U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# 2017 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WATER POWER TECHNOLOGIES OFFICE

## Summary Report
## February 2018

## VOLUME I

# Notice



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# Volume I: Overview and Summary of Evaluation Results

This report details the results of the 2017 Peer Review for the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy Water Power Technologies Office (WPTO). The purpose of the review was to evaluate projects funded by DOE from fiscal year 2014 through fiscal year 2016 for their contribution to the mission and goals of the office, assess progress against stated objectives, and appraise WPTO's overall management and performance.

This volume (Volume I) includes Sections 1–5 of the report: the executive summary, synopses of the program- and project-level evaluation results, and WPTO's response to the 2017 Peer Review findings. Volume II includes Sections 6 and 7—the complete program-level and project-level evaluation results—as well as the report appendices.

# Preface

Dear Colleague:

On behalf of the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy, Water Power Technologies Office (WPTO), I am pleased to announce the release of the 2017 Water Power Peer Review Report. This report details the results of the Water Power Peer Review Meeting, which was held in February 2017 in Arlington, VA. The purpose of the review was to evaluate WPTO-funded projects for their contribution to the mission and goals of the WPTO and DOE, assess progress against stated objectives, and appraise WPTO's overall management and performance.

As an independent, expert evaluation of the office and its body of research, the peer review is an essential part of developing and assessing the WPTO research portfolio. At the review, principal investigators from the national labs, universities, and private industry presented the scope and progress of DOE-funded WPTO research and development projects to 16 highly qualified, independent reviewers. The reviewers examined and scored the technical, scientific, and business results of the projects, as well as the management and objectives of WPTO itself.

The office is grateful to the reviewers for their candid and constructive scoring, comments, and recommendations, and we will use this valuable feedback to assess and revise current and future portfolio decisions. This report includes WPTO's response to reviewer comments, which describes our consideration of this input and the actions underway to address issues of concern.

WPTO is committed to developing a portfolio of technologies for clean, domestic power generation from water resources, including rivers, waves, and ocean currents. The office aims to establish U.S. leadership in marine energy technologies and to leverage existing and new hydropower resources to produce environmentally sustainable, cost-effective hydroelectric power and ensure U.S. energy security. The 2017 Peer Review results will help WPTO evaluate and plan its research portfolio, ensuring effective investment of taxpayer dollars to realize these goals for the benefit of the nation.

Sincerely,

Alejandro Moreno
Director
Water Power Technologies Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

## Acknowledgments

Organizing, planning, and executing the Water Power Peer Review requires a dedicated and integrated effort from numerous participants. WPTO would like to offer special thanks to the peer review chairs and reviewers for contributing their time and expertise to this vital event. WPTO would also like to acknowledge the time and work dedicated to this effort by the peer review planning team; principal investigators; and WPTO staff.

Cameron Fisher, *48 North Solutions*
2017 Peer Review Chair
Marine and Hydrokinetics Panel

Herbie Johnson, *Southern Company*
2017 Peer Review Chair
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# Nomenclature or List of Acronyms

| | |
|---|---|
| ALFA | Advanced Laboratory and Field Arrays |
| AOP | Annual Operating Plan |
| ASME | American Society of Mechanical Engineers |
| BOEM | Bureau of Ocean Energy Management |
| CERC-WET | Clean Energy Research Center for Water Energy Technologies |
| DOE | U.S. Department of Energy |
| EERE | Office of Energy Efficiency and Renewable Energy |
| EIA | Energy Information Administration |
| EMF | electromagnetic field |
| FERC | Federal Energy Regulatory Commission |
| FMC | Field Measurement Campaign |
| FOA | Funding Opportunity Announcement |
| FY | fiscal year |
| GW | gigawatt(s) |
| IEA | International Energy Agency |
| IEA-OES | International Energy Agency-Ocean Energy Systems |
| IEC | International Electrotechnical Commission |
| INL | Idaho National Laboratory |
| ISO | Independent Service Operator |
| kW | kilowatt(s) |
| LBNL | Lawrence Berkeley National Laboratory |
| LCOE | levelized cost of energy |
| MHK | marine and hydrokinetics |
| MOIS | Modular Ocean Instrumentation System |
| MYPP | Multi-Year Program Plan |
| MW | megawatt(s) |
| NASA | National Aeronautics and Space Administration |
| NERC | North American Electric Reliability Corporation |
| NNMREC | Northwest National Marine Renewable Energy Center |
| NREL | National Renewable Energy Laboratory |
| O&M | operations and maintenance |
| OE | Ocean Energy |
| ORNL | Oak Ridge National Laboratory |
| OSU | Oregon State University |
| PI | principal investigator |
| PMEC-SETS | Pacific-Marine Energy Center South Energy Test Site |
| PNNL | Pacific Northwest National Laboratory |
| PRID | Peer Review identification number |
| PSH | pumped-storage hydropower |
| PTO | power take-off |
| PUD | public utility district |
| QA/QC | quality assurance/quality control |
| R&D | research and development |
| RTO | Regional Transmission Operator |
| RUS-REA | Rural Utilities Service-Rural Electrification Administration |
| SNL | Sandia National Laboratories |
| WEC | wave energy converter |
| WPTO | [U.S. Department of Energy] Water Power Technologies Office |

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# Executive Summary

Completion of the 2017 Water Power Technologies Office (WPTO) Peer Review report marks an opportunity for the office to reflect on and continue to improve its work to best serve the American public. A peer review conducted by a technology office within the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) is defined as, "a rigorous, formal, and documented evaluation process using objective criteria and qualified and independent reviewers to make a judgment of the technical/ scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of an Office's portfolio of project."[1]

The 2017 WPTO Peer Review highlighted expertise from a range of knowledgeable parties in the water power industry, national laboratories and academia. Results have yielded beneficial dialogue and feedback for the office to integrate into the daily operations of the projects reviewed and provides learned lessons to projects that did not meet the need for review. WPTO has compiled this final report to provide the results of the Peer Review in a thoughtful manner for practical utilization of the feedback. Peer reviews are a cornerstone that WPTO values to continue its legacy for successful program management and implementation for enabling water power nationwide.

## 2017 WPTO Peer Review Objectives and Details

The U.S. Department of Energy's (DOE's) Water Power Technologies Office (WPTO) 2017 Peer Review was held on February 14–17, 2017 in Arlington, VA. The purpose of the peer review was to evaluate a selection of DOE-funded projects for their contribution to the mission and goals of the office, to assess progress made against stated objectives, and to assess the office's overall management and performance.

The WPTO will use the results of this peer review to help inform programmatic decision making, modify or discontinue existing projects, guide the future funding and direction of newly funded projects and future opportunities, and support other budget and strategic planning objectives.

WPTO consists of two distinct programs: the Hydropower Program and the Marine and Hydrokinetic Program (MHK). During the 2017 Peer Review, reviewers evaluated projects within these two WPTO programs as separate presentation "tracks": (1) the Hydropower track and (2) the MHK track. Both tracks were divided into three subprograms for the peer review.

The three Hydropower subprograms were:

- Growth
- Sustainability
- Optimization.

The three MHK subprograms were:

- Environmental Research, Resource Characterization and Analysis ( "MHK 2A" for the peer review)
- Technology Research and Development ("MHK 2B" for the peer review)
- Demonstration and Infrastructure. ("MHK 2C" for the peer review)

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[1] The EERE Peer Review Guide is available on the DOE website: https://www.energy.gov/eere/downloads/eere-peer-review-guide. The Peer Review description is drawn from definitions used by DOE, the National Academy of Sciences, the White House Office of Management and Budget, the U.S. General Accounting Office, and other federal agencies and institutions.

The MHK agenda sessions (by subprogram) were further divided into three topic areas each (Table ES-1).

Table ES-1. MHK sub-tracks and topic areas

| MHK-2A | MHK-2B | MHK-2C |
|---|---|---|
| Environmental | Components | Demonstration |
| Market and Industry Development, Analysis, and Data Dissemination | Survivability | Infrastructure |
| Site and Resource | Systems | Sensors and Measurement |

WPTO projects were evaluated by 16 expert reviewers from industry, academia, other government agencies, and the private sector. There were eight reviewers for the Hydropower track and eight reviewers for the MHK track. Reviewers completed evaluations electronically, submitting one program-level scoring sheet for their assigned WPTO track and one project-level scoring sheet for each WPTO project they reviewed.

