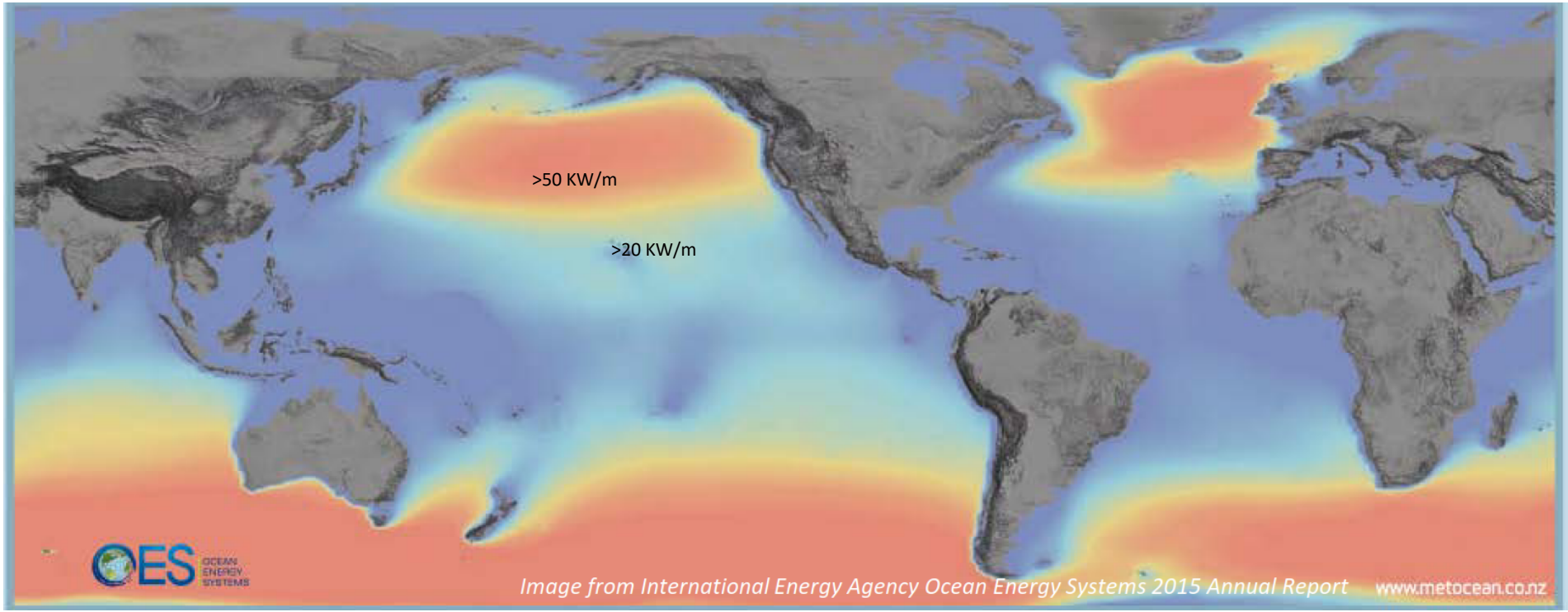
Port of Grays Harbor, WA Renewable Ocean Wave Energy Demonstration Project

Dr. Vladimir Shepsis
Applied Ocean Energy Corporation
November 18, 2020

APPLIED OCEAN ENERGY

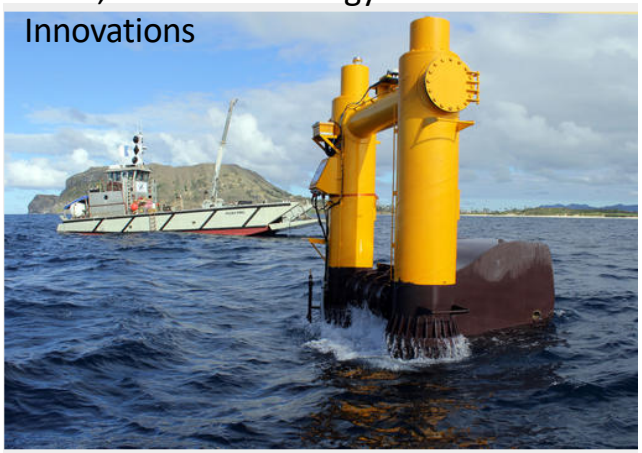
Global Distribution of Annual Mean Wave Power



APPLIED OCEAN ENERGY

2012, Columbia Power Technologies, Inc.

2015, Northwest Energy Innovations



2016, Norwegian Co

2017, Wave4Power, Norway

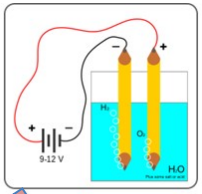
APPLIED OCEAN ENERGY

Differences and Advantages of AOE Technology

- **Enable storage of extracted wave energy:** No connection to the grid, no cables through the coastal areas, no dependance on demand in the grid
- **Installation offshore, as minimum 3 miles, but may be 100s miles from coastline**: Minimal regulatory control and approval; Limited or no intrusion on fishing/crabbing grounds; Outside of wave breaking zones and impacts from violent breaking wave forces
- **No moving parts and no direct contact with water column:** Increase durability, No corrosion due to salt water and no debris impact.
- **All installation is on a deck of regular barge.** No special and unique hall design; Proved to be appropriate for ocean conditions
- **Significant footprint of the barge:** Potential for high energy extraction; May not require multiple installations to produce commercially valuable energy
- **Other**

APPLIED OCEAN ENERGY

AOE Technology Diagram



$2H_2O \rightarrow 2H_2 + O_2.$

Wave Energy

Mechanical Energy of Wave Energy Converter (WEC)

Electricity

Electrolysis

Hydrogen H2

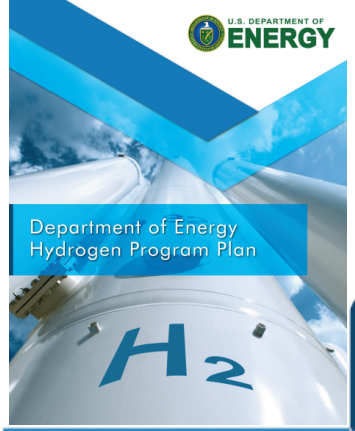
Compression and Storage

Oxygen O2

Compression and Storage

50 KW/h Electrical Energy + 9 Liters of Water =
1 Kg of Hydrogen (H_2) + 8 Kg of Oxygen (O_2)

APPLIED OCEAN ENERGY



Department of Energy Hydrogen Program Plan

	Transportation Applications	Chemicals and Industrial Applications	Stationary and Power Generation Applications	Integrated/Hybrid Energy Systems
Existing Growing Demands	• Material-Handling Equipment • Buses • Light-Duty Vehicles	• Oil Refining • Ammonia • Methanol	• Distrubuted Generation: Primary and Backup Power	• Renewable Grid Integration (with storage and other ancillary services)
Emerging Future Demands	• Medium-and Heavy-Duty Vehicles • Rail • Maritime • Aviation • Contruction Equipment	• Steel and Cement Manufacturing • Industrial Heat • Bio/Synthetic Fuels	• Reversible Fuel Cells • Hydrogen Combustion • Long-Duration Energy Storage	• Nuclear/Hydrogen Hybrids • Gas/Coal/Hydrogen Hybrids with CCUS • Hydrogen Blending

