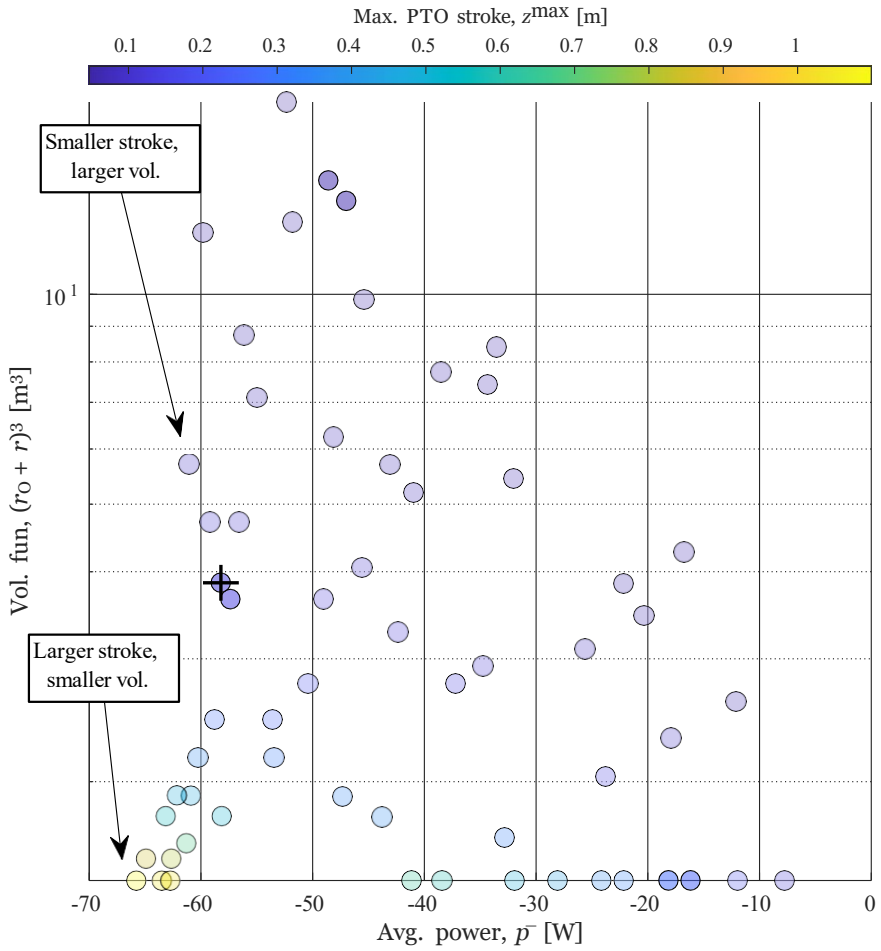
2.1.3.704 – WEC Design Optimization



Presenter(s): Ryan Coe, Giorgio Bacelli
Organization(s): Sandia National Labs

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Presentation Date: July 20, 2022

Sandia National Laboratories

Project Overview

Project Summary

WEC developers need faster, more robust, analytical design approaches/tools, utilizing optimization algorithms. This project seeks to overcome these critical issues in WEC design by creating a hybrid optimization system that simultaneously optimizes geometry and controls of existing WEC concepts.

Intended Outcomes

The WEC design optimization tool developed by this project is applicable for all resonating WEC devices and is available on an open-source platform for free, giving developers a means of performing rapid and holistic design optimization studies to improve performance and reduce LCOE.

Project Information

Principal Investigator(s)

- Ryan Coe
- Giorgio Bacelli

Project Partners/Subs

- AquaHarmonics
- CalWave

Project Status

Ongoing

Project Duration

- Project Start Date: July 2018
- Project End Date: Sept. 2024

Total Costed (FY19–FY21)