Reviewers evaluated 110 total water power projects representing over 80% of WPTO's total project budget, in accordance with EERE guidelines for peer reviews. These projects had a combined value of approximately $178 million ($134 million in DOE funds; $44 million in awardee cost share). Every project was reviewed by a minimum of three reviewers. Two independent chairpersons were invited to oversee the peer review tracks and review process: Mr. Herbie Johnson presided over the Hydropower track, and Mr. Cameron Fisher presided over the Marine and Hydrokinetics track. The primary role of the chairs was to provide oversight and guidance that ensures consistency, transparency, and independence throughout the review process. Chairs also contribute program and project evaluations. Information and biographies for the chairs and reviewers are available in the 2017 Peer Review Program Guide on the DOE website.

## Evaluation Metrics

As noted, reviewers in the 2017 WPTO Peer Review provided evaluations at both the program and project levels. Table ES-2 provides a summary of the respective program- and project-level metrics. Definitions for the metrics and additional detail about the scoring methodology are in Sections 3 and 5, and in Appendix E.

Table ES-2. Summary of evaluation metrics for 2017 Water Power Technologies Office Peer Review

<table>
<tr><th colspan="2">Program-Level Evaluation Metrics</th><th colspan="2">Project-Level Evaluation Metrics</th></tr>
<tr><td colspan="2">Individual metrics: scored numerically on a scale of 1–5</td><td colspan="2">Individual metrics: scored numerically on a scale of 1–5</td></tr>
<tr><td colspan="2">Program Objectives</td><td colspan="2">Methods / Approach</td></tr>
<tr><td colspan="2">Research and Development Portfolio</td><td colspan="2">Accomplishments / Progress</td></tr>
<tr><td colspan="2">Management and Operations</td><td colspan="2">Project Management</td></tr>
<tr><td colspan="2">Communications and Outreach</td><td colspan="2">Collaboration / Tech Transfer</td></tr>
<tr><td colspan="2"></td><td colspan="2">Future Research</td></tr>
<tr><td>Strengths (Overall)<br>Weaknesses (Overall)<br>Recommendations</td><td>Written comments only</td><td>Performance</td><td>Calculated score based on weighted average of individual metrics</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Relevance</td><td>Stand-alone numeric score</td></tr>
<tr><td>Strengths (Overall)<br>Weaknesses (Overall)<br>Recommendations</td><td>Written comments only</td></tr>
</table>

## Synopsis of Program-Level Scoring

As part of the 2017 Peer Review process, reviewers were asked to perform a quantitative and qualitative analysis of the two WPTO tracks based on four aspects: Program Objectives; Research and Development (R&D) Portfolio; Management and Operations; and Communications and Outreach. This evaluation is also called the "program-level" assessment.

Each of the four scored program-level metrics was scored as a stand-alone value on a numeric scale of 1–5, with qualitative descriptors for the numerical scoring index (i.e., a score of 1 corresponds to a "Poor" rating, 2 corresponds to a "Fair" rating, 3 corresponds to an "Average" rating, 4 corresponds to a "Good" rating, and 5 corresponds to an "Outstanding" rating). Reviewers were also asked to submit qualitative narrative for strength, weaknesses, and recommendations. Table ES-3 summarizes the program-level evaluation metrics.

Table ES-3. Summary of program-level evaluation metrics for 2017 Water Power Technologies Office Peer Review

<table>
<tr><th colspan="2">Program Evaluation Metrics<br>(Completed for the WPTO as a whole)</th></tr>
<tr><td>• Program Objectives<br>• R&D Portfolio<br>• Management and Operations<br>• Communication and Outreach</td><td>Scored individually on a scale of 1 - 5</td></tr>
<tr><td>• Strengths (Overall)<br>• Weaknesses (Overall)<br>• Recommendations</td><td>Written Comments Only</td></tr>
</table>

Figure ES-1 represents the reviewers' quantitative assessment of how the two WPTO program tracks (Hydropower and Marine and Hydrokinetics) are performing using the four evaluation criteria: Program Objectives, R&D Portfolio, Management and Operations, and Communications and Outreach.

Program-level results are summarized in Section 3. Full program-level results and comments are in Volume II, Section 6.

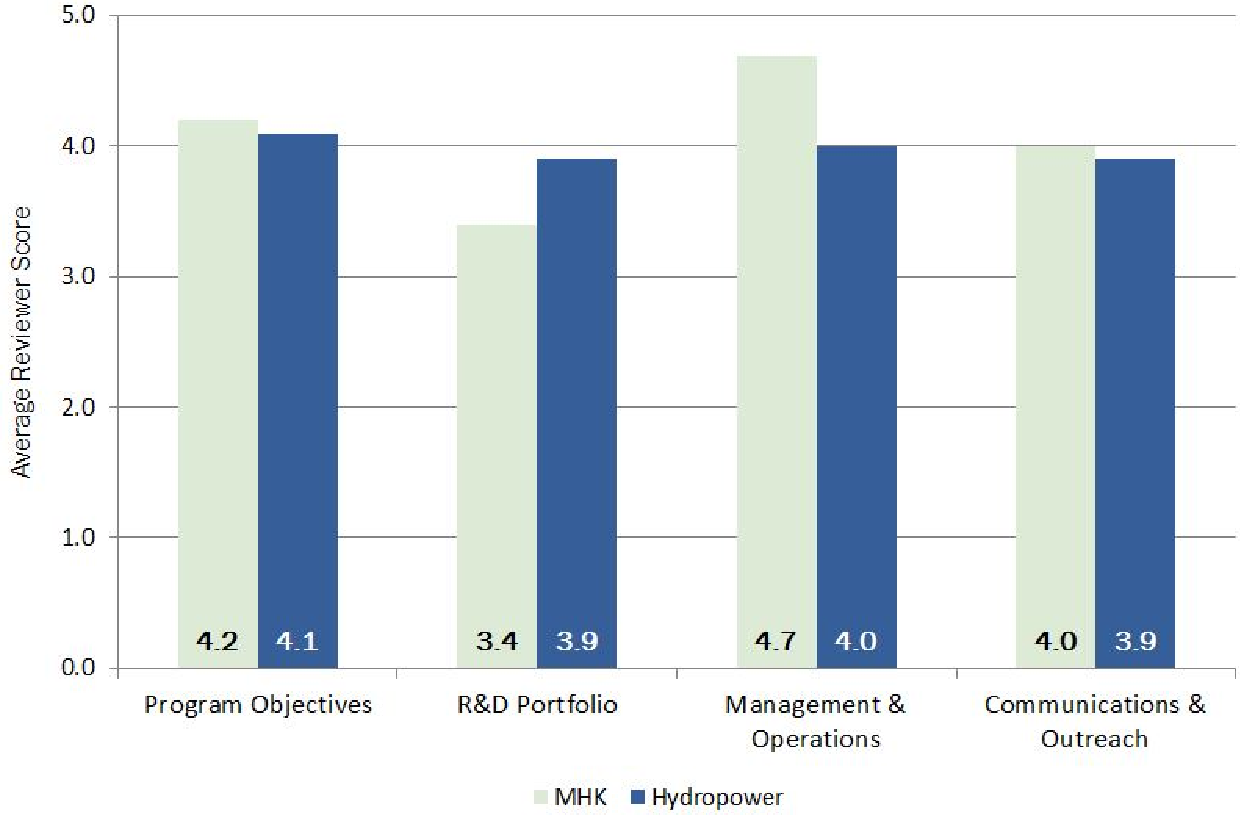



Figure ES-1. Average program-level scores by metric

## Synopsis of Project-Level Scoring

Within the two program tracks, there were 107 individual projects reviewed (39 Hydropower projects and 68 MHK projects). Each of the projects received two cumulative scores. The first score reflected the project's relevance to industry needs and overall WPTO objectives. The second score assesses performance, based on a weighted average of the five component metrics.

Each metric was scored on a numeric scale of 1–5, with qualitative descriptors for the numerical scoring index (i.e.,, a score of 1 corresponds to a "Poor" rating, 2 corresponds to a "Fair" rating, 3 corresponds to an "Average" rating, 4 corresponds to a "Good" rating, and 5 corresponds to an "Outstanding" rating). Reviewers were asked to submit qualitative narrative for overall strengths, weaknesses, and for specific recommendations. Table ES-4 summarizes the project-level evaluation metrics.

Of the primary scored project evaluation metrics, "Relevance" refers to the overall perceived value of a project in addressing WPTO objectives and the needs of the stakeholders. "Performance" is an indicator of how well the project is being executed based on a weighted average of scores in five separate but related metrics. Project level metrics and scoring are defined further in Section 5.1 of this report, including the weighting used in determining the performance score.

