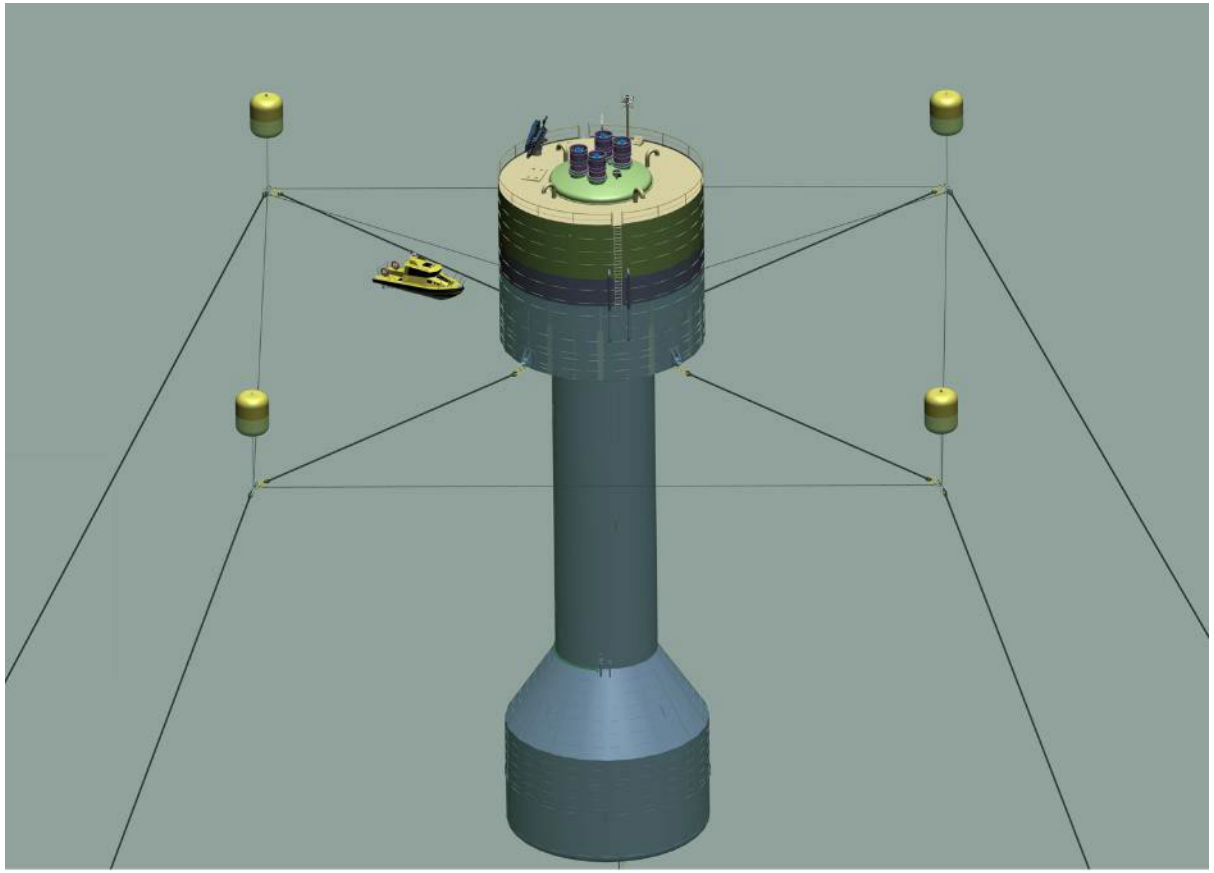
EE0008952 – MARMOK- Oscillating Water Column (OWC)



Borja de Miguel
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July 20th 2022

Project Overview

Project Summary

The aim of this project is to advance towards the future commercial viability of the floating Oscillating Water Column (OWC) technology through the development of a commercial size wave energy converter (WEC) specifically suited to PACWAVE-South site conditions. This spar type WEC design is based on a previous low power prototype deployed and tested offshore for 2+years and it incorporates several innovations to contribute to the LCOE reduction potential of the technology. It is a grid connected prototype in which applicable IEC/IEEE standards have been followed. A technology commercialization plan has also been developed identifying potential markets for each of the development stages.

Intended Outcomes

- Detailed design of a commercial size wave energy converter suited to PacWave-South site. It is a grid connected prototype capable of ensuring device survivability and operability & maintainability over a two-years operational life.
- Technology Commercialization Plan, identifying the targets markets, product development plans and the overarching commercialization strategy for the proposed technology.

