Prototype and Codesign of Nascent Flexible Wave Energy Converter Concepts
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Domain 1 – The Mainstream: Monolithic Rigid Bodies With Singular Power Take-Off

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Distributed Embedded Energy Converter Technologies

Domain 1 Hallmarks
• Relatively large, monolithic, rigid bodies.
• Singular means of power take-off (e.g., relative motion between rigid bodies).
• Solo, prime-mover mechanisms (e.g., rotary generator, hydraulic piston).
• Gears, bearings, hydraulic pressures, accumulators, fluids, seals.

Prevailing mainstream ocean wave energy converter archetypes.
Figures sourced from https://aquaret.com/

Long Histories of Interest and Investment
• Existed for decades.
• Significant funds put forth for research & development.
Supporting Compliant Material Framework

Layers of DECCs

Embedded Power Conductors and Interconnects

A sample volume illustrating an overview of the subcomponents of a stretched/deformed DECC-Tec.

Illustration by Blake Boren, NREL

Stretched

Twisted and Stretched

Compression

Illustrative sample volume being dynamically deformed; principal manners of operation.

Illustration by Blake Boren, NREL

DEEC-Tec structures are used to create whole flexible wave energy converters (flexWECs).

FlexWEC, being a portmanteau word, means:

1. The compliant nature of DEEC-Tec structures.
2. The overall structure’s purpose to harvest and convert ocean wave energy.

Example from industry:
SBM Offshore’s S3 device

Domain 2 Hallmarks

- Energy conversion directly in situ throughout distributed embedded energy converter technologies (DEEC-Tec) structures.
- Inherent broad-banded ocean wave energy conversion; near continuous degrees of freedom.
- No focus or concentration of forces into centralized, prime movers.
- Inherent redundancy.
Motivation
An opportunity for cursory investigations into some areas of applied DEEC-Tec.

Prototyping Seedling Investigations
• Material types
• Fabrication techniques
• Evaluation methods
• Laboratory structures
• Computer-aided design (CAD) modeling
• Data acquisition requirements
• Instrumentation needs.

Codesign Seedling Investigations
• Fluid-structure interaction
• Modeling elastic and hyperelastic materials
• Topologies (flexWEC geometries and forms)
• Morphologies (flexWEC compliant characteristics)
• Applied, high-performance-computing modeling methods.

And Outreach
(Diversity, equity, and inclusion via interns and postdocs)
Prototyping

R&D for Fabrication and Evaluation of DEECs
- Identify possible transducers for use as DEECs.
- Design and CAD modeling.
- Develop requirements for instrumentation and laboratory requirements.

Notable Outcomes
- Developed design capable of both fabrication and evaluation of dielectric elastomer generators (DEGs).
- Designed and acquired laboratory space for prototyping.
- Cursory evaluation of elastomers; displacement models.

Design developments: DEG fabrication and an evaluation rig

Codesign

An Investigation for Codesign and Multiphysics
- Computational demands aiming to truly enable codesign of flexWEC technologies.
- Avenues for numerical modeling.
- Numerical modeled wave tank.
- Deformable geometries.

Notable Outcomes
- Isolated conducive methods for numerical modeling and enabling codesign of flexWECs via Siemens Star-CCM+; Eulerian multiphase, volume of fluid, hyperelastic materials.
- Generated report showcasing success.

The investigation centered on two geometries.