Table ES-4. Summary of project-level evaluation metrics for 2017 Water Power Technologies Office Peer Review

| Project Evaluation Metrics (Completed for each project) | |
|---|---|
| • **Relevance** | Scored 1- 5 |
| • **Performance** | Calculated based on weighted average of the 5 metrics below |
| o Methods / Approach<br>o Accomplishments / Progress<br>o Project Management<br>o Collaboration / Tech Transfer<br>o Future Research | Scored individually on a scale of 1 - 5 |
| • **Strengths** (Overall)<br>• **Weaknesses** (Overall)<br>• **Recommendations** | Written Comments Only |

Score tabulations in this report include averages and standard deviations, providing relative as well as absolute assessments of WPTO and its projects.

Project-level results are summarized in Section 5. Full project-level results and comments are in Volume II, Section 7.

## Hydropower Track (39 Projects)

### Project Scoring Summary Charts

Table ES-5 presents the average score for each evaluation metric for all reviewed hydropower projects and for all WPTO projects. The table also includes average scores from each of the eight hydropower reviewers across all projects they reviewed. The reviewers did not review projects for which they had a conflict of interest. Reviewer results are anonymized before results are calculated. The table lists reviewers in order of their respective relevance scores, not in order by their identifying reviewer number.

Table ES-5. Average score by reviewer across all Hydropower project evaluations

| *Hydropower Track* | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Average Score across All Peer-Reviewed WPTO Projects* | *4.1* | *3.8* | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| *Average Score across All Hydropower Projects* | *4.0* | *3.6* | *3.7* | *3.6* | *3.7* | *3.6* | *3.5* |
| Reviewer | Relevance | Performance | *Scores Used in Determining Performance (Weighted Average)** | | | | |
| | | | Methods/ Approach | Accomplishments/ Progress | Project Management | Collaboration/ Tech Transfer | Future Research |
| Reviewer1 | 4.4 | 4.3 | 4.4 | 4.3 | 4.1 | 4.2 | 4.1 |
| Reviewer 8 | 4.4 | 3.6 | 3.7 | 3.4 | 3.5 | 3.7 | 3.5 |
| Reviewer 7 | 4.2 | 3.2 | 3.3 | 3.2 | 3.2 | 3.1 | 3.2 |
| Reviewer 3 | 4.0 | 3.9 | 3.9 | 3.9 | 4.0 | 3.8 | 3.9 |
| Reviewer 5 | 4.0 | 3.6 | 3.7 | 3.5 | 3.6 | 3.5 | 3.4 |
| Reviewer 4 | 3.9 | 3.6 | 3.6 | 3.5 | 4.2 | 3.7 | 3.1 |
| Reviewer 2 | 3.9 | 3.8 | 3.8 | 3.8 | 4.1 | 3.6 | 3.5 |
| Reviewer 6 | 3.7 | 3.2 | 3.2 | 3.2 | 3.2 | 3.3 | 3.4 |

*See Section 5 for the weighted average methodology used to determine the “Performance” metric scores.

## Marine and Hydrokinetics Track (68 Projects)

### Project Scoring Summary Charts

Table ES-6 presents the average score for each evaluation metric for all reviewed marine and hydrokinetics projects and for all WPTO projects. The table also includes average scores from each of the eight reviewers across all projects they reviewed. The reviewers did not review projects for which they had a conflict of interest. Reviewer results are anonymized before results are calculated. The table lists reviewers in order of their respective relevance scores, not in order by their identifying reviewer number.

Table ES-6. Average score by reviewer across all Marine and Hydrokinetics project evaluations

| *MHK Track* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Average Score across All Peer-Reviewed WPTO Projects* | | *4.1* | *3.8* | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| *Average Score across All MHK Projects* | | *4.2* | *4.0* | 4.0 | 4.0 | 3.9 | 4.0 | 3.7 |
| Reviewer | Subprogram | Relevance | Performance | *Scores Used in Determining Performance (Weighted Average)** | | | | |
| | | | | Methods/ Approach | Accomplishments/ Progress | Project Management | Collaboration/ Tech Transfer | Future Research |
| Reviewer 10 | MHK-2A and MHK-2C | 4.6 | 4.6 | 4.5 | 4.7 | 4.6 | 4.5 | 4.2 |
| Reviewer 16 | | 4.3 | 4.2 | 4.3 | 4.3 | 4.1 | 4.2 | 3.9 |
| Reviewer 12 | | 4.0 | 3.9 | 4.0 | 3.9 | 3.8 | 3.9 | 3.6 |
| Reviewer 15 | | 3.9 | 3.7 | 3.8 | 3.8 | 3.6 | 3.9 | 3.3 |
| Reviewer 11 | MHK-2B and MHK-2C | 4.3 | 4.0 | 4.1 | 4.1 | 4.0 | 4.4 | 3.6 |
| Reviewer 13 | | 4.3 | 3.9 | 4.0 | 4.0 | 3.8 | 3.8 | 3.8 |
| Reviewer 9 | | 4.1 | 3.6 | 3.6 | 3.6 | 3.7 | 3.7 | 3.4 |
| Reviewer 14 | | 4.0 | 3.7 | 3.7 | 3.7 | 3.5 | 3.9 | 3.6 |

*See Section 5.1 for the weighted average methodology used to determine the "Performance" metric scores.

## Synopsis of Office Response

The leadership and staff of the Water Power Technologies Office (WPTO) are grateful to the peer reviewers for undertaking a thorough examination of the office's initiatives. The review comments and recommendations were candid and constructive. WPTO is carefully considering the peer review panel's inputs to help determine whether the WPTO portfolio aligns with industry R&D priorities and projects are being executed effectively.

In general, reviewers confirm that both the Hydropower and MHK program objectives align with the overall DOE mission as well as industry needs. Feedback indicates that the office is successfully advancing MHK technology as well as reducing barriers to entry for new market participants. Reviewers also note success for the Hydropower program in minimizing costs associated with small hydropower and aligning program activities to the recent *Hydropower Vision* report.

WPTO will consider improvements suggested by reviewers and integrate these improvements into planning as appropriate. Suggestions in this vein include evaluating the potential to implement or partner on multiple MHK test sites, and expanding efforts to educate stakeholders about the role and value of hydropower with respect to grid resiliency and stability.

The office's full response to the 2017 Peer Review is in Section 4.

# 1 Peer Review Overview

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) recognizes the value of objective review and advice from peers—known as "peer review"—as an important tool for, "enhancing the relevance, effectiveness and productivity of EERE's projects." [2] As such, EERE requires its offices to conduct regular peer reviews and to consider the findings of those peer reviews in program planning. Under EERE peer review guidance, "Results of Peer Reviews should inform Office planning, including Multi-Year Program Plan (MYPP) development, Lab and Annual Operating Plans (AOP) Planning, and Funding Opportunity Announcement (FOA) Planning."[3]

On February 14–17, 2017, DOE EERE's Water Power Technologies Office ("WPTO" or "the office") conducted its 2017 Peer Review at the Sheraton Pentagon City hotel in Arlington, VA. The purpose of the WPTO review was to evaluate a selection of DOE-funded projects for their contribution to the mission and goals of the office, to assess progress made against stated objectives, and to assess overall management and performance of the office.

The objectives of the 2017 WPTO Peer Review were to:

- Review and evaluate the strategy and goals of the Water Power Technologies Office
- Review and evaluate the progress and accomplishments of projects funded by the office in FYs 2014, 2015, and 2016
- Foster interactions among the national laboratories, industry, and academic institutions conducting research and development on behalf of the program.

DOE offices generally hold peer reviews such that activities are reviewed on a recurring basis approximately every two years. WPTO held its previous peer review in 2014, covering activities for FYs 2012 and 2013. The 2014 WPTO Peer Review report and presentations are available on the DOE website.[4] The 2017 WPTO Peer Review evaluated activities for FYs 2014, 2015, and 2016. The event was co-located with the 2017 Peer Review for DOE's Wind Energy Technologies Office, which is now a separate office from WPTO. (Prior to 2016, the two offices combined as the Wind and Water Power Technologies Office.) A total of 275 principal investigators (PIs), researchers, and stakeholders attended the combined reviews.

As part of the 2017 Peer Review, reviewers evaluated projects in two WPTO programs (referred to as "tracks" for the peer review)—Hydropower, and Marine and Hydrokinetics (MHK)—and six related subprograms. The three MHK subprograms were further divided into three topic areas each. Table 1-1 details these tracks, subprograms, and topic areas.

