MARITIME MARKETS @ PACWAVE

Workshop Summary Report

WORKSHOP DETAILS

July 9, 2019
OSU Portland Center
555 SW Morrison St.
Portland, OR 97204

PRESENTED BY

PMEC
Pacific Marine Energy Center

PacWave

synthesis report

INTRODUCTION

On July 9th, the Pacific Marine Energy Center (PMEC) and PacWave hosted national and international experts from government, academia and industry, and across maritime sectors, to explore future research and testing opportunities associated with the development of the PacWave testing facilities. This report summarizes the findings from the strategic break-out sessions, presents major take-ways for marine energy in specific markets, and suggests associated implications for improving PacWave's value to maritime markets.

PMEC is a consortium of universities focused on the responsible advancement of marine energy, including wave, tidal, riverine, and offshore wind resources. Researchers from Oregon State University, the University of Washington, and University of Alaska Fairbanks work closely with marine energy technology developers, academic and National Laboratory researchers, coastal community members, ocean users, federal and state regulators, and other government officials to address key challenges in the sector and accelerate its emergence. PMEC serves as an objective voice regarding the opportunities, capabilities, and effects of marine energy.

The PacWave wave energy testing sites build on a legacy of PMEC marine energy research at Oregon State University that goes back over four decades. Now, in 2019, as the global ocean economy undergoes exponential expansion and the many impacts of human reliance on fossil fuels come into focus, the impetus for advancing marine energy applications has never been stronger. Concurrently, as the 'Blue Economy' concept gains international recognition and focus, the market opportunities for marine energy are expanding dramatically to include new sectors, partners and research questions.

During the meeting, experts used a PESTEL analysis framework to identify emerging maritime market opportunities and challenges with respect to their Political, Economic, Social, Technological, Environmental and Legal dimensions. A PESTEL framework is designed to organize and understand macroscopic factors that are likely to impact new and emerging markets and therefore well-suited to MRE and maritime markets.

For an overview of the Pacific Marine Energy Center, and current details for PacWave, visit **pmec.us** and **pacwaveenergy.org.**

The U.S. Department of Energy Water Power Technologies Office's 2019 report "*Powering the Blue Economy; Exploring Opportunities for Marine Renewable Energy in Maritime Markets*" also provides critical background for this workshop and the markets discussed. It is available online at **energy.gov/eere/water.**

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MARKET-BY-MARKET SYNTHESIS

Ocean Observations

TAKE-AWAYS

- Clear break-in market with broad public confidence – high value to stakeholders.
- Cost-effective opportunities for co-design and co-development for small scale, low power demand sensor platforms.
- Integrated MRE generators need to be reliable. Sites are often very remote and expensive to maintain.

PACWAVE IMPLICATIONS

- Co-location of new MRE-powered sensors with PacWave baseline environmental monitoring sensors packages provides excellent validation, technology de-risking and broader client base.
- Are MRE-powered ocean observations a long-term market, or a near-term limited scale opportunity for PacWave? What are the values and risks associated with additional infrastructure investments?

Resident Autonomy

TAKE-AWAYS

- Significant federal agency funding and industrial support for MRE to provide strategic forward deployed and/or resident power supply.
- AUV/ROV provide feasible methodology to monitor and maintain subsurface aspects of MRE devices under a broad range of operating conditions.
- Costs are still high – focus on task-specific technology pathways or improved integrated design.

PACWAVE IMPLICATIONS

- Collaborate with industry to identify 'standard' docking infrastructure and install at PacWave.
- Little formal regulations re: resident autonomy. PacWave may provide a formally recognized location to show regulatory of developing industry best practices.

Aquaculture

TAKE-AWAYS

- Significant and rapidly expanding global industry. US likely to need to expand efforts or maintain significant trade deficit. US currently lagging behind many other global players.
- Labor and energy are 2nd and 3rd cost contributors (after feedstock). MRE + Resident Autonomy may provide opportunities for cost reduction and lowered environmental impact.
- Seaweed industry growing and has potential to be a major player – but dwarfed by fin-fish market.

PACWAVE IMPLICATIONS

- Fin-fish aquaculture does not have social license in Oregon. Opportunity to test supporting technology at PacWave for future commercial deployment elsewhere.
- PacWave provides a site to test survivability of aquaculture infrastructure in harsh/winter conditions.

Desalination

TAKE-AWAYS

- Globally, demand for water is increasing. Economic opportunity for desalinated water may be near term due to higher production costs from current competing technologies.
- Environmental impacts need to be quantified and accounted for in order to gain broad public acceptance.
- Wide interest across multiple agencies, but no single responsible agency. Use-case dependent.

