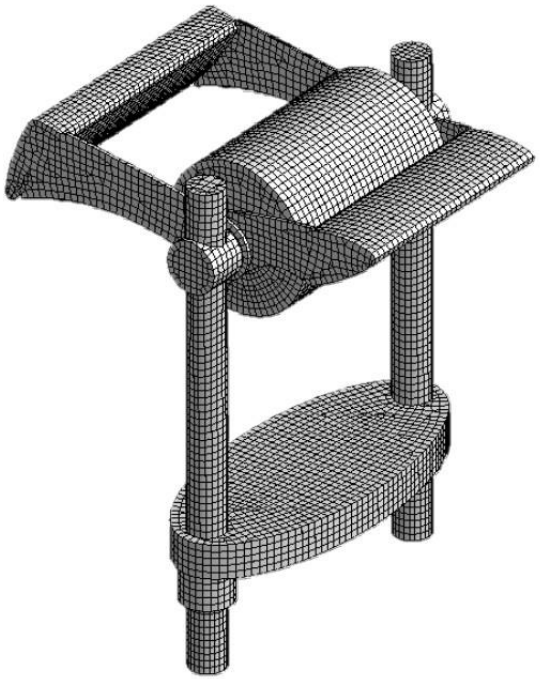

Surface mesh for StingRAY v3.2
AQWA model

Wave Energy Converter Structural Optimization Through Engineering and Experimental Analysis

Ken Rhinefrank - PI

Columbia Power Technologies, Inc.
krhinefrank@columbiapwr.com 541.760.1833

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Wave Energy Converter Structural Optimization through Engineering and Experimental Analysis

The Challenge:

Materially decrease the levelized cost of energy for a wave energy converter (WEC) through improved power-to-weight ratio (PWR) performance.

Partners:

Ershigs

National Renewable Energy Laboratory (NREL)

Program Strategic Priorities

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

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

Project Strategic Alignment

Cost improvement through innovative hull structure R&D

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

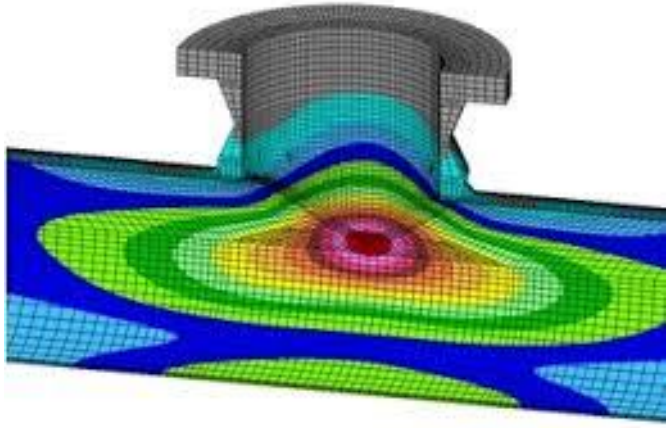
Improvement Goal	
AW PWR	DW PWR
64%	15%

Project Impact:

- Advances technical performance of StingRAY WEC
- Delivers hull design for Wave Energy Test Site (WETS) deployment
- Industry-pioneering advancement of composite hull structures

