POSTION PAPER 2:

MARINE ENERGY PRIORITIES

National Hydropower Association Marine Energy Council

May 2023

I. Mission of the Marine Energy Priorities Working Group

The mission of the Marine Energy Priorities Working Group (MEP WG) is to support the National Hydropower Association's (NHA) Marine Energy Council (NHA-MEC) in providing a common voice and platform regarding the needs of the Marine Energy industry in the U.S. The MEP WG will identify common priorities for technology and project developers across the range of Marine Energy resources and provide direct feedback to the MEC regarding technical areas in need of funding and/or clear gaps in knowledge.

II. Executive Summary

Key Recommendations by MEP WG

- Increased federal funding for the advancement of U.S. marine energy technologies
- Increased number of FOAs and in predictable increments
- Data sharing
- Knowledge/Lessons Learned sharing
- Stage-gated funding from small systems up to large system development
- Ensure funding for concurrent robust supply chain and manufacturing development
- Clarity of different requirements for different sectors

All target audiences of this document should note that there is a clear and expressed need for component and subsystem R&D funding. Component and subsystem R&D is a high-level need to the success and much-needed rapid development of the marine energy sector.

In a survey conducted by the MEP WG sent to developers and stakeholders in the marine energy industry the results reflected that the three main priorities are:

1. Funding of Research and Development
2. Array Testing at Macro and Meso Scale
3. Developing and adhering to IEC Standards

In the "Ocean Climate Action Plan" released by the White House Office of Science and Technology Policy in March 2023, a clear message is included – marine energy technology commercialization needs to rapidly and responsibly advance. With this message from the Executive Branch of the U.S. government, the MEP WG is hopeful the priorities laid out within this document will be met and marine energy technology funding will be on par with the funding appropriated to the solar and wind technology offices.

III. Background & Motivation

The MEP WG of the NHA-MEC was established in early 2021 to identify and prioritize specific needs and knowledge gaps wherein federal R&D funds could be most effectively applied to advance the Marine Energy (ME) industry to commercialization as rapidly as possible. To date, the MEP WG has met monthly to debate the issues associated with industry priorities, and in September 2021, a poll was circulated that requested MEP WG members to identify and prioritize the needs and knowledge gaps that are most critical to the achievement of the sector's technology and project development goals. In July 2022 the MEP WG circulated a survey to developers and stakeholders in the MEC of which the results are shown in this paper.

The following report summarizes the methods the MEP WG used to obtain and analyze poll and the survey results by segregating the highly diversified ME stakeholders into distinct categories that include device size, Technology Readiness Level (TRL), commercial application and priority ranking. The purpose of this exercise was to determine how broadly the knowledge gaps applied across all categories, which can be used as a proxy for the 'criticality' of needs and specific knowledge gaps. This report is intended to be updated regularly based on additional input and natural changes in the industry priorities.

In summary, the object of this report is to communicate the most critical needs of the ME and recommend funding initiatives focused on research & development that will be the most effective in reducing the time to commercialization.

For the purposes of this document, the MEP WG has used the following scales for discussion:

1. Micro-scale: Marine Energy Converters (MEC) for powering isolated oceanographic instrumentation or similar Powering the Blue Economy (PBE) activities.
2. Meso-scale: MEC that could be installed individually to support a facility or community (may or may not be grid-connected).
3. Macro-scale: MECs that are intended to be installed in arrays to provide commodity power to a distribution network (i.e., grid-connected).

IV. Target Audiences

At the start of the analysis, the MEP WG identified several audiences potentially benefiting from the position paper. In no particular order, those audiences include:

- **Industry and NHA-MEC.** The outcomes of this paper will be further utilized to develop a roadmap to widespread commercial applications for the marine energy sector. Eventually, the MEP WG will request input and feedback into the priorities set out in this position paper from NHA-MEC members.

- **Government funding agencies.** Outputs from this document will be utilized in preparing the Marine Energy Roadmap efforts led by the NHA-MEC. Based on information in this position paper, recommendations for government funding agencies will be presented.
- **Testing Expertise and Access for Marine Energy Research (TEAMER) and the University Marine Energy Research Community (UMERC).** These programs have a broad network of people and areas of expertise. The MEP WG and the information gathered in this position paper will be shared with both the TEAMER and UMERC groups. These groups will also provide the MEP WG with industry needs as they arise within their discussions.
- **International Electrotechnical Committee (IEC).** Standards at the Technical Committee 114 (TC 114) and certification at the IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications (IECRE - Renewable Energy). As standards are developed, they should be aligned with the priorities of the industry to accelerate commercialization of the ME industry.

