

DE-EE0007819 : Demonstration of an Advanced Multi-Mode Point Absorber for Wave Energy Conversion



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Organization(s) Oscilla Power

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Project Summary

- Develop the Triton-C, a 100kW wave energy converter for remote locations and power-at-sea applications. The Triton-C fills the gap between larger utility-scale systems and smaller PBE units and is targeted at niche, near-term applications. The Triton-C shares the same hull design and architecture as Oscilla’s larger 1MW Triton WEC, although with specific adaptations for its size including a rotary long-travel drivetrain. The similarities to the larger 1MW Triton also help to de-risk future development of the Triton-C.

Intended Outcomes

- The overall goal for this project is as follows:
 - Complete design for a 100kW WEC suitable for remote locations
 - Construct the Triton-C System
 - Deploy and operate the Triton-C system at the WETS site
 - Provide functional verification of the Triton-C
 - Complete performance verification & numerical model validation
 - Develop operating experience
 - Identify future design improvements
 - Capture lessons learned

Project Information

Principal Investigator(s)

- Tim R Mundon (PI).

Project Partners/Subs

- Glosten, Snow & Company, Spencer Fluid Power, Applied Motion Systems, Applied Control Engineering, Sea Engineering, Powertrain Engineers, Marine Systems Modelling.
- NREL.

Project Status

Ongoing

Project Duration

- April 2017
- September 2023

Total Costed (FY19–FY21)

\$7,033,031.16

Relevance to Program Goals:

