DESIGN FOR EXTREME CONDITIONS

COLUMBIA POWER TECHNOLOGIES

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COLUMBIA POWER TECHNOLOGIES

power from the next wave
COLUMBIA POWER TECHNOLOGIES

• Offices
  • engineering – Corvallis, OR
  • administrative – Charlottseville, VA

• Partners, supply chain
  • federal and state
  • international supply chain

• Mission
  • commercializing utility scale WEC technology

• Commercialization
  • cost viability
  • low impact
  • survivability
STINGRAY v3.2

- Floating WEC
- 3 bodies, 8 DOFs
  - relative pitching
- FRP structure, with some steel components
- 2 independent DDR PMG generators
  - 7.8 m air gap diameter
STINGRAY v3.2 OPERATION
PRODUCT DEVELOPMENT

1:50 Scale Unit Test (v3.0)  1:33 Scale Unit Test (v3.0)  1:15th Scale Unit Test (v3.0)  5 x 1:33 Scale Units Wave Farm Test (v3.1)  Intermediate Scale Unit Sea Trial (v3.1)  Design Optimization Complete (v3.2)  Verification Test Small Scale (v3.2)


Government Funding Key: U.S. Dept of Navy  U.S. Dept of Energy

Test Location: Oregon State Univ. Test Facilities  Puget Sound, Seattle, USA

For sake of presentation, project milestones show starting point only.
SeaRAY v3.1 – Intermediate Scale

• 13 months in Puget Sound
• Scaled seas
  • WEC scaled to match
• Design
  • large uncertainty and moderate capex → large SF
• Extreme conditions
  • Hm0 up to 11 m
• Data for model validation
  • structural strain
  • end stop and mooring loads
PROJECT LIGHTNING – DESIGN OPTIMIZATION

- New v3.2 design features
  - dual spars
  - aft float shifted back
  - compliant single-point mooring system

- Benefits
  - no range limits or end-stops
  - reduced loading (no end-stop strikes)
  - improved survivability
  - shallow draft transport mode
  - 30%+ performance improvement
  - weathervaning allows head seas

Extreme Survival Mode

Transport Mode
33 LIGHTNING v3.2 – SMALL SCALE TANK TEST

- Test setup
  - 1:33 scale model with PMCs
  - instrumented for waves, WEC position, mooring loads
    - data for model validation
- Wave conditions
  - regular waves up to H=5m
  - irregular seas up to Hm0=14m
- WEC configuration
  - PTO damping
  - float position
  - ballast modifications
- Response
  - position, acceleration
  - mooring loads
STINGRAY v3.2 – DESIGN AND DEMONSTRATION

• Utility scale prototype WEC
  • 25.4 m draft
  • 1,130 ton displacement
  • 500 kW rating

• Demonstration at WETS in Kaneohe Bay, Hawaii

• Risk reduction
  • prototype certification
    • DNV-GL Renewables Certification
  • failure modes, effects and criticality analysis (FMECA)
  • land based component testing
  • extensive modeling → loading for system/component
    design/analysis

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PROTOTYPE CERTIFICATION – DNV-GL RC

• Review of design basis
  • metocean conditions
  • WEC modes of operation
  • design principles and applicable standards
  • no established set of standards specific to WEC technology
  • methodology for load and structural analysis
• Prototype design assessment
  • control and safety system
  • load and response assumptions
  • structural design and analysis
• Surveillance
  • fabrication, transport and installation, commissioning
• Prototype certificate
CRITICAL COMPONENT TESTING

- De-risk critical components before going to sea
- LandRAY test at US DOE NREL NWTC 5 MW dynamometer
  - application of torque and non-torque loads to PTO
  - demonstrate and characterize generator mechanical design
  - confirm water-tight integrity
  - confirm supervisory control and data collection (SCADA)
MODELING AND DESIGN

• Design load cases
  • extreme environmental conditions
  • WEC modes of operation and faults
  • abnormal events
• Numerical modeling
  • set up, validate
  • quality control, post processing
  • loads and response estimates
• Design
  • structural analysis
  • component design
MODELLING/ANALYSIS ISSUES AND NEEDS

- Large, steep waves
- Large amplitude motions
- PTO controls
- Failures and faults
- Slapping, slamming loads
- Assessment, inclusion of viscous drag
- Pressure distribution over hull (time domain)
- Multi-body hydrodynamic interactions
- All relevant loads coupled, non-linear, time domain
- Accurate! Fast! Inexpensive!

- Which instances, from which DLCs, are critical to each failure mode?