Project Information

Principal Investigator(s)

- Borja de Miguel Para

Project Partners/Subs

- NREL
- Sandia

Project Status

Sunsetting

Project Duration

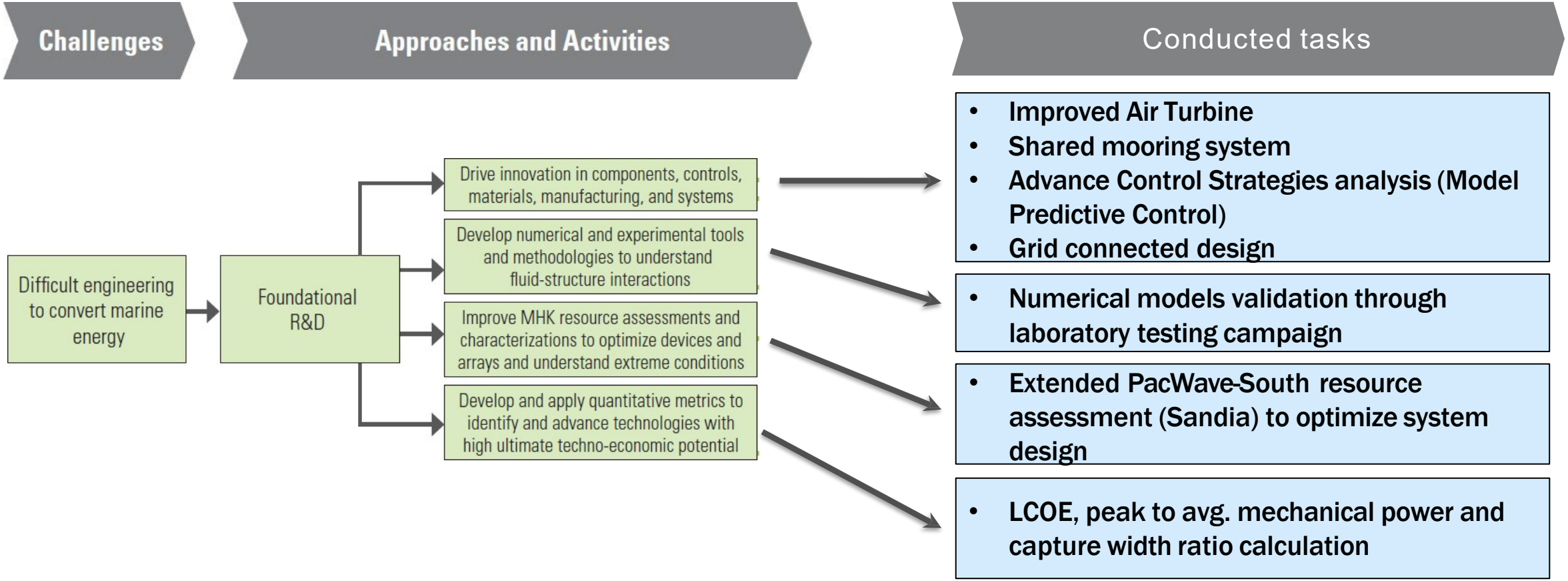
- May 1st 2020
- October 31st 2022

Total Costed (FY19–FY21)

$1,053K

Project Objectives: Relevance

Relevance to Program Goals, Challenges & Activities:



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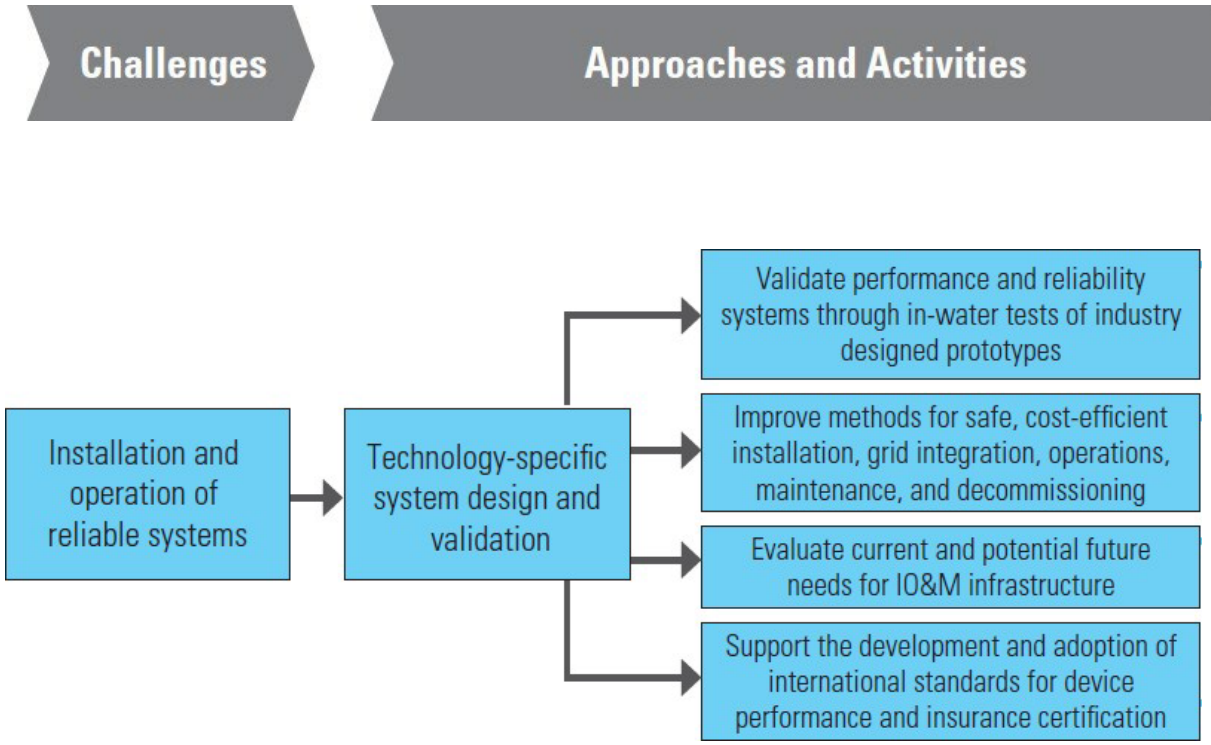
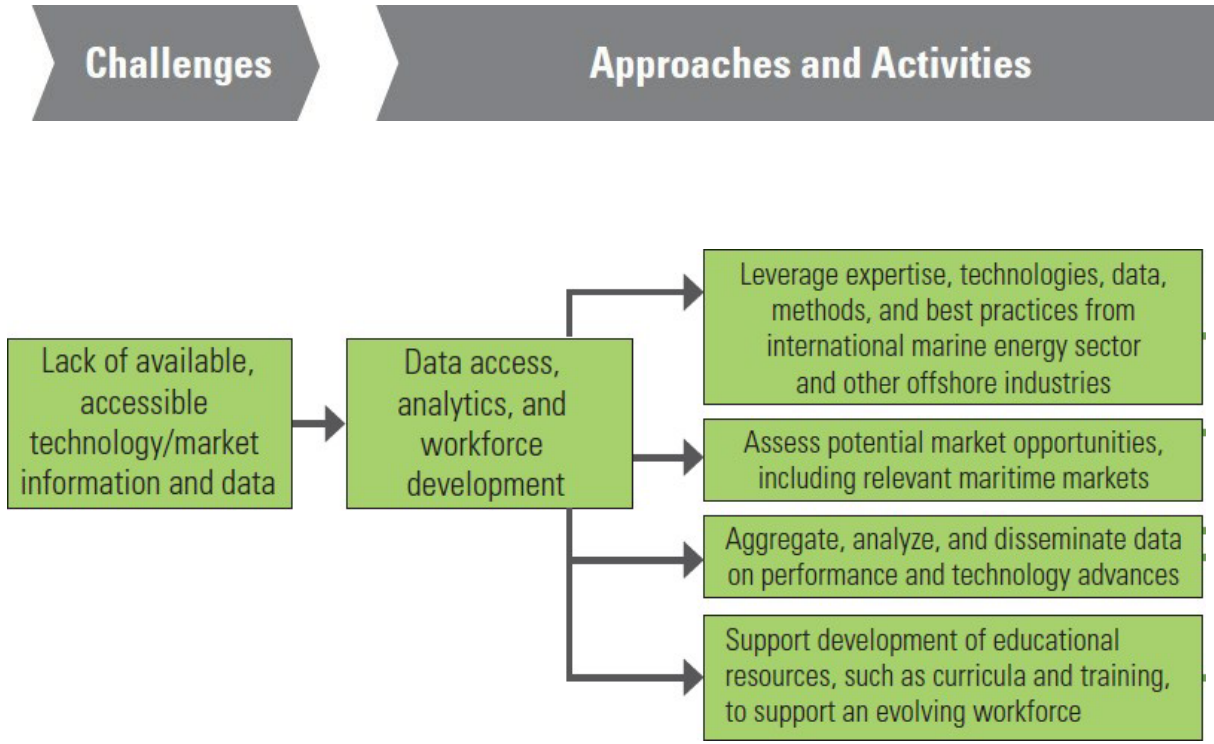


Conducted tasks

- Design suited to PacWave-South conditions (average and survival)
- Main O&M operations analyzed and derived requirements integrated into the design
- IEC TS 62600 standards applied
  - 2 – Structural design
  - 10 – Mooring design
  - 103 – Tank testing

Project Objectives: Relevance

Relevance to Program Goals, Challenges & Activities:



Conducted tasks

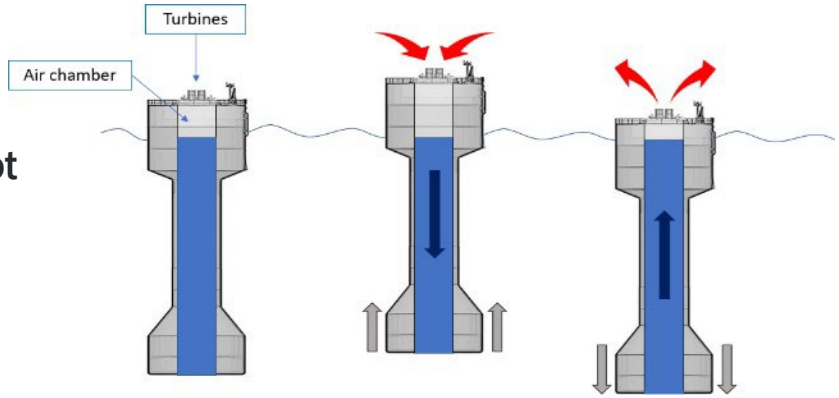
- **Development based on previous experience on a low power prototype deployed and tested offshore in BiMEP test site (Spain)**
- **Potential niche market opportunities analyzed such as Isolated power systems, Offshore Oil & Gas and Aquaculture**

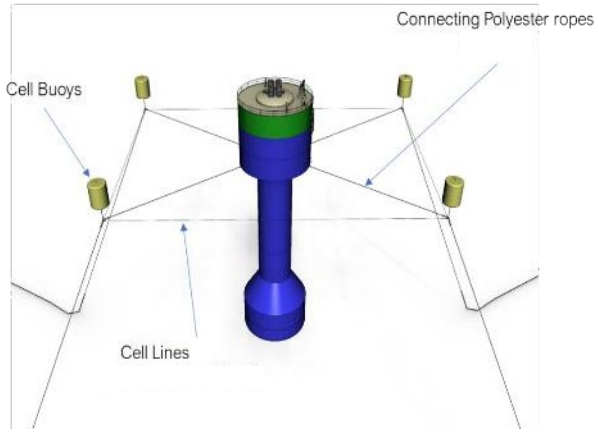
Project Objectives: Approach

The technology:

Spar type OWC ➔ technology with outstanding simplicity and survivability (a single moving part, not submerged).

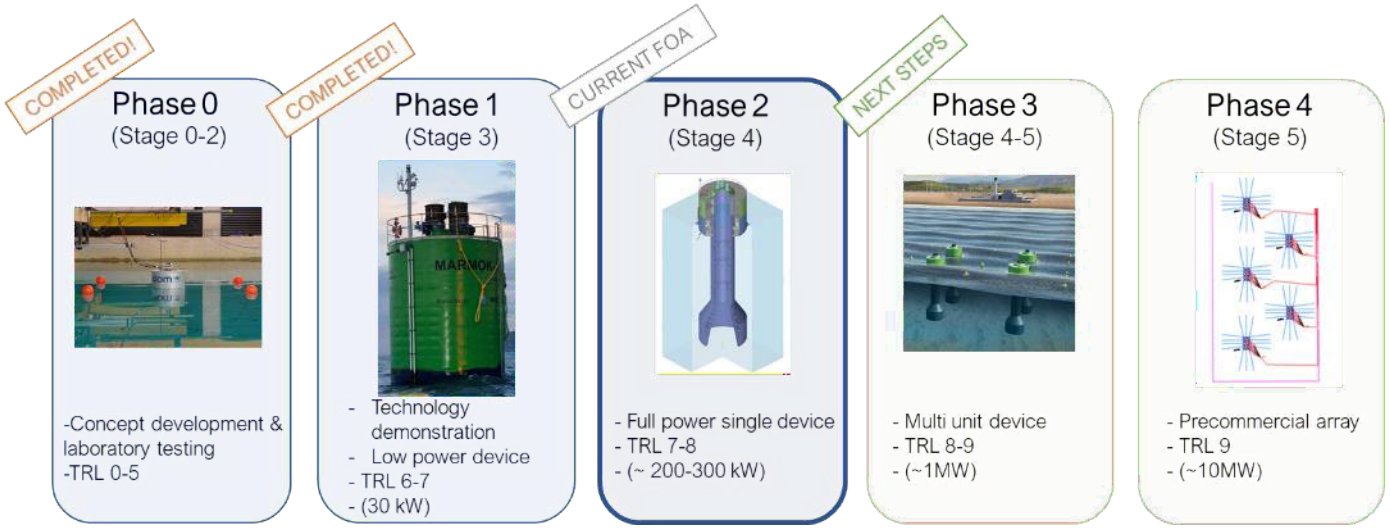
Mooring system ➔ designed to minimize its influence on power performance and reduce cost when array deployments.