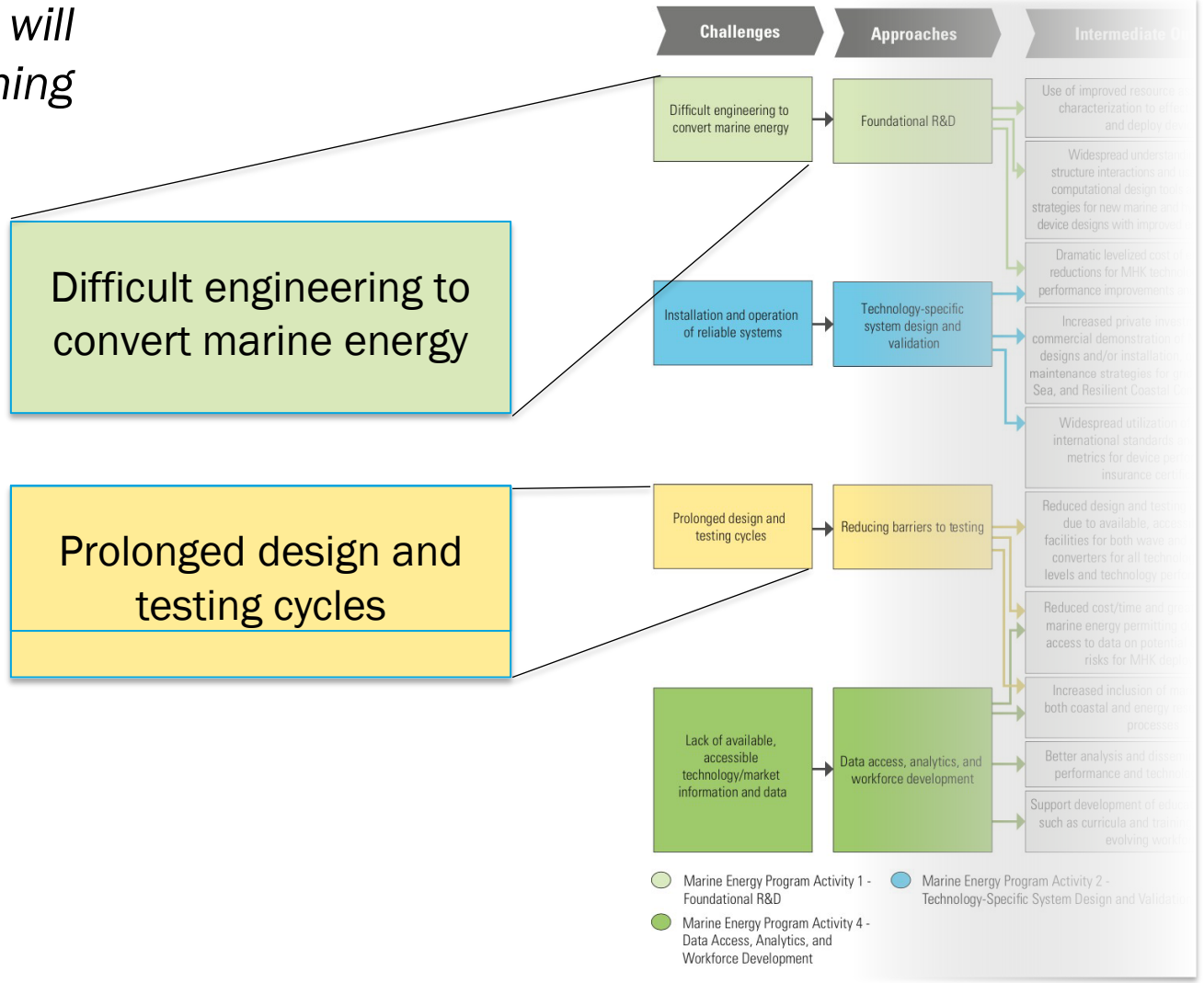
$482k

Project Objectives: Relevance

A holistic tool for WEC modeling, control, and design will streamline design cycles and produce better performing machines

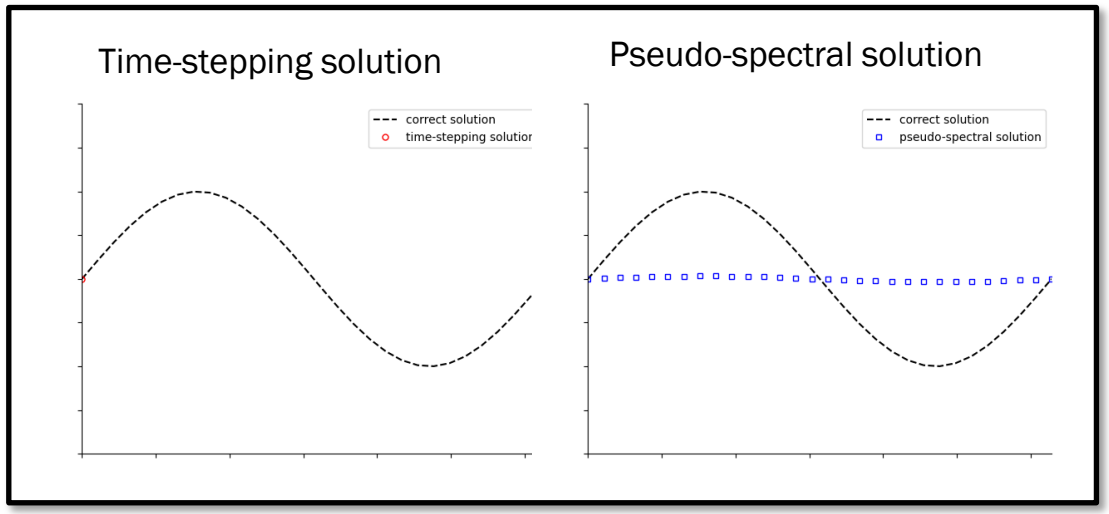
Directly address difficult engineering problems with <u>new theoretical frameworks</u>