The MEP WG does recognize that there are other potential audiences, not mentioned above, who may be interested in this document and will strive to include the audiences as they are identified.

V. Methodology

The MEP WG first identified current needs and gaps within the industry. Once the straw-man list was created, the group reevaluated the list and eliminated or grouped 'like' ideas. The re-evaluation of the list took place in three successive steps. A list of 22 subject line items relevant to all marine energy was developed. This list was then placed within a survey for ranking of each item by priority of high, medium, or low. The survey also requested that participants assign an associated development scale – ***micro*** (ocean observation/PBE), ***meso*** (small communities) or ***macro*** (utility). The survey was sent to the MEP WG participants and marine energy developers and stakeholders on August 31st, 2021 and was completed on September 9th, 2021. The results of the survey are shown in Figure 1 and Table 1. Additionally, some interesting and valuable comments were made by Marine energy developers and stakeholders which are listed below Table 1.

VI. Industry Priorities

The figure below shows the priorities broken into higher, medium, and lower based on the survey responses. Under each priority heading, the priorities are presented in no particular order and do not yet fully map to the associated TRL and development scales.

HIGHER PRIORITIES	MEDIUM PRIORITIES	LOWER PRIORITIES
Funding for development and testing of the industry	Controls/Power Take-off optimization	Non-electrical applications: direct desalination
Continued support of process that will retire environmental risk	Power aggregation of multiple MEC	Data Issues at higher TRL
Array testing facilities at higher TRL	Offshore & electrical safety	Basic Research
Installation, Operation, Maintenance and Decommissioning	Hybrid systems at lower TRL	Circular economy aspects
Standards supported development suitable for utility-scale market	Advanced materials development thermoplastics and composites etc.	Health monitoring of dynamic elements / predictive maintenance
Export cables; Anchoring; Mooring	Alternative power carriers to eliminate the export cable	
Streamlining the regulatory process	Technology Qualification at lower TRL	
Robust Federal staffing	Workforce development	
	Manufacturing including Additive/Subtractive Manufacturing	

Figure 1. Generalized Industry Priorities

VII. Discussion

The MEP WG acknowledges that industry priorities differ based on the end-use or target market of a device or project development. One essential finding that remains true for all stages of development within marine energy is the need for increased funding in the form of Federal Funding Opportunities Announcements (FOA) or other financial investments for the sector to reach commercialization. These federal funding opportunities are necessary for developers to reach commercial readiness. The reliability for such funding is extremely important as it is critical to have both higher frequency and greater certainty of dedicated resources for component and device research, development, and demonstration (RD&D).

FOAs are most important to support the middle portion of development projects, the so-called TRL 4-7 'Valley of Death'. Developers often manage to raise funding to finance the startup of a project. Once a device reaches a TRL 7, developers can raise capital from the private sector more easily because ROI is in the near future. However, the middle portion of development is the most important to have financing available for development and testing in the form of FOAs and testing schemes, such as the TEAMER program.

As mentioned in the methodology section, the MEP WG had participants assign a development scale to a priority. It could be equally important for priorities to be examined at the system TRL versus the target development level. Therefore, breaking down individual needs into specific development and system size categories may benefit the ability to prioritize the needs of the industry.