Strategy:

Staged development path to reduce technical and financial risk

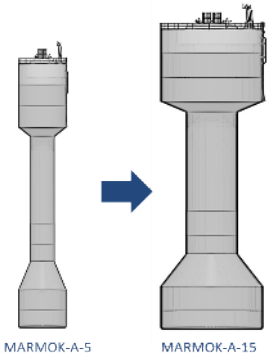


Product pre-commercialization (Niche markets)

Project Objectives: Approach

Approach:

- Leverage previous deployment experience into this larger WEC
- Geometry optimization to maximize power output/cost ratio
- All subsystems design (Structure, Mooring, PTO…)
- Laboratory testing of a scaled prototype to validate numerical models
- Marine operations preliminary analysis to identify design requirements
- Third party manufacturability review feedback incorporated into the design
- Standards incorporation to the largest extent possible
- Risk management following NREL procedure covering a potential testing phase
- Technology commercialization plan and LCOE projections
- Support of partners (NREL, Sandia) on key subsystems (Geometry, PTO, array mooring system)



Sandia National Laboratories

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Detailed WEC design report including all subsystems
- CAD design drawings
- Laboratory testing campaign report
- Third party manufacturability review
- Risks register including a potential testing phase
- Performance metrics assessment for single device, small array and medium size array (LCOE, peak to avg. ratio, capture width)
- Technology commercialization plan

Outcomes:

- Completion of the design phase of the next technology development stage
- Ready to build WEC design to be deployed and grid connected at PacWave-South
- Reliable LCOE projections of the technology and identification of potential niche markets

Project Timeline

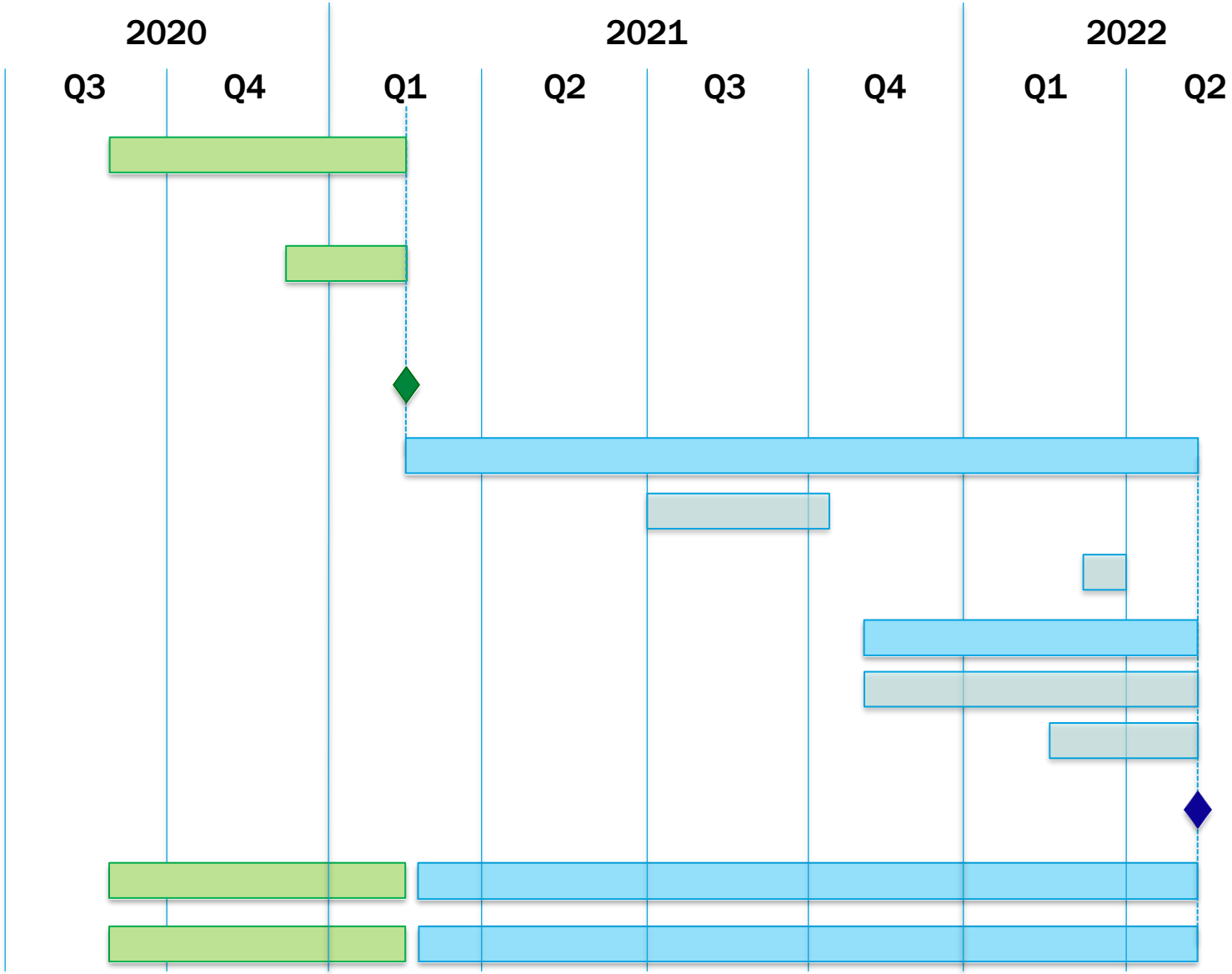
- Preliminary design
- Preliminary assessment of performance metrics & commercialization plan