Numerical optimization tool allows for <u>fast, complete, and systematic</u> design studies



Multi-Year Program Plan, pg. xv

Project Objectives: Approach



Pseudo-spectral solution method

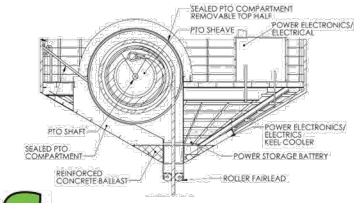
- *Efficient for constrained problems w. nonlinear dynamics*
- *Find solution and maximize power*
- *Unstructured & structured (e.g., PID) controllers*
- *Model entire "wave-to-wire" system*

GitHub

Fully open-source: written in Python (no license fees), available on GitHub (https://github.com/SNL-WaterPower/WecOptTool)

CalWave Power Technologies

AQUA HARMONICS



Direct collaboration with developers helps tailor tool for realist problems

Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Peer-reviewed journal articles and technical reports
- Presentations and webinars
- Open-source code

Outcomes:

- Developers have access to holistic modeling and design tool
- More efficient and effective design cycles
- Higher performance and lower cost WECs

Project Timeline

FY 2019

- WaveSparc coordination – Meeting WaveSparc team to discuss plans for this project and coordinate efforts/communication
- v0 release – Release a beta version of the WEC Design Optimization Toolbox
- Webinar – Host a public webinar demonstrating usage of the WEC Design Optimization Toolbox

FY 2020

- Select industry partner – Select an industry partner for case study and establish necessary CRADA, etc. for guarding proprietary information
- v1 release & webinar – Release fully functional version of WecOptTool

FY 2021

- User survey – complete a survey of at least 5 potential or current users to get feedback
- Transition to Python (from MATLAB)
- Add automatic differentiation (better handling of high-dimensionality problems relevant in industry collaborations)

Project Budget

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$190K	$172K	$120K	$482K

COVID impacts

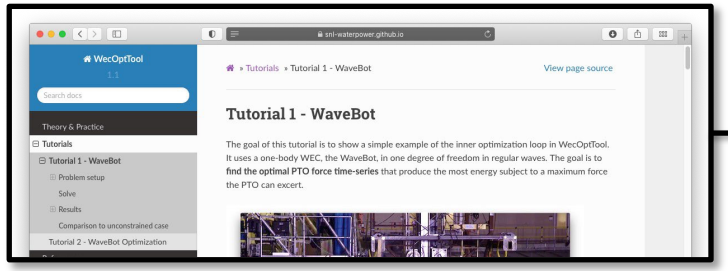
- Personnel availability

WecOptTool utilized to support

- FOA1663
- FOA1837
- FOA2080
- WEC Co-Design

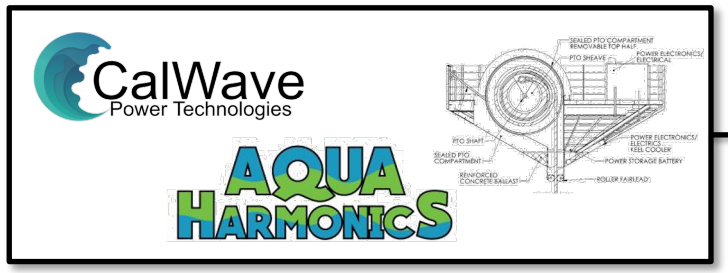
End-User Engagement and Dissemination

Open-source tool for WEC developers and researchers to apply to their own problems, request features, and contribute



Open-source case-studies to investigate application of design optimization tool and showcase usage