PACWAVE IMPLICATIONS

- PacWave sites are generally too far from shore for testing of WECs coupled to terrestrial fresh water production plants; however, in-situ testing of integrated WEC systems is feasible.
- PacWave provides excellent opportunity to investigate and quantify possible environmental impacts.

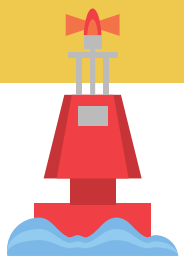
Isolated Communities

TAKE-AWAYS

- High costs of electricity – due to remote location and limited scale. MRE devices need to be resilient and reliable to provide value proposition.
- MRE could create significant social and economic opportunities beyond simply providing power.
- MRE will be a single aspect of a renewables, fossil and storage system. Further integration research required.

PACWAVE IMPLICATIONS

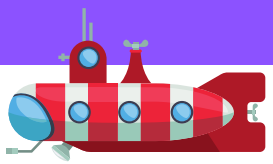
- PacWave could provide opportunity to test integration challenges with specific infrastructure additions.
- PacWave is far from shore with different 'deep water' wave conditions – less representative for remote communities looking to minimize cabling costs (driving projects close to shore).



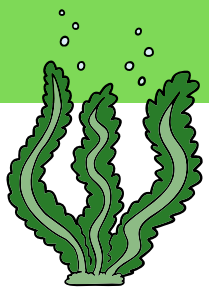
PESTEL ANALYSIS - OCEAN OBSERVATIONS

	Opportunities	*Challenges*
Political	• Alternative power option for existing oceanographic/meteorological instruments already operated by federal and state agencies • Enhanced resource management capability in 'Blue' water • Assist with national defense/security concerns • Information to drive/inform the Blue Economy	• Misinformation with public and public-officials • Producing power and pursuing resources outside the EEZ or Oregon water • Political opposition to renewable energy and climate change
Economic	• Ocean observations/Big Data can have value to coastal industries: fishing, SAR, CG, etc. • Research and development grants available from DOE, Navy, NOAA, NSF • Competing sources of energy at sea are expensive (marine batteries)	• Cost of small-scale solar (including floating) and wind falling rapidly - competition • If marine energy system maintenance needs are greater than cost and value of sensors = dramatic cost increase • Market not that large, hard to capture sufficient funds in competitive funding environment
Social	• It's green renewable energy! • More data to prove claims and inform policies and stakeholders (create social license) • Heightened environmental awareness	• Engaging biological and chemical oceanographers is needed but difficult • Privatization of common waters & tension with existing users • More surface expression ⇒ view shed ⇒ space conflict, which may turn stakeholders against technologies (doubtful at PacWave with small ocean observation sensors)
Technological	• Possibility for integrated design (MRE and ocean observations) • Extended deployments, higher power sensors possible, in broader global regions (arctic) • Subsurface generation from high intensity resources, small footprint to meet power needs • **PacWave**: Colocation of measurement using new sensors, low-risk testing and validation, broader partner/client base	• Technology risk when coupling two early stage techs (MRE and ocean obs.) • Powering sensors may disrupt/degrade measurements • Seasonal incompatibility between demand and supply and supply variability • **PacWave:** Designed for 25-year lifespan but what if we solve the PBE problems in 5 years? Is point site representative?
Environmental	• Persistent sensing at remote locations; e.g. overfishing control; OOI capacities with cable, long-term environmental discovery • Improved baseline and perturbation quantification • Less use of non-rechargeable batteries (including disposal) • **PacWave:** Monitoring data (required by permitting agencies) will be valuable for observing programs	• Unknown long-term impacts • Sensor litter: small sensors may be deployed but not recovered • May only be viable in "energy dense" sites – applicability in deep/cold/severe conditions?
Legal	• Sensor permitting simpler than MRE process • Appropriate insurance and guarantees will allow for more economic design spiral (small devices, quicker innovation) • Streamline permitting due to increased amount of data becoming available	• Total loss likely • Overlapping laws! Utility, land (sea) use, navigation, etc. • Increased scrutiny of all instrumentation due discussions of marine energy integration and agency concerns about MRE devices (could we harm ocean observations?)