Preliminary design review

- Final design
  - Testing campaign
  - Third party manufacturability review
- Technology commercialization
  - Performance metrics
  - Commercialization plan

Final design review

- Risk management
- National labs support



Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$1,640K	$420K (20%)	$2,060K

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$ 0	$ 145K	$ 908K	$ 1,053K

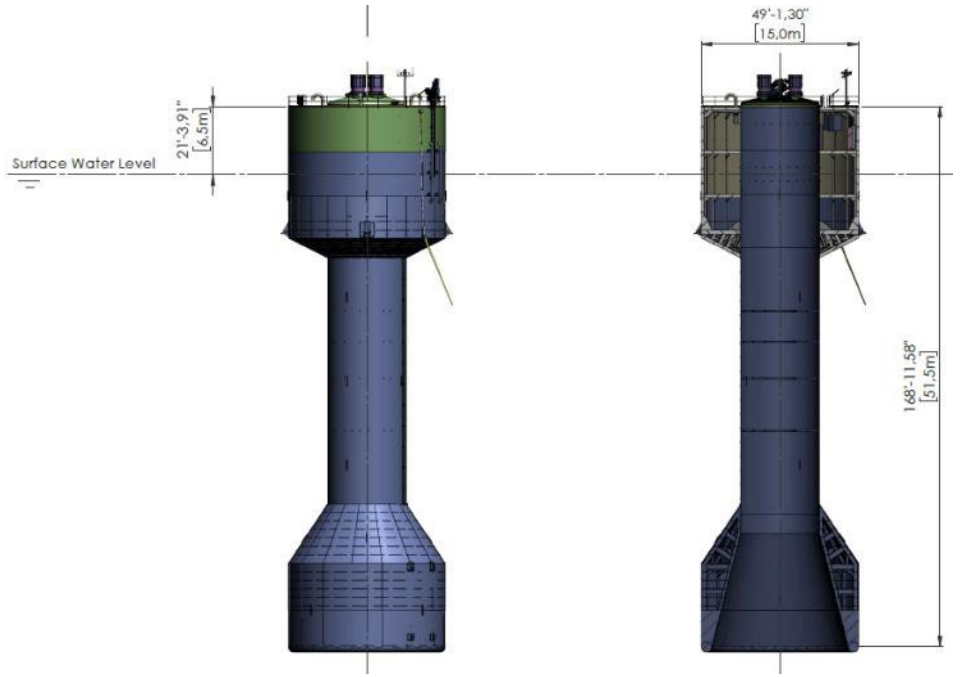
- Project will be completed with no additional budget required
- $400K of technical assistance budget for NREL and Sandia to support IDOM on this project

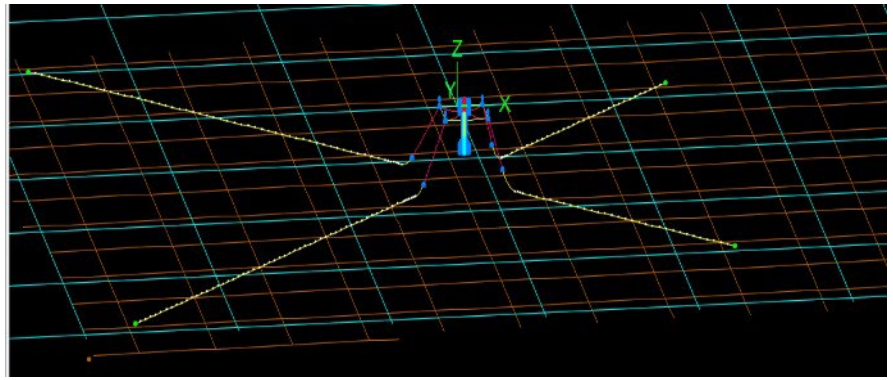
End-User Engagement and Dissemination

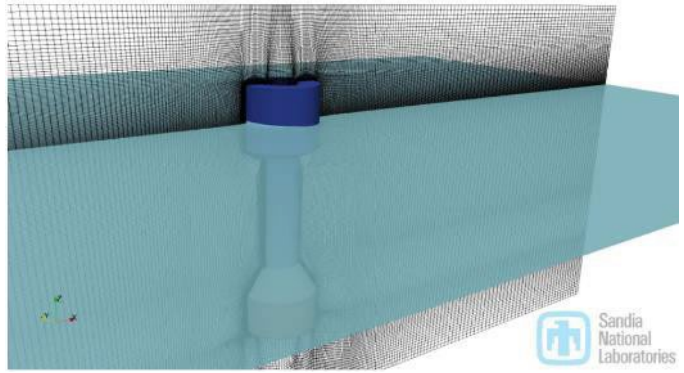
- Key stakeholders involved in the project
  - DOE providing feedback (monthly meetings) to reconduct project activities
  - NREL and Sandia supporting on the technology development
  - PacWave providing feedback during design reviews
- Dissemination activities
  - Conference presentations
    - ICOE2021 (Washington D.C/Virtual)
    - IEEE PES General Meeting 2022 (Denver)
    - ICOE 2022 (San Sebastian, Spain)
      - Technology (IDOM)
      - Air turbine (Sandia)
      - Mooring array (NREL)
  - MHK data repository
    - Data sets from the testing campaign
    - LCOE estimation for a MW deployment using SAM tool
- Diversity equity and inclusion
  - IDOM is fully committed with these aspects as gathered in the code of conduct of the company. This code is applied during whole lifecycle of the projects and in the daily basis works

