



Technology-Specific Design and Validation

J. Elaine Buck

Tessa Greco, Carrie
Schmaus, Yana Shining,
Simon Gore

Activity Area Overview

Technology Specific System Design & Validation

Validate performance and **reliability** of marine energy systems through **prototype testing**, including **in-water testing**, for grid-scale, power at sea, and **resilient coastal community markets**.

Powering the Blue Economy

Lab/Open
Water Testing

Power at Sea

Resilient
Coastal
Communities

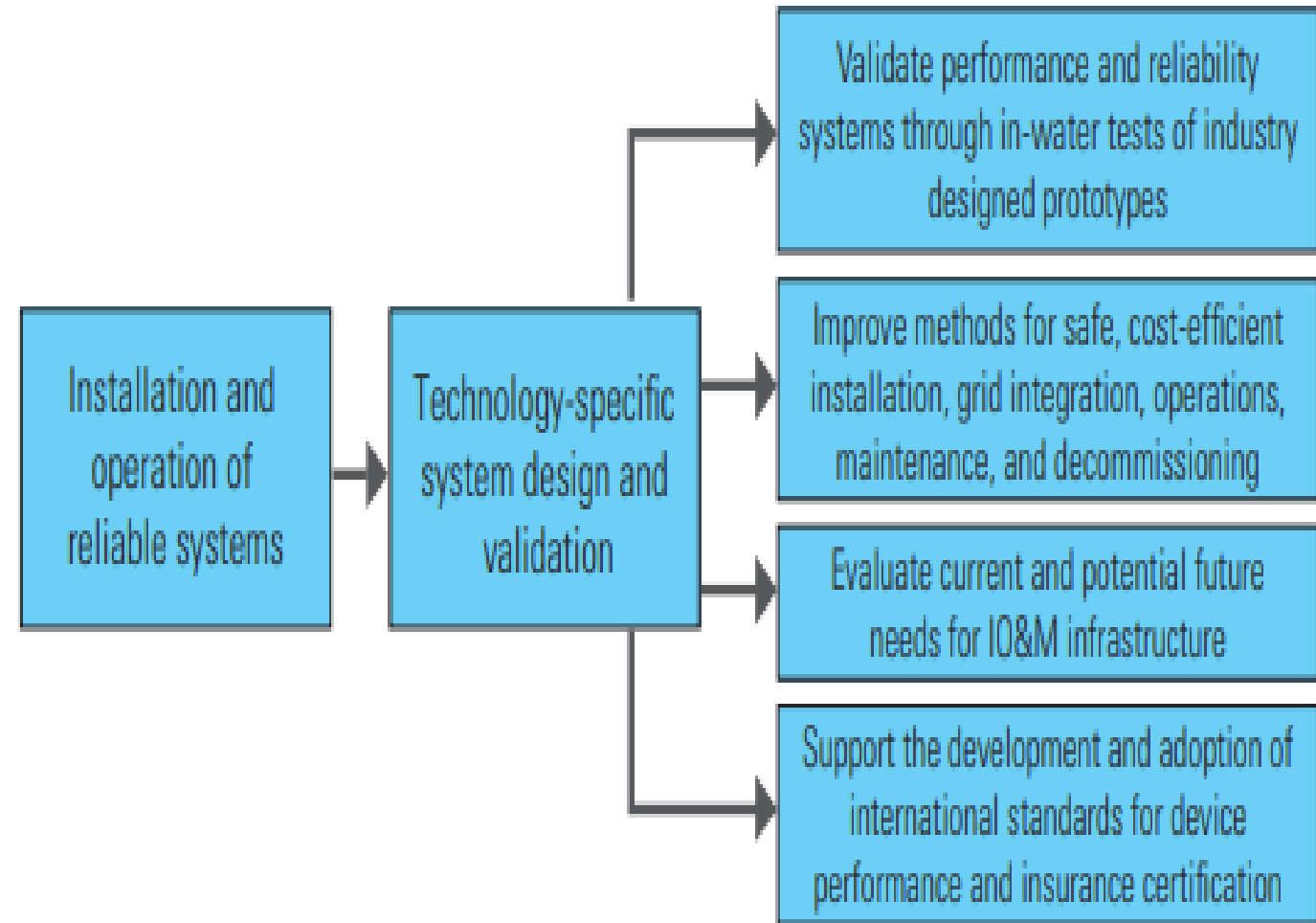
IEC/IECRE ME
standards
integration

Challenge: Installation and Operation of reliable systems

Limited infrastructure to deploy marine energy devices



Difficulties in developing methods for IO&M



Stakeholder Engagement Activities



Marine Energy in the United States: An Overview of Opportunities

Levi Kilcher, Michelle Fogarty, and Michael Lawson

National Renewable Energy Laboratory



Peer Review Feedback

FOA development/RFI's

Industry Conferences

Workshops/Webinars

Projects/FDRs

Lab targeted studies

Performance Objectives

Key Results and Performance Goals (2021–2025)

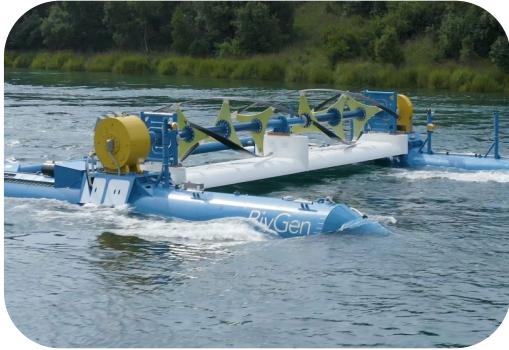
- Complete initial field-testing for modular current energy converter systems that capture hydrokinetic river energy in low-flow environments (less than 2 m/sec) and can incorporate and advance IO&M techniques, which require only limited use of port and deployment vessel infrastructure.
- Complete first year-long field tests of wave energy converter device designs in fully energetic wave environments (likely at the PacWave facility).
- Complete at-sea, pre-commercial demonstrations of newly developed marine energy-powered ocean observing systems and desalination systems.