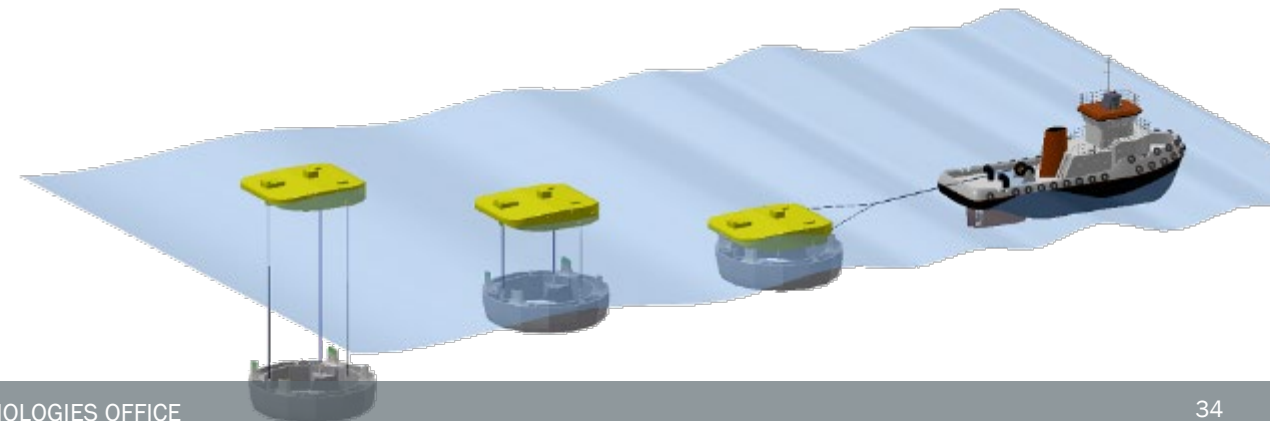
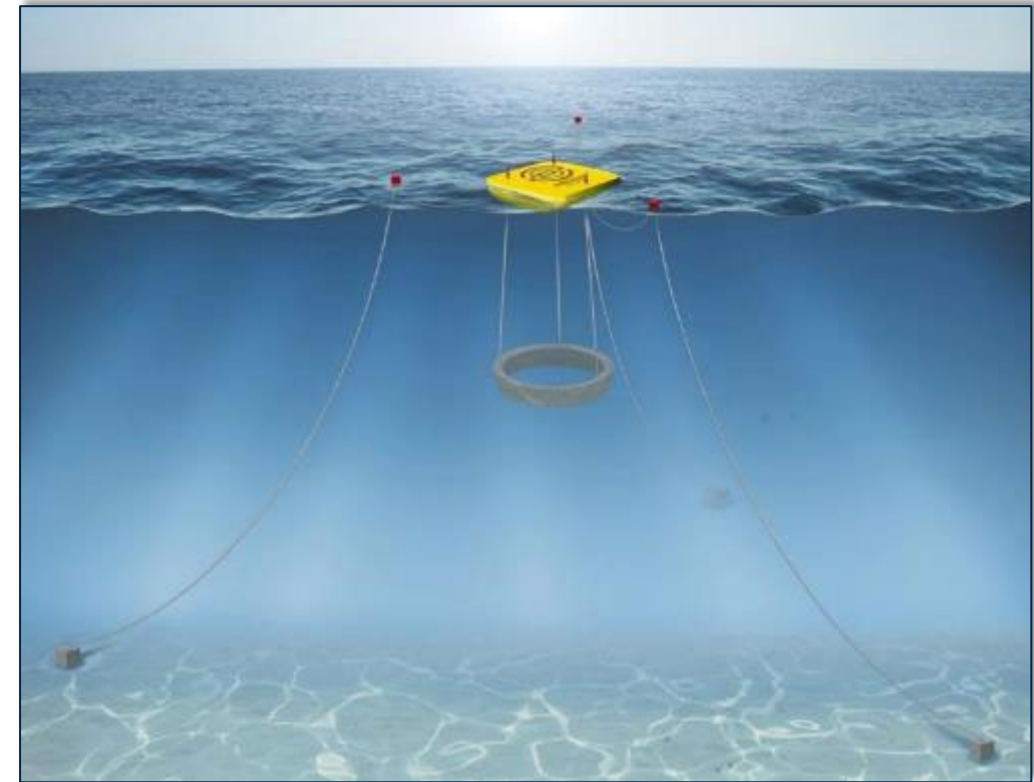
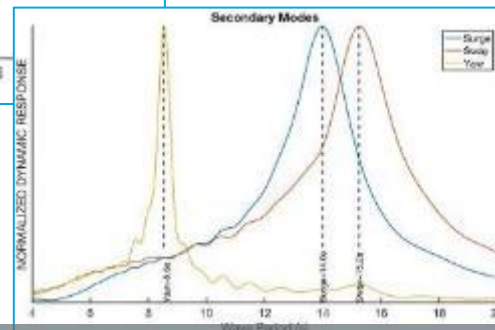
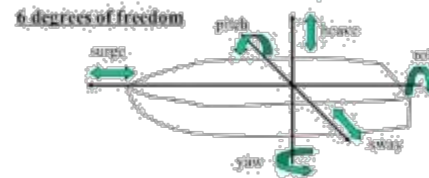
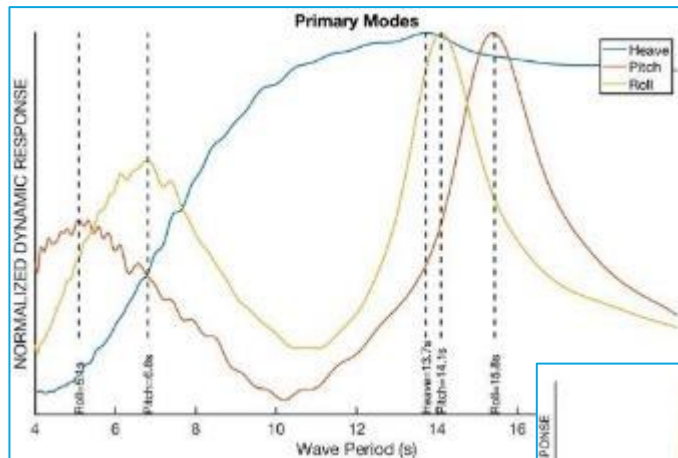
- Foundational R&D:
 - Develop and test tendon materials
 - Develop an advanced control system to be evaluated during testing. (TEAMER assistance).
 - Validate multiple numerical models of the Triton-C system through open water testing.
 - Demonstrate Ditre's wet-mate (pass-through) connector (Konekta) in a real WEC application.
 - Demonstrate a simple Tow-and-Drop installation methodology that allows the use of smaller, simpler install vessels.
- Technology Specific System Design and Validation:
 - Test Triton-C in fully energetic wave climate (WETS).
 - Complete a pre-commercial demonstration of the Triton-C. *OPI has already received multiple inquiries about the use of the Triton-C to support high-power PBE applications.*
 - Provide a platform to validate UW's environmental Adaptable Monitoring Package (AMP).
 - Host a demonstration of a HI State emergency radio transmitter. A near-term PBE application.