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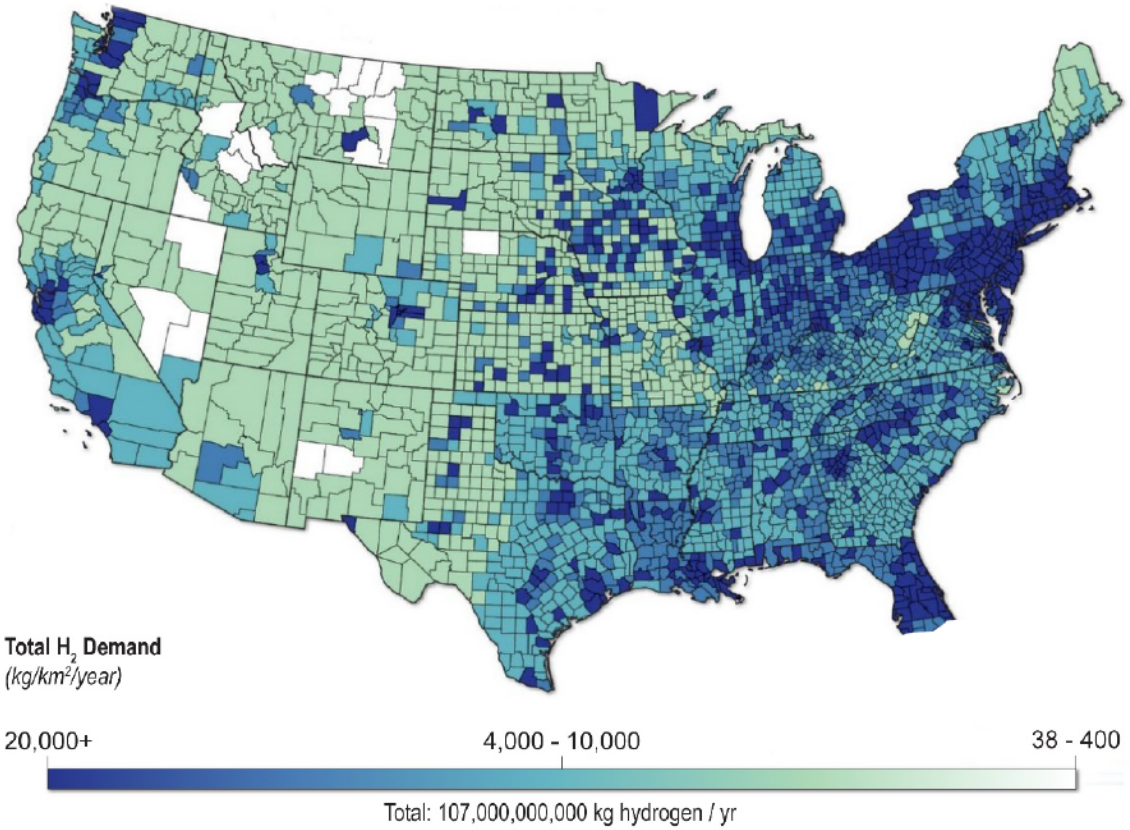
2015 Toyota

2017 Hyundai ix35 Fuel Cell

2017 Honda Clarity FCV

- More than 10 million metric tons of hydrogen are produced annually in the United States.
- There are 1,600 miles of hydrogen pipeline in the United States and large hydrogen production facilities in almost every state.
- Market for Hydrogen - $115 Billions/year at 6.5%/year growth

Hydrogen Consumption by Location



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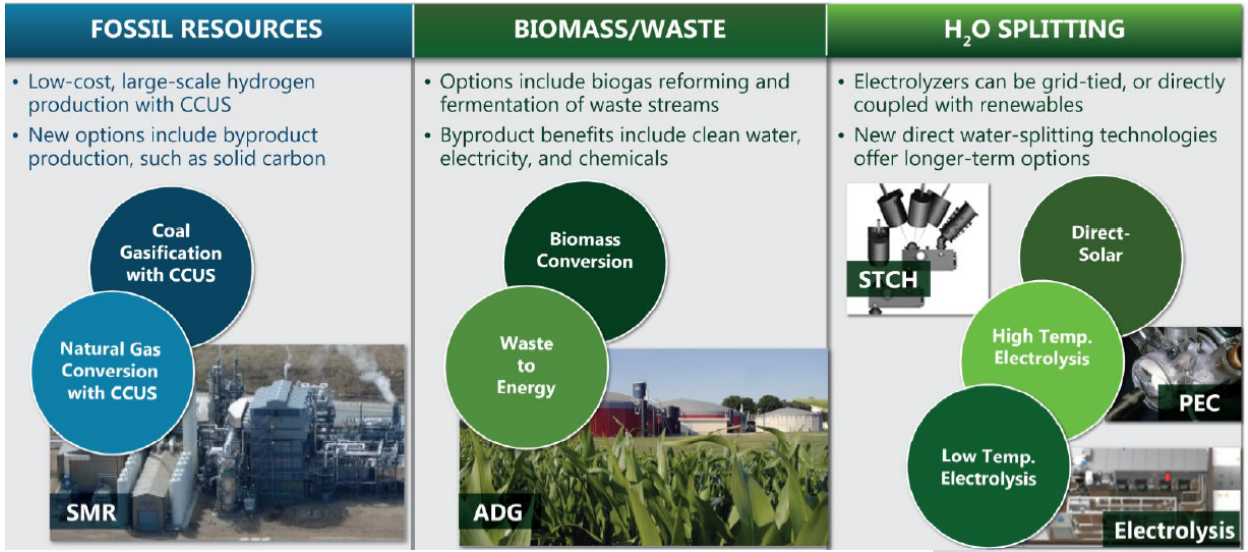
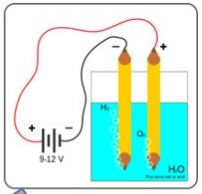
Hydrogen Production



95% of hydrogen is produced from fossil fuels, such as coal, natural gas, and oil by separating methane (CH_4) on hydrogen (H_2) and carbon dioxide (carbon dioxide, CO_2).

AOE Technology



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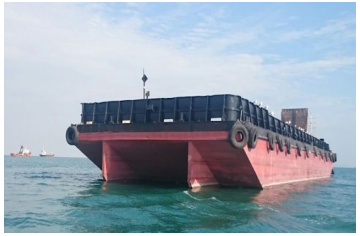
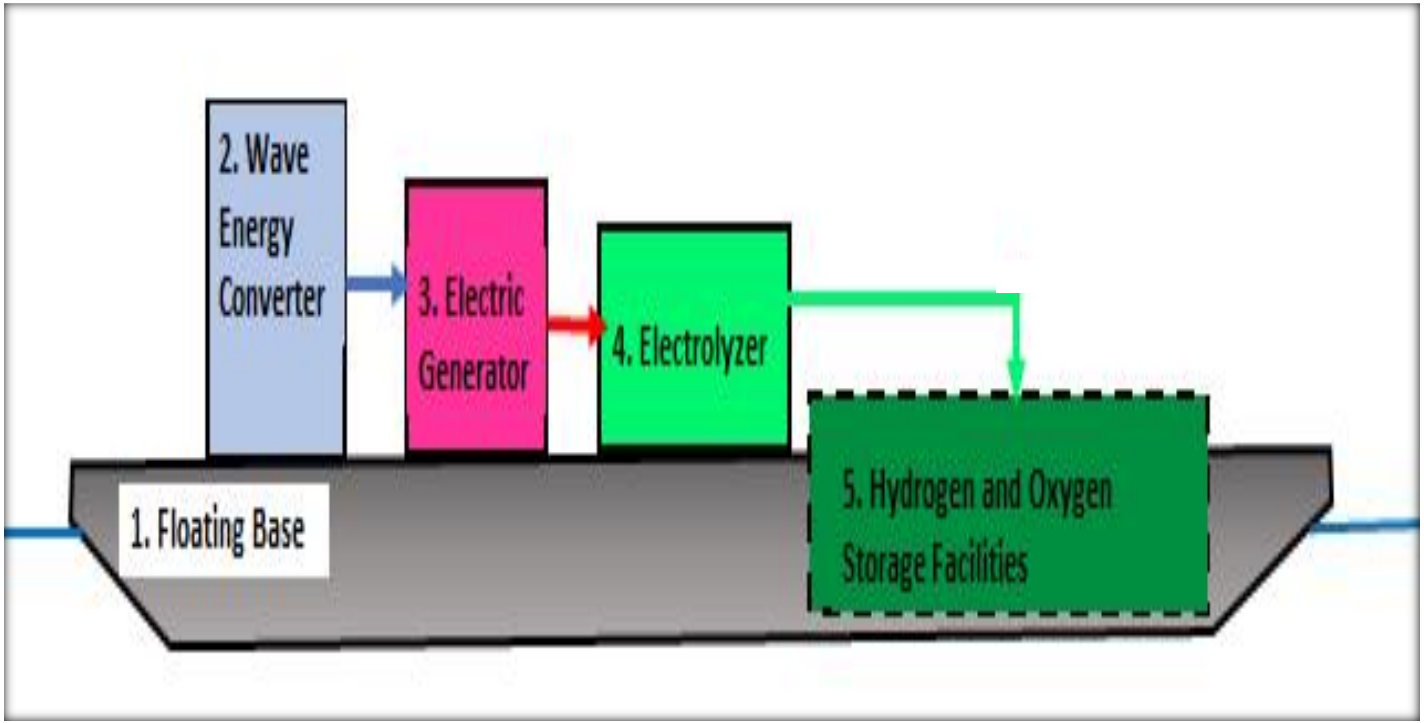
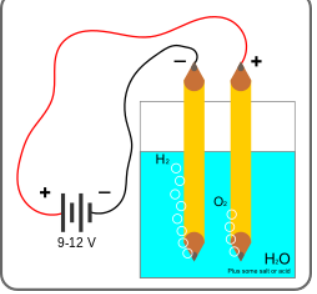
APPLIED OCEAN ENERGY