PESTEL ANALYSIS - RESIDENT AUTONOMY



	Opportunities	*Challenges*
Political	• Resident systems can improve national security, protect parts • Submerged power production/under radar	• Docking stations for defense purposes come with challenge of UUV coming out of hiding • Communication between community (industry, academic, govt.) • XL UUVs using alternative energy source (e.g. nuclear)
Economic	• Newport/OSU growth and economic development through industry partnerships, Devron 5, NAVSEA, DARPA • Reducing O&M costs of blue economy • Safety: Resident systems with persistence remove people from operating location	• Bringing down cost of sensors and platforms (hardware) • High risk of loss of something can't afford to replace • Existing infrastructure may have power, communications, ROI implications
Social	• AUV monitoring, inspection, manipulation to replace/augment divers • Reduced risk of life for O&M, etc.	• Unmanned systems changes job profiles - diversity in workforce • Public acceptance of AUV operations, articulating value of autonomy – conflicts with existing ocean users. • Technical development that leads undesired industries or perception that 'Big Brother' is watching
Technological	• Opportunity to expand area of interest and dynamically change for events • Ability to perform AI tasks in friendlier (than O+G) atmosphere • Integrated designs: power generation, charging, communication, maintenance	• Keeping equipment operating for long term at depth; biofouling, reliable docking, O&M in remote locations… • Interaction between sensor and delivery system • OPS, autonomous navigation, and docking in high-current or low-vis environments
Environmental	• Reduce cables, batteries, fuel requirements and carbon footprint • Greater opportunity to perform monitoring of environment, and dynamically change monitoring • AUV OPS could provide critical environmental monitoring of WEC OPS	• Waste/debris pollution from lost systems • Marine mammal/fisheries conflict • Lack of controls for accidents
Legal	• Lack of regulations – freedom to operate • Underwater data centers require less permitting than onshore	• Lack of regulations require more diligence • Extended range – more chances for hardware to cross boundaries • Very little international agreement on standards



PESTEL ANALYSIS - AQUACULTURE

	Opportunities	Challenges
Political	• Political support for wave energy @ PacWave, aquaculture may be able to build on that message that PacWave as a Blue Economy technology test site for later deployment somewhere else • Soy is the largest component of aquaculture feed -- may drive political support from farm states	• Full system development at PacWave not politically agreeable, given the sensitives of aquaculture • Lack of focused political will for aquaculture • Groups of people in Oregon really opposed to aquaculture, groups of people really opposed to waves...if you combine those two populations did you just create a political firestorm?
Economic	• Per capita seafood consumption is increasing fast – need more seafood • Seafood trade deficit is growing • Well earning jobs, both educated and practical labor – leverage existing labor expertise	• Low level of research funding for aquaculture - NOAA spends for all aquaculture nationally $25 million • Lost much of our fish processing capabilities and working waterfronts • Local impacts on fisheries products prices if not managed
Social	• Improved human health from seafood consumption – if costs go down, good for health and wallet • People like their seafood and using renewable energy could provide "green" labeling opportunities • Deep water could allow you to do some things subsurface, out of site, mitigating some social concerns	• Finfish suffers from social license issues (but most lucrative aquaculture market): not as good as wild, GMO, industrialization of the ocean... • Fishing community will not support any species that competes with the price of their target catch • Visual impact concerns
Technological	• Seaweed industry is growing rapidly, technology is relatively mature and proven from other countries • Oregon/PacWave could be a good proving ground for high energy/harsh environment aquaculture (O&M) – cross over to other industries • 50% of cost is feed...the next two are labor and energy - the further you move offshore, the more energy becomes a factor and remote charging an opportunity (tie to other markets)	• Depth, high waves, increased mooring costs for offshore. Oregon coast is a rough place and uncertainty on technology • R&D targets may be less clear than what you might want to do at PacWave for other tech • Risk propagation: The more you put together on the same platform, your risk of failure goes up -- need a good economic case and understanding of risk when you put two high risk technologies together
Environmental	• Environmental research could potentially benefit both industries if done across technologies • In a world of energy abundance.... can we use electricity to perhaps provide a beneficial service other than what you might normally think of? Reducing biofouling, for example, or elimination of fish waste	• What does electricity do to marine life and are there unknown consequences? • Legitimate concerns about fish diseases from farms getting into wild stocks • Does the combination of environmental impacts from aquaculture and wave energy create concerns? • **PacWave:** May not be a great place for aquaculture: big storms, deep quickly, upwelling can be a challenge, etc.
Legal		• No mature regulatory framework for offshore aquaculture • US capabilities are lagging China, Norway, other places