Project Objectives: Approach

Approach:

OPI's Triton architecture is based around a multi-mode implementation of the two-body point absorber WEC concept.

High Efficiency and Simple Installation



Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Demonstrate Triton-C WEC
- Performance dataset (MHK-DR)
- Lessons learned and experience shared through publications



Outcomes:

- Pre-commercial demonstration of the Triton-C wave energy system
- Successful demonstration will catalyze a subsequent capital raise to support work on a larger 1MW Triton
- Open order book for Triton-C models
- Increased public profile of Wave Energy, resulting in increased funding to WPTO and a higher likelihood of private capital becoming available for other developers

Project Timeline



TRITON-C
Community-Scale Wave Energy

FY 2019



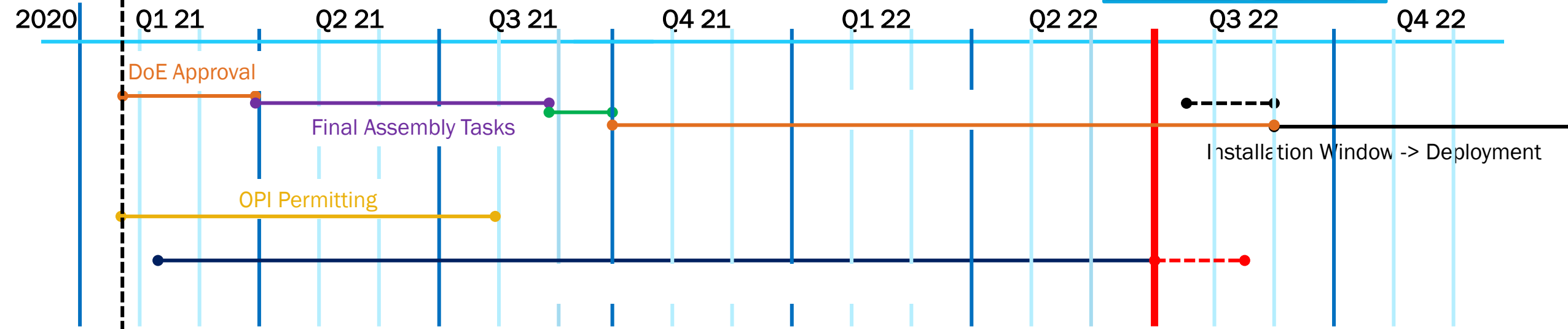
FY 2020



FY 2021



BP2/3 GNG



Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
\$7,721K	\$1,934K	\$9,655K

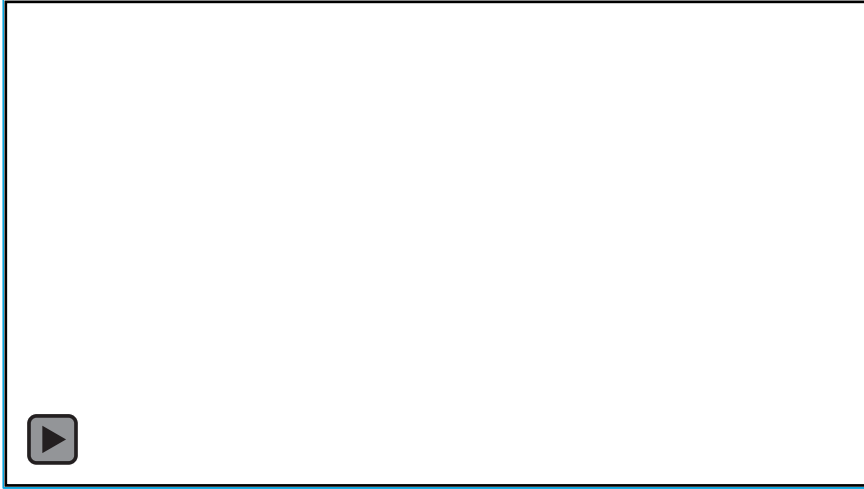
FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
\$1978K	\$3262K	\$1793K	\$7,586K