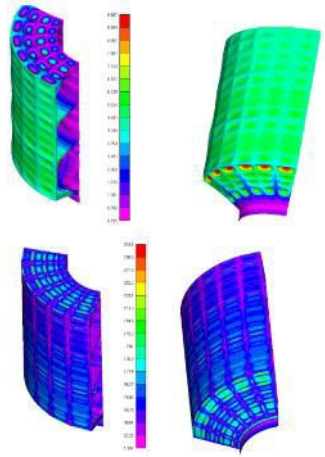
Performance: Accomplishments and Progress

- WEC dimensions optimized to maximize power/cost ratio at PacWave-South site
- CFD model developed by Sandia to estimate drag losses and optimize geometry
- Detailed structural design developed covering all load cases along the lifecycle of the WEC; Ultimate and Fatigue limit states (ULS, FLS)
- Manufacturing drawings developed and reviewed by a third-party company
- Detailed mooring system design (ULS, FLS and Accidental limit state ALS)
- Umbilical cable routing designed to ensure survivability



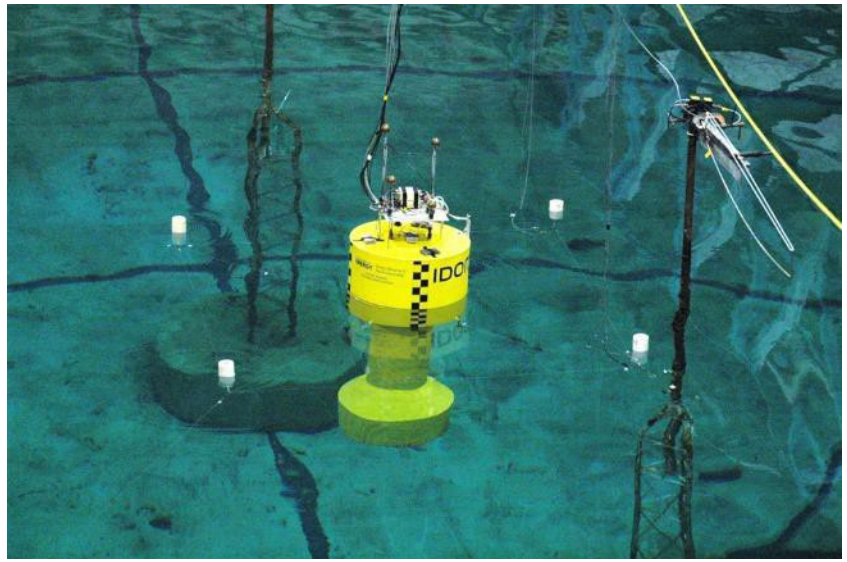


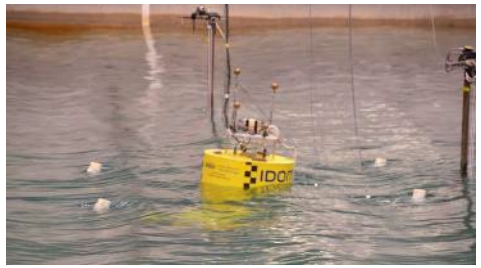


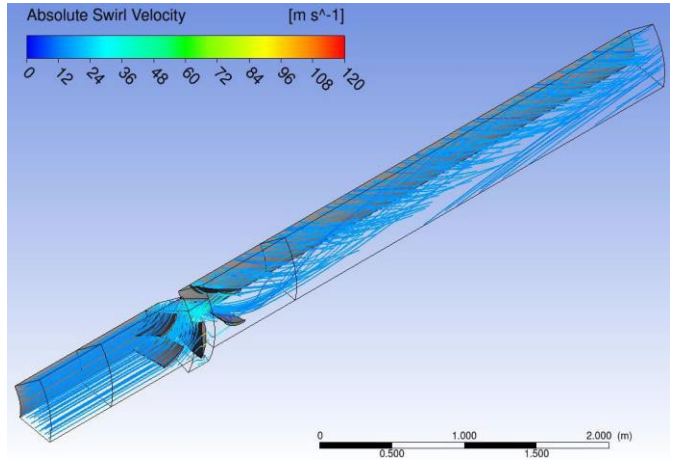


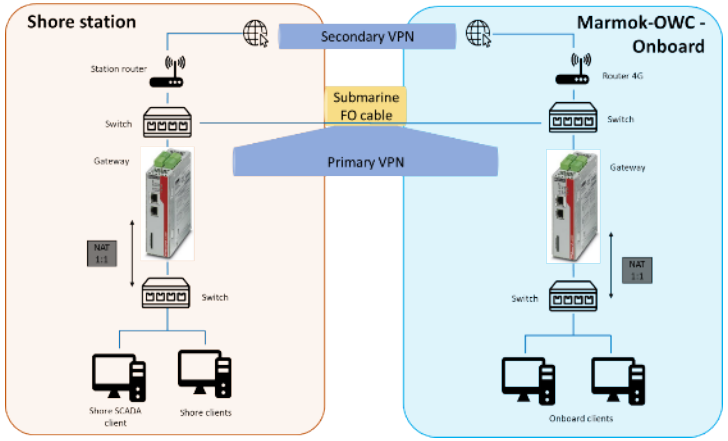
Performance: Accomplishments and Progress

- Testing Campaign completed at OTRC (Texas University) (1/23 scale) to validate numerical models (power performance, structural and mooring design)
- PTO system design completed using a baseline turbine and off-the-shelf generator and power electronics (4x75kW turbines)
- SCIG and PMG generators compared through numerical models developed by NREL
- Improved air turbine developed with the support of Sandia and Penn State University
- Baseline control strategy defined (Torque as a function of rotational speed), and advance control strategy (Model Predictive) potential evaluated (15% improvement estimated)
