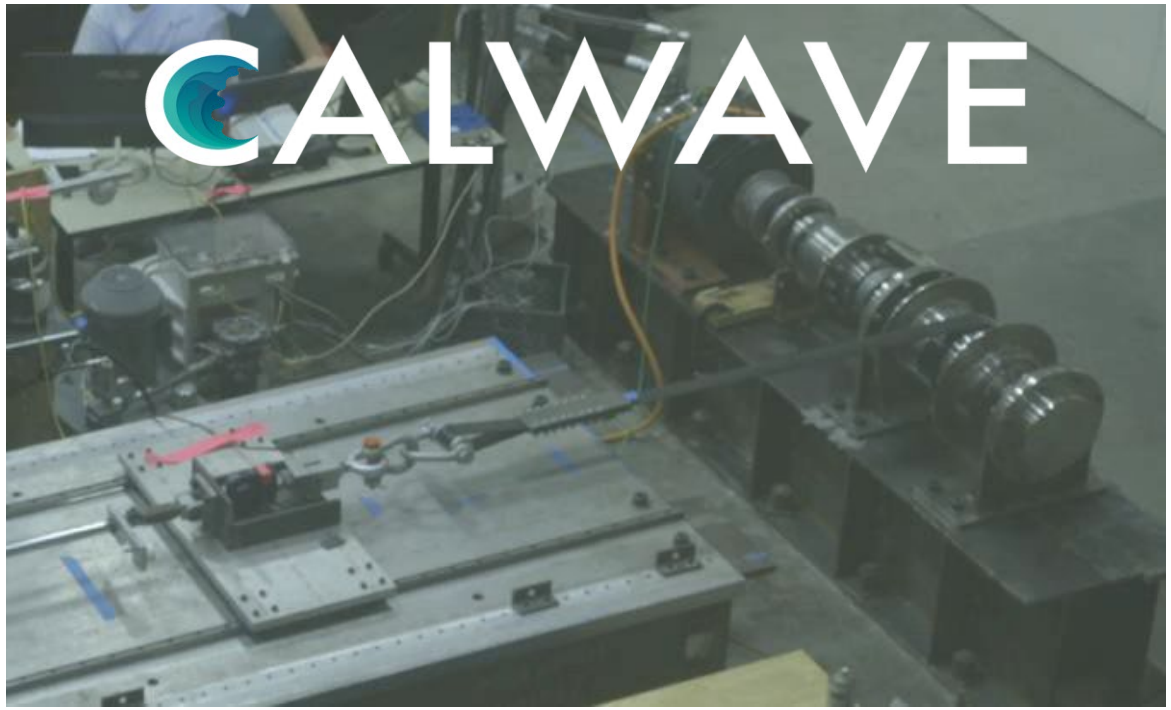
EE0008632 Holistic Control Embedded Power Take Off (PTO) Development



Dan Petcovic, P.E.
CalWave

dan@calwave.energy

7/19/2022

Disclaimer: this device was not manufactured and deployed under this award.

Project Overview

Project Summary

- Within this holistic controls project, CalWave Power Technologies, Inc. (CalWave) is continuing to further advance our collaboration with an R&D consortium of industry, national lab, and academic partners, to advance the physical PTO and controls design as well as the TRL of CalWave's commercial scale PTO subsystem. The PTO is the most critical subsystem of CalWave's xWave wave energy converter and past experience has found a hybrid mechanical-hydraulic PTO to be best suitable to achieve the total system requirements of the xWave while achieving a high conversion efficiency.

Intended Outcomes

- Within this project, CalWave is advancing the controls - and physical PTO design as well as the TRL of CalWave's commercial scale PTO subsystem by continuing established R&D collaborations with Sandia National Lab, National Renewable Energy Lab, Evergreen Innovations, UC Berkeley, and commercial partners. The focus is on a novel systematic holistic controls design approach into the TRL advancement of the PTO development, meaning that the TRL advancement of the PTO is inherently coupled to the WECs hydrodynamic tuning approach (HyTune™).

Project Information

Principal Investigator(s)

- Thomas Boerner, CTO
- Marcus Lehmann, CEO

Project Partners/Subs

- National Renewable Energy Laboratories
- Sandia National Laboratories
- UC Berkeley
- Czero
- Evergreen Innovations

Project Status

Ongoing

Project Duration

- 04/01/2019
- 09/30/2022

Total Costed (FY19–FY21)

$347k

Project Objectives: Relevance and Approach

Relevance to Program Goals:

Approach:

- Based on state-of-the-art control strategies for wave energy converters and CalWave's prior development of effective WEC absorber load management strategies the proposed holistic controls and PTO design project plans to;

a)inherently couple the design of the PTO architecture with PTO control design for cost and performance efficient PTOs,
b) further development of a full wave-to-wire simulation including a precise PTO model coupled with the inherently required PTO control strategy,
c)integrate primary (absorber geometry) and secondary (PTO) conversion step control strategies into a holistic control framework to
d) achieve synergies for lean and efficient design of the PTO in means of specified PTO metrics (e.g., Peak-to-mean force or power).

