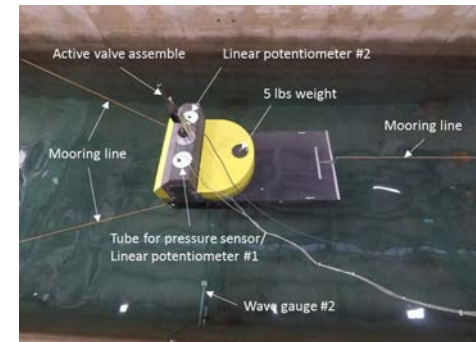


Overview of Foundational and Crosscutting Research and Development



Marine and Hydrokinetics Program

Tuesday, October 8, 2019

Bill McShane,
Marine Energy Technology
Manager
Water Power Technologies Office

Marine and Hydrokinetics (MHK) Program Strategic Approaches

Data Sharing and Analysis

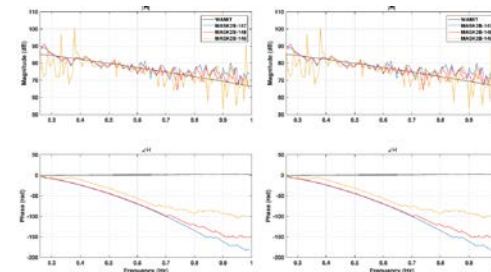
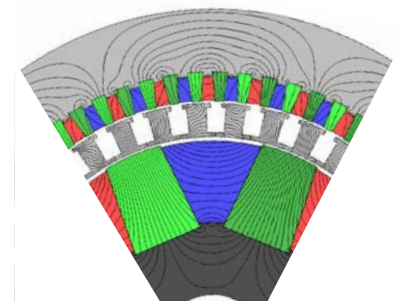
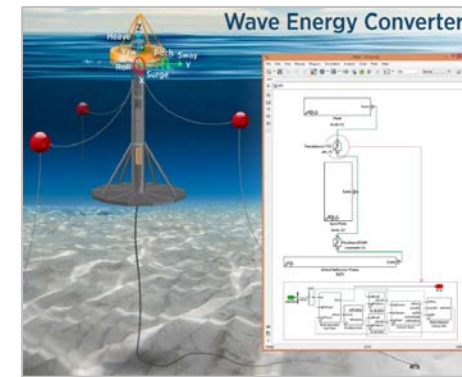
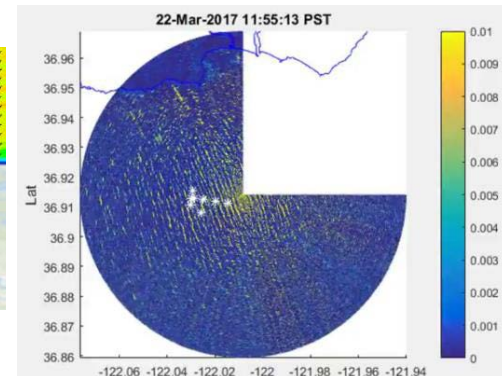
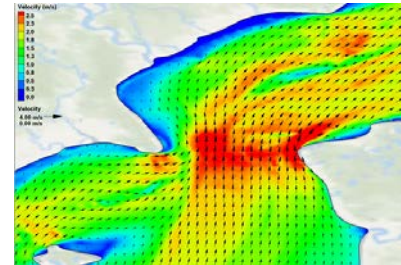
Foundational
and
Crosscutting
R&D

Technology-
Specific
Design and
Validation

Reducing
Barriers to
Testing

Foundational and Crosscutting R&D

- Drive innovation in components, controls, manufacturing, materials and systems with early-stage R&D specific to MHK applications
- Develop, improve, and validate numerical and experimental tools and methodologies needed to improve understanding of important fluid-structure interactions
- Improve MHK resource assessments and characterizations needed to optimize devices and arrays, and understand extreme conditions
- Collaboratively develop and apply quantitative metrics to identify and advance technologies with high ultimate techno-economic potential for their market applications



Foundational and Crosscutting R&D Presentations: Tuesday, October 8th

Start	End	Agenda Session	Presenter	Affiliation	Track
1:20 PM	1:40 PM	Overview of Foundational & Crosscutting R&D	Bill McShane	WPTO	Foundational R&D
1:40 PM	1:50 PM	Introduce FOA Projects	Yana Shininger	WPTO	Foundational R&D
1:50 PM	2:20 PM	Reduction of System Cost Characteristics through Innovative Solutions to Installation, Operations and Maintenance	Michael Ondusko	Columbia Power Technologies, Inc.	Foundational R&D
2:20 PM	2:50 PM	Demonstration of an Advanced Multi-Mode Point Absorber for Wave Energy Conversion	Tim Mundon	Oscilla Power, Inc.	Foundational R&D
2:50 PM	3:20 PM	Advanced TidGen Power System	Jarlath McEntee	Ocean Renewable Power Company (ORPC) - Maine	Foundational R&D
3:20 PM	3:35 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Foundational R&D
3:35 PM	3:50 PM	Coffee Break			
3:50 PM	4:00 PM	Introduce Lab Projects	Jeff Rieks	WPTO	Foundational R&D
4:00 PM	4:30 PM	Wave Energy Converter (WEC) Modeling	Yi-Hsiang Yu	NREL, SNL	Foundational R&D
4:30 PM	5:00 PM	DTOcean (Optimal Design Tools for Ocean Energy)	Jesse Roberts	SNL	Foundational R&D
5:00 PM	5:30 PM	Material Design Tools for Marine and Hydrokinetic Composite Structures	Bernadette Hernandez-Sanchez	SNL, PNNL, NREL	Foundational R&D
5:30 PM	5:45 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Foundational R&D
5:45 PM	6:15 PM	Peer Reviewer Only Meetings			

