

## Controls Technology Overview:

- Studies have shown that advanced control can provide significant increases (on the order of 200-300%) in Wave Energy Capture (WEC) energy absorption.
- Controls strategies and technologies are being leveraged from other industries (e.g. aerospace, defense) that can maximize ocean energy capture over a range of ocean conditions.
- We have more wave controls projects than current / tidal projects (the controls value proposition is greater for WECs)

**The Challenge:** The kinetics of the oceans are complex, random, and harsh. An Marine Hydrokinetic (MHK) device that can't be tuned to real-time or near real-time ocean conditions will seldom extract the maximum amount of energy available. A clever design or control strategy, extracting the maximum amount of energy over a wide band of ocean conditions, is essential for increasing energy capture and reducing Levelled Cost of Energy (LCOE).

# Controls Session Overview (continued)

**2014 Peer review and response:** In 2014, DOE controls research was just beginning.

- More industry projects should be initiated and that National Laboratory projects should engage with industry to maximize industry benefit.
- Leverage Controls from other sectors (Defense, Aerospace, etc.)

**The WPTO listened. Please let us know if we have taken Controls projects in the most beneficial direction.**

- Six industry projects and two National Laboratory projects have been undertaken.
- National Laboratories have engaged directly with industry to refine research efforts through webinars as well as planning an upcoming controls workshop during the IMREC METS conference in May.
  - Ensure Lab products are relevant
  - Ensure Lab products are disseminated
- Controls research and testing has leveraged defense and aerospace successes.

