



California Wave Energy Test Center (CalWave)

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Challenges, Barriers, and Knowledge Gaps:

- Provide affordable access to world-class test facility for emerging wave energy components and systems
- Reduce technical and financial risks
- Reduce the cost of testing for individual developers and the industry as a whole
- Reduce the time-to-market of commercially-ready systems
- Testing infrastructure “systems integration” to accommodate a wide variety of emerging wave energy converter (WEC) technologies
- Permitting requirements/pathway for ocean marine and hydrokinetics (MHK) facility per federal and California standards to accommodate a wide variety of emerging WEC technologies

Partners:

- Cal Poly – San Luis Obispo/IATPP – Prime/Academic
- Kearns & West – Stakeholder Facilitation
- Leidos – Systems Engineering & Integration
- CH2M - Permitting
- Protean Wave Energy LLC – Project Management
- Omega Engineers – Electrical Engineering
- Virginia Tech – Technical Review & Academic Partner
- University of California, San Diego (UCSD)- Scripps Institute of Oceanography – Wave Regime Data/Expertise
- UK Wave Hub – Existing Facility Benchmarking/Consultation
- Electric Power Research Institute – Technical Review/Consultation
- Sandia National Laboratories – Technical Review/Consultation
- National Renewable Energy Laboratories – Technical Review/Consultation
- Pacific Gas & Electric Company – Grid Integration and Other Technical Contributions
- California Natural Resources Agency – Regulatory Agency Engagement
- Columbia Power Technologies – WEC Consultation/Collaboration
- University of California (UC), Davis – Technical Collaboration
- William Lyte (Consultant Phase I)

Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- **Conduct R&D for innovative MHK systems & 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

Technology Maturity

- Test and demonstrate prototypes
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The Impact

- 12 -15 cents/kWh—levelized cost of energy (LCOE) for Technology Readiness Level (TRL) 9+
- Systems design and integration of a multi-berth testing facility that can accommodate multiple technologies (TRL 7-9)
- Would provide WEC developers an affordable facility for open-water, grid connected testing
 - Power Purchase Agreement (PPA) opportunity/offset costs (potential of 12 cents/kWh)
- An MHK testing facility that greatly accelerates commercialization of grid-scale WEC technologies

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The Impact

- A permitted MHK testing facility in California
- Robust engagement with stakeholders as well as California and federal regulatory agencies
- California's high standards will inform and improve the permitting process everywhere else
- Will provide environmental monitoring and research opportunities for emerging WEC technologies
- An MHK facility that helps to accelerate permitting for future MHK facilities nationally and globally

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The Impact

- Understanding current and future LCOE of WEC technologies
- Understand environmental impact of WEC's and permitting requirements
- If permitted, this facility will trail blaze MHK permitting requirements in high standard environment (California)
- Testing of TRL 7-9 WEC technologies at grid integrated facility will provide LCOE data to inform incentive requirements
- An MHK testing facility that illuminates permitting pathways for emerging WEC technologies and provides LCOE data to inform future policy strategies