Foundational and Crosscutting R&D Presentations: Wednesday, October 9th

Start	End	Agenda Session	Presenter	Affiliation	Track
9:50 AM	10:00 AM	Introduce Lab & FOA Projects	Bill McShane	WPTO	Foundational R&D
10:00 AM	10:30 AM	Optimal Wave Energy Converter (WEC) Controls using Causal and MPC Methods	Mirko Previsic	Re Vision Consulting, LLC	Foundational R&D
10:30 AM	11:00 AM	Wave Prediction Leveraging Multiple Measurement Sources – A Sensor Fusion Approach	Mirko Previsic	Re Vision Consulting, LLC	Foundational R&D
11:00 AM	11:10 AM	Coffee Break			
11:10 AM	11:40 AM	Advanced Wave Energy Converter (WEC) Dynamics and Controls	Ryan Coe	SNL	Foundational R&D
11:40 AM	12:10 PM	Wave Energy Converter (WEC) Design Optimization	Ryan Coe	SNL	Foundational R&D
12:10 PM	12:30 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Foundational R&D
12:30 PM	1:15 PM	Lunch			

Foundational and Crosscutting R&D Portfolio

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Advanced Materials

- Advanced Materials
- Three Labs collaborating

Controls

- Dehlsen (FOA 1182)
- Advanced WEC Dynamics and Controls
- Advanced WEC Controls IAA (2015 Project)
- ReVision Optimal WEC Controls (DE-EE0007173)
- ReVision Wave Prediction Sensor Fusion (DE-EE0008099)
- Portland State University –(FOA 1837)
 - SNL Support to Portland State University (FOA 1837)
- CalWave Power Technologies, Inc. - FOA 1837
 - NREL Support to CalWave (FOA 1837)
 - SNL Support to CalWave (FOA 1837)
- SPA I and II: supporting HQ evaluation of awardee technical progress in controls and structures
- Fatigue and Structural Load Analysis and Control for Variable Geometry Wave Energy Converters

Modeling

- Wave Energy Converter Modeling
- M3 Wave - WEC-Sim (SBV)
- DTOcean
- WEC Array Power Management And Output Simulation Tool
- WEC Design Optimization

13 lab projects
11 industry FOAs
4 FY19 SBIRs / STTRs
1 SBV / 3 lab support / 1 IAA

Components

- Virginia Tech (FOA 1182)
- Columbia Power PTO Dyno Testing (System Performance Advancement FOA)
- Columbia Power PTO Validation Award, DE-EE0006399
- Columbia Power Structural Optimization Award, DE-EE0006610
- Columbia Power Full Size Float Structural Testing (System Performance Advancement FOA)
- Siemens (formerly Dresser Rand) Hydro Air Turbine Project, DE-EE0006609
- Wave Energy Converter Interlink Umbilical Cables Design Requirements, Best Practices And Recommended Design Improvements
- 2019 SBIR/STTR
 - 14.b. Ocean Energy Storage Systems: Oscilla
 - 14.c. Pumping and Compression using MHK energy: PCCI, Resolute Marine, Pliant Energy

Resource Characterization

- Model Validation and Site Characterization for Early Deployment MHK Sites and Establishment of Wave Classification Scheme
- National Resource Refinement Using 30 Year Hindcast Data
- DoD MHK Deployment Opportunity Identification
- Early Market Opportunity Hot Spot Identification and Resource Characterization (Tidal Resource Gap Analysis)