# The Controls Portfolio Aligns with Program Strategic Priorities

## 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 among coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

**Five Industry lead and two Lab lead projects**

## 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
- Form 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

**One Industry lead project**

# Marine and Hydrokinetic Controls Technologies

## Phase I/Phase II Projects Timeline

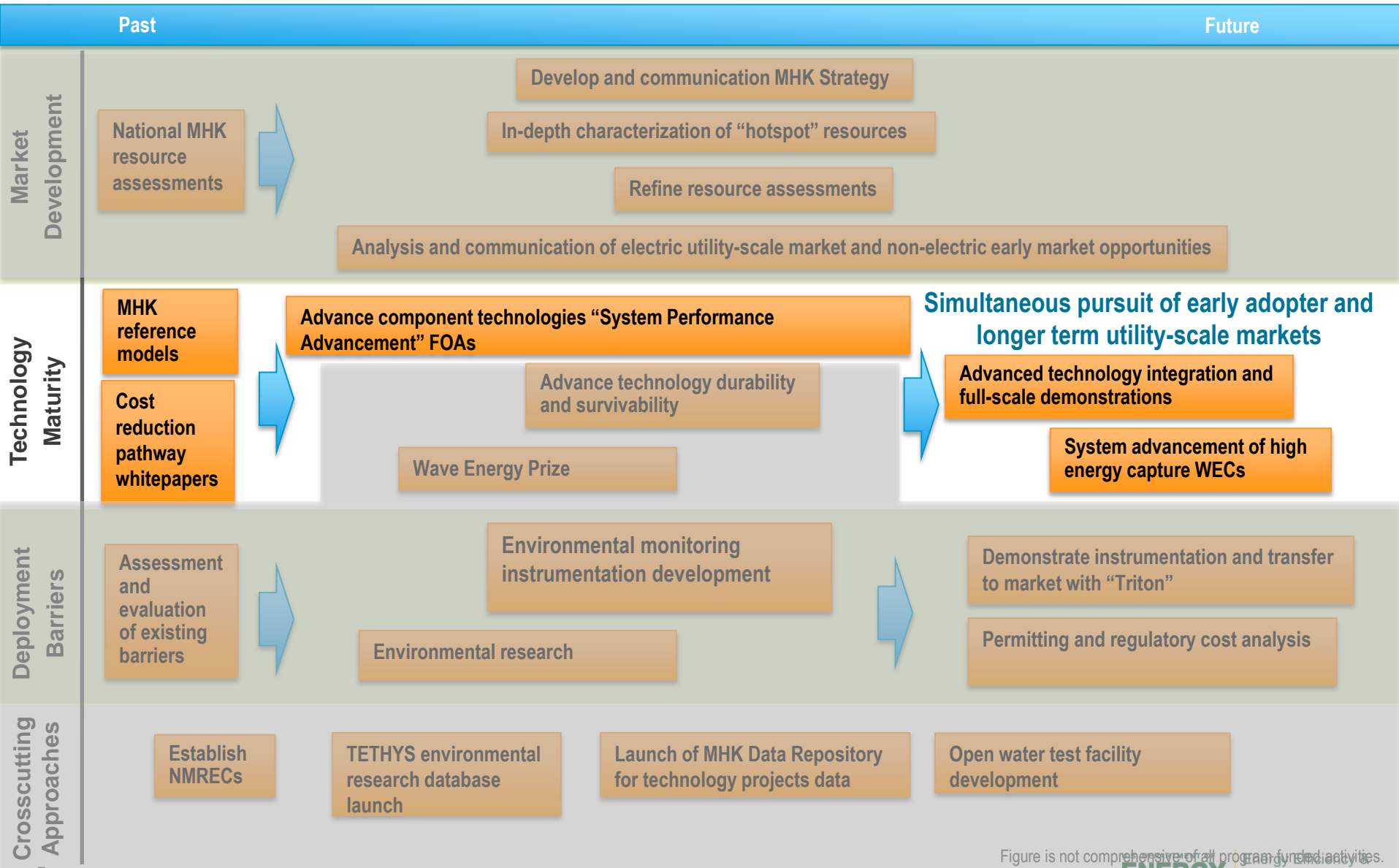


Figure is not comprehensive of all program-funded activities.

# Marine and Hydrokinetic – Controls Technology Projects

## Cost Reduction Opportunities-informing Investments

**Cost reduction opportunity**

- Averaged across wave and tidal
  - Wave: 63¢ per kWh
  - Tidal: 33¢ per kWh

**Installed Capital Cost**

- Advanced Materials, innovative manufacturing, array layout, design for resource class, efficient installation and permitting