- Describe any variances from planned budget and identify if/how the project plan was modified.
- Describe any relevant context for your project budget. This is an opportunity to explain any sizeable discrepancy in the costed vs authorized numbers, delay in budget execution, mid-year scope increase/decrease, etc.
- Note, if any, other funding sources.

End-User Engagement and Dissemination

- End-user engagement strategy
 - The Triton-C is targeted at small and remote communities or facilities, and power-at-sea applications.
 - The 100kW power level is at a scale where it utilizes many utility-scale WEC technologies, yet its size makes it quicker and cheaper to prototype and bring to market.
 - OPI has started engagements with at least three potential end-users who are interested in the Triton-C in the following areas:
 - Power security for the remote community (Tribal community)
 - Power for remote O&G applications
 - Monitoring and security platform for defense applications (Surveillance radar)
 - AUV recharging
- Dissemination and commercialization
 - Specific results will be disseminated through DoE data-sharing channels such as MHK-DR
 - General results and experience will be shared through technical publications, journals, and conference presentations
 - If successful, OPI will look to start sales of the first commercial Triton-C units within the areas identified above through a specific business development team (to be established)
 - OPI expects first orders within 12-18 months after successful demonstration.

Performance: Accomplishments and Progress



Construction of the Triton-C completed September 2021

- Construction completed at the height of COVID-19 pandemic
- Delays due to drivetrain supplier issues
- OPI attempted to accelerate the schedule to compensate



Performance: Accomplishments and Progress

Transportation to Hawaii, launching, and mating with reaction structure completed

- Triton-C launched in October 2021 (All operations went well, and as planned)
- COVID created huge transportation disruption and cost increases
- Finding a berth in Honolulu Harbor was (and is) a challenge due to Harbors history with other WECs



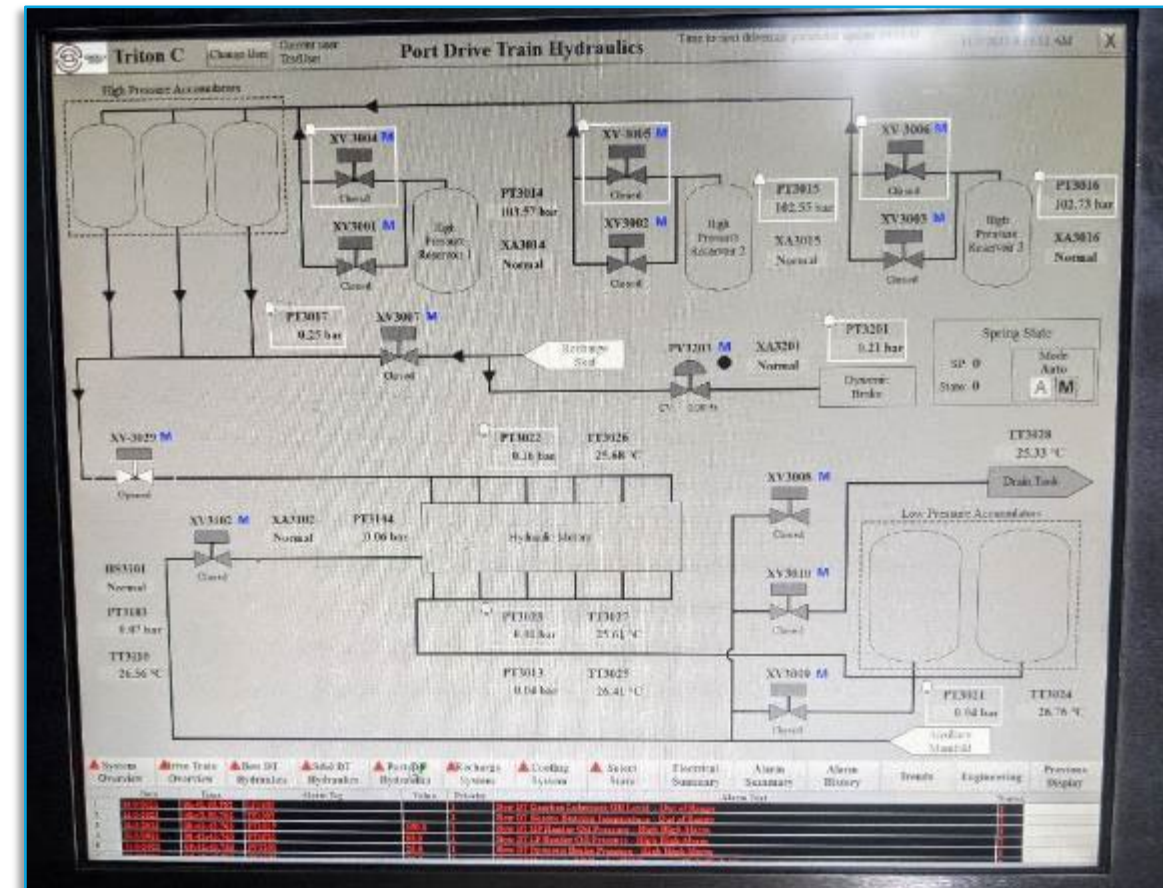
Completed installation of two peripheral projects:

- UW Adaptable Monitoring Package
- Installation of State of HI radio transmitter

Performance: Accomplishments and Progress

Testing of all subsystems completed in Seattle and Hawaii.

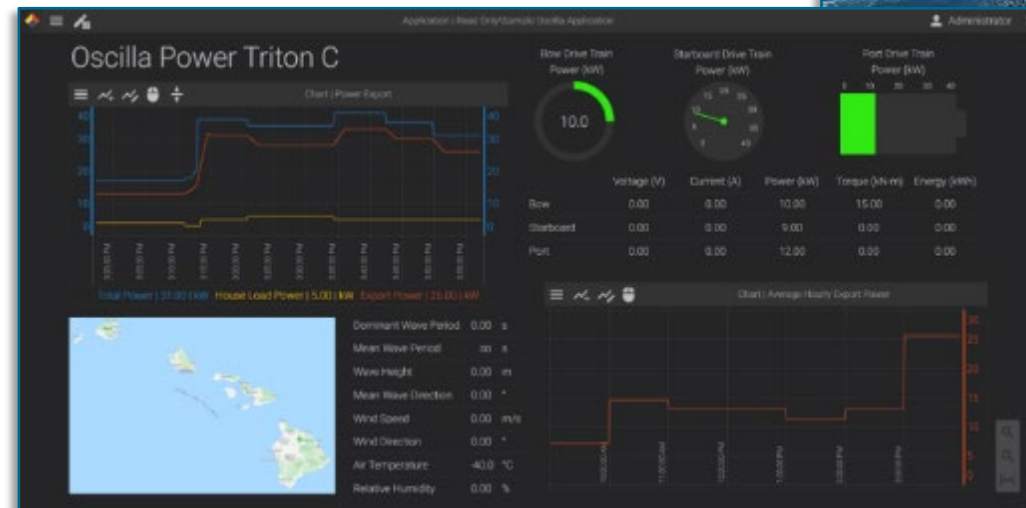
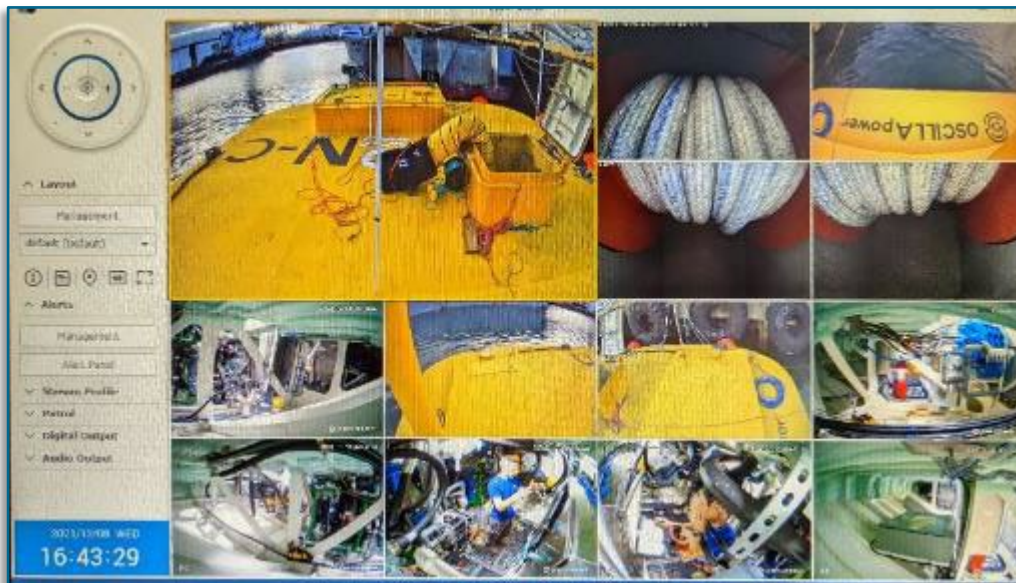
- Various issues identified and resolved:
 - Cooling system – PVC piping fluid incompatibility
 - Hydraulic vendor QA issues (multiple)
 - Re-testing and minor fixes being applied during waiting period