AOE Technology





Hydrogen- The World's Cleanest Energy Production and Transportation - Conventional Technologies



$$2H_2O \rightarrow 2H_2 + O_2.$$

HYDROGEN GENERATOR, 500ML/MIN.

PARKER HANNIFIN | ZORO #: G4060309 | MFR #: 60H

0.0 No Reviews | Write the First Review

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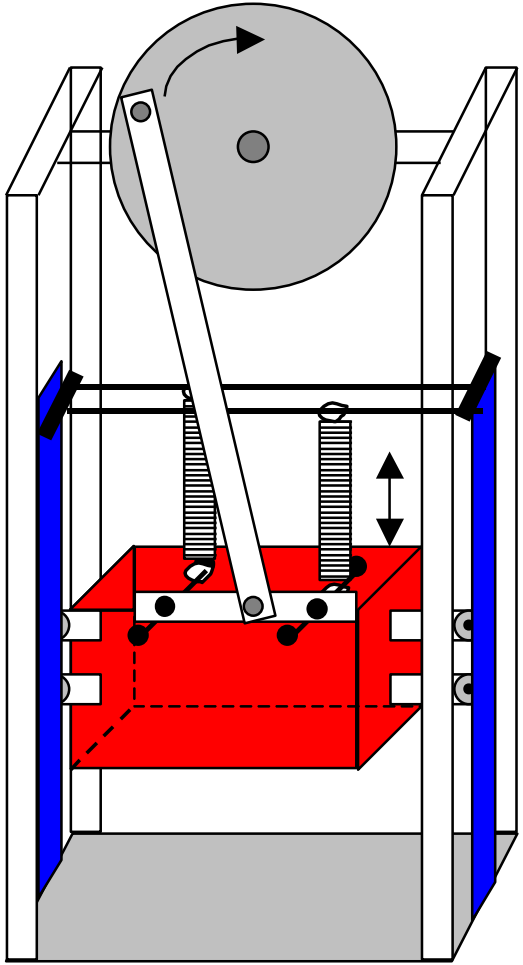
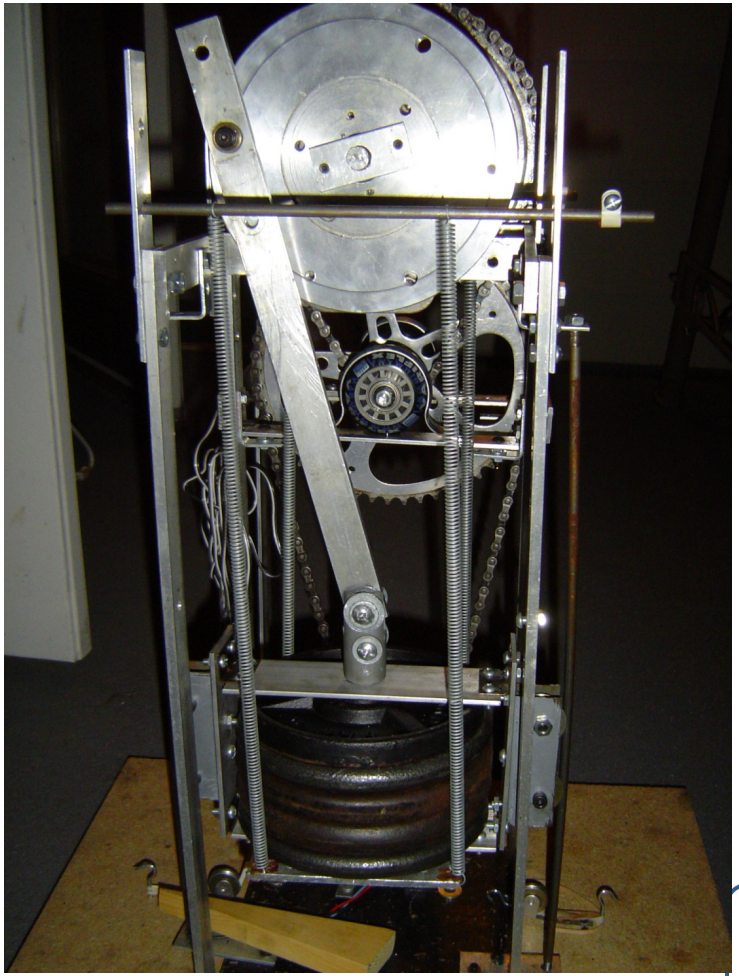
WEC Type 1