Webinars to demonstrate usage and receive user feedback



Developer collaborations and published case-studies when possible

Downloads: 3k+
Paper reads: 1.4k+
Webinar attendees: 100+

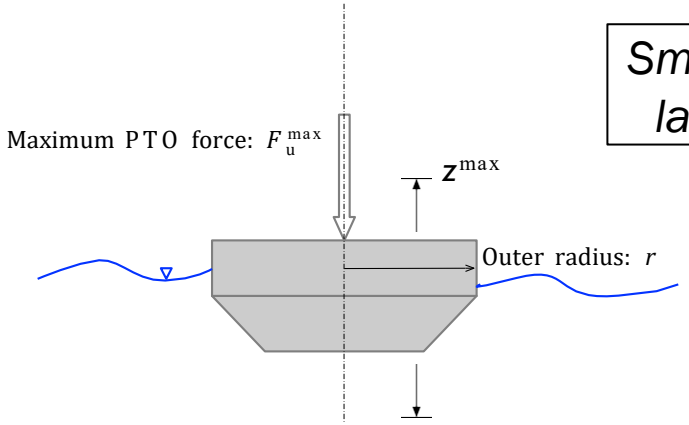
Performance: Accomplishments

volume*

max PTO stroke

power

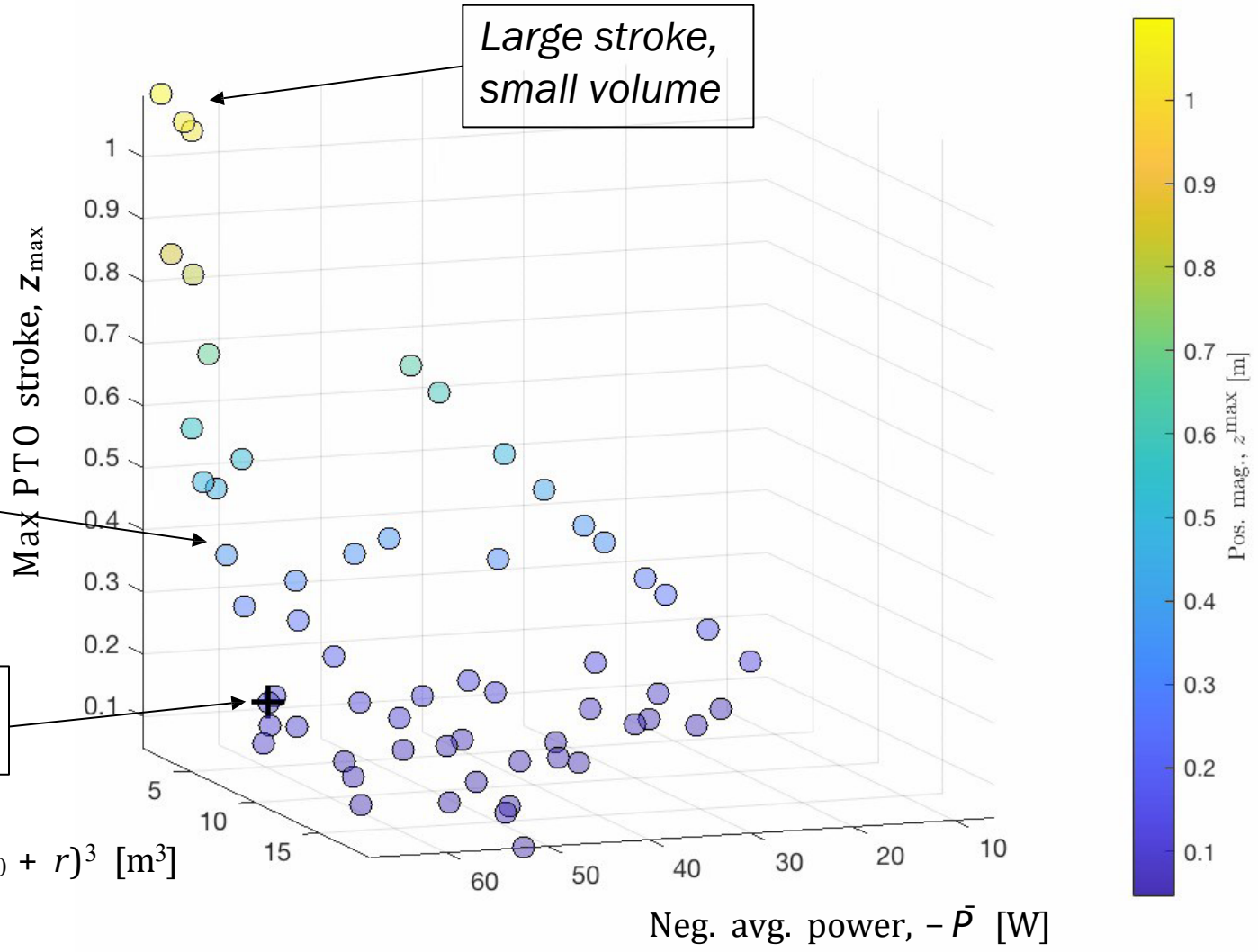
Varying the outer radius and power, find the volume, PTO stroke*