- Concept refinement, design, and small-scale prototype testing of new wave energy system concepts with high techno-economic potential.
- Establish U.S. capabilities for third-party certification of compliance to IEC Technical Specifications to include Power performance assessment, Assessment of mooring systems, Electrical power quality requirements, and Measurement of mechanical loads at PacWave wave energy test facility, and Power performance assessment of Current Energy Converters tested with the Mobile Test Vessel.

Performance Objectives

Follow-On Objectives (2026–2030)

- New, commercially available marine energy-powered ocean observation systems are deployed for a variety of uses.
- Wave powered desalination systems are deployed for the first uses in disaster recovery or international development scenarios.
- Documented improvements in energy-water system resilience and security for a number of targeted remote communities, enabled by marine energy systems.
- International standards developed for device performance and insurance certification for grid-scale and blue economy market applications. Standards use established as best practice for all device tests and deployments.
- First in-water, integrated system tests for newly developed wave energy device concepts.
- Design and testing of megawatt (MW) scale current energy converter devices/arrays that incorporates installation, operation, and maintenance lessons.

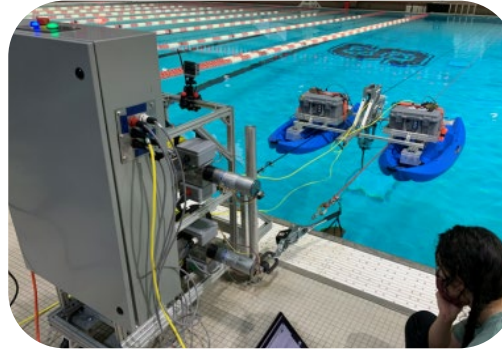
Research Priorities System Design and Laboratory Testing



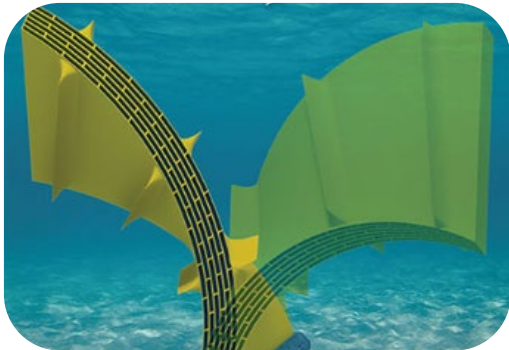
Design/Test modular, low flow river instream devices