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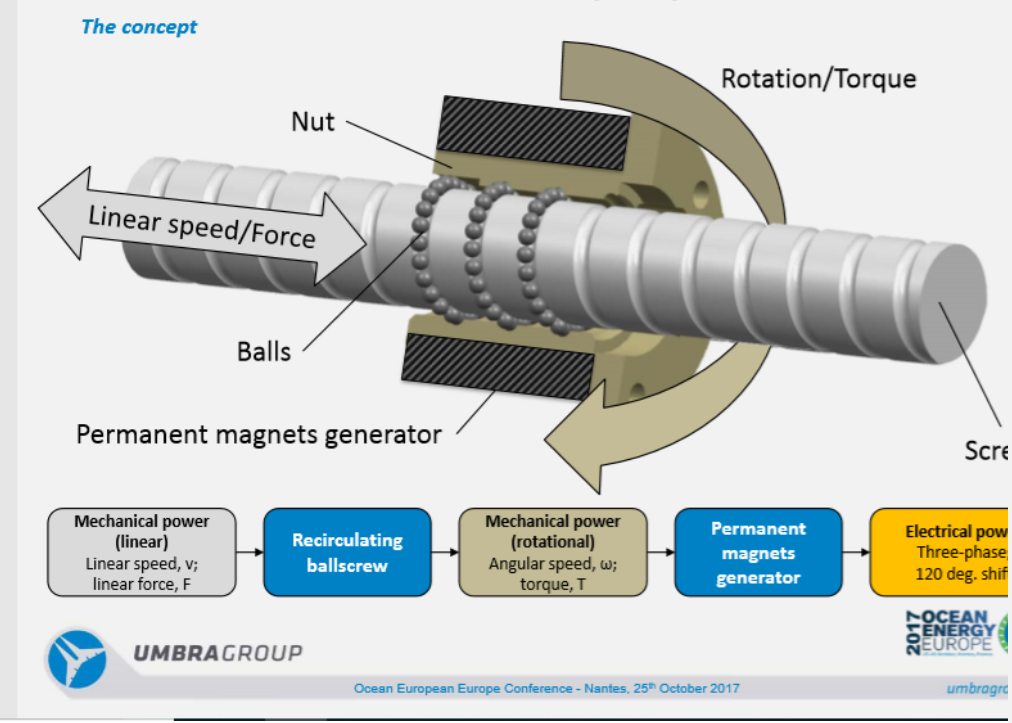
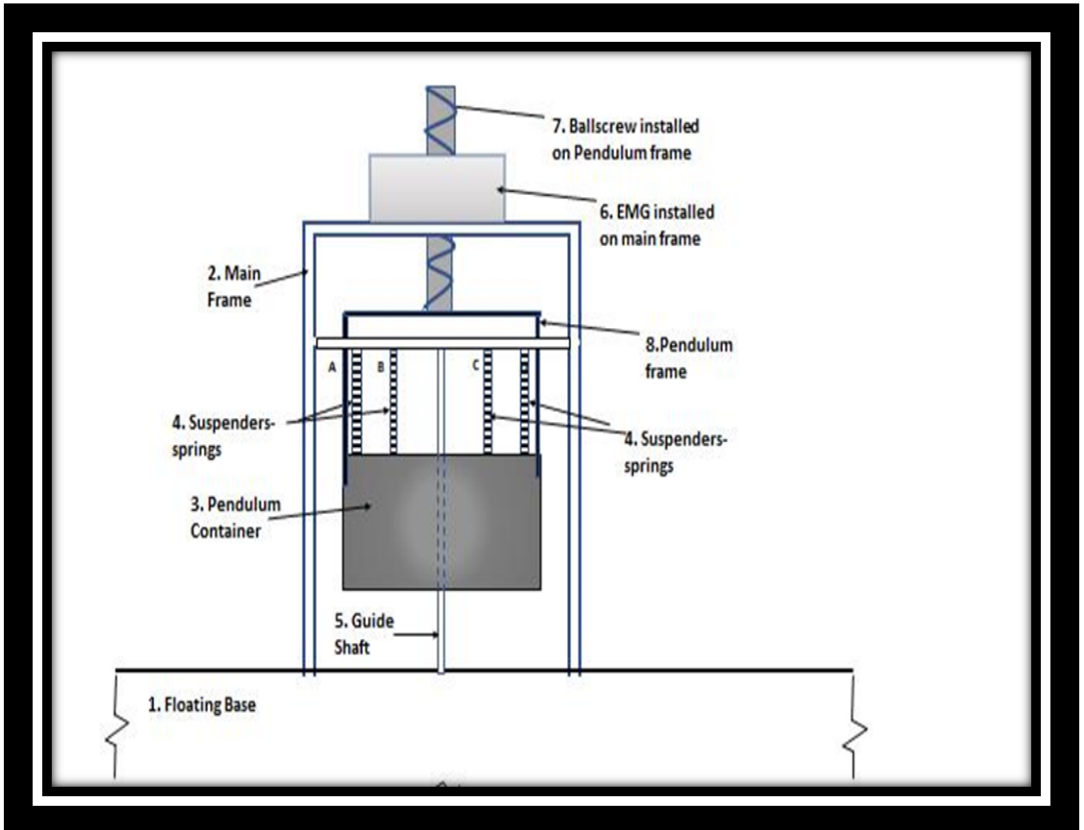
Linear Electro-Mechanical Generator, UMBRA GROUP spa

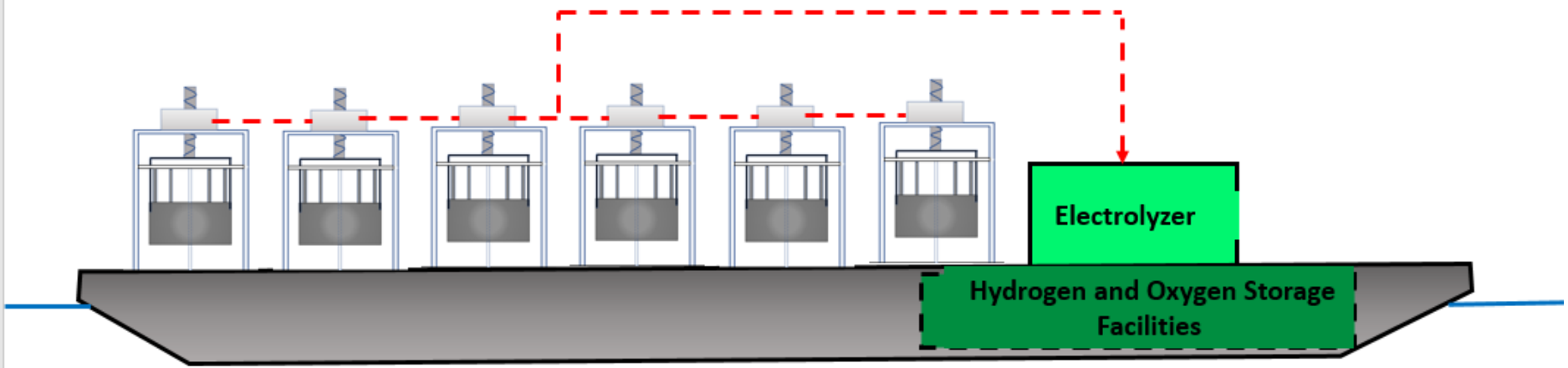


WEC Type 2, Wave Energy Converter & Linear Electro Mechanical Generator



APPLIED OCEAN ENERGY

AOE Technology



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Support for Demonstration Project

- Port of Grays Harbor
- Port of Willapa Harbor
- Port of Ilwaco
- Columbia River Crab Association
- Pacific County
- Cape Shoal Indian Reservation
- City of Raymond
- Quinault Indian Nation

APPLIED OCEAN ENERGY

2019-2020

PSHB 1102
(H-2522.1)

national laboratory.

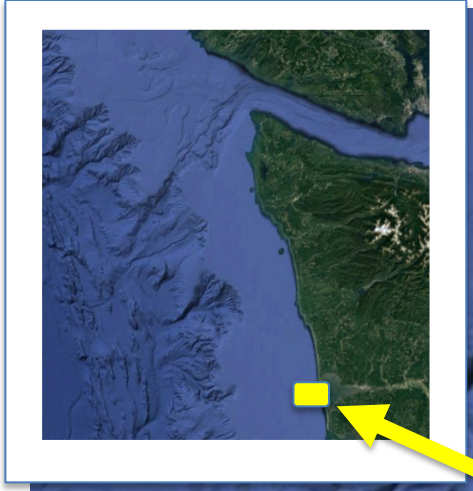
(10) $593,000 of the state building construction account—state appropriation is provided solely to the port of Grays Harbor for an offshore ocean wave renewable energy demonstration project.

Appropriation:

ENERGY

Demonstration Project Goals and Objectives

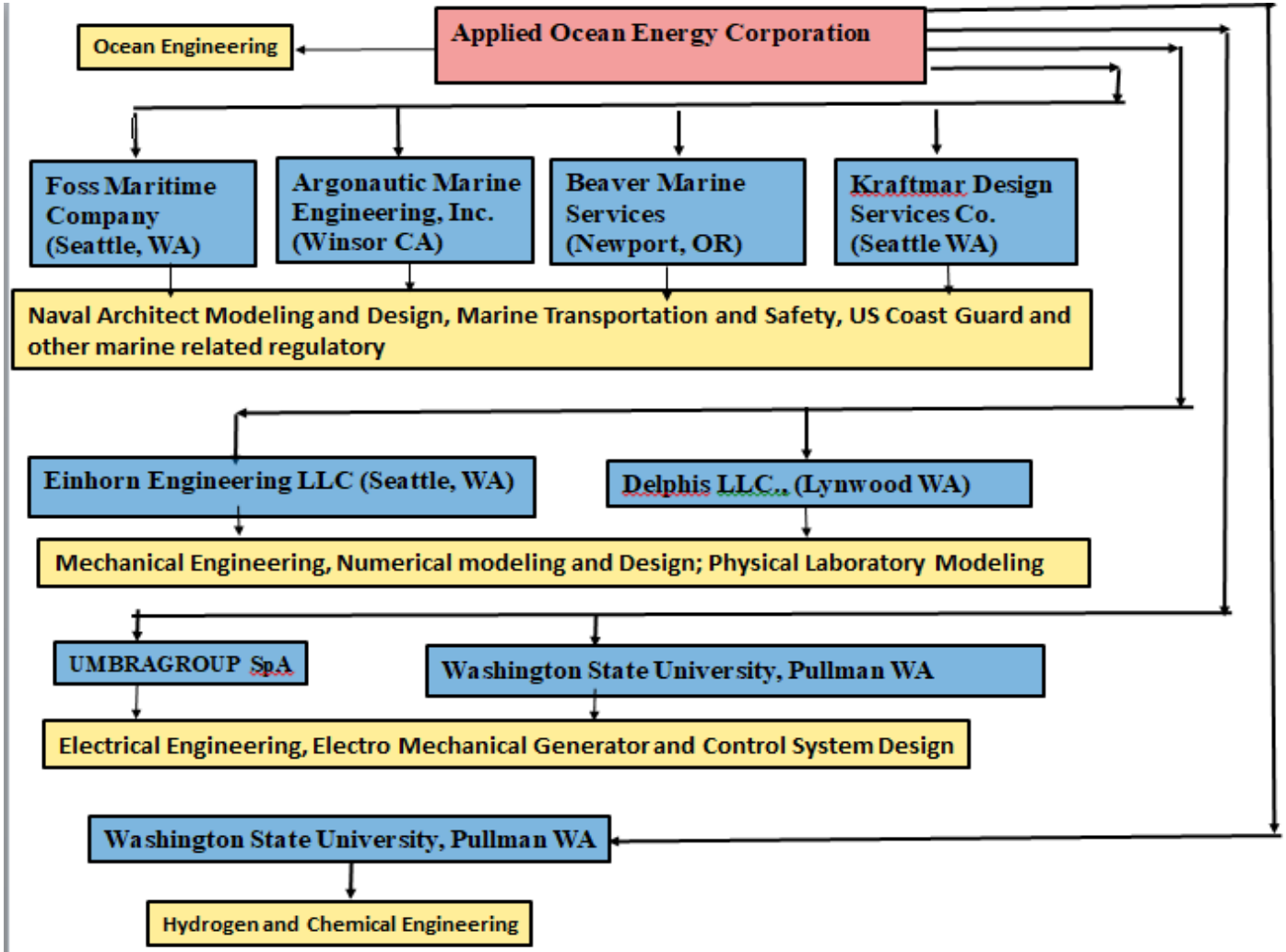
- Evaluate technical feasibility of AOE Technology for demonstration project at the offshore of Grays Harbor Estuary
- Prepare conceptual level design of the technology and protocol of the demonstration project (drawings, specifications, cost estimate)
- Identify all pertinent regulatory requirements for implementation of the demonstration project and obtain the required permits.



Grays Harbor Estuary

Demonstration Project Approximate Location

~3 miles



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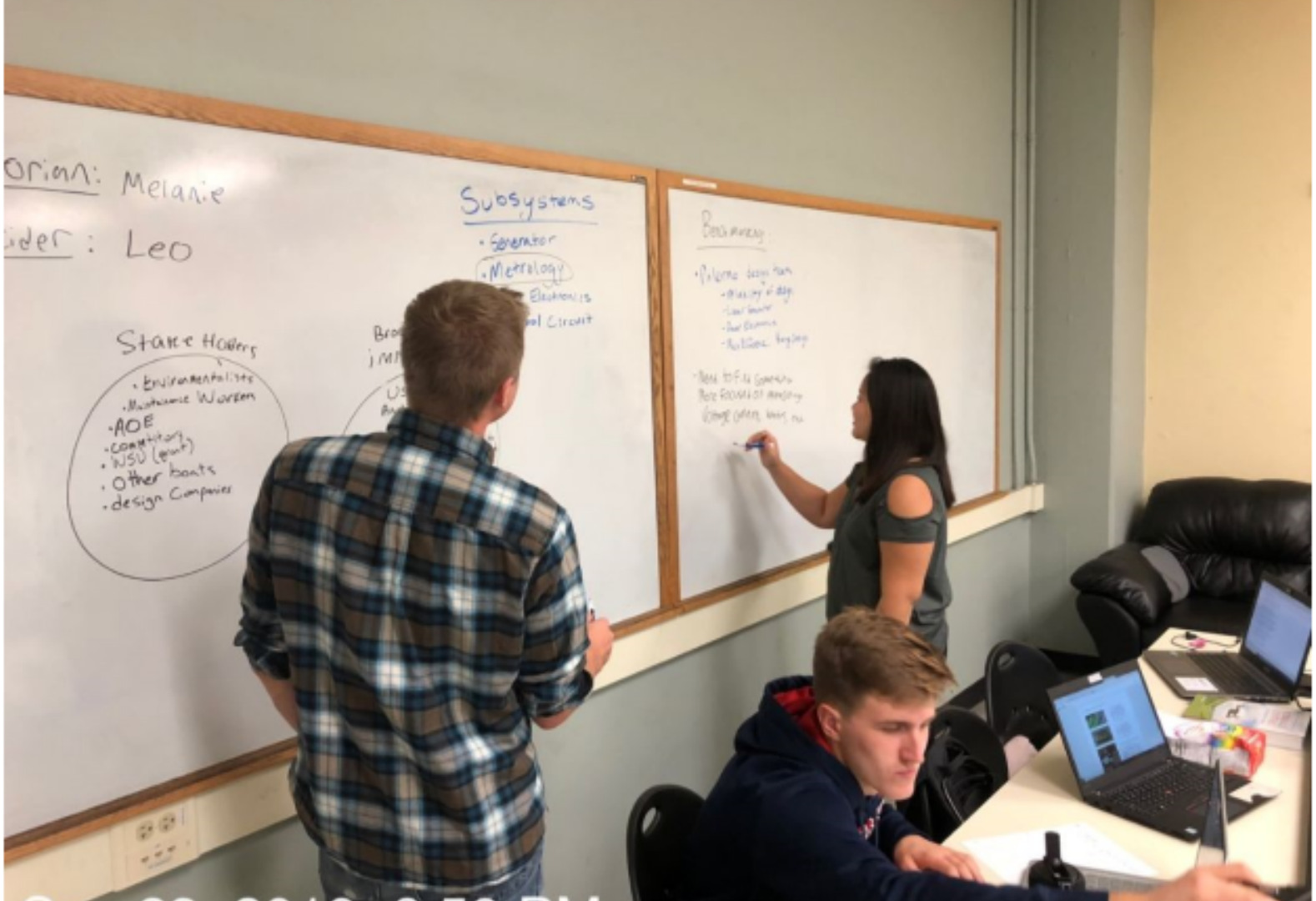
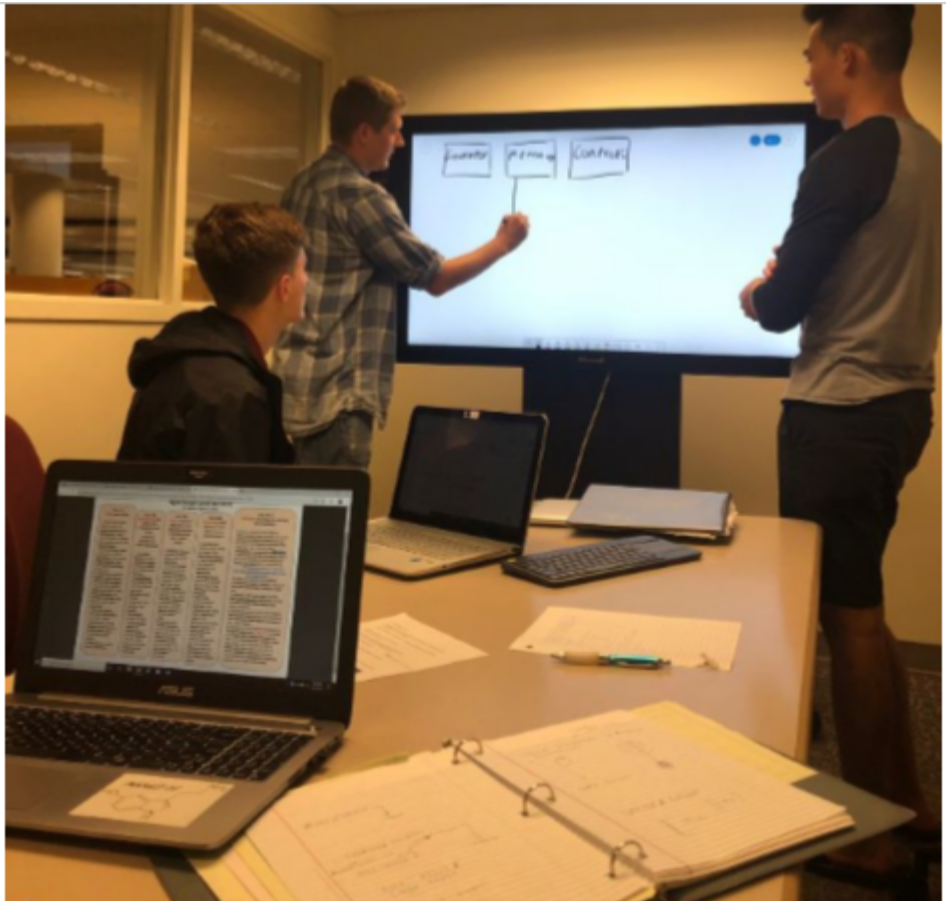
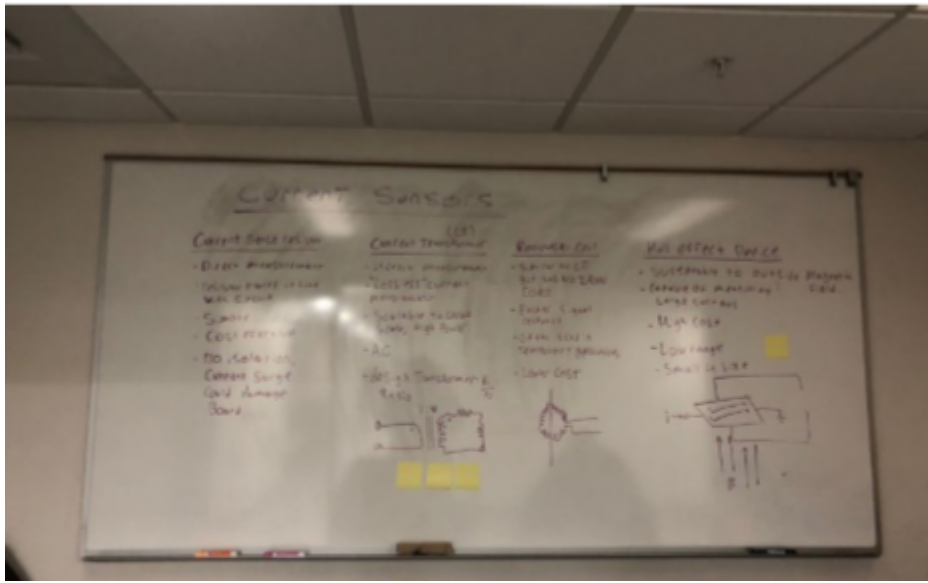