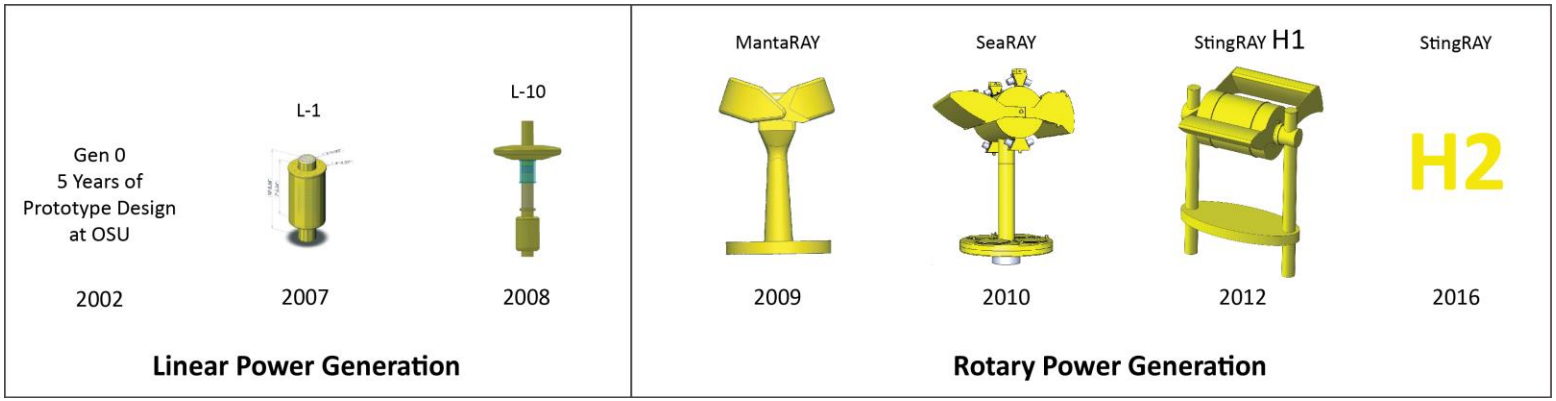
Technical Approach

- Hull design optimization to improve energy capture and lower capital cost
  - Baseline hull design (H1) was product of separate DOE project
  - Focus on top-end mass reduction and lowering center of gravity
    - Similar to wind turbine design
    - Advantage from substitution of lower-cost materials
- Finite Element Analysis (FEA) confirmed by physical testing
  - Design Load Cases (DLC) consider appropriate range of
    - Environmental conditions
    - Design and operational situations
    - Limit states
  - Load confirmations intended to allow smaller design margins and lower cost



Accomplishments and Progress

- Optimized H2 design concept offers significant PWR improvement
  - H2 WEC hydrodynamic model has been developed
  - DLCs established and load calculations modeled and reviewed
  - Hydrodynamic simulations run with post-process analysis
  - Hull design concept delivered for WETS deployment
- Improved core competencies in design analysis
  - Internal FEA capabilities and expertise have been developed



Project Plan & Schedule

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- Period of Performance: 10/01/14 – 09/30/17
  - Extension discussions underway
- Schedule delays
  - Vendor strategic change
  - Scope modifications and increase
  - Internal resource constraints
- Go/No-Go decision point for Budget Period 1 expected in Feb/Mar 2017
- Budget Period 2 plans
  - Comprehensive H2 design assessment and review
  - Select, design, and test structural components

Project Budget

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Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
		$232K	$58K	$141K	$145K

- Scope modifications and increases
  - CPower took over FEA and design load modeling; new requirement to build appropriate internal capacity and expertise
  - Insertion of modeling and design of advanced H2 concept conceived ex-Project
- 118% of BP1 budget expended, CPower absorbing cost of increased scope
- No external cost-share

Total Project Budget					
BP1		BP2 (pending go/no-go)		Total (pending BP2 go/no-go)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$373K	$203K	$350K	$116K	$723K	$319K

Research Integration & Collaboration

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Partners, Subcontractors, and Collaborators:

Ershigs – Structural assessment and design

NREL – Physical testing facilities and support

Communications and Technology Transfer:

- 2016 IEEE Power and Energy Society General Meeting—July 2016
- CPower-NREL Open House at National Wind Technology Center—November 2016
- Small Business Voucher (SBV)—NREL and Sandia National Laboratories

Next Steps and Future Research

FY17/Current research:

- H2 structural design and assessment
- Physical testing
  - Selection of test articles
  - Test Plan execution
  - Analysis and possible incremental FEA effort
- Deliverables
  - System Structural Report
  - Test Article Design Report
  - Continuing Application
  - BP2 Reporting

Proposed future research:

- Incremental FEA effort – Sandia/NREL SBV
- Focus on structural FRP manufacturability