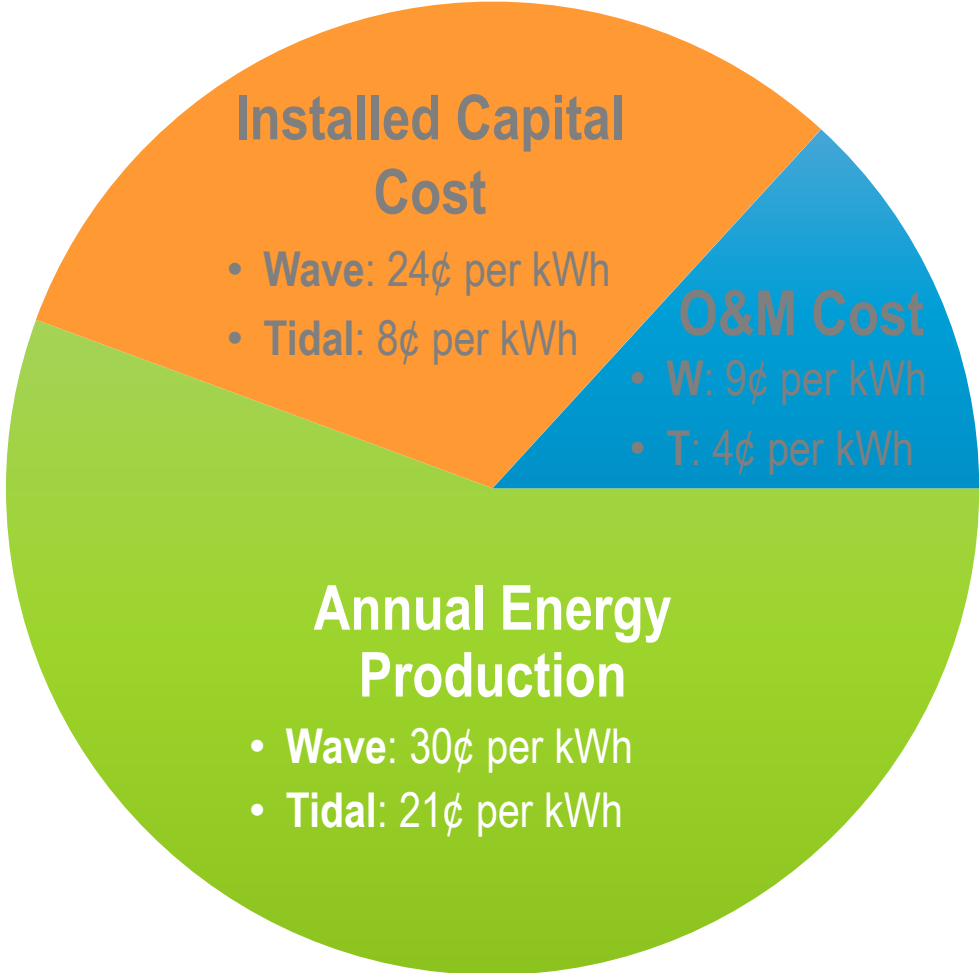
**Operations & Maintenance (O&M)**

- Prognostic maintenance, design for service/survivability, advanced coatings

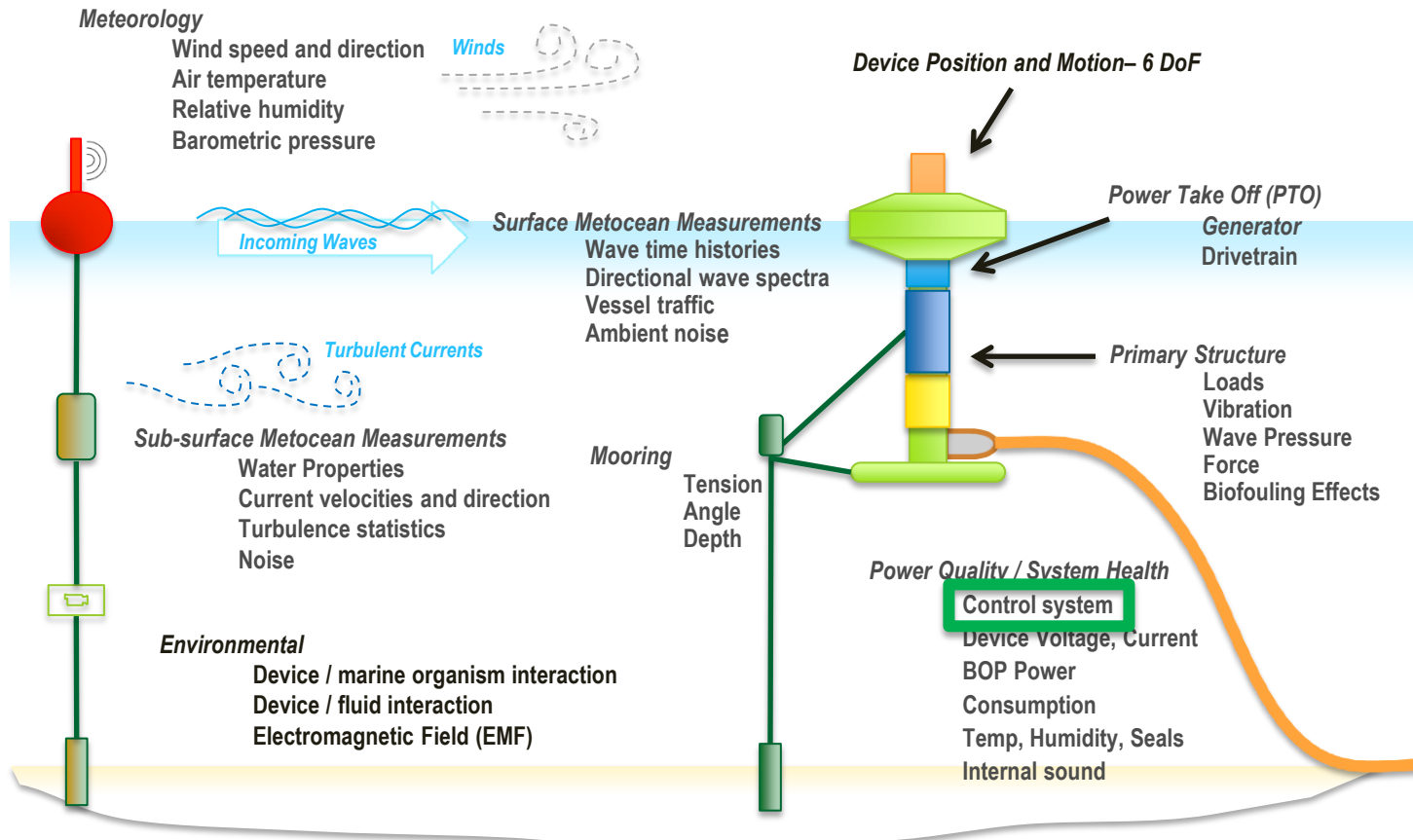
**Annual Energy Production**

- Energy Capture/Conversion Efficiency, Resource Characterization **Advanced Controls**, Optimized Structures