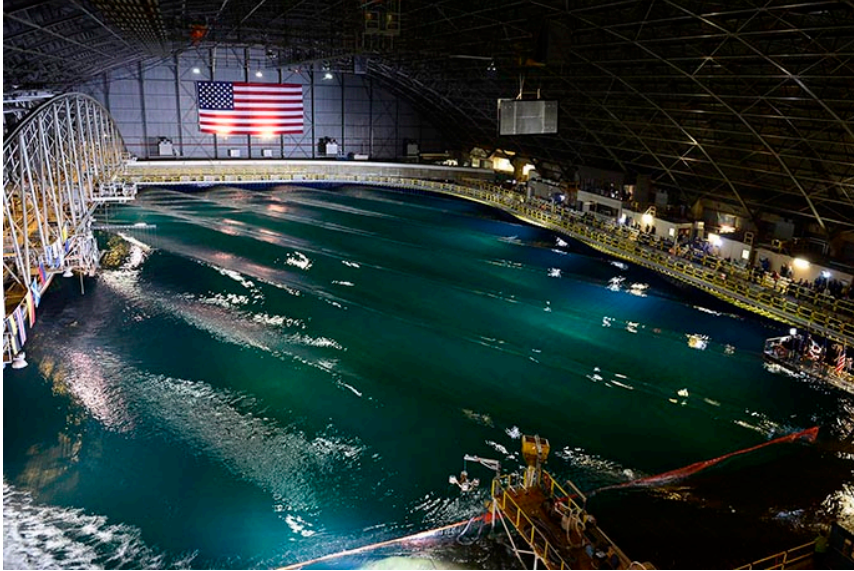
- Several cohorts of projects within the Foundational and Crosscutting R&D technology space address challenging high impact technology areas
- Q4FY19 - NREL researchers, in collaboration with PNNL, developed a refined wave resource assessment methodology that includes the wave resource due to local winds, and accounts for wave directionality. Earlier version of the U.S. wave resource assessment fell under criticism for not properly accounting for these factors. The new methodology results in a 30% increase in the US wave resource total, and these results were presented to DOE and at the European Wave and Tidal Energy Conference in Napoli, Italy. Now, the NREL/PNNL team is working on publishing these results in a top-ranking journal, and building international consensus around the new methodology.
- Controls portfolio has investments in causal and non causal methodologies
- Projects test in multiple venues: in US Navy Maneuvering and Seakeeping basin (MASK); other test basins or tanks; and the open ocean
- Many projects have a mix of industry, university, and Lab collaboration spreading knowledge and improving research

Program Management Approach

FY17-FY19 MHK Program Budget by Activity



Program Management Approach



- Large scale Columbia Power Technologies dynamometer testing at National Wind Technology Center in 2017 (largest generator ever tested at facility)
 - Leveraged Navy radar data sets on ReVision sensor fusion project
 - Portland State to design, fabricate, and test a hermetically sealed 50 kilowatt (kW) multistage 59:1 gear ratio magnetically geared generator (MGG). A 5 kW sub-scale version was also built to reduce risk.
-
- Advanced WEC Control tests in U.S. Navy MASK Basin three separate times, validating theoretical control methodologies and novel approaches; Dehlsen conducted survivability research in the MASK Basin (above)
 - WEC Control Competition (WECCOMP) results presented Q1FY19
 - Updated MHK Resource Atlas in 2019
 - Public Release of DTOcean V2.0, 2019

- Industry engagement of Lab projects via Marine Energy Council (MEC) transparency series and through individual projects outreach
- Numerous conference papers published (Advanced WC Controls dataset is the most popular download on MHKDR); open source code posted on GitHub; training courses and informational webinars given
- WEC control competition (WECCOMP)
- Teaming approach
 - Projects set up and use advisory boards with industry members for feedback
 - Industry, university, and Lab collaboration on many projects
 - Diverse subcontractors with relevant marine energy companies and universities

National and International Influence



International Electrotechnical Commission Technical Committee (IEC TC) 114 marine energy specifications and standards participation and collaboration



Support International Energy Agency Ocean Energy Systems (IEA OES) tasks

DTOcean was an international collaboration between 18 European institutions from 11 countries and Sandia National Labs (SNL) in the United States.

- Research foundational technologies that are applicable to PBE and grid
- Marine and Hydrokinetic Graduate Student Research Program
 - Supports MHK Foundational and Crosscutting Research and Development portfolio
- Marine energy materials strategy publication
 - WPTO has a Fellow on staff with materials background
- Co-Design
- Engagement with other DOE and federal offices
 - DOE, ARPA-E, NOAA, DoD, ...
- Numerical modeling and code validation
 - Some incremental and some strategic improvements are desired
- Complete high-resolution wave models for all remaining U.S. EEZ regions; publicly release high-resolution wave energy resource time series
- Continued international collaboration with IEC TC 114, IEA OES, and DTOceanPlus



The poster features two photographs of marine energy devices: a blue and yellow floating structure in the water, and a brown and yellow device mounted on a barge. Below the photos, the text reads: **MARINE AND HYDROKINETIC GRADUATE STUDENT RESEARCH PROGRAM**. To the right, it says: **Further your career and advance your doctoral thesis at the same time!**. Below this, it states: **Open to full-time doctoral students with research thesis/dissertation at a U.S. institution. U.S. Citizen or LPR only.** **Benefits include:** Stipend, Health Insurance Supplement, Relocation, Training and Travel Allowance, and Tuition Reimbursement. A red **Apply Now!** button is present. At the bottom, it says: **Visit the program website at orise.oraui.gov/mhk-research-program** and **Application Deadline: December 9, 2019**. Logos for the U.S. Department of Energy, Energy Efficiency & Renewable Energy, and the Oak Ridge Institute and Science Center are at the bottom.