Video device

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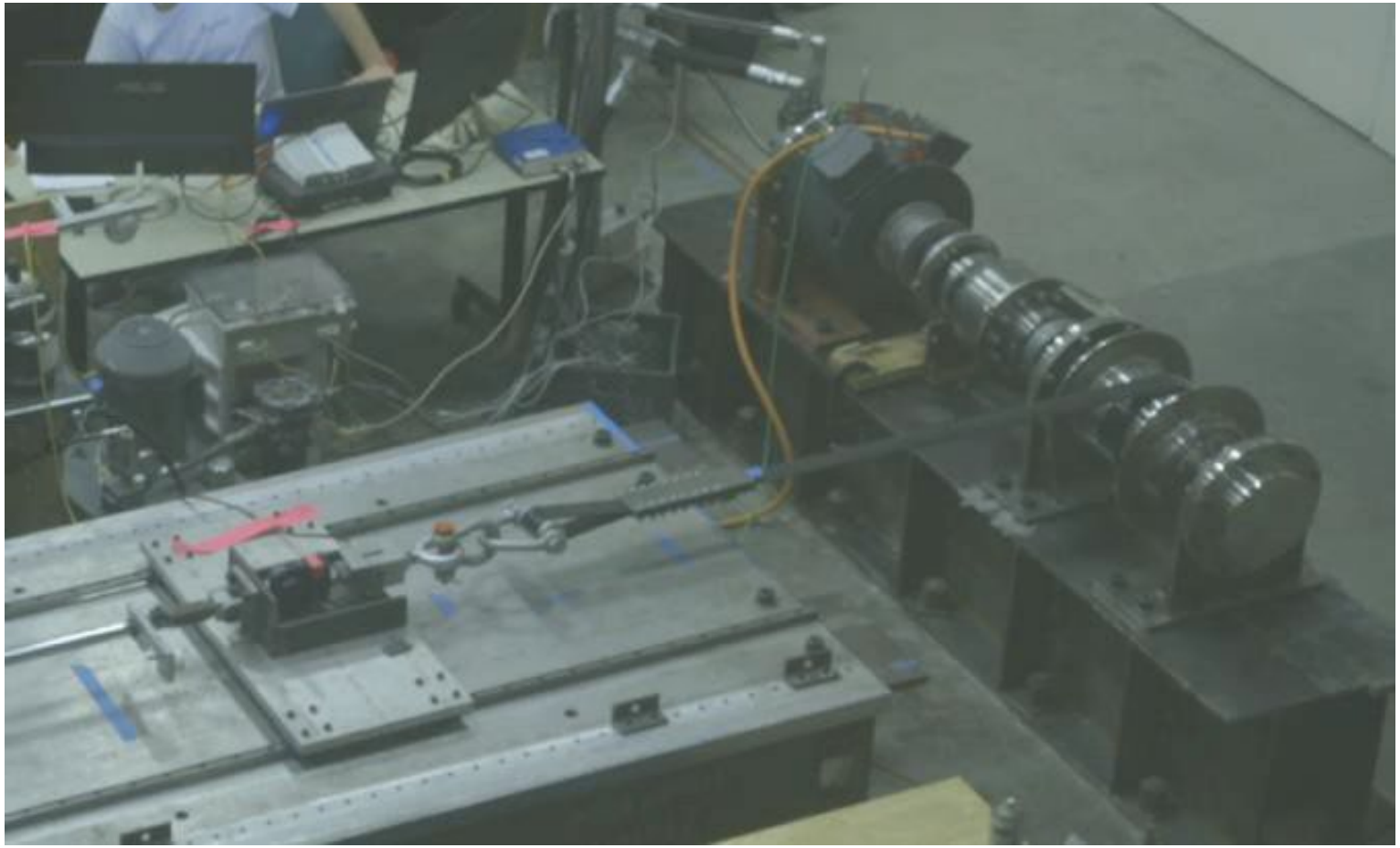
Video PTO