- Control architecture, Instrumentation, DAQ and communications defined



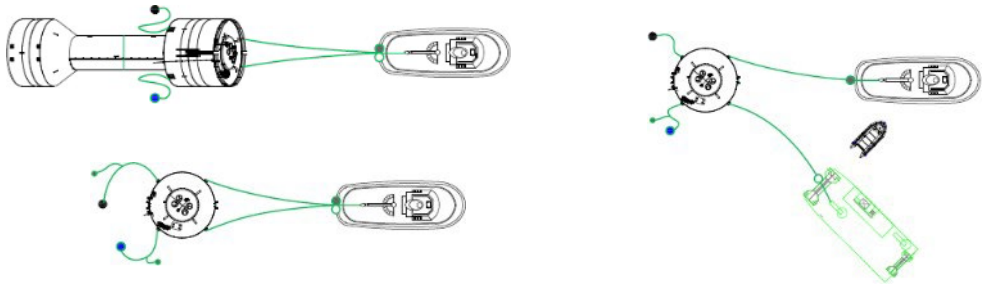


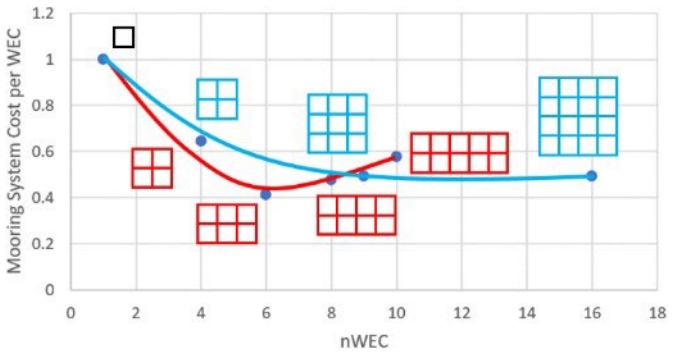


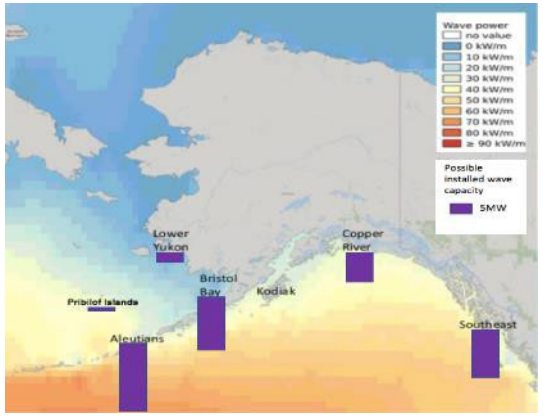


Performance: Accomplishments and Progress

- Auxiliary systems design (bilge, ventilation…)
- Onboard electrical design completed
  - Power generation system
  - Auxiliary system
  - Transmission system (transmission voltage study developed)
- Main marine operations description to identify means required (piping, vessels, onboard crane…)
- Preliminary maintenance plan developed based on previous experience
- LCOE calculation based on a detailed cost breakdown of the single device and projection for larger deployments (4 WECs and 42 WECs array) for PacWave-South and CalWave sites
  - Mooring cost reduction potential estimated by NREL using MoorDyn
- Technology commercialization plan developed, and potential niche markets analyzed in more detail linked with this tech. characteristics
  - Isolated power systems (large potential, medium size deployments)
  - Offshore Oil & Gas (large potential, medium-large size deployments)
  - Aquaculture (medium potential, small deployments)
- Detailed case studies for Alaska and Canary Islands







Q&A