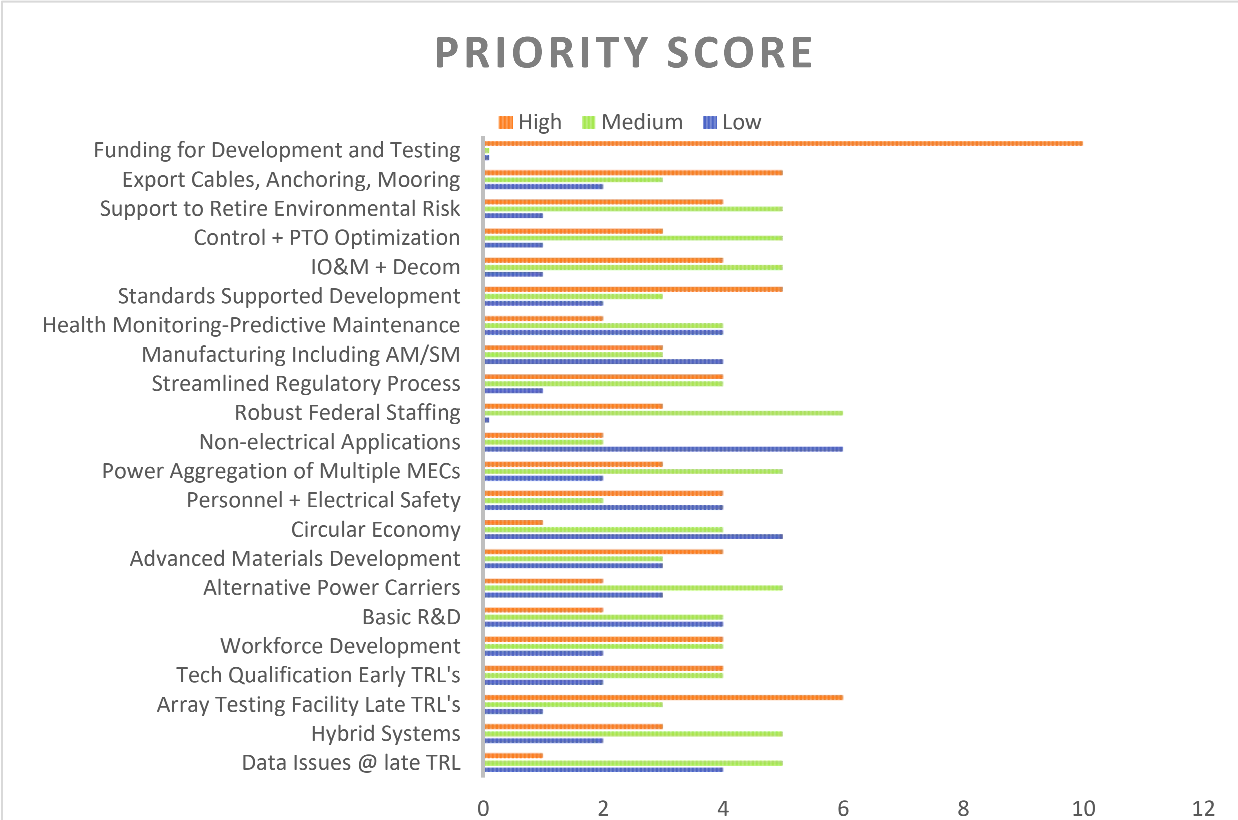
In the table below, each unique priority line item is assigned a letter and a number two reflects the combined results of the survey answered by MEC members, industry developers and stakeholders. However, since most development projects or technologies start at a small scale and evolve to a medium scale before they end up qualifying for large scale production, the group determined the focus should be Field A, E, and I (indicated in red as a higher priority).