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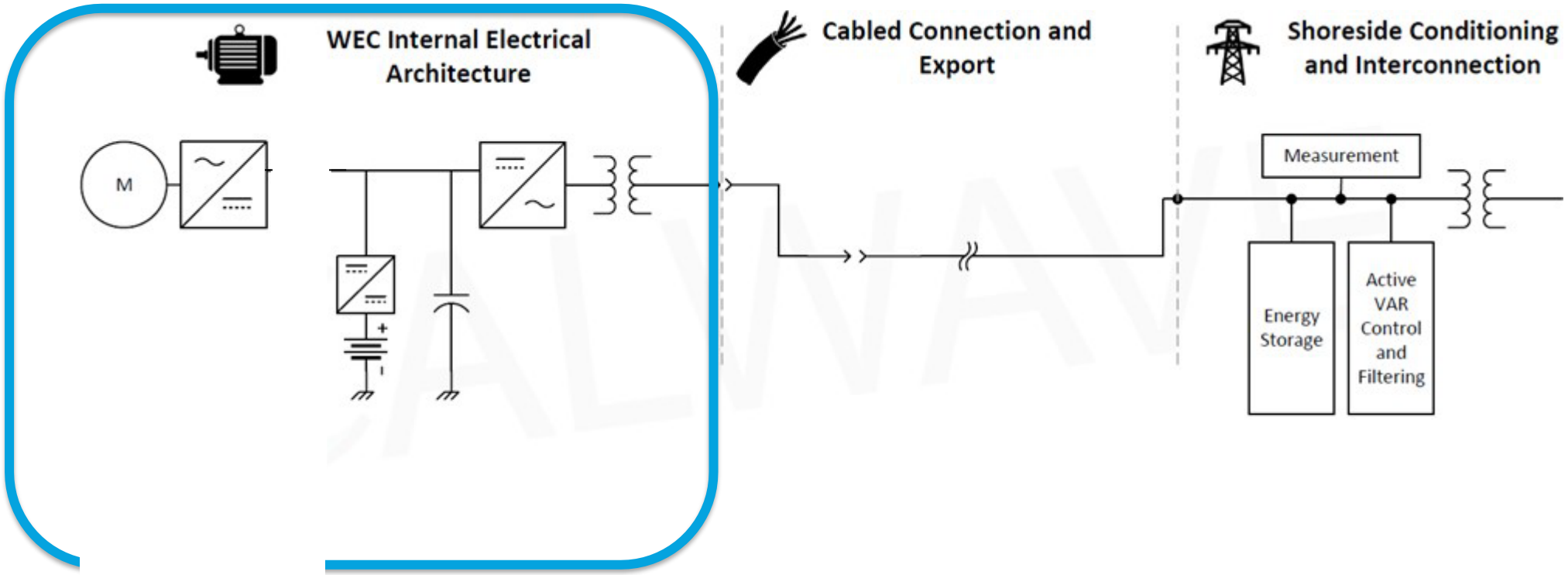
Project Objectives: Expected Outputs and Intended Outcomes



Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

1. Project and Risk Management Plan
2. Target Metrics Identification and Benchmarking
3. PTO Requirements Defintion
4. Controls Design
5. Hydraulic and Electric Circuit Design
6. Component Selection and Characterization
7. Mechanical PTO and Bench Test Design
8. Numerical Modeling
9. Feasibility Review
10. Bench Test Planning, SCADA Design

Outcomes:

- Emphasis is put on integration of primary (absorber geometry and submergence) and secondary (PTO) conversion step control strategies into a holistic control framework. Further outcomes of BP1 include results from numerical simulations including characterized component models indicating the synergies and benefits of a co-designed controls/PTO architecture.

- Primary outcome of BP2 is the completion of an experimental HIL test bench that is used to measure the capability of the designed PTO/controls architecture to meet the target metrics. The collected data allows for experimental verification of the numerical simulation models and the prove of successful integration of holistic device controller with PTO controls in an experiment.

Project Timeline

FY 2019

Partner engagement and kickoff

Identification of PTO requirements

FY 2020

Risk Register completion and Review by NREL

Target Metrics Definition and Evaluation

Design Load Cases Definition via IEC

FY 2021

Design Load Cases Definition via IEC

Device Co-Optimization

Updated Device & PTO Model

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$1,558K	$500K	$2,058K

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$67K	$194K	$86K	$347K

- Currently underspent due to delay in engaging external partners
- Significant budget allocated to installation & commissioning of test bench in BP2

End-User Engagement and Dissemination

- ➔INORE Symposium – Panel Discussion – Victoria British Columbia – Q2 FY19
- ➔ Maritime Markets at PacWave Workshop – Q4 FY19
- ➔MIT Clean Energy Prize Success Stories – Alumni Spotlight – Q2 FY20
- ➔Greentown Labs: ClimateTech Action Summit – Q1 FY21
- ➔Rice Technology Venture Forum – Q1 FY21
- ➔EnVest.Earth Presentation – Q1 FY21
- ➔Solar Impulse Label Awarded – Q1 FY21
- ➔IEEE Silicon Valley Sustainability – Ocean Energy – Opportunities & Challenges – Q2 FY21
- ➔Activate.org newsletter on Activate Fellows (CalWave) and the Blue Economy – Q2 FY21

Performance: Accomplishments and Progress

- **Identification of PTO requirements such as required forces, strokes, velocities, power input, energy storage requirements as an input into the first circuit and PTO level control iteration**
- Risk Register completion and Review by NREL
- Target Metrics Definition and Evaluation
- Design Load Cases Definition via IEC
- Device Co-Optimization
- Updated Device & PTO Model
- Assessment of electrical circuit designs and effect on performance and cost
- Mechanical component identification and supplier engagement for quotation

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Sandia

EVERGREEN INNOVATIONS

Czero ENGINEERING TOMORROW

Future Work

- Budget Period 2 – Demonstration and Evaluation
- Design, Order, Assembly of HIL Test Bench
  - Order, Assembly, and Safety Checkout
  - Component Functionality Testing, Simulation & SCADA Integration
- Control Implementation, Tuning, PTO HIL Testing
  - Experimental System Identification (SID) of Coupled Components
  - Controls Deployment and HIL PTO Performance Assessment
  - HIL PTO Load Management Assessment
- Reporting and Evaluation
  - Metrics Evaluation and Final Report

Q&A