MTV



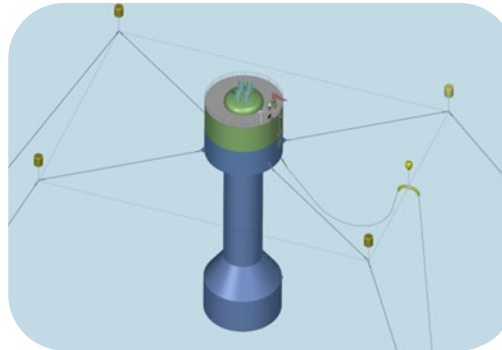
Lab/tank testing novel designs



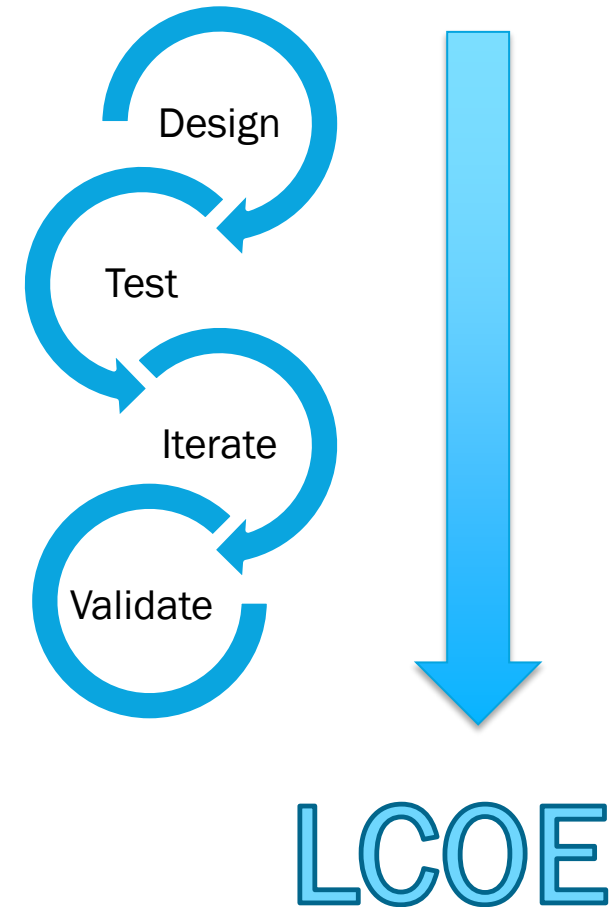
Perform initial investigation of new wave device archetypes; flexible, non-rigid-body



Develop kW WEC's



Develop PacWave compatible WECs



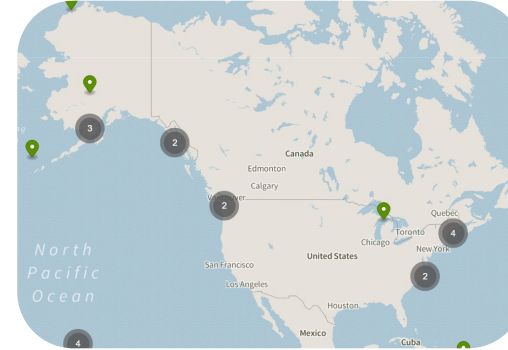
Research Priorities Open Water Testing



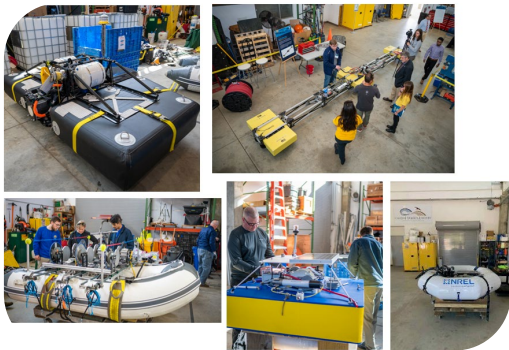
Field validation
WETS



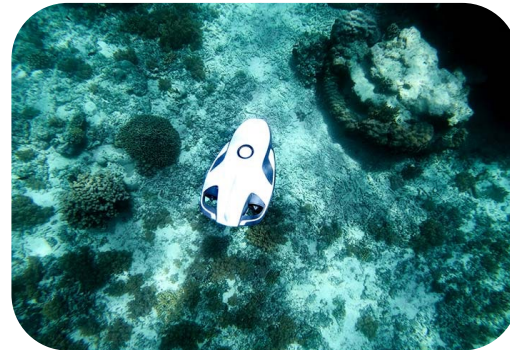
Field validation of
tidal/river current
sites