Performance: Accomplishments and Progress

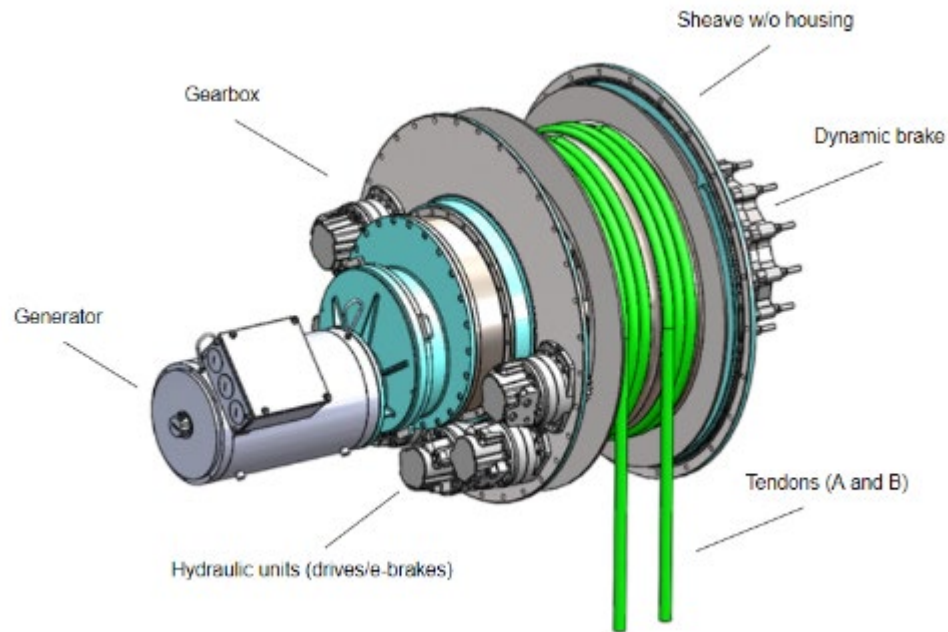
Status

- Waiting for WETS upgrades to be completed. Triton-C has been waiting in water for 9 months.
- Regular (infrequent) visits to continue system testing and monitoring.
- Extended wait in harbor causing problems:
 - No drivetrain motion to mitigate biofouling /corrosion buildup.
 - System designed for 1 year operation.
- The anticipated window for deployment is now slated for August.