Melanie
Leo
Subsystems
Generator
Metrology
Stake Holders
Environmentalists
Maintenance Workers
AOE
competitors
WSU (grant)
Other boats
design Companies





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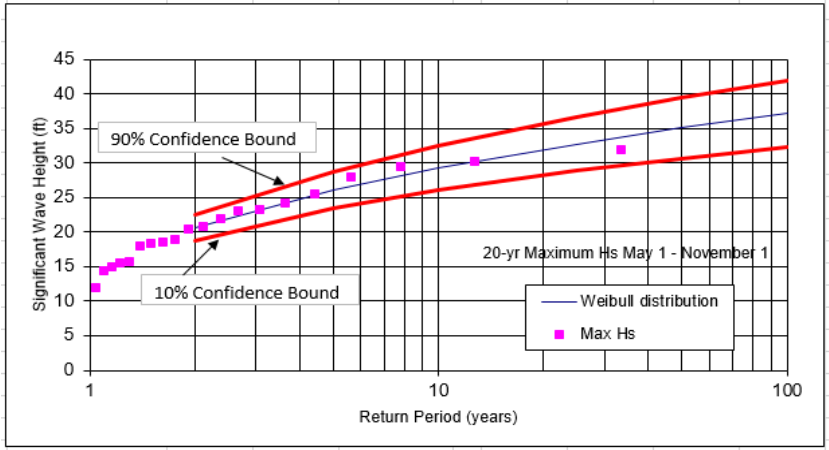
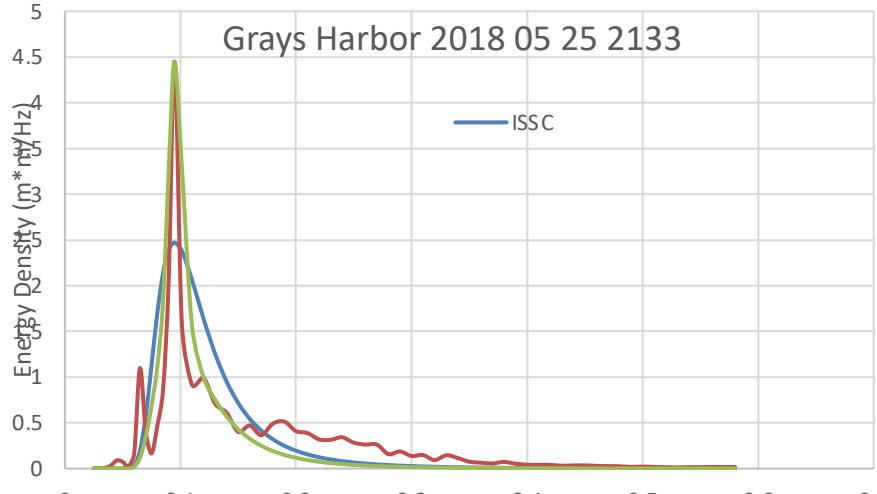
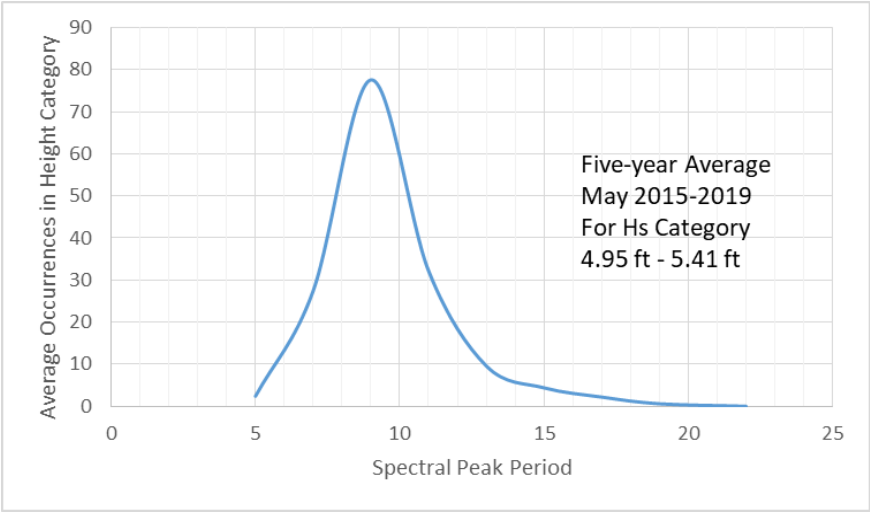
Ocean Engineering –Completed