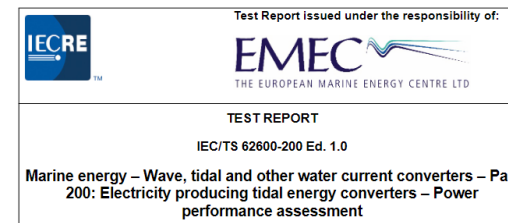
ETIPP



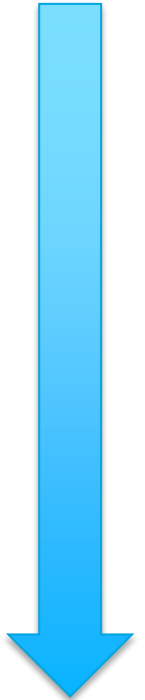
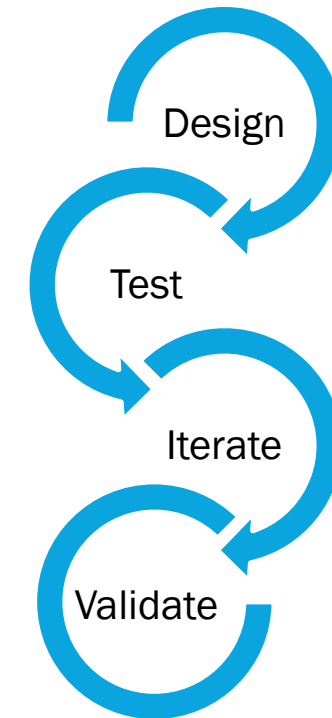
PBE Waves to Water



PBE Ocean
Observation



Standards



LCOE

Key Accomplishments

2019

Waves 2 Water Launched
ME Collegiate Competition
ME Seedlings Lab call
FOA for advancing WEC
designs; ME centers
research infrastructure
upgrades



Propose a Wave Powered System Up to 20 Winners (\$200,000 Cash Prize Pool)	90 days
Develop Detailed Plan and Model 10-20 Winners (\$800,000 Cash Prize Pool)	120 days
Design for Testing Up to 10 winners (\$900,000 Cash Prize Pool)	180 days
Demonstrate Working Principles Up to 7 Winners (\$500,000 Cash Prize Pool)	180 days
Test & Demonstrate in the Ocean Grand Prize up to \$500,000; and individual Metrics Prizes up to \$500,000	180 days

2020

Marine Energy
Infrastructure Lab Call
SBIR Phase 1 Marine
Energy funding
Operation and
Maintenance of the Ocean
Energy Institute (OESI)