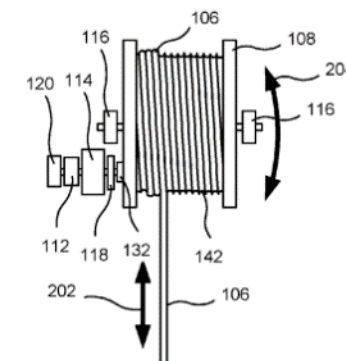


Performance: Accomplishments and Progress (cont.)

- OPI has been awarded US patent US11293398B2 for the Triton-C Drivetrain:
 - <https://patents.google.com/patent/US11293398B2/>
 - OPI's drivetrain is specific for a two-body WEC; It includes a compact, energy-neutral mechanism to apply a variable spring force to offset the mass of the reaction structure.



(12) United States Patent Mundon	(10) Patent No.: US 11,293,398 B2 (45) Date of Patent: Apr. 5, 2022
(54) DRIVETRAIN FOR A WAVE ENERGY CONVERTER	2009/0309366 A1* 12/2009 Moore F03B 13/1845 290/53
(71) Applicant: Oscilla Power, Inc. , Seattle, WA (US)	2012/0285544 A1 11/2012 Westby et al. F16H 1/46
(72) Inventor: Timothy R Mundon , Seattle, WA (US)	2013/0200626 A1* 8/2013 Sidenmark H02K 7/1892 290/53
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.	2015/0054285 A1* 2/2015 Hobdy F03B 13/182 290/53
	2017/0114769 A1* 4/2017 Pasanen F03B 13/182
	FOREIGN PATENT DOCUMENTS
(21) Appl. No.: 16/896,170	CA 2831560 A1 10/2011 GB 2469728 A 10/2010
(22) Filed: Jun. 8, 2020	OTHER PUBLICATIONS
(65) Prior Publication Data US 2021/0010452 A1 Jan. 14, 2021	Thomas "PCT International Search Report for International Application No. PCT/US2020/036707" dated Sep. 4, 2020, 2 pages. Thomas "Written Opinion of the International Searching Authority for International Application No. PCT/US2020/036707" dated Sep. 4, 2020, 7 pages.
Related U.S. Application Data	* cited by examiner
(60) Provisional application No. 62/858,148, filed on Jun. 6, 2019.	Primary Examiner — Shafiq Mian (74) Attorney, Agent, or Firm — Intellectual Strategies
(51) Int. Cl. F03B 13/18 (2006.01)	(57) ABSTRACT
(52) U.S. Cl. CPC F03B 13/1885 (2013.01)	An apparatus, system, and method are disclosed for WEC system for a wave energy converter. The system includes a buoyant object, a reaction body and a line coupling the reaction body and the buoyant object. The system further includes a drivetrain coupled to one of the buoyant object or reaction body. The drivetrain includes a sheave coupled to one of the buoyant object or reaction body and an actuator coupled to the sheave. The line is coupled to the sheave, wherein movement of the buoyant object relative to the reaction body applies a force to the sheave. The force on the sheave drives the actuator, wherein the actuator is configured to apply a spring force.
(58) Field of Classification Search CPC F03B 13/26; F03B 13/16; F03B 13/14; F03B 13/188; F03B 13/1885; F03B 13/20; F03B 15/00; F05B 2240/93; F05B 2260/4031; F05B 2220/706; F05B 2240/97; F05B 2280/5001 See application file for complete search history.	11 Claims, 6 Drawing Sheets
(56) References Cited	
U.S. PATENT DOCUMENTS	
6,247,308 B1* 6/2001 Solell F03B 13/1815 60/495	
7,443,046 B2* 10/2008 Stewart F03B 13/20 290/53	



Future Work

- Once WETS upgrades are complete, OPI will install the Triton-C.
- OPI expects a 6-month deployment with the following deployment activities:
 - Constant remote monitoring & regular in-person visits
 - Ongoing data analysis through NREL MHKit and OPI numerical processes
 - Functional verification
 - Performance verification & model validation
 - Extended (advanced control) evaluation
 - Hosting of peripheral UW AMP and State of HI Radio projects

Q&A