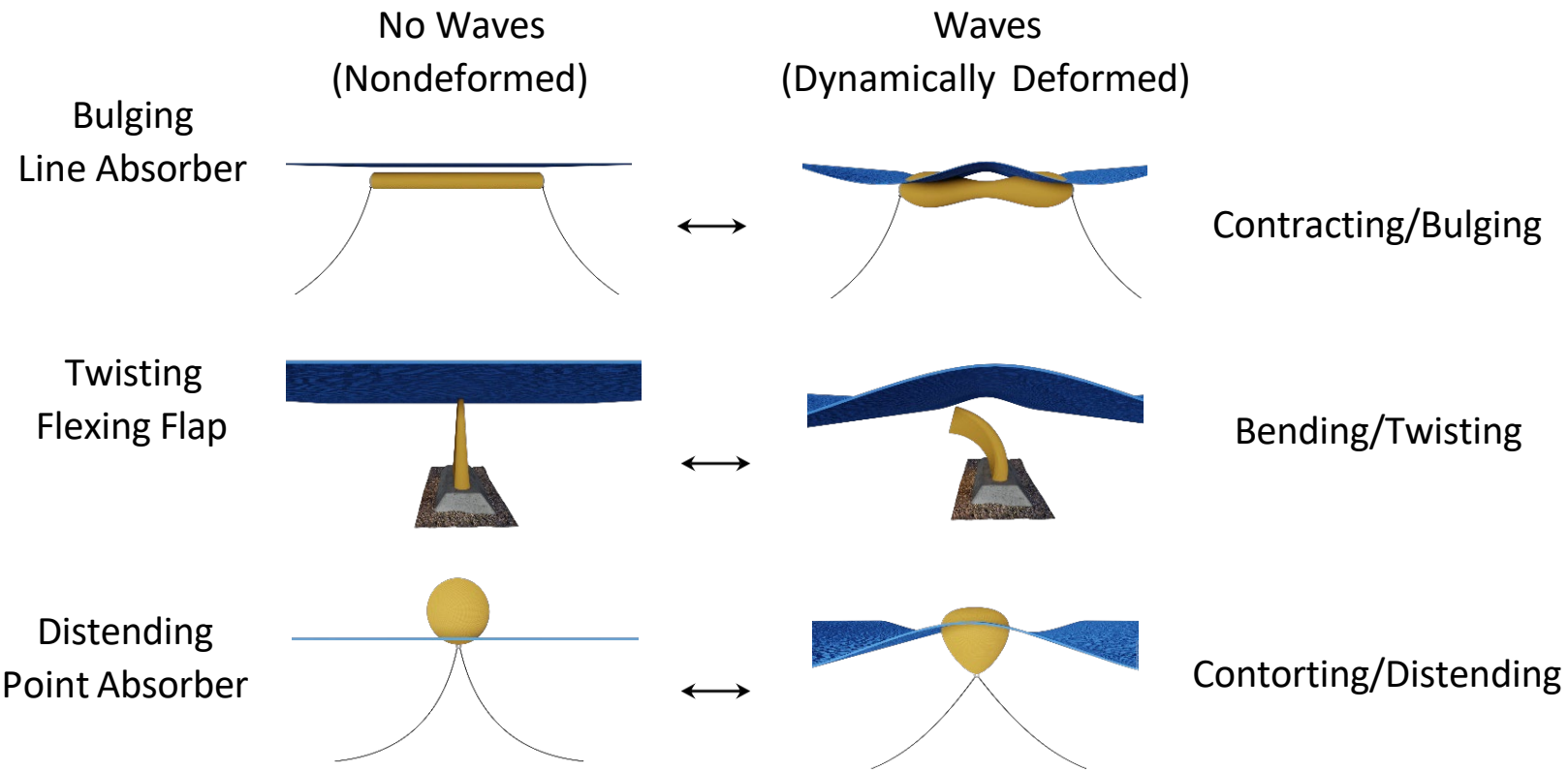
WBS: 2.2.1.407 Flexible Wave Energy Converters (FlexWEC)



Three flexWEC archetypes - illustrating their methods of operation: ocean waves induce active deformations into the wave energy converter structures. The structures are made from distributed embedded energy converters (DEECs) that can convert those dynamic deformations directly into electricity; ocean wave energy conversion occurs throughout the structure without need to concentrate loads into a singular prime-mover or lone generator.