2021

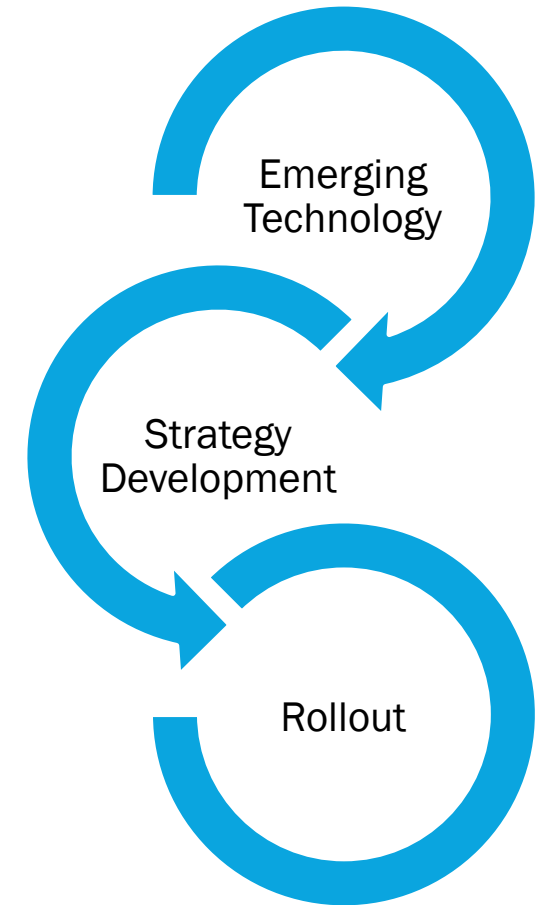
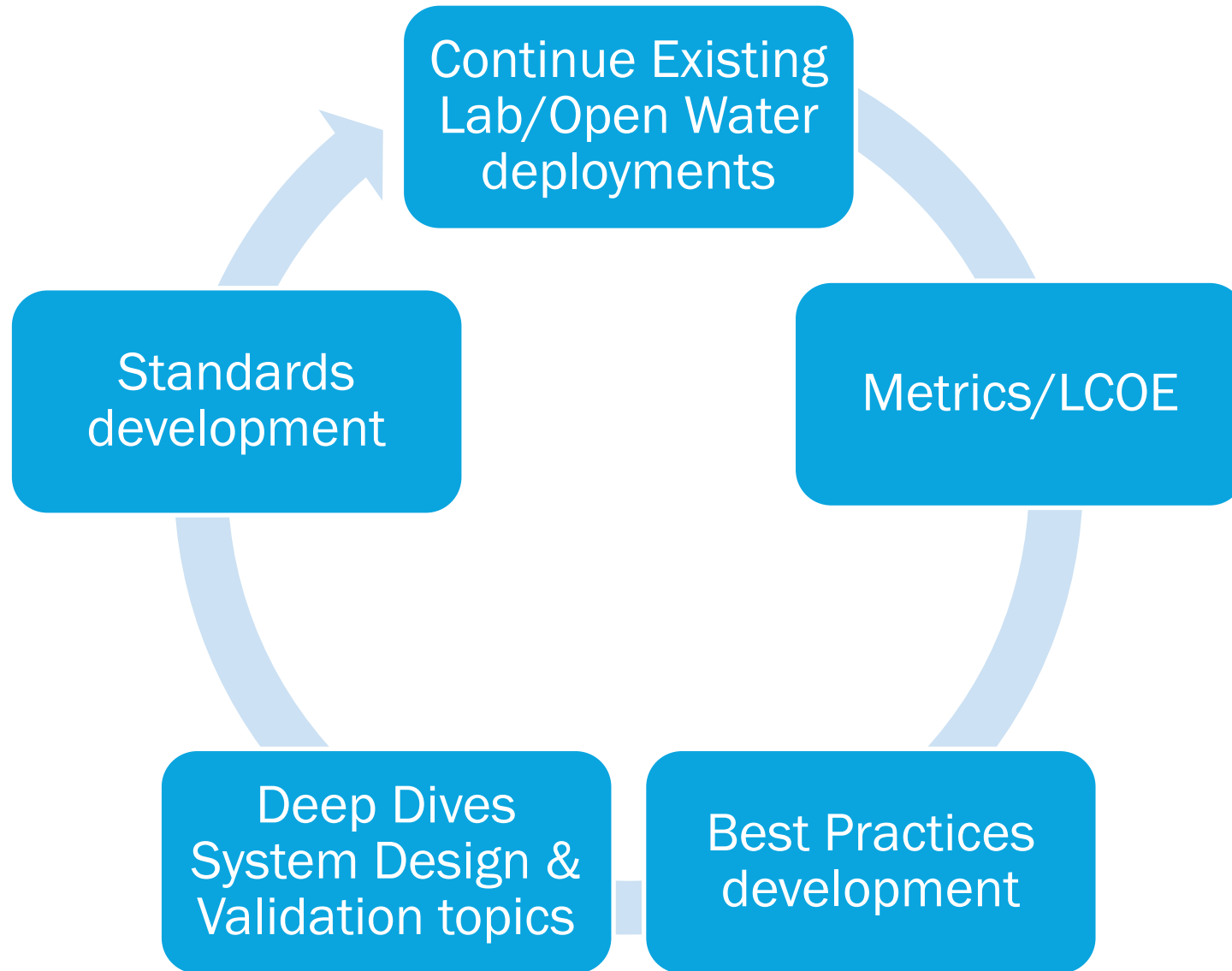
Ocean Observing Prize
Launched
FOA: PacWave
RFP Coastal communities
Co-Existence with ME.