[2] The EERE Peer Review Guide is available on the DOE website: https://www.energy.gov/eere/downloads/eere-peer-review-guide.
[3] The EERE Peer Review Program Guide is available on the DOE website: https://www.energy.gov/eere/downloads/eere-peer-review-guide.
[4] The 2014 WPTO Peer Review Report is available on the DOE website: https://energy.gov/eere/wind/downloads/2014-wind-program-peer-review-report; and the WPTO 2014 Peer Review Presentations are available on the DOE website: https://energy.gov/eere/wind/downloads/2014-wind-program-peer-review-compiled-presentations.

Table 1-1. 2017 Water Power Technologies Office peer review tracks and subprograms

| Track: Hydropower | Track: Marine and Hydrokinetics |
|---|---|
| Growth [19 projects] | MHK-2A: Environmental Research, Resource Characterization and Analysis [27 projects] |
| Sustainability [12 projects] | MHK-2B: Technology Research and Development [28 projects] |
| Optimization [8 projects] | MHK-2C: Demonstration and Infrastructure [13 projects] |

Reviewers evaluated 110 total WPTO projects, representing over 80% of WPTO's total project-related funding in accordance with EERE guidelines for peer reviews. Every project was reviewed by a minimum of three experts, each of whom provided both numeric evaluations and written comments. The peer review panel evaluated two aspects of WPTO: (1) an evaluation of the management, performance, and effectiveness of the office and its research as a whole ("program-level" evaluation, Section 3 and Section 6 [in Volume II]); and (2) each of the individual projects supported by the office and selected for review ("project-level" evaluation, Section 5 and Section 7 [in Volume II]).

This report details the observations and findings of the WPTO reviewers, WPTO's response to these findings, and the supporting meeting materials, including an agenda and list of participants. In accordance with the EERE Peer Review Guide, peer reviewers provided both quantitative and narrative evaluations of the materials and projects presented at the peer review. This report includes summarized versions of reviewer comments (in Sections 3 and 5) as well as the full body of verbatim program- and project-level reviewer comments (in Sections 6 and 7, both of which are in Volume II of the report).

## 1.1 WPTO Peer Review Panels

For the 2017 Peer Review, WPTO organized a peer review panel comprising 16 reviewers to conduct the formal peer review. Reviewers were experts from water power organizations, including industry, academia, trade organizations, non-governmental organizations, and other federal agencies. Reviewers evaluated the progress and relevance of WPTO-funded projects, based on presentations by the project principal investigators (PIs). Projects were evaluated according to a defined set of criteria, as described in Section 5. Reviewers also provided a quantitative and qualitative evaluation of the overall management and direction of WPTO, as discussed in the program-level evaluations.

WPTO screened reviewers to ensure no conflicts of interest existed on reviewed projects. Reviewers submitted recusals from projects on which they worked or for which they had relationships with project team members or a financial interest in the subject matter. Table 1-2 lists the WPTO peer reviewers for 2017.

Table 1-2. Water Power Technologies Office 2017 peer reviewers

| Hydropower Reviewers | | Marine and Hydrokinetics Reviewers | |
|---|---|---|---|
| *Reviewer* | *Affiliation* | *Reviewer* | *Affiliation* |
| **Herbie Johnson, Chair** | Southern Company | **Cameron Fisher, Chair** | 48 North Solutions |
| Dana Hall | Low Impact Hydro Institute | Mary Boatman | Bureau of Ocean Energy Management |
| Michael Kerr | New England Hydropower Company | Elaine Buck | European Marine Energy Centre) |
| Mike Pulskamp | Bureau of Reclamation | Elizabeth R. Butler | Butler Law Offices, LLC |
| John Seebach | Pew Charitable Trusts (formerly with American Rivers) | Peter Donalek | MWH Global |
| Doug Spaulding | Nelson Energy LLC | Henry Jeffrey | The University of Edinburgh |
| Kevin Ross Young | Young Engineering Services | Philip Vitale | U.S. Navy |
| Larry Weber | University of Iowa | Jason Wood | SMRU Consulting |

Two chairpersons were invited to oversee the peer review tracks and review process: Mr. Herbie Johnson presided over the Hydropower track, and Mr. Cameron Fisher presided over the Marine and Hydrokinetic Energy track. The primary role of the chairs is to provide oversight and guidance that ensures consistency, transparency, and independence throughout the review process. The chairs also submitted program and project evaluations. Biographies for the chairs and reviewers are available in the 2017 Peer Review Program Guide on the WPTO website.

The peer review planning team provided reviewers with briefing materials and guidance prior to the meeting via a series of web conference sessions and a Microsoft SharePoint site. This information included a Peer Review Plan that included reviewer instructions, the peer review agenda, the PowerPoint presentations[5] and 2-page project summary documents submitted by project PIs, a review of the overall goals of the office, and the evaluation workbooks (in Microsoft Excel). Reviewers were also required to submit conflict of interest forms as well as honorarium and travel reimbursement forms.

## 1.2 Project Selection Process

WPTO used a multi-step process to identify and select projects to be reviewed at the 2017 Peer Review, and to plan the agenda. This process is described in more detail in Section 2.

## 1.3 Evaluation Criteria and Process Overview

In accordance with DOE EERE peer review guidance, the peer review panelists were asked to submit both quantitative (i.e., numerical scores) and qualitative (i.e., narrative comments)[6] evaluations as part of their review of WPTO and its research portfolio. Assessments were submitted using electronic Excel workbooks, which were provided to reviewers prior to the event.

Scores and qualitative assessments at the program and project level are detailed in this report. Scoring criteria and calculations are discussed in Section 3 and Volume II, Section 6 (program-level review) and Section 4 and

[5] The 2017 WPTO Peer Review presentations are available on the WPTO website: https://energy.gov/eere/wind/wind-program-peer-reviews.
[6] Reviewers were not required to provide narrative evaluations for every program-level review category or for every project.
[6] Reviewers were not required to provide narrative evaluations for every program-level review category or for every project.

Volume II, Section 7 (project-level review). The program-level scoring sheets used by reviewers are in Appendix B (Hydropower) and Appendix C (MHK), and the project-level scoring sheet (both tracks) is in Appendix D.

On the last day of the peer review, the WPTO program leads convened with reviewers to debrief about the event and evaluation findings. After the peer review, responses and comments were compiled into databases and charts for WPTO to consider, and for development of this report. Review chairs also had the opportunity to read the preliminary 2017 Peer Review report.

# 2 DOE's Water Power Technologies Office

## 2.1 Mission

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy's (EERE's) Water Power Technologies Office (WPTO) works with industry, universities, national laboratories, and other federal agencies to conduct research and development through competitively selected, directly funded, and cost-shared projects. The office is pioneering research and development in both marine and hydrokinetic and hydropower technologies to improve performance, lower cost and ultimately support the ability of the United States to sustainably meet its evolving energy needs. WPTO's work directly supports EERE's strategic objectives of increasing energy affordability, improving grid reliability, and reducing barriers to technology development. This, in turn, supports DOE's mission to ensure U.S. security and prosperity by promoting transformative science and technology solutions to meet the nation's energy and environmental challenges.

Since 2008, the efforts of the WPTO have led to technology innovation, cost reduction, and process improvements. These advancements have provided positive benefits for conventional, established hydropower facilities as well as more nascent hydropower and marine and hydrokinetic technologies. Achievements from the office in this time period include:

- Completing the Wave Energy Prize, an innovative design-build-test competition for early-stage wave energy technologies that attracted more than 90 design teams and demonstrated a 5-fold increase in technology performance, easily surpassing the established goal to double energy capture efficiency
- Supporting the development and demonstration of a now commercially-successful, innovative new small hydropower technology pioneered by Natel Energy, who recently opened their first U.S. manufacturing facility in Alameda, CA
- Initiating development of a fully-energetic, grid-connected U.S. wave energy test facility, off the coast of Newport, Oregon in partnership with Oregon State University and an array of other project partners
- Establishing the first marine research centers at U.S. universities in the Pacific Northwest, Southeast, and Hawaii
- Coordinating with the Federal Energy Regulatory Commission and U.S. Army Corps of Engineers to improve regulatory processes for private development of federal non-powered dams
- Partnering to successfully test the first grid-connected U.S. tidal energy projects (with Ocean Renewable Power Company in Cobscook Bay, ME and Verdant Power in the East River of New York City) Publishing an assessment of U.S. non-powered dams to help evaluate opportunities to power such facilities, along with an updated comprehensive assessment of remaining undeveloped streams
- Conducting the first national assessments of marine energy potential for all resource types and having those findings reviewed by the National Academy of Sciences.

In 2016, WPTO published the *Hydropower Vision* report, a multi-year study conducted by DOE in collaboration with more than 300 individuals representing more than 150 organizations. The Hydropower Vision analysis found that with continued technology advancements, innovative market mechanisms, and a focus on environmental sustainability, U.S. hydropower could grow from its current 101 gigawatts (GW) to nearly 150 GW of combined electricity generating and storage capacity by 2050.[7]

[7] U.S. Department of Energy, *Hydropower Vision: A New Vision for U.S. Hydropower.* 2016. Available on the DOE website at https://energy.gov/eere/water/new-vision-united-states-hydropower.

## 2.2 Organizational Structure

The WPTO portfolio includes two programs (referred to as "tracks" for the 2017 Peer Review): Hydropower, comprising hydroelectric and pumped storage technologies; and Marine and Hydrokinetics, comprising wave energy and current energy. WPTO's portfolio is structured to help the United States meet its growing energy demands sustainably and cost-effectively by developing innovative renewable water power technologies, breaking down market barriers to deployment, building the infrastructure to test new technologies, and assessing water power resources for integration into the nation's grid.

The office conducts work in a number of key areas to advance its goals for both marine energy and hydropower technologies:

| Marine and Hydrokinetics (MHK) | Hydropower |
|---|---|
| System Design and Validation | New Hydropower Technology Development and Testing |
| Resource Characterization | Pumped Storage Hydropower (PSH) and Grid Reliability |
| Environmental Monitoring Instrumentation Development and Research | Optimization / Environmental Research and Analysis |
| Testing Infrastructure | |

WPTO collaborates with and supports a range of stakeholders to conduct water power research:

- **Industry—**Engagement in competitively selected and cost-shared projects with key industry partners to research, develop and test new technologies, often making use of federally-funded national test facilities
- **National laboratories—**Directly-funded early-stage research targeted at addressing foundation scientific challenges which can benefit the entire industry
- **Universities and other academic institutions—**Engagement in R&D, workforce development, and other activities with university and other academic partners
- **Interagency partners—**Cooperation through formal Memoranda of Understanding and other informal coordination with government agencies and departments, e.g., U.S. Navy, U.S. Army Corps of Engineers, Department of Interior, and Federal Energy Regulatory Commission
- **International partners—**Collaboration through international R&D partnerships, including engagement with several International Energy Agency tasks.

More information about the WPTO and its activities is available on the DOE website.

## 2.3 Budget Overview

The 2017 Water Power Technologies Office (WPTO) Peer Review evaluated projects that were funded over the course of three fiscal years: FY 2014, FY 2015, and FY 2016. The cumulative WPTO congressional appropriations over these three years totaled $189.57 million. Of this total, approximately $158 million was directly allocated to projects. The balance of the appropriated funds supported Office functions such as technology management, facilities support, small business vouchers, and technology commercialization.

The FY 2014–2016 budgets for the 110 projects presented at the peer review totaled approximately $134 million, or approximately 85% of the project-related budget for that period. Some projects also used unexpended funds from prior fiscal years during the period. Of the reviewed total, three projects totaling $3.7 million were presented and evaluated programmatically, but are not included in the scoring statistics since they were too early in their implementation to have meaningful results. Figure 2-1 illustrates the WPTO funding flow for peer-reviewed projects.

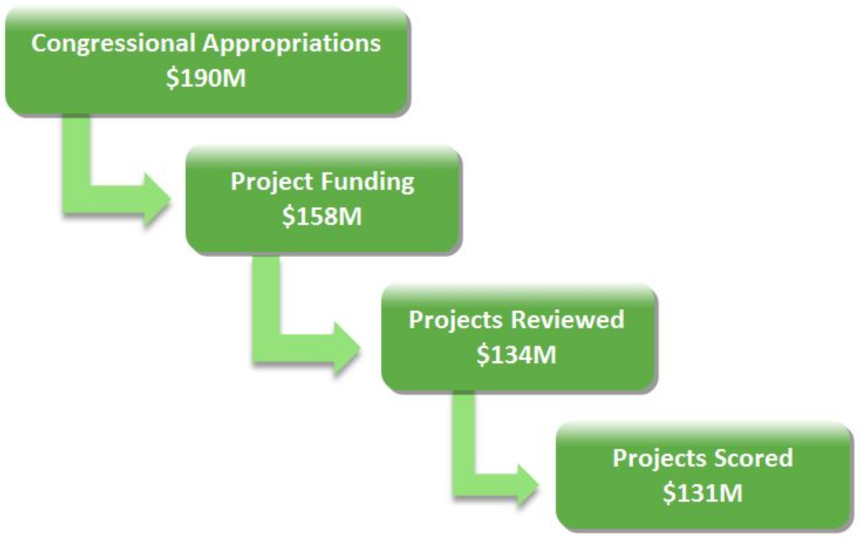



Figure 2-1. Funding of peer-reviewed projects relative to total WPTO FY 2014–FY2016 appropriations (all numbers are approximate)

As explained in the overview section of this report, the peer review was divided into tracks representing the two discreet WPTO technology programs: Hydropower, and Marine and Hydrokinetics (MHK). Figure 2-2 illustrates the total peer-reviewed project funding ($134 million) by track and by the topic-based subprograms within each track.

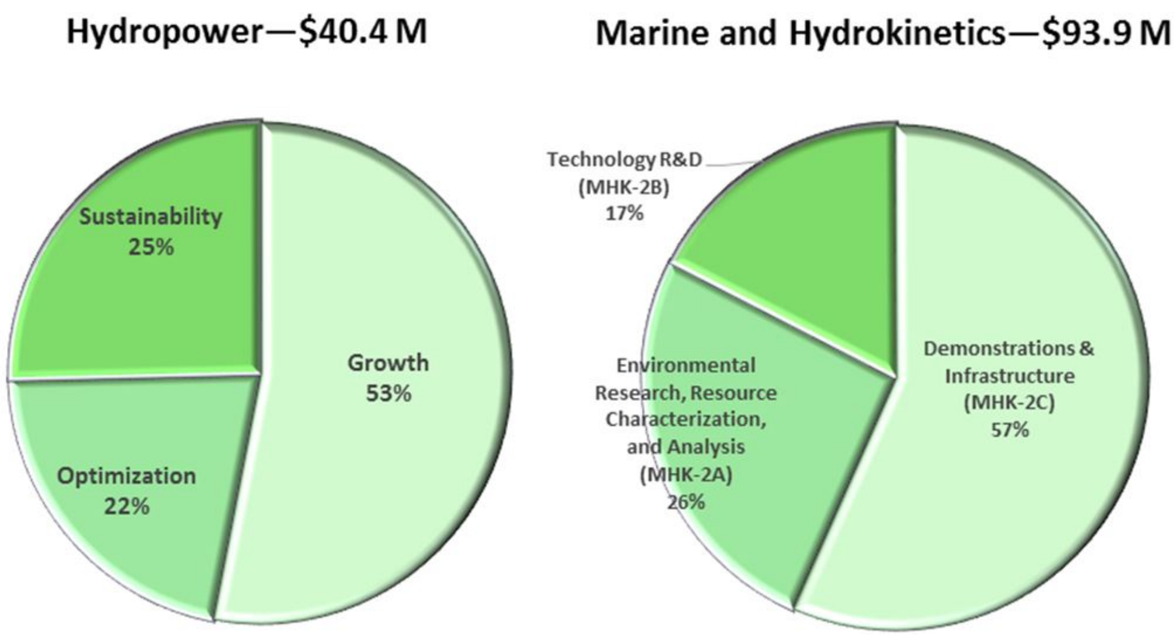



Figure 2-2. Breakdown of funding for peer-reviewed projects by track and subprogram

## 2.4 Project Selection for the Peer Review

Below is a description of the steps WPTO used for selecting the projects to be reviewed at the 2017 Peer Review:

1. The office evaluated all projects funded in FY 2014, FY 2015, and FY 2016.

- The master list of projects included those with direct funding to national laboratories, as well as projects awarded to recipients in industry and academia under competitive solicitations.

2. The WPTO director provided high-level guidance regarding project selection and the associated peer review agenda planning, including:

- Total amount of time to allocate at the peer review for project presentations
- Key research areas to be presented at the Office level instead of as individual projects
- Priority projects considered mandatory to be presented.

3. WPTO team leads and technology managers were provided with the director-pared project list and identified treatment at the peer review for each project as "to be presented," "optional," or "exclude."

- WPTO selected projects based on criteria including magnitude of funding, relevance/importance of research, project stage, desire for peer review feedback on project, and overall diversity of each program portfolio represented at the review.

4. The peer review team synthesized inputs and rankings provided the WPTO team leads and technology managers.

- All "to be presented" projects were identified and listed in a preliminary agenda. "Optional" projects were added where and when possible, depending on other constraints including time.

5. Project selection was further narrowed based on additional criteria.

- To comply with EERE peer review guidelines, approximately 80% of WPTO's budget needed to be represented at the review. This included a mix of office-level and project-level presentations.
- Every national laboratory that received funding within the review period (FY 2014-2016) was required to present at least one project at the review.
- The allocated projects and subject-matter areas were designed to accommodate a two-track session agenda that reflected overall WPTO priorities and funding areas.

6. Agenda details were finalized with input from principal investigators.

- The office adjusted presenters (i.e., allowing PI substitutions) and presentation times as needed to accommodate schedule availability and travel requirements.
- As appropriate, agendas were modified to provide more complex projects with sufficient presentation time.

# 3 Summary of Program-Level Evaluations

Reviewers were asked to provide comments and numeric scores as part of an overall evaluation of both WPTO tracks: (1) Hydropower, and (2) Marine and Hydrokinetics (MHK). The program-level assessment results in an overall view of the WPTO's programmatic management and research portfolios. This section provides a summary of program-level quantitative and qualitative results for each track.

## 3.1 Process Overview

Peer reviewers were asked to provide comments and numeric scores as part of an overall evaluation of WPTO at the program level, based on the reviewed projects. This program assessment provides a high-level view of the reviewed portion of the WPTO portfolio, by track.

The reviewers scored the program tracks on seven criteria: four of which included numeric scores as well as written comments, and three of which included written comments only. Numeric scores were submitted based on a 5-point scale, where 1 = Poor and 5 = Outstanding.

The four assessment criteria that were scored as stand-alone metrics and accompanied by written comments were:

- Program Objectives
- Research and Development Portfolio
- Management and Operations
- Communications and Outreach

The three qualitative criteria for which only written comments were submitted were:

- Program Strengths
- Program Weaknesses
- Recommendations

Details about the descriptors and metrics associated with each criterion are in Section 3. The program-level scoring sheets used by reviewers are included in Appendix B (Hydropower) and Appendix C (MHK).

Results for the program-level evaluations have been tabulated for each of the WPTO tracks and are reported in the subsequent sections.

## 3.2 Hydropower Program-Level Scoring Worksheet and Summary of Results

Table 3-1 contains the evaluation criteria used for program-level scoring in the Hydropower track.

Table 3-1. Hydropower program peer review evaluation criteria

| | | |
|---|---|---|
| **1: <u>Program Objectives</u> - How well do Program objectives align with industry needs and Administration Goals?**<br><br>- **Improve Technology Costs and Performance**<br>- **Develop Environmentally Sustainable Hydropower**<br>- **Optimize Regulatory Processes**<br>- **Enhance Revenue and Market Structures** | | |
| 5 | Outstanding | All Program objectives fully support industry needs. |
| 4 | Good | Most Program objectives fully support industry needs. |
| 3 | Average | Program objectives marginally support industry needs. |
| 2 | Fair | Some Program objectives do not support industry needs. |
| 1 | Poor | Few or none of Program objectives support industry needs; objectives should be re-evaluated and revised. |
| **2: <u>Research and Development (R&D) Portfolio</u> - Is the Water Program investment portfolio appropriately balanced across research areas and recipient organizations to achieve the program's mission & goals?** | | |
| 5 | Outstanding | Program investment portfolio is excellent across research areas and organizations to achieve program mission and goals. |
| 4 | Good | Program investment portfolio is fairly balanced across research areas and organizations to meet program mission and goals. |
| 3 | Average | Program investment portfolio mix and diversity is adequate. |
| 2 | Fair | Program investment portfolio has some weaknesses in balance across research areas and recipients. |
| 1 | Poor | Program investment portfolio will not enable program to achieve its mission and goals. |
| **3: <u>Management and Operations</u> - Please evaluate the quality of the Water Program's team, management practices, and operations.** | | |
| 5 | Outstanding | Program has excellent leadership, personnel, and program operation practices. |
| 4 | Good | Program management and operations appears mostly effective. |
| 3 | Average | Program management and operations is adequate. |
| 2 | Fair | Some of the Program team and practices reduce its effectiveness. |
| 1 | Poor | Program team and practices are not effective. |
| **4: <u>Communications and Outreach</u> - How effective is the Program at engaging with industry, universities, other agencies, international actors, and other stakeholders?** | | |
| 5 | Outstanding | Program is extremely effective in communications, coordination, and outreach with relevant stakeholders. |
| 4 | Good | Program does a good job with communications, coordination, and outreach to relevant stakeholders. |
| 3 | Average | Program communications, coordination, and outreach are adequate. |
| 2 | Fair | Program needs improvement on communications, coordination, and outreach activities. |
| 1 | Poor | Program's ineffective communications, coordination, and outreach impede its overall success. |
| **5: <u>Program Strengths</u> - Discuss the aspects of the program that support successful outcomes or that provide an advantage to the program. Factors may be internal or external.** | | |
| *Comment entry only (no scoring)* | | |
| **6: <u>Program Weaknesses</u> - Discuss the aspects of the program that hinder successful outcomes or that disadvantage the program. Factors may be internal or external.** | | |
| *Comment entry only (no scoring)* | | |
| **7: <u>Program Recommendations</u>** | | |
| *Comment entry only (no scoring)* | | |

Figure 3-1 represents the reviewers' quantitative assessment of how the reviewed portion of the **Hydropower** portfolio is performing in the assessed areas: 1) Program Objectives, 2) R&D Portfolio, 3) Management and Operations, and 4) Communications and Outreach.

| Hydro | Program Objectives | R&D Portfolio | Management & Operations | Communications & Outreach | *Avg. for all Metrics* |
|---|---|---|---|---|---|
| Reviewer 1 | 5.0 | 5.0 | 4.0 | 3.0 | *4.3* |
| Reviewer 2 | 4.5 | 4.0 | 4.5 | 3.5 | *4.1* |
| Reviewer 3 | 4.5 | 3.0 | 5.0 | 4.0 | *4.1* |
| Reviewer 4 | 4.0 | 4.0 | 3.0 | 5.0 | *4.0* |
| Reviewer 5 | 4.0 | 3.0 | 5.0 | 4.0 | *4.0* |
| Reviewer 6 | 4.0 | 3.5 | 4.8 | 3.5 | *4.0* |
| Reviewer 7 | 4.0 | 3.5 | 3.8 | 4.0 | *3.8* |
| Reviewer 8 | 3.0 | 4.0 | 3.0 | 4.0 | *3.5* |

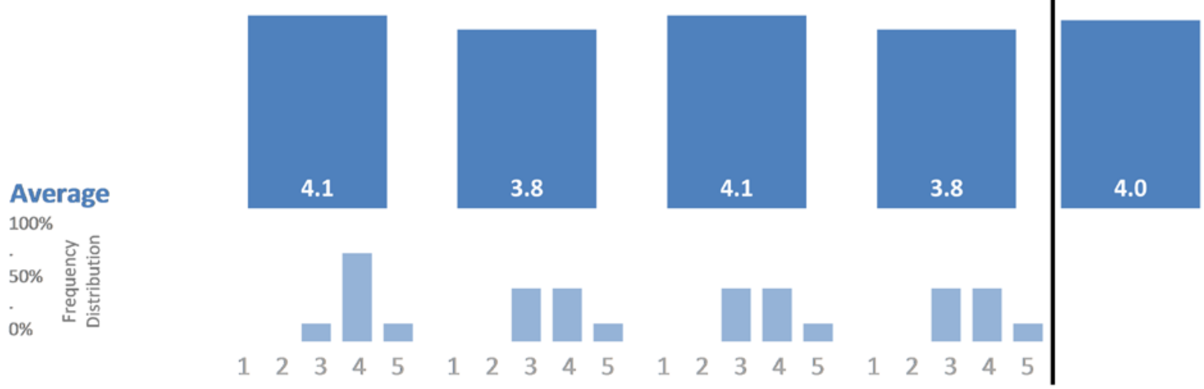



Figure 3-1. Quantitative results for Hydropower program-level evaluation

## 3.3 Hydropower Program-Level Comment Summaries

### Comments by Evaluation Metric

Table 3-2 features selected comments from reviewers' qualitative assessments of how WPTO's Hydropower portfolio is performing on the four evaluated metrics. This section also features comments related to program overall strengths, weaknesses, and recommendations, which were not scored quantitatively. This information was compiled through a comprehensive review of the Hydropower reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive, but are intended to provide a representative selection of both positive and negative input from reviewers. The goal is a balanced snapshot of feedback about the WPTO portfolio.

Table 3-2. Select program-level comments: Hydropower

| |
|---|
| **Program Objectives**<br>• Overall, the DOE Hydropower Program is addressing crucial needs of the industry, particularly those identified in the *Hydropower Vision*.<br>• DOE should continue to focus on technology costs as well as opportunities such as small, low-head facilities that minimize civil costs.<br>• There is a need to address regulatory issues related to hydropower and, recognizing DOE's role here is limited, increased collaboration between DOE and regulatory agencies could be beneficial. |
| **R&D Portfolio**<br>• DOE's hydropower portfolio includes several projects with potential to advance the industry, such as research into fish-friendly turbines and instrument development.<br>• DOE should expand its focus on optimization and sustainability, and should consider engaging new private industry partners for its R&D efforts, particularly with a focus on manufacturability.<br>• Research should primarily comprise broadly applicable projects rather than site-specific studies. |
| **Management and Operations**<br>• The overall management of the DOE Hydropower Program is strong and led by a dedicated team of professionals.<br>• This peer review was a well-executed event.<br>• Most projects appear to be advancing well, although regulatory issues remain a gap in the overall portfolio. |
| **Communication and Outreach**<br>• Communication and outreach are important facets of the DOE Hydropower Program.<br>• The program should continually enhance its outreach efforts and ensure that research results and other information are readily available to stakeholders and easy to find.<br>• The *Hydropower Vision* is a strong point in the program's outreach efforts and has the potential to have real impact on the industry. It should be revisited at regular intervals for maximum effectiveness. |
| **Program Strengths**<br>• The DOE Hydropower Program research portfolio covers solid depth and breadth.<br>• The diverse topics addressed by the projects are aligned with program objectives and the *Hydropower Vision*.<br>• The Program is showing good results, especially considering funding that is low relative to other energy technologies. |
| **Program Weaknesses**<br>• Although the Hydropower Program's portfolio is overall strong, there are still topics that need more attention, especially small hydropower, permitting, workforce development, and FERC's [the Federal Energy Regulatory Commission's] role in hydropower development.<br>• The Program should also fight for more funding to invest in developed technologies, not just new technologies. Topics to consider include R&D in mature markets and ways to realize gigawatt-hour gains in power produced from existing facilities. |
| **Program Recommendations**<br>• DOE should look more closely at real world obstacles. This includes real job growth bias and products that can drive exports through competitive manufacturing local acceptance, as well as outreach to municipalities and counties that control local infrastructure and have interest in developing resources.<br>• DOE needs to develop industry and research lab focus groups to ensure that FOAs address the right objectives to advance hydropower.<br>• The program should continue to look outside DOE to identify best practices and to conduct outreach at relevant venues such as industry conferences. |

### Key Program Management Feedback

Table 3-3 summarizes qualitative program-level recommendations and suggested areas of improvement for the Hydropower track, as noted by reviewers. These inputs focus on overall programmatic management; specifically, these findings assess the overall management, priorities, oversight, and organization of WPTO activities. This table was compiled through a comprehensive review of the Hydropower reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive, but are intended to provide a representative selection of both positive and negative input from reviewers. The goal is a balanced snapshot of feedback about the Hydropower Program's status and opportunities.

Table 3-3. Select program management comments: Hydropower

| Hydropower Programmatic Management |
|---|
| • Overall, the DOE Hydropower Program is adequately addressing issues that affect hydropower, particularly those identified in the *Hydropower Vision*.<br>• The most significant gap in the Hydropower Program appears to be in addressing regulatory issues, but reviewers acknowledge that DOE may not be able to engage significantly in changing the regulatory process. This is an area where DOE needs to determine its optimal and viable role.<br>• The DOE Hydropower Program is well run and well staffed. The team consistently engages with hydropower stakeholders and appears dedicated to the work of advancing hydropower technologies.<br>• The DOE Hydropower Program has made strides in communicating research results, with the *Hydropower Vision* noted as a particular success. However, room remains for the Program to improve its outreach efforts. Specifically, DOE should concentrate additional effort on communicating with other regulatory agencies at both the federal and state levels, and should ensure stakeholders can easily find tools and resources on the Hydropower Program website. |

## 3.4 Marine and Hydrokinetics Program-Level Scoring Worksheet and Summary of Results

Table 3-4 contains the evaluation criteria used for program-level scoring in the Marine and Hydrokinetics (MHK) track.

Table 3-4. Marine and Hydrokinetics program peer review evaluation criteria

| | | |
|---|---|---|
| **1: Program Objectives - How well do Program objectives align with industry needs and Administration goals?**<br>**MHK Program Mission: Support the development of safe, reliable, and cost-competitive MHK technologies and reduce deployment barriers. DOE's MHK program portfolio also simultaneously pursues early market and longer-term utility scale market opportunities.**<br>Program goals:<br>- Cost Reduction: Reduce the levelized cost of energy (LCOE) by 80% compared to the 2015 baseline LCOE values for wave (0.84 $/kWh) and current (0.58 $/kWh) technologies by 2030.<br>- Reduce Deployment Barriers: Enable the industry to rapidly increase MHK technology deployments by supporting research and stakeholder outreach activities to reduce deployment barriers and to accelerate project permitting processes<br>Major Phases of Activities (as identified in Draft Strategy):<br>- Phase I (~2009-~2015):Complete critical foundational work to determine existing technology costs and performance, R&D needs, resource opportunities and deployment barriers<br>- Phase II (~2015-~2020):Aggressive technology innovation and demonstration of Marine and Hydrokinetic systems for multiple resource and market applications | | |
| 5 | Outstanding | All Program objectives fully support industry needs. |
| 4 | Good | Most Program objectives fully support industry needs. |
| 3 | Average | Program objectives marginally support industry needs. |
| 2 | Fair | Some Program objectives do not support industry needs. |
| 1 | Poor | Few or none of Program objectives support industry needs; objectives should be re-evaluated and revised. |
| **2: Research and Development (R&D) Portfolio - Is the Water Program investment portfolio appropriately balanced across research areas and recipient organizations to achieve the program's mission & goals?** | | |
| 5 | Outstanding | Program investment portfolio is excellent across research areas and organizations to achieve program mission and goals. |
| 4 | Good | Program investment portfolio is fairly balanced across research areas and organizations to meet program mission and goals. |
| 3 | Average | Program investment portfolio mix and diversity is adequate. |
| 2 | Fair | Program investment portfolio has some weaknesses in balance across research areas and recipients. |
| 1 | Poor | Program investment portfolio will not enable program to achieve its mission and goals. |

| | | |
|---|---|---|
| **3: Management and Operations - Please evaluate the quality of the Water Program's team, management practices, and operations.** | | |
| 5 | Outstanding | Program has excellent leadership, personnel, and program operation practices. |
| 4 | Good | Program management and operations appears mostly effective. |
| 3 | Average | Program management and operations is adequate. |
| 2 | Fair | Some of the Program team and practices reduce its effectiveness. |
| 1 | Poor | Program team and practices are not effective. |
| **3: Communications and Outreach - How effective is the Program at engaging with industry, universities, other agencies, international actors, and other stakeholders?** | | |
| 5 | Outstanding | Program is extremely effective in communications, coordination, and outreach with relevant stakeholders. |
| 4 | Good | Program does a good job with communications, coordination, and outreach to relevant stakeholders. |
| 3 | Average | Program communications, coordination, and outreach is adequate. |
| 2 | Fair | Program needs improvement on communications, coordination, and outreach activities. |
| 1 | Poor | Program's ineffective communications, coordination, and outreach impede its overall success. |
| **5: Program Strengths - Discuss the aspects of the program that support successful outcomes or that provide an advantage to the program. Factors may be internal or external.** | | |
| *Comment entry only (no scoring)* | | |
| **6: Program Weaknesses - Discuss the aspects of the program that hinder successful outcomes or that disadvantage the program. Factors may be internal or external.** | | |
| *Comment entry only (no scoring)* | | |
| **7: Program Recommendations** | | |
| *Comment entry only (no scoring)* | | |

Figure 3-2 represents the reviewers' quantitative assessment of how the reviewed portion of the **MHK** portfolio is performing in the assessed areas: 1) Program Objectives, 2) R&D Portfolio, 3) Management and Operations, and 4) Communications and Outreach.

| MHK | Program Objectives | R&D Portfolio | Management & Operations | Communications & Outreach | *Avg. for all Metrics* |
|---|---|---|---|---|---|
| Reviewer 9 | 4.5 | 4.5 | 5.0 | 4.5 | *4.6* |
| Reviewer 10 | 4.0 | 4.0 | 5.0 | 4.0 | *4.3* |
| Reviewer 11 | 4.0 | 4.0 | 5.0 | 4.0 | *4.3* |
| Reviewer 12 | 4.5 | 3.5 | 4.5 | 4.0 | *4.1* |
| Reviewer 13 | 4.0 | 3.5 | 5.0 | 4.0 | *4.1* |
| Reviewer 14 | 4.0 | 2.0 | 5.0 | 5.0 | *4.0* |
| Reviewer 15 | 3.8 | 3.7 | 3.7 | 3.8 | *3.8* |
| Reviewer 16 | 5.0 | 2.0 | 4.0 | 3.0 | *3.5* |

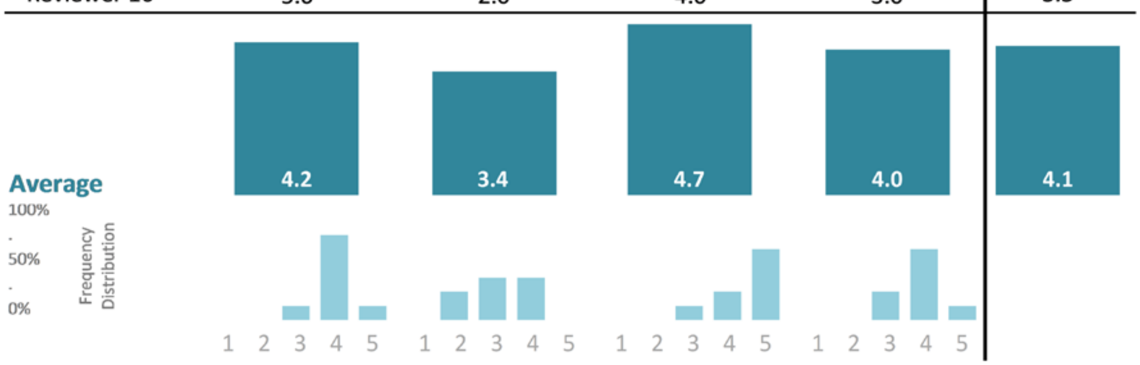



Figure 3-2. Quantitative results for Marine and Hydrokinetics program-level evaluation

## 3.5 Marine and Hydrokinetics Program-Level Comment Summaries

### Comments by Evaluation Metric

Table 3-5 features selected comments from reviewers' qualitative assessments of how WPTO's MHK portfolio is performing on the four evaluated metrics. This section also features comments related to program strengths, weaknesses, and recommendations, which were not scored quantitatively. This information was compiled through a comprehensive review of the MHK reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive, but are intended to provide a representative selection of both positive and negative input from reviewers. The goal is a balanced snapshot of feedback about the WPTO portfolio.

Table 3-5. Select program-level comments: Marine and Hydrokinetics

| |
|---|
| **Program Objectives**<br>• The objectives of the WPTO are aligned with DOE's overall mission.<br>• WPTO's MHK progress to date has been overall successful across a range of goals, including technology advancement and reduction of deployment barriers.<br>• Future work should include cross-cutting approaches, use of multiple test sites, and support for more capital intensive and longer term technology development. |
| **R&D Portfolio**<br>• While WPTO-funded MHK projects have achieved solid results across a useful and relevant body of topics, looking at ways to rebalance the research portfolio could be beneficial to the industry. This includes ensuring that DOE funds research for MHK projects and technologies that are viable and that address industry needs.<br>• WPTO's MHK program can leverage its resources and support industry growth by funding technologies that are close to commercialization as well as timing funding opportunities in a way that helps industry avoid the "drag and delay" between DOE funding and private investment.<br>• DOE should consult with interested private sector manufacturing, marine servicing, and state/regional innovation and economic development partners to evaluate a partnered approach to investing in more mature technologies that can accelerate the timeframe for MHK technology development. |
| **Management and Operations**<br>• The WPTO staff are bright, capable, dedicated individuals who exhibit high levels of professionalism and have the respect of the MHK industry.<br>• The WPTO MHK program has and should continue to exhibit leadership in innovation and collaboration in MHK research. Maintaining this role will require communicating and coordinating with industry as well as other federal agency partners |
| **Communication and Outreach**<br>• The MHK program has generally been successful in its communication and outreach to stakeholders. The DOE-funded tool Tethys is a primary example of this success.<br>• The program should continue to expand its engagement with industry and stakeholders, with particular concentration on working with other federal and state agencies as well as international organizations.<br>• WPTO should improve the availability of and ease of access to of publications and findings on its website—e.g.,, through social media—in order to increase the impact of its taxpayer-funded work |
| **Program Strengths**<br>• WPTO has excellent staff and solid leadership, which results in strong program and project oversight and implementation.<br>• The program portfolio is well managed and provides clear expectations about project deliverables and the impacts on industry.<br>• Communication with other federal agencies and MHK developers enhances DOE's investment value by sharing lessons learned and developing collaborative strategies. |
| **Program Weaknesses**<br>• WPTO funding provides solid support for technology research, but does not adequately support plans that can get new technologies to market. The program should consider playing a larger role as a catalyst to accelerate MHK to the point where it can secure private investment and as a facilitator for the federal agency collaboration necessary to support the permitting and testing of MHK technologies.<br>• WPTO needs to work with the national laboratories more closely to ensure that lab projects align with current MHK industry needs.<br>• The base of players in MHK project supported by DOE funding is too limited. DOE should consider other partners to drive more diversity in research and innovation. |

Program Recommendations

- DOE should invest in collaboration with the U.S. Department of Defense (DOD)—i.e., Navy, Marines, Coast Guard—to accelerate MHK to meet mission-critical base and expeditionary force energy needs. The Program could also expand to other federal and international partners to address humanitarian and disaster relief needs (desalinization) to meet emergent critical global threats to U.S. national security due to water and power shortages.
- It would be beneficial to both the MHK program and industry if DOE were to focus on near-term goals of development. This should include reaching out to commercial development stakeholders in the MHK commercialization spectrum, to attract the expertise and financing needed from the private sector (MHK supply chain of manufacturing, marine services, and financing) and state and regional economic development centers. Field tests should be part of this process to the extent that funding permits.
- As a long-range recommendation, if WEC energy supplies into regional power grids reach a significant level, there will be a need to make such energy available consistently. DOE's MHK program should consider whether surplus WEC energy can be stored versus requiring WEC units to disconnect or shut down until demand increases.

### Key Program Management Feedback

Table 3-6 summarizes qualitative program-level recommendations and suggested areas of improvement for the MHK track, as noted by reviewers. These inputs focus on overall programmatic management; specifically, these findings assess the overall management, priorities, oversight, and organization of WPTO activities. This table was compiled through a comprehensive review of the MHK reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive, but are intended to provide a representative selection of both positive and negative input from reviewers. The goal is a balanced snapshot of feedback about the MHK Program's status and opportunities.

**Table 3-6. Select program management comments: Marine and Hydrokinetics**

MHK Programmatic Management

- The DOE MHK research activities and organizational structure are overall well aligned to industry needs and objectives.
- DOE should continue to focus in current areas, but should also consider broadening its research and collaborative activities that support technology and industry growth.
- Specific areas of potential improvement include broader industry partnerships, innovation funding strategies/market solutions, equal support for varied technologies (e.g., tidal as well as wave), and work on disruptive technologies.
- The personnel and leadership for the Program have demonstrated competence and success in developing and managing research projects that support MHK growth.
- DOE has made progress in enhancing communication and outreach in sharing project information as well as research results to stakeholders including other federal agencies.
- DOE should continue to foster strong outreach efforts and should make better use of social media and other tools to communicate with the full range of stakeholders. This includes expanding international collaboration and communication.

# 4 Program Response