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Illustrations by Blake Boren, NREL

Project Overview

Project Summary

Using DEECs to be both the structure and the direct means of ocean wave energy conversion, could revolutionize how we conceptualize ocean wave energy conversion and how we consider ocean waves to be a viable source of renewable energy. Nevertheless, the creation of "flexWECs" via such DEEC based structures is still a nascent area of research and development – needing greater understanding and evaluation of its potential. The overall goals of this project, therefore, are to understand the scientific and engineering merits of flexWECs and to assess how they could be best utilized to create effective and viable harvesters and converters of marine renewable energy.

Intended Outcomes

Major deliverables aim to:

- Report upon the potential for flexWECs to be a disruptive step change in how we conceptualize ocean wave energy converters.
- Identify research and development pathways for achievement of flexWEC technology's economic viability and competitiveness for large-scale continental grid electricity markets.
- Identify and assess key cost and performance drivers associated with flexWEC technologies—identification of flexWEC technology bottlenecks.
- Develop a road map to those numerical methods and strategies best suited for the benefit of flexWEC technology developments.

Project Information

Principal Investigator(s)

Blake Boren
Jochem Weber

Project Partners/Subs

- N/A

Project Status

New

Project Duration

- Project Start Date: Quarter 1; 2019
- Project End Date: Quarter 4; 2021

Total Cost (Fiscal Year [FY] 2022)

$705,000

Project Objectives

Relevance to the U.S. Department of Energy Water Power Technologies Office (WPTO) Program Goals:

The FlexWEC Project contributes to WPTO's mission by enabling research and development of a new technology domain that has strong paradigm-shifting potential for the conversion of ocean wave energy into more usable forms, e.g., electricity. The project's efforts fall under "Marine Energy Program Activity #1: Foundational R&D to address difficult engineering for the conversion of marine energy." Thus, such foundational research and development – into the new domain of flexWEC – will contribute to WPTO's long-term outcomes for the increased growth in both: utility-grid-scale ocean wave energy to electricity conversion efforts and, also, Powering the Blue Economy (PBE) Initiative efforts.

Approach:

The FlexWEC Project accomplishes its goals and objectives, primarily, by assessing the potential of flexWEC technologies to enable a positive disruptive step change in how WECs are conceptualized and developed. Likewise, the project's approach aims to flesh out those avenues for accelerated flexWEC research and development; e.g., leveraging preexisting technology domains to build and gain insights into flexWEC technology advancement. Contributing to and supporting these approaches, are the project's efforts to identify key flexWEC cost and performance drivers coupled with the distillation of numerical tools (and tactics) deemed advantageous for the modeling and optimization of flexWEC technologies. In this way, the FlexWEC project is strategically researching those key aspects of the flexWEC technology's domain such that the project outcomes directly contribute to WPTO'S goals – aiming at "Foundational R&D to address difficult engineering for the conversion of marine energy."

Project Objectives (cont'd)

Expected Outputs:

- Reports and memos describing research approaches and methodologies for assessment of how flexWEC technologies can be positive disruptive step changes in how ocean wave energy converters are conceptualized.
- Identification of those research and development pathways needed for the advancement of flexWEC technologies into successful realms of economic viability, especially in terms of large-scale market applications for the continental electrical grid.
- Identification and assessment of key cost and performance drivers of flexWEC technologies – identification of those bottlenecks that could stymie flexWEC technology development.
- Communications and outreach materials (articles, conference presentations, etc.) describing research approaches, assessments, identified developmental pathways, and techno-economic cost drivers of flexWEC technologies.