Large stroke, small volume

Smaller stroke, larger volume

"knee in the curve"

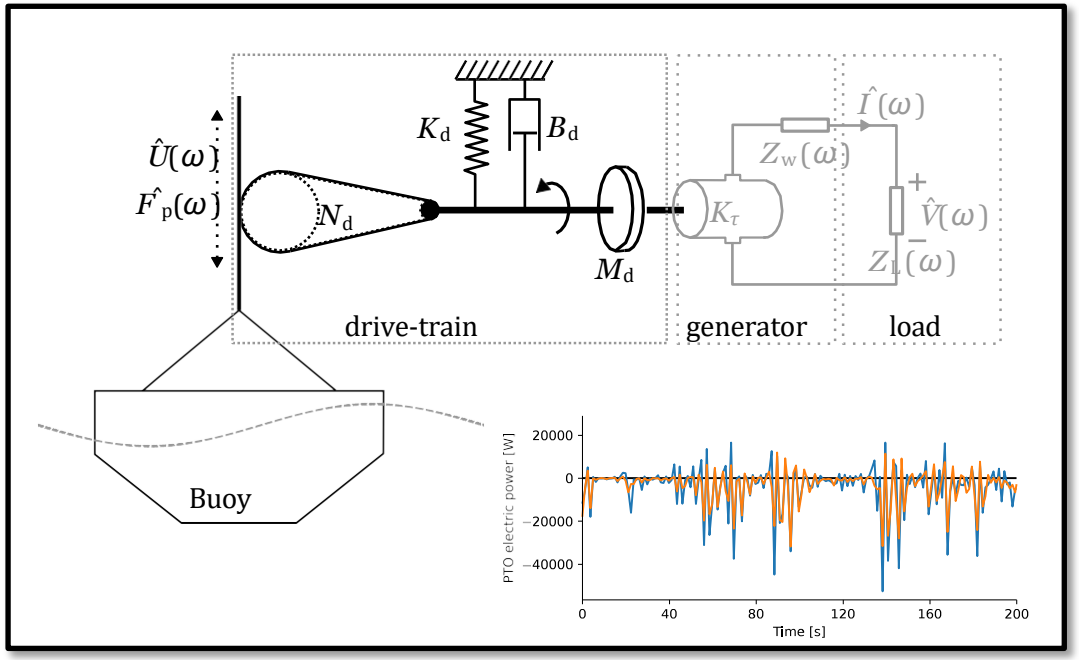


tackle challenging engineering problems

Coe *et al.* Initial conceptual demonstration of control co-design for WEC optimization. *J. Ocean Eng. Mar. Energy* **6,** 441–449 (2020). https://doi.org/10.1007/s40722-020-00181-9

Performance: Accomplishments and Progress

Fully-feature power take-off system modeling now allows users to optimize designs for electrical power



CalWave Power Technologies

Evergreen Innovations

CalWave, with help from EverGreen Innovations, is using WecOptTool to model their device

- *Good agreement with existing models*
- *Initial results for improved control tuning are promising*

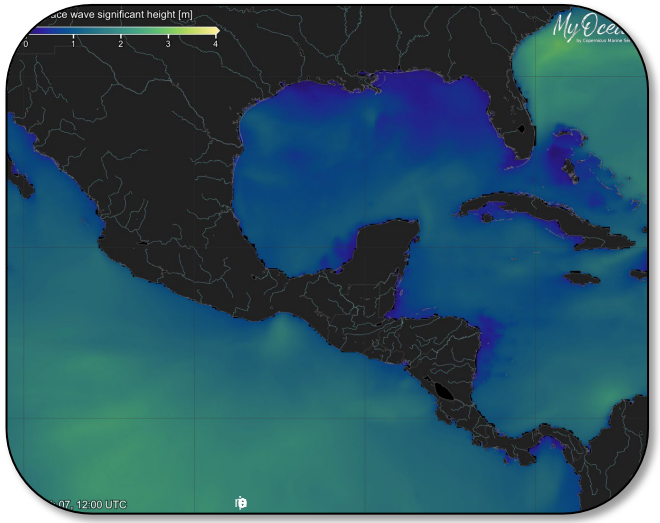
faster design cycle timelines | *developer access to open-source tools*

Future Work

- Engage users through outreach and dissemination
- Investigate fundamental cross-cutting design concepts
- Explore and expand capabilities

Power take-off

WEC array layout



Optimal deployment location

Q&A