PESTEL ANALYSIS - DESALINATION

	Opportunities	Challenges
Political	• Everyone needs water, it's currently a hot topic with plenty of high-level political support (Secretary Perry, AMO, WPTO, etc.) • Provides a means to increase water security in drought prone regions of the U.S., e.g. California	• Departmental uncertainty: No U.S. Department of Water - multiple agencies involved at both the federal and state level • Perception - Is "renewable desalination" being used to "sell" a technology that is unpopular in certain quarters? (consistent across all PBE segments)
Economic	• PacWave can provide needed OPEX data and permitting for WEC-powered desalination systems • Multiple international collaboration opportunities • Significant export market potential and IP sharing • Water is expected to greatly increase in value over time • Valuable by-products, e.g. salt and potentially rare minerals • Preserves/grows blue economies	• No piping to shore at PacWave • Cost / benefit ratio lacks independently verified empirical data • Limited participation of reputable supply chain and project development partners • Limited demand for fresh water on the Oregon coast • Is wave-powered desal cost-competitive versus other renewables?
Social	• PacWave can demonstrate disaster response technologies • PacWave can provide installation and operations training • Water scarcity a well-known and growing global crisis • Significant social benefits associated with providing water vs. electricity	• Public acceptance of coupled-technology? • Competing uses (commercial fishing, shipping, surfing, etc.) • Social benefits yet to be fully quantified
Technological	• Multiple opportunities for collaborative research • PacWave co-located with the energy resource and the raw material needed for production • PacWave/PMEC can provide testing services that generate reliable data that can accelerate the industry	• Permitting, brine discharge, entrapment/entrainment of marine life, etc. • Distance from shore makes frequent maintenance visits difficult/expensive
Environmental	• PacWave/PMEC can monitor and report environmental effects • PacWave/PMEC can test and de-risk environmental impact mitigation technologies	• Permitting, brine discharge, entrapment/entrainment of marine life, etc. • Desalination is perceived as having negative environmental effects
Legal	• Fewer risks associated with producing water than with high voltage power • Desalination a mature technology, i.e. similar tech has already been licensed and tested • Access to project finance may be easier due to a broader universe of financing sources, e.g. DFI's, impact investors, foundations, etc.	• Lack of clear permitting process for wave-powered desalination • PacWave currently not permitted for water production • Multiple use permitting may be more difficult

PESTEL ANALYSIS - ISOLATED COMMUNITIES

	Opportunities	*Challenges*
Political	• Job creation is an opportunity for local reps to gain political win • Seek out communities that are interested in shifting to renewables	• Inherent difficulty in transitioning to new energy systems that can increase rates in the near term
Economic	• Existing high energy prices require subsidies from local/state governments • Long term PPAs attract investors and insulate communities from volatile fuel prices • Job opportunities - system operations, maintenance, and ancillary tourism	• Spare parts, limited infrastructure, technical support, and shipping are all particularly difficult in remote communities • Funding CAPEX required for project installation
Social	• PacWave could provide training opportunities for microgrid operations to local operators (requires microgrid emulator at PacWave) • Positive environmental impact shifting to renewable energy, success of projects like ORPC deployment in AK, energy independence, connection of renewable energy to nature, and job creation in Northwest • Pacific atoll islands in particular who are experiencing sea level rise are particularly interested in renewables	• Some communities will be unnecessarily concerned about the detrimental impact of installing MHK devices in local waters
Technological	• Improved resilience of MHK in some remote communities • Testing hybrid system, e.g. MHK and solar microgrids, but also provide desalination, hydrogen generation, etc. • Integrating wave energy with offshore wind farms. • **PacWave:** Expand to provide shallow water test site at a nearby location	• Wave energy is more variable than ocean, tidal and river currents which makes it more challenging • Scale of opportunity: How many remote communities have available wave resources? • Voltage and frequency regulation is challenging in microgrids • **PacWave:** Ability to simulate remote community loads, Ocean Sentinel survivability, DC capacity?
Environmental	• Train developers on permitting processes/provide agencies with common baseline • Gather information on diesel fuel spills during transport to demonstrate the value of renewables?	• Debris impact from logs and ice in some northern rivers • Difference in wave resource at PacWave where device is tested compared to wave resource at remote communities • Potential impact of natural disasters to MHK microgrids, including the grid connections
Legal	• In some cases, permitting for microgrids in state waters is easier • Some states can help fund MHK projects by utilizing their current diesel fuel subsidies, e.g. AK.	• Liability issues if the microgrid causes an electrical fault that damages equipment powered from the grid • Liability insurance