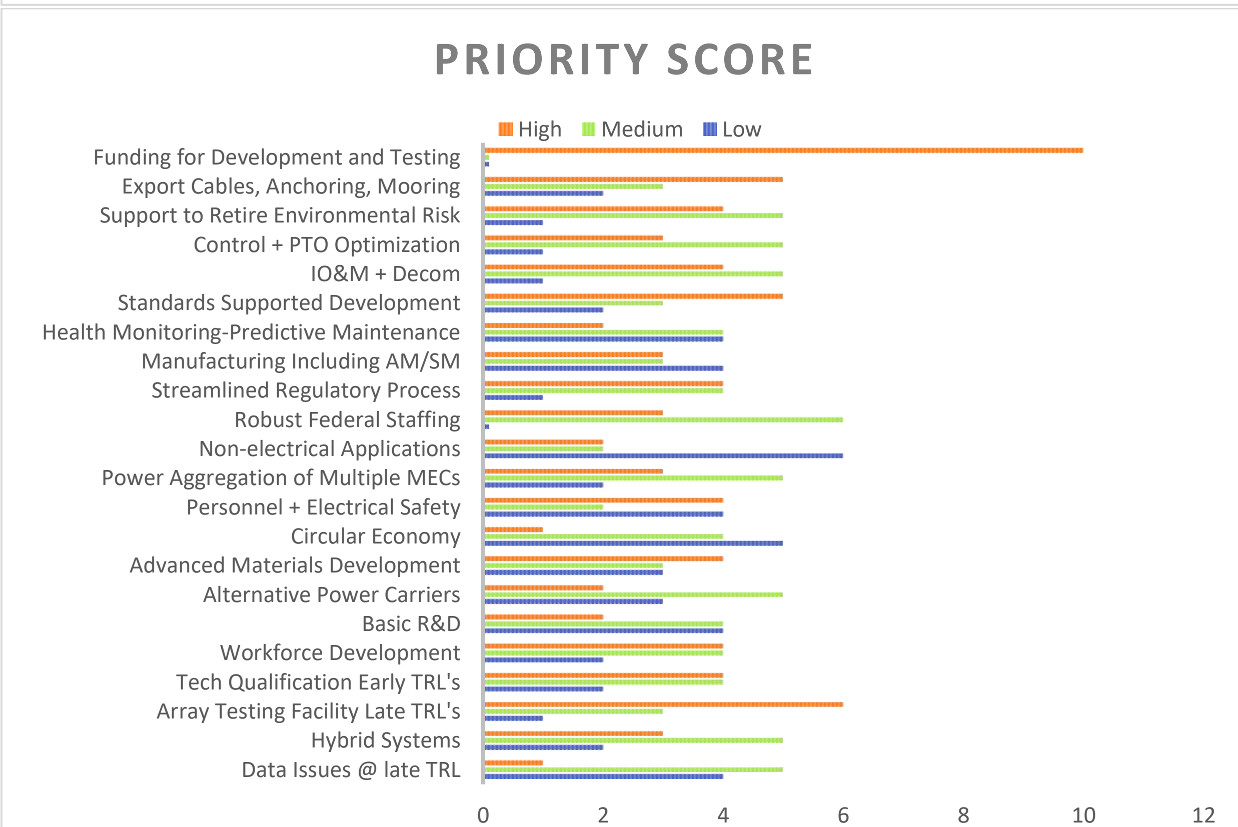
A more complete mapping of the industry priorities in Figure 1 to the categories in Table 1 is an outstanding exercise for the MEP WG to conduct during the next document revision cycle, based on additional input from an NHA-MEC membership-wide survey to be conducted in 2023. Initial results suggest that most of the higher priorities are relevant at multiple development scales while other priorities are clearly mapped to TRL and/or development scale.

TRL/Target system size	**Micro (Ocean Obs/PBE)**	**Meso (Island/Community)**	**Macro (Utility, grid-connected)**
1 – 3	**A**	**B**	**C**
4 – 6	**D**	**E**	**F**
7 – 9	**G**	**H**	**I**

Colors: HIGHER PRIORITY; MEDIUM PRIORITY; LOWER PRIORITY.

Table 1. System to enable mapping of Industry Priorities to TRL and Development/System Size.


PRIORITY SCORE
High
Medium
Low
Funding for Development and Testing
Export Cables, Anchoring, Mooring
Support to Retire Environmental Risk
Control + PTO Optimization
IO&M + Decom
Standards Supported Development
Health Monitoring-Predictive Maintenance
Manufacturing Including AM/SM
Streamlined Regulatory Process
Robust Federal Staffing
Non-electrical Applications
Power Aggregation of Multiple MECs
Personnel + Electrical Safety
Circular Economy
Advanced Materials Development
Alternative Power Carriers
Basic R&D
Workforce Development
Tech Qualification Early TRL's
Array Testing Facility Late TRL's
Hybrid Systems
Data Issues @ late TRL
0
2
4
6
8
10
12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Robust Federal Staffing
Non-electrical Applications
Power Aggregation of Multiple MECs
Personnel + Electrical Safety
Circular Economy
Advanced Materials Development
Alternative Power Carriers
Basic R&D
Workforce Development
Tech Qualification Early TRL's
Array Testing Facility Late TRL's
Hybrid Systems
Data Issues @ late TRL
0
2
4
6
8
10
12

Another issue identified revolves around the resources type within the ME sector, the priorities are likely to differ between wave technologies and current technologies. The MEP WG aimed to identify common challenges and overlaps between the different technologies when developing the list. For instance, export, anchoring, and mooring are cross-cutting components that are a higher priority for both wave and current technologies or decreasing the time and cost of IOM&D by developing best practices and levering best practices from other relevant sectors such as floating offshore wind could help accelerate the industry to commercialization.