Crosscutting Approaches

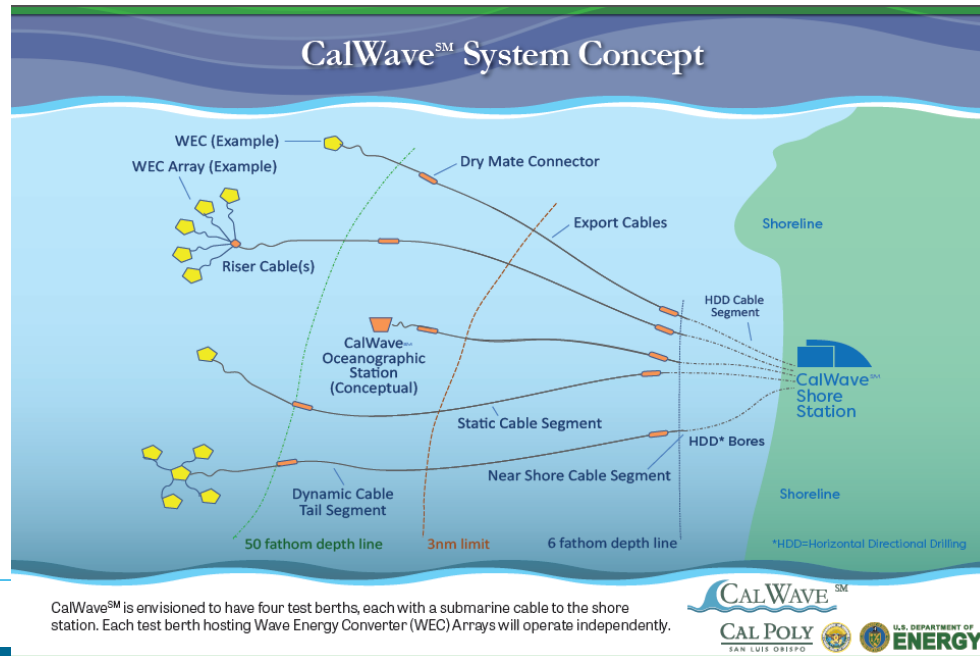
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- Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets
- **Exchange of data information and expertise**

The Impact

- Robust engagement with national laboratories, academic institutions, regulatory agencies, stakeholders, and industry
- Aid in the establishment, advancement, and validation of international technical standards for WEC technology
- National test facility would provide a nexus/hub of MHK expertise and a centralized location for WEC technology testing, validation, and development as well as local/regional development hub for MHK industry
- An MHK testing facility that in the short term will establish a knowledge center of MHK expertise, and in the long term establish a business corridor

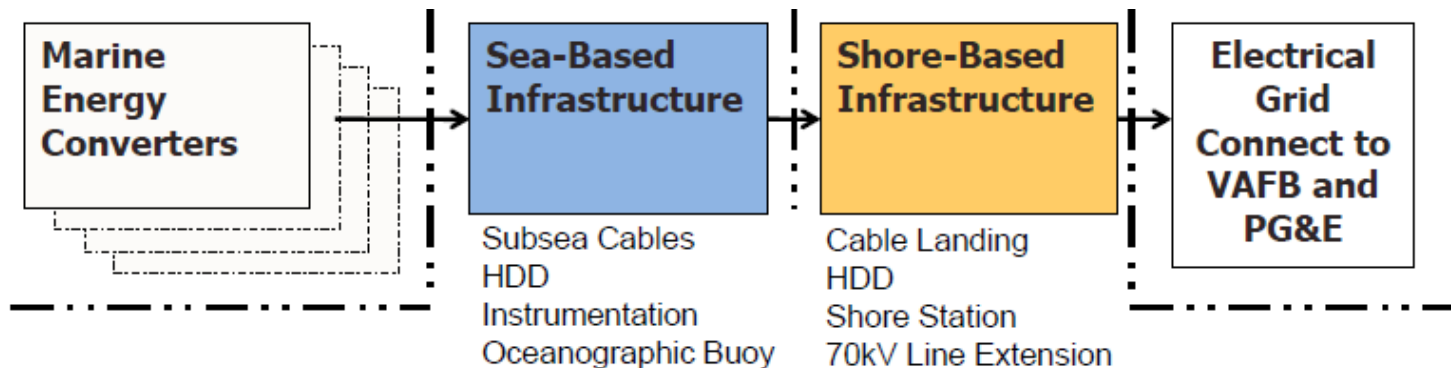
Technical Approach & Methods

- Project Management Practices
- Systems Engineering Approach
- Benchmarking Existing Facilities
- Regulatory Agency Engagement
- Permitting Envelopes
- Stakeholder Outreach



Unique Aspects of Project

- Bring Your Own Anchoring and Mooring
- Dynamic Riser Cables and Dry-mate Connectors
- On-shore Power Conditioning Option
- PPA Opportunity for WEC Developers and Energy Security for U.S. Department of Defense (DOD) Installation
- Potential for Varying Energy and Depths Between Berths



2014 Technical Accomplishments

- Develop and Use Criteria to Rank and Finalize Choice for Candidate Ocean Test Sites

2015 Technical Accomplishments

- Shore-Side Support Infrastructure Assessment
- Utility Grid Interconnection Assessment
- Environmental Constraints and Progress on Permitting
- Permitting and Stakeholder Consultation
- Top-Level Requirement and Site Selection Criteria
- Develop Prelim. Design Drawings
- Develop Estimates of Construction Quantity and Costs
- Develop Operations, Maintenance, and Testing Cost Estimates

2016 Technical Accomplishments

- Completion of Conceptual Design
- Facility Benchmarking with Partners (UK Wavehub and Others)
- Design/Engineering Site Visits
- Establishment of Stakeholder Advisory Group
- Establishment of Marine Industry Technical Advisory Group
- Three Regulatory Agency Meetings Held
- One Stakeholder Meeting Held
- Completion of Draft Preliminary Design

- Phase I Start Date: 6/1/14
- Phase I End Date: 6/30/15 (plus 3 mo. no cost extension)
- Phase II Start Date: 2/19/16
- Projected Completion Date: 2/28/17

- The Phase I Final Technical Report submission was delayed due to delayed report collation/contribution synthesis
- Phase II efforts are currently on track

- FY14 Go/No-Go
 - Siting down selection to Vandenburg Air Force Base
- FY15 Go/No-Go
 - Final technical report review by DOE and Phase II funding decision
- FY16 Go/No-Go
 - N/A

Budget History

FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$151.177k	\$95.931k	\$383.356k	\$189.543k	\$568.858k	\$137.538k

- Phase I funding was not fully expended as some cost share partners and project partners did not expend efforts as quickly and robustly as predicted
- Phase I Funding Spent (incl. cost share): 79%
- Phase II Funding Spent up to 6Q (incl. cost share): 36.5%
- **Note that Phase II efforts increase in 7Q, 8Q, and 9Q by design

Partners, Subcontractors, and Collaborators:

Phase II

Cal Poly – San Luis Obispo, Kearns & West, Leidos, CH2M, Protean Wave Energy LLC, Omega Engineers, Virginia Tech, UCSD - Scripps Institute of Oceanography, UK Wave Hub, Electric Power Research Institute, Sandia National Laboratories, National Renewable Energy Laboratories, Pacific Gas & Electric Company, California Natural Resources Agency, Columbia Power Technologies, UC Davis, William Lyte (Consultant)

Communications and Technology Transfer:

- (2015) Final Report of the Feasibility Study for the California Wave Energy Test Center (CalWave) Final Report
- Leidos – Rick Williams presented at the Hydrovision International Conference on Wednesday, July 27, 2016 in Session 1C: Electrical Issues: The Heart of the Matter – Electrical Infrastructure Planning for the CalWave Wave Energy Test Center
- CH2M – Doug Davy presented at the California Energy Commission (CEC) Offshore Renewable Energy Planning Workshop on the need for a comprehensive marine spatial planning process in advance of marine renewable energy development
- Bill Toman – Protean Wave Energy LLC presented at the CEC Offshore Renewable Energy Planning Workshop on the status update of the CalWave project
- CalWave Phase II Final Technical Report (In progress)
- CalWave Draft Preliminary Application Document (In progress)

FY17/Current research:

Remaining Barriers

- Final project description to inform permitting application
- Additional surveys as required to fulfill permitting requirements
- Bureau of Ocean Energy Management research lease application
- Submission of Federal Energy Regulatory Commission and state permit applications

1Q of FY17

- Completion of Preliminary Design
- Final Regulatory Agency Consultations/Presentations
- Draft PAD (Preliminary Application Document)
- Construction Cost Estimate Complete
- Final Technical Report in Draft PAD format

Proposed future research:

- Phase III – Permitting and Construction Phase Work