Intended Outcomes:

- A greater understanding of those facets of flexWEC technologies that can truly enable disruptive step changes (paradigm shifts) in how ocean wave energy is converted into more usable forms of energy, e.g., electricity.
- A resolved description and understanding of those research pathways found highly advantageous for further development and promotion of flexWEC technologies.
- An appreciation and distillation for the developmental bottlenecks associated with both the technological and public promotion of flexWEC technologies.
- Successful promotion for greater public understanding of this, a largely unknown technological domain, flexWEC project.

Project Timeline

FY 2019

- Exploration and evaluation of possible cost and performance drivers.

FY 2020

- Development and study of numerical models of a flexWEC archetype.
- **Identification of key** features of flexWEC systems and isolated specific cost and performance drivers.

FY 2021

- **Identification of** preexisting technologies' methodologies to support flexWEC technology development.
- **Distillation of** specific design and development strategies for the conceptualization, fabrication, and evaluation of flexWEC technologies.
- **Mapping of** numerical strategies for multiple aspects of flexWEC technologies and sub-technologies.
- **Evaluation** and **listing of** those manufacture and fabrication methods uniquely suited for flexWEC technologies.

Project Budget

FY 2019	FY 2020	FY 2021	Total Actual Costs FY 2019 - FY 2021
Costed	Costed	Costed	Total Costed
$244,000	$246,000	$215,000	$705,000

End-User Engagement and Dissemination

- Stakeholder and/or end-user engagement strategy:
  - The primary beneficiaries and audiences for the FlexWEC project are domestic and international marine energy researchers and developers. Indeed, the success of this project will advance the marine energy industry by identifying and enabling researchers and developers to more fully explore promising areas and technology developments for marine renewable energy that heretofore have not yet been widely considered or known about.
  - The FlexWEC project engaged stakeholders via virtual and in person correspondence.
  - Evaluation and feedback from stakeholder engagement will be collected, analyzed, and incorporated into the identification and evaluation of flexWEC technology features.
  - Diversity, inclusivity and equity plan: The project aims to help ameliorate underrepresented communities by developing knowledge and research outcomes. Namely, this alternative clean, renewable energy, from flexWEC technologies, could power these communities, their transportation, and their medical-healthcare facilities, and provide a source of clean water. This example is especially cogent for remote coastal and island communities – areas with readily available ocean wave energy for flexWECs – in greater need of desalinated water and fossil-fuel-free electricity, especially during drought conditions.
- Project results/information plans for dissemination:
  - Project results will be disseminated via conferences, an article, and a website. Moreover, reports alerting WPTO of the viability and worthwhile nature of continued flexWEC domain development and exploration will be generated.
  - Two patent applications were submitted for flexWEC technology.

Performance: Accomplishments and Progress

- Five+ quarterly reports/memos
- Two International Conference on Ocean Energy
- European Wave and Tidal Energy Conference
- FlexWEC article

- Patent Applications:
  - Surging flexWEC, application number 17112338
  - Hex-DEEC, application number 16997455
- NREL Record of Invention:
  - Bifurcating Origami FlexWEC

Future Work

New DEEC-Tec Annual Opperating Plan (FY 2022—FY 2025)

- FY 2022 Quarter (Q)1–Q3: Establish laboratory space, complete three internal memos
- FY 2022 Q4: Submit DEEC-TEC paper to *Journal of Marine Science & Engineering*
- FY 2022 Q4: Submit Hex-DEEC paper to *Energies* journal
- FY 2023 Q1: Present at International Conference on Ocean Energy, NREL news/headlines article
- FY 2023 Q4: Present at European Wave and Tidal Energy Conference
- FY 2024 Q3/Q4: Submit patent application for sub-1-kilowatt (kW), PBE-oriented, proof-of-concept flexWEC
- FY 2024 Q4: Go/No-Go WPTO review of sub-1-kW, PBE-oriented, proof-of-concept flexWEC design
- FY 2025 Q2: Large wave basin evaluation of sub-1-kW, PBE-oriented, proof-of-concept flexWEC
- FY 2025 Q4: Present at European Wave and Tidal Energy Conference
- FY 2025 Q4: Publish journal article of sub-1-kW, PBE-oriented, proof-of-concept flexWEC design and results from large wave basin evaluation effort/results.

Q&A