It is the NHA-MEC's MEP WG's position that the DoE's focus on smaller size devices and PBE is valuable as a mechanism to increase interest in this field, and spur investment. Effort must continue to be focused on using this approach as a route to the adoption of larger, grid-tied marine energy projects. Nonetheless, smaller devices will also have a place in the market for installation in a variety of setting, such as aquaculture facilities, remote micro-grids, underserved off-grid communities and native lands and even grid connected end-users in coastal communities where tidal flow or riverine flow is available. This is an area where current devices at Meso scale under development can have the biggest impact.

Comparison with Commercialization Strategy

In 2021, NHA's Marine Energy Council issued the 'Commercialization Strategy for Marine Energy,' which outlined 10 federal actions needed to meet the 50 MW by 2025, 500MW by 2030 and 1GW by 2035 targets. This section provides a comparison of those needed federal actions, identified in Commercialization Strategy and the industry priorities identified through the MEP WG.

The list below highlights the necessary federal actions outlined in the Commercialization Strategy and how they align with the industry priorities:

Commercialization Strategy for Marine Energy	10 Top Priorities Concluded from MEC Survey
1. System Design, Fabrication and Demonstration –captured as several higher priority items.	P1) Funding for development and testing
2. Fostering Distributed Generation Capabilities – captured as several higher and medium priorities.	P7) Installation, operation, maintenance and decommissioning
3. Emerging Opportunities for Off-Grid Power – captured as higher and medium priorities.	P9) Controls/PTO optimization
4. Foundational Research and Engineering Assistance –captured as a medium priority. See additional information regarding UMERC	P2) Array testing and higher TRL's
5. Testing Infrastructure and Validation – captured as a medium priority. See additional information regarding TEAMER below.	P3) Export cables, anchors, mooring
6. Financial Incentives for Deployment – as a higher priority.	P10) Support to retire environmental risk
7. Leveraging International Experience and Standards – captured as a higher priority.	P4) Standards supported development
8. Streamlining Permitting and Reducing Regulatory Barriers – captured as a higher priority.	P8) Streamline the regulatory process
9. Workforce Development – captured as a medium priority.	P6) Workforce development
10. Federal Planning, Staffing and Industry Engagement – captured as a higher priority.	P5) Robust federal staffing

We can see that the industry priorities align well with the Commercialization Strategy federal action requirements.

It is also noted that some of the priorities are currently being funded through programs like TEAMER and UMERC, which is discussed further.

Integration with UMERC and TEAMER

As can be seen in the priorities list, development and testing for the industry sector is a higher priority and basic research is a medium priority. It is evident that the Department of Energy's Water Power Technologies Program (WPTO) recognized the gaps in testing and basic research.

The Testing Expertise and Access for Marine Energy Research (TEAMER) program, coordinated by the Pacific Ocean Energy Trust (POET), provides funding support for marine energy system developers to test their systems at facilities around the U.S. The facility network consists of national labs, university and private-industry facilities with expertise and capabilities from numerical modeling, bench testing, and tank, basin, flume, and tunnel testing. TEAMER has also added select open-water facilities to the network. While the PacWave and WETS test sites will address higher-TRL, larger scale testing, significant lack of facilities remain for current energy converter testing at, or near, full-scale.

TEAMER allows marine energy system developers to access testing that may otherwise be cost prohibitive, allowing for a more iterative design process. Developers can test whole systems or components. This organization has been enormously beneficial to the industry so far and must continue to be funded far into the future.

The WPTO awarded funding to POET in Aug 2021 as the coordinator of the University Marine Energy Research Community (UMERC). The aim of this program is to facilitate communication between university researchers, labs, and industry to ensure that industry research needs are being met, while also identifying existing capabilities of researchers. This should create more alignment between research stakeholders and make sure that short, medium, and long-term research needs are met.

UMERC is working with technology developers to identify common foundational research challenges, and how we can link those common themes with the priorities identified in this paper. UMERC will continue to use this information to help facilitate workshops and seminars, as well as an annual summit in an aim to share information to a broad audience.