Month	Representative Hs (ft)	Representative Hmax (ft)	Most Frequent Associated Tp (sec)	Estimated Average Period (sec)
May	5.30	9.54	9.0	6.2
June	4.56	8.21	9.0	6.3
July	4.15	7.47	8.5	5.9
August	4.43	7.97	8.3	6.1
September	5.95	10.71	9.0	6.5
October	7.37	13.27	11.0	7.7

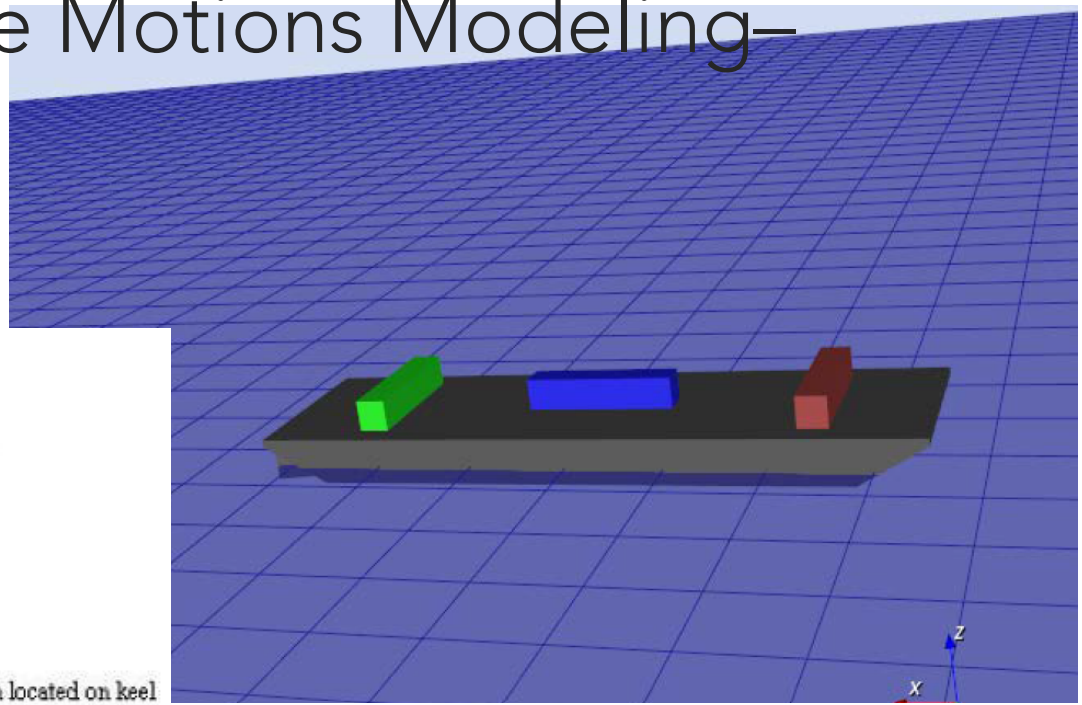


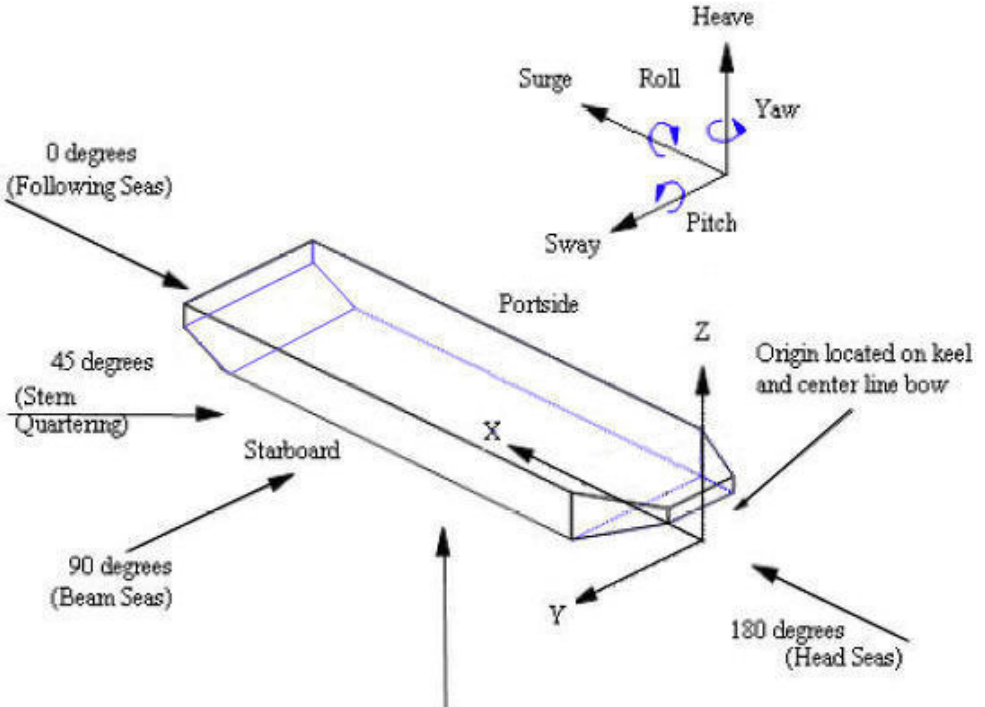




Naval Architect, Barge Motions Modeling– Completed

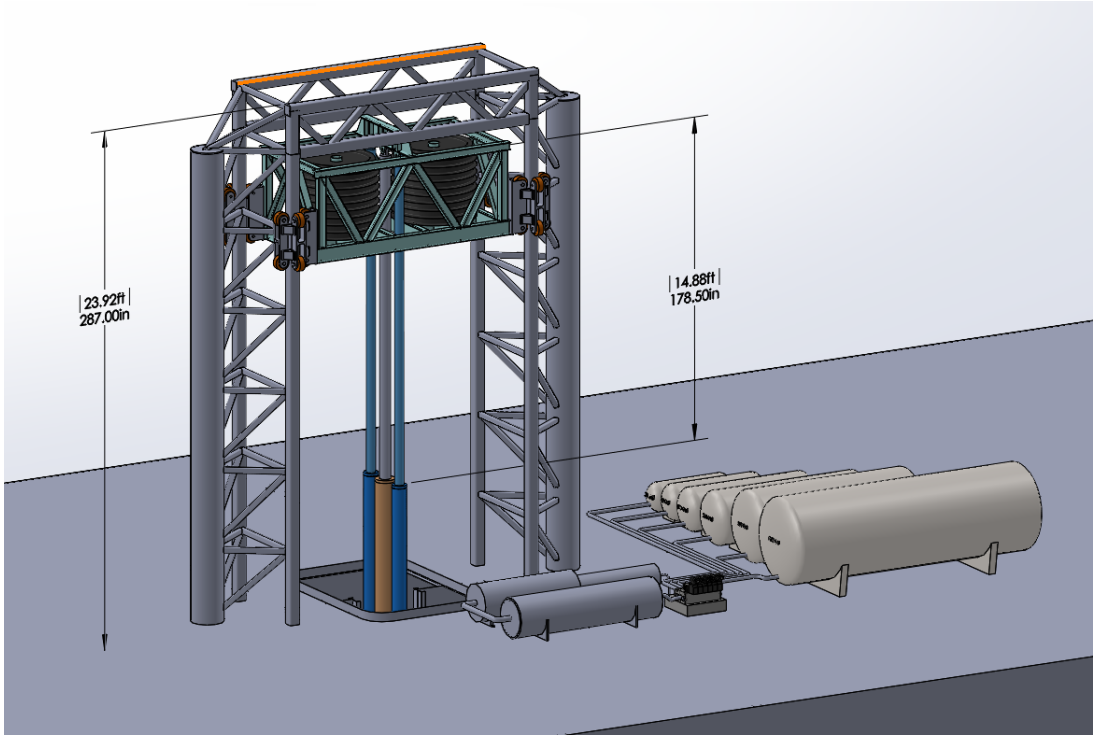
Particulars		
Length overall	180	ft.
Width	54	ft.
Depth	12.5	ft.
Lightship	457	ST