### Cost reduction potential between now and 2030

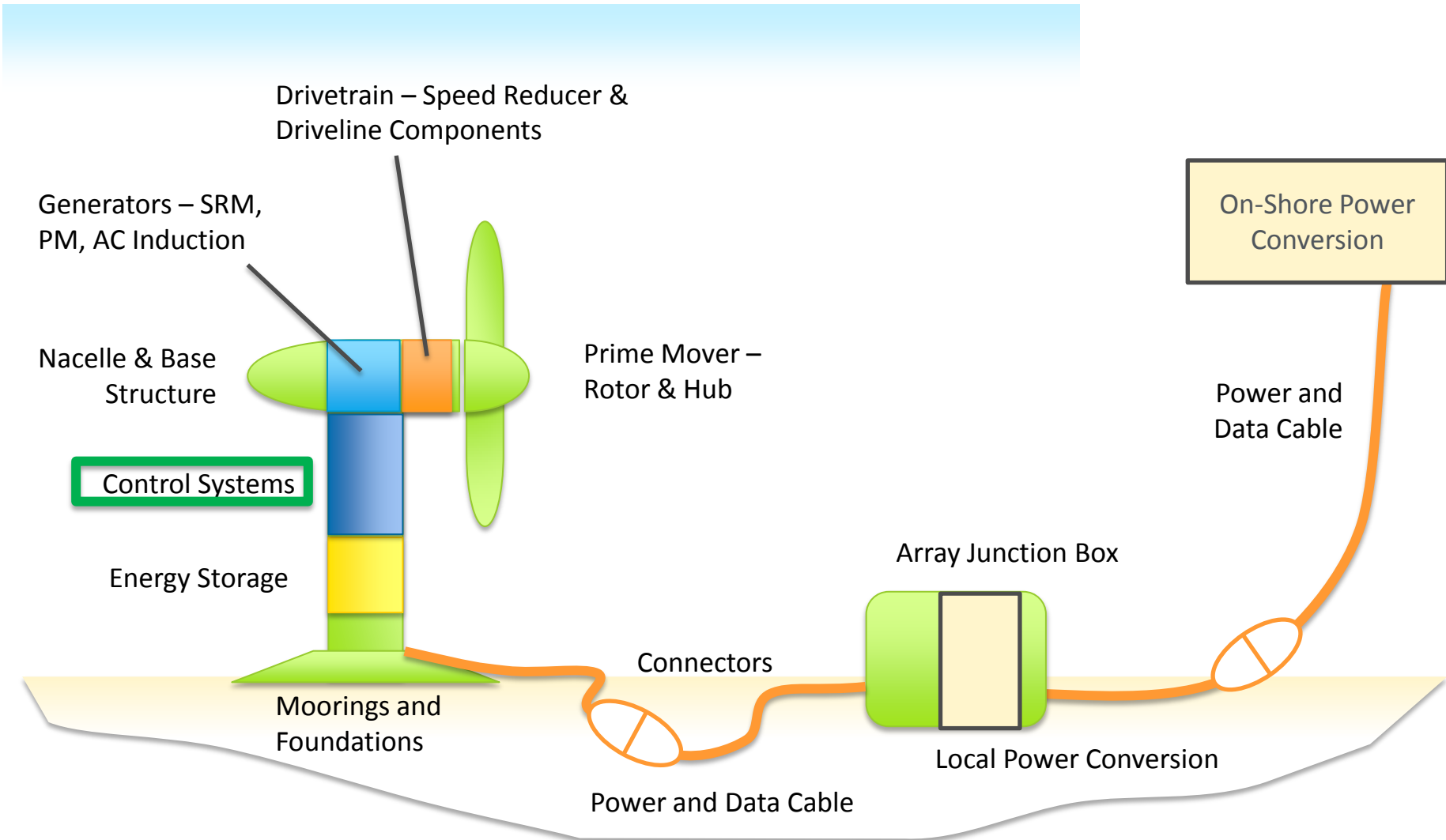


# MHK Controls Opportunity: Responding to the Real-Time Environment



# Opportunity:

## Controls Can Be Used to Maximize Tidal /Current Energy Capture





# Control Projects Timeline

Key:

**Green:** Wave technologies

**Blue:** Current technologies

Gray: not briefed in this session

re vision

specific wave energy technologies:



three Industry projects



Resolute Marine Energy  
Clean Power from Ocean Waves

potentially supporting **multiple wave device archetypes:**  
one Industry and two Lab projects

Oregon State  
UNIVERSITY



2013

2014

2015

2016

2017

2018

2019

specific current energy  
technologies:  
one Industry project



specific current energy technologies:  
one Industry project (see task 5 in ALFA)

## Rapid Innovation

- 92 teams registered in competition to double energy capture from waves
- **Five-fold improvement** from winning team; four of nine finalists exceeded DOE's goal
- **Technology advancements** are helping to accelerate the pace of commercialization
- Winner **implement a fast tuning control system** in the tank test
- Sandia's Advanced Controls project provides a **public test data and analysis** provides a 'roadmap to controls'



**Controls technologies are essential for the MHK Industry to thrive**