Appendix A (Industry Priorities Organized by Technical Content, Not R&D Priority)

- Export cables
- Anchoring/Mooring/Shore Connections (applying existing knowledge / knowledge transfer / non-IP specific solutions)

    - Anchor Sharing
    - Mooring/electrical/hydraulic connections (quick connection and combined)
    - Both dry-connect and wet-connect
    - Smaller capacity electrical cables
    - Development of much lower cost export cable installation approaches for community-scale systems.
    - Cable handling (data / power) - (large dynamic cables)
    - Cost-effective wet-mate connectors. Remote operation.
- PTO
    - Direct-drive turbines
    - Scalable gearboxes
    - Scalable power electronics
    - Magnetic gearboxes
- Power aggregation of multiple MEC (arrays)
- Power quality grid integration for utility scale and microgrid for community scale
- Manufacturing: including Additive/Subtractive Manufacturing (3D printing of concrete, polymers, and fiber reinforced thermoplastics)
- QA/QC/QMS
    - Product Lifecycle Management (PLM) tools
    - Document/Drawing control
- Lack of experience and knowledge on installation
    - Knowledge transfer
        - New database/portal vs. existing resources (PRIMRE, NHA OpEx, etc.)
        - Installation specific MHKDR inputs
        - Workshop/Forum format vs. database/excel spreadsheet format
    - Multi-use vessel
- Installation Guidelines / Standards
- IOM&D Challenges
    - Staff training / STEM initiatives
    - Develop best practices - Avoid overly conservative O&G procedures/standards
    - AUV/ROV remote maintenance - reducing staff maintenance/increasing safety
    - Remote monitoring
    - Activities in extreme conditions - Minimizing time onboard
    - Cost estimation tools
- Technology Qualification at earlier TRL (using IEC standards)
- Standards supported based on development of MEC's suitable for the utility-scale market.
    - Deployments at PACWAVE - technology gated
    - PACWAVE is still relevant.
- Advanced materials development
    - Corrosion resistance
    - Mass reduction
    - Friction/Abrasion resistance (fairleads, etc.)
    - Coatings for biofouling

    - Thermoplastic composite materials (circular economy consideration)
- Health monitoring of dynamic elements (electrical cables, ropes, blades, gearbox, etc.)
    - Predictive Maintenance
      Use of digital twin for ease of maintenance, repair, and monitoring
- Controls/Power Take-off optimization
- Alternative power carriers (storage vectors) to eliminate the export cable and open new export markets. The ability to produce a commodity offshore as an alternative to electricity (hydrogen, ammonia, etc.) to eliminate the export cable.
    - Need partners - not developer core IP
    - Wireless power transfer, this technology is already being employed
- Non-electrical applications, including direct desalination
    - Direct drive for pumping fluids (aquaculture, agriculture)
- Hybrid Systems
    - Offshore wind/Wave/Current
    - Floating solar/Wave/Current
- Basic Research
    - Hydrodynamic performance
    - Wake modeling (aka array dynamics)
    - Computational Fluid Dynamics (CFD) simulation, analysis, digital optimization
    - Erosion/Scour/Sediment transport
- Data:
    - Acquisition/management
    - Common analysis techniques
    - Utilize/Interface with: AI, Big Data, Cloud, etc.
- Array Testing Facilities
- Safety
    - Personnel/Electrical safety
- Continued support of processes that will ultimately retire environmental risk and streamline the regulatory process. While continuing to respect the positive environmental change that MEC can provide.
- Circular Economy
    - Recyclability vs. landfill
    - Non-toxic lubricants
    - Rare-earth elements
    - Product life-cycle assessment (access to, and training in, software tools)

Appendix B (MEP WG Participants as of June 2022)

Jonathan Colby, Streamwise Development, LLC, Co-Leader
Walter Schurtenberger, Hydrokinetic Energy Corp., Co-Leader
Dan Petcovic, CalWave Power Technologies, Inc., Member
Shana Hirsch, Pacific Marine Energy Center (PMEC), Member
Chris Lee, Tidal Energy Corporation, Member
Reenst Lesemann, Columbia Power Technologies (C-Power), Member
Tim Mundon, Oscilla Power, Inc., Member
Samantha Quinn, Pacific Ocean Energy Trust (POET), Member
Bill Staby, Resolute Marine Energy, Member
Balky Nair, Oscilla Power Inc, Member
Kelly Rogers, National Hydropower Association (NHA), Staff
David Hoyle, Tide Mill Institute, Member

Appendix C (Technology Readiness Level Definition)