Project accomplishments

Project Title	Recipient
Technology-Specific System Design and Validation Activity Area Overview	WPTO
REDUCTION OF SYSTEM COST CHARACTERISTICS THROUGH INNOVATIVE SOLUTIONS TO INSTALLATION, OPERATIONS, AND MAINTENANCE	Columbia Power Technologies, Inc.
OPEN WATER TESTING OF A SCALED NEXT GENERATION POINT ABSORBER WAVE ENERGY DEVICE WITH PHASE CONTROL	Aquaharmonics, Inc.
WATER HORSE HYDROELECTIC HARVESTER DEVELOPMENT	University of Alaska Fairbanks
Performance Optimization and System Demonstration of a Multi-Mode Point Absorber	Oscilla Power, Inc.
CYCLOIDAL WAVE ENERGY CONVERTER	Atargis Energy Corporation
DESIGN, BUILD AND TEST OF NOVEL, REMOTE, LOW-POWER WAVE ENERGY CONVERTER FOR NON-GRID APPLICATIONS	Columbia Power Technologies, Inc.
Hawaii Wave Surge Energy Converter (HAWSEC)	University of Hawaii Systems
XCT SYSTEM FOR HARVESTING IN-CURRENT HYDROKINETIC ENERGY FROM LOW-VELOCITY SITES	Littoral Power Systems Inc
AN INNOVATIVE SR-WEC FOR A MARKET-DISRUPTIVE LCOE	Texas A&M Engineering Experiment Station
DEVICE DESIGN AND ROBUST PERIODIC MOTION CONTROL OF AN OCEAN KITE SYSTEM FOR HYDROKINETIC ENERGY HARVESTING	North Carolina State University
LOW-FLOW MARINE HYDROKINETIC TURBINE FOR SMALL AUTONOMOUS UNMANNED MOBILE RECHARGE STATIONS	Florida Atlantic University
MODULAR RIVGEN	Ocean Renewable Power Company, Inc.
ADVANCING CALWAVE'S WEC DESIGN FOR PACWAVE	CalWave Power Technologies Inc
FLOATING OSCILLATING SURGE WAVE ENERGY CONVERTER USING CONTROLLABLE EFFICIENT POWER TAKEOFF SYSTEM	Stevens Institute of Technology (Inc)
MARMOK- Oscillating Water Column (OWC)	Idom, Inc.
OPTIMIZATION, DESIGN, AND COMMERCIALIZATION PLANNING OF NEXT-GENERATION STINGRAY H3 WAVE ENERGY CONVERTER	Columbia Power Technologies, Inc.
Waves to Water: Desalination Prize	NREL, WPTO
Ocean Observing Prize	NREL, WPTO
Wave-SPARC – Structured Innovation	NREL, SNL
Distributed Embedded Energy Converter Technologies DEEC-TEC	NREL
Significant Cost Reduction Potential for Wave Energy Conversion Devices with Variable Geometry Modules	NREL
Verdant/NREL Research Measurement Campaign	NREL

Future Work



Agenda Overview – July 19

START (ET)	END (ET)	PRESENTATION TOPIC	ORGANIZATION	SPEAKER
10:00 AM	10:40 AM	Technology-Specific System Design and Validation Activity Area Overview	WPTO	Elaine Buck
10:40 AM	11:10 AM	Reduction of System Cost Characteristics Through Innovative Solutions to Installation, Operations, And Maintenance	Columbia Power Technologies, Inc.	Michael Ondusko
11:10 AM	11:35 AM	Open Water Testing of a Scaled Next Generation Point Absorber Wave Energy Device with Phase Control	AquaHarmonics, Inc.	Alex Hagmuller
11:35 AM	11:45 AM	BREAK		
11:45 AM	12:10 PM	Water Horse Hydroelectric Harvester Development	University of Alaska Fairbanks	Jeremy Kasper

Agenda Overview – July 19

12:10 PM	12:35 PM	Performance Optimization and System Demonstration of a Multi-Mode Point Absorber	Oscilla Power, Inc.	Tim Mundon
12:35 PM	1:25 PM	LUNCH BREAK		
1:25 PM	1:50 PM	Cycloidal Wave Energy Converter	Atargis Energy Corporation	Stefan Siegel
1:50 PM	2:15 PM	Design, Build and Test of Novel, Remote, Low-Power Wave Energy Converter for Non-Grid Applications	Columbia Power Technologies, Inc.	Erik Hammagren
2:15 PM	2:40 PM	Hawaii Wave Surge Energy Converter (HAWSEC)	University of Hawaii Systems	Patrick Cross
2:40 PM	3:05 PM	Reviewer Debrief	Reviewers	

Agenda Overview – July 20

START (ET)	END (ET)	PRESENTATION TOPIC	ORGANIZATION	SPEAKER
10:00 AM	10:25 AM	XCT System for Harvesting In-Current Hydrokinetic Energy from Low-Velocity Sites	Littoral Power Systems Inc.	David Duquette
10:25 AM	10:50 AM	An Innovative SR-WEC for a Market-Disruptive LCOE	Texas A&M Engineering Experiment Station	HeonYong Kang
10:50 AM	11:15 AM	Device Design and Robust Periodic Motion Control of an Ocean Kite System for Hydrokinetic Energy Harvesting	North Carolina State University	Chris Vermillion
11:15 AM	11:25 AM	BREAK		
11:25 AM	11:50 AM	Low-Flow Marine Hydrokinetic Turbine for Small Autonomous Unmanned Mobile Recharge Stations	Florida Atlantic University	Manhar Dhanak
11:50 AM	12:15 PM	Modular RivGen	Ocean Renewable Power Company, Inc.	Ryan Tyler

Agenda Overview – July 20

12:15 PM	1:00 PM	LUNCH BREAK		
1:00 PM	1:25 PM	Advancing CalWave's WEC Design for PacWave	CalWave Power Technologies Inc.	Thomas Boerner
1:25 PM	1:50 PM	Floating Oscillating Surge Wave Energy Converter Using Controllable Efficient Power Takeoff System	Stevens Institute of Technology (Inc)	Muhammad R. Hajj
1:50 PM	2:15 PM	MARMOK - Oscillating Water Column (OWC)	Idom, Inc.	Borja de Miguel Para
2:15 PM	2:40 PM	Optimization, Design, And Commercialization Planning of Next-Generation Stingray H3 Wave Energy Converter	Columbia Power Technologies, Inc.	Pukha Lenée-Bluhm
2:40 PM	3:05 PM	Reviewer Debrief	Reviewers	

Agenda Overview – July 21

START (ET)	END (ET)	PRESENTATION TOPIC	ORGANIZATION	SPEAKER
10:00 AM	10:40 AM	Waves to Water: Desalination Prize	NREL, WPTO	Scott Jenne, Simon Gore
10:40 AM	11:20 AM	Ocean Observing Prize	NREL, PNNL, WPTO	Jenny Wiegele, Carrie Schmaus
11:20 AM	11:30 AM	BREAK		
11:30 AM	11:55 AM	Wave-SPARC - Structured Innovation	NREL, SNL	Jochem Weber

Agenda Overview – July 21

11:55 AM	12:20 PM	Distributed Embedded Energy Converter Technologies DEEC-TEC	NREL	Blake Boren
12:20 PM	1:05 PM	LUNCH BREAK		
1:05 PM	1:30 PM	Significant Cost Reduction Potential for Wave Energy Conversion Devices with Variable Geometry Modules	NREL	Nathan Tom
1:30 PM	1:55 PM	Verdant/NREL Research Measurement Campaign	NREL	Robynne Murray
1:55 AM	2:25 PM	Reviewer Debrief	Reviewers	

System Design and Validation Reviewer Introductions



Henry Jeffrey, *Program Chair and Panel Lead*
Head of Policy and Innovation Group,
University of Edinburgh



Beth Dickens
Director, Quoceant



Claudio Bittencourt Ferreira
Business Development Director,
DNV Renewables



Sue Molloy
President and CEO,
Glas Ocean Electric



Donna Vincent Roa, *Prize Reviewer*
Partnership Director, USAID's Partnerships
Incubator, The Kaizen Company



Sally Gutierrez, *Prize Reviewer*
Senior Advisor, Center for Environmental
Solutions & Emergency Response Office of
Research & Development, U.S.
Environmental Protection Agency

Q&A