APPLIED OCEAN ENERGY

WEC Design - Pneumatic Spring Alternative



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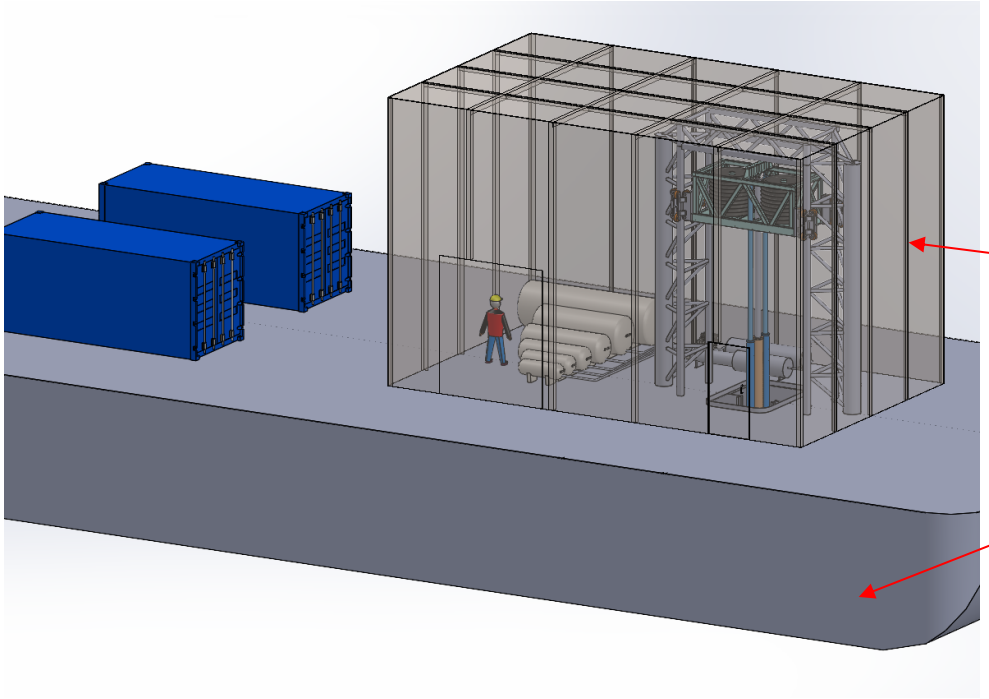
WEC Design



WEC housing structure shown transparent

Barge

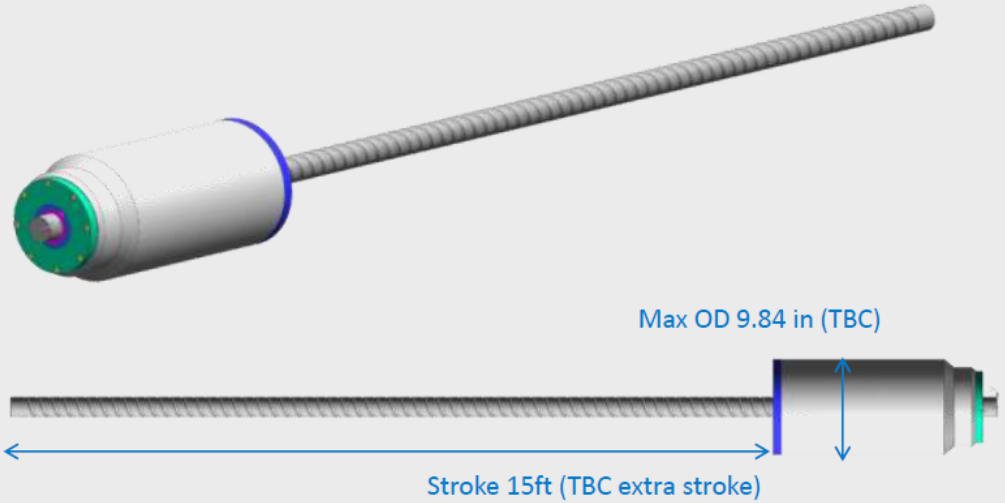
APPLIED OCEAN ENERGY

WEC Linear Electro –Mechanical Generator Design

Preliminary design proposal:

Diameter:	*1.97 inches*
Pitch:	*3.15 inches*
Pole pairs:	*8*
Speed Constant KE:	$181.0 \frac{V_{RMS\ ph-ph}}{krpm}$
Torque Constant KT:	$2.9 \frac{Nm}{A_{RMS}}$

ng



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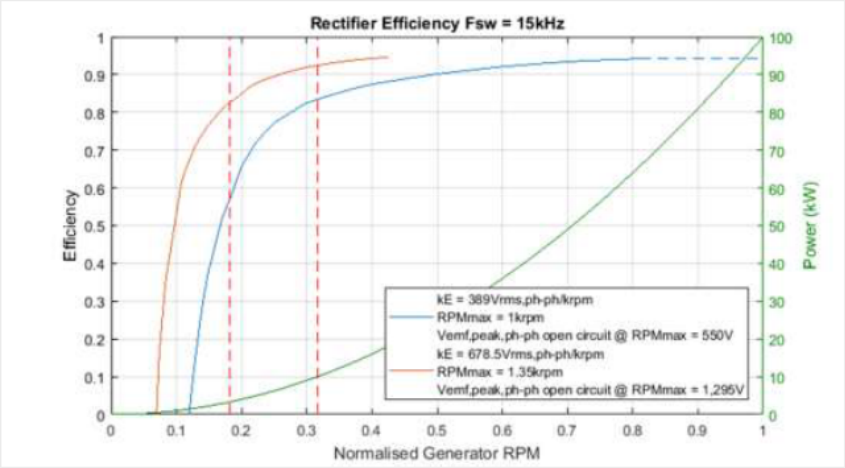
WEC Electro –Mechanical Generator Design

PRELIMINARY SELESCTION OF PARTS

A market analysis was done on AC/DC and DC/DC inverter manufactures to identify flexible and cost effective proposals.

OPEN POINTS:

- *Output DC level of the electrolyzer;*
- *Output AC level of the electrolyzer (120 Vac 60 Hz);*



PROJECT TASKS

Task	Title	Timeline	Deliverable
1	Data Collection and Analysis	Q2 2020	Section of the Technical Report that summarizes the project data and major Requirements/Criteria for the Demonstration Project.
2	Marine and Naval Architecture Design	Q2 2020	Section of the Technical Report that summarizes the marine and naval architect study with recommendations for the demonstration project.
3	Mechanical and Structural Engineering Design	Q3 2020	Section of the Technical Report that summarizes the electrical engineering study and design, including recommendations for the electromechanical generator and estimates for PTO during the demonstration project
4	Electrical Engineering and Design	Q3 2020	Section of the Technical Report that summarizes the electrical engineering study and design, including recommendations for the electromechanical generator and estimates for PTO during the demonstration project
5	Chemical and Hydrogen Engineering Design	Q4 2020	Section of the Technical Report with specifications on the equipment on water electrolysis, compression and storage of hydrogen, and recommendations for handling of oxygen.
6	Environmental Permitting Requirements	Q4 2020	Section of the Technical Report that summarizes the requirements for obtaining environmental and operational permits and develop general guidance for obtaining these permits. Prepare draft environmental and operational permit applications (where appropriate).
7	Conceptual Design and Cost Estimates	Q1 2021	Preliminary drawings, specifications, and cost estimates.
8	Project Coordination, Meetings, Reporting	Q1 2021	Final report

Project Plan and Schedule

Phase 1 - Feasibility Engineering and Preliminary Design of the Demonstration Project, Completion April 2021

Phase 2- Demonstration Project Final Design, Construction, and 6-months Open Ocean Testing (with objective to evaluate efficiency and economic validity of the AOE Technology), Start and Completion TBD

Phase 3 - Commercialization Plan and Implementation, Start and Completion TBD

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Port of Grays Harbor, WA Renewable Ocean Wave Energy Demonstration Project

THANK YOU

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