Build and Test of a Novel, Commercial-Scale Wave Energy Direct-Drive Rotary Power Take-off under Realistic Open-Ocean Conditions

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Project Overview

Build and Test of a Novel, Commercial-Scale Wave Energy Direct-Drive Rotary Power Take-off under Realistic Open-Ocean Conditions

The Challenge: Design, build, and test a novel power take-off (PTO) that can reliably and cost effectively produce grid-compliant power from a low-speed and dynamically variable energy resource.

Partners:

Ershigs
National Renewable Energy Lab (NREL)
Siemens
SpenTech

Greenberry
Katon
Northern Power Systems
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 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
Drive innovation in MHK-specific applications

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
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Project Impact:

- Delivers Technology Readiness Level 6
- Advances technical performance of StingRAY wave energy converter (WEC)
- Validates wave-energy-specific electro-mechanical power take-off
- Validates novel air-gap control system for wave- and, potentially, wind-market
- Delivers stakeholder confidence, risk reduction and supply chain required in support of WEC open-water demonstration

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<thead>
<tr>
<th>Targeted Improvements</th>
<th>PWR</th>
<th>Availability</th>
<th>LCOE</th>
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<td>55%</td>
<td>10%</td>
<td>-28%</td>
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Technical Approach

- Design, manufacture, assembly and validation of a first-in-kind PTO using experienced, highly-qualified suppliers
- Land-based test of large-scale PTO prior to WEC open ocean deployment
  - Safe, lower-risk, methodical approach
  - Modular design allows over-the-road transportation
  - Safely expose the PTO to controllable forces
  - Time- and cost-efficient exposure to wide range of operating conditions
  - Tests significant portion of supervisory control and data acquisition (SCADA) hardware and software, and PTO controls
  - Tests electric plant and small-scale energy-storage system
Technical Approach

• 12-stage test plan
  – Stages 1–5: assembly, inspection, verification and set-up procedures for characterization of major sub-components
  – Stages 6–12: test various aspects of the generator—using IEEE and IEC test recommendations for continuous and cyclic modes of operation—and address any contingency testing

• Current Issues
  – High learning rate due to pioneering use of wind energy test facility for wave energy system
  – Impact on team due to remote test location
  – Seal manufacturing failure
  – Ensuring all pre-test procedures and requirements are completed
Accomplishments and Progress

- First-in-kind utility-scale direct-drive WEC PTO
  - Organizational and test planning and final PTO design completed
  - Equipment manufactured, pre-assembled remotely, disassembled and shipped to the National Wind. Technology Center (NWTC)
  - Testing initiated
- Impact on Wave Energy Test Site (WETS) deployment
  - Improved core competencies and confidence
  - Supply chain advancement
- Identification of areas for design and process improvement
- Metric Improvements recorded at BP1 Go/No-Go

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• Period of Performance: 12/1/13 – 6/30/17
• Major Schedule Impacts
  – Pre-assembly of modular rotor wheel components
  – Test Stand
    • Shift from FRP to steel
    • Significant delay and increased design and material cost
    • Proof Testing
• BP2 Go/No-Go passed in 1Q16
Project Budget

• Mod 05 Budget $5,023K
• Expected final budget ≈$6,250K
  – Test stand cost increases
    • Substitution of steel for fiberglass
    • Logistics, proof-testing and integration with generator
  – Pre-assembly cost increases
  – Remote assembly difficulties
  – Increased time for test center integration
• 90% of expected budget expended to date
• Oregon Wave Energy Trust – $100K

Budget History

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<th>FY2016</th>
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DOE Cost-share

FY2014: $1,085K
FY2015: $909K
FY2016: $98K

Oregon Wave Energy Trust

– $100K
Partners, Subcontractors, and Collaborators:

Ershigs, Inc. – Generator and Test Stand Structural Design
NREL – NWTC Test Facility and Support
Siemens – Generator Active Materials and Power Electronics Supplier
Northern Power Systems – Generator Mechanical Design
Greenberry – Test Stand Supplier
Katon – Bearings Supplier
SpenTech – Drive Shaft, Fixed Shaft, and Drivetrain Flanges Supplier

Communications and Technology Transfer:

• 2016 IEEE PES General Meeting – July 2016
• CPower-NREL Open House at NWTC – November 2016
Next Steps and Future Research

**FY17/Current research:**
- Completion of Test Plan
- Decommissioning and Shipping
- Design Report
- System Performance Advancement and Integration Report
- Final Report

**Proposed future research:**
- Next generation air-gap control system
  - Improved installation and maintenance capabilities
  - Smaller air-gap
  - Reduced weight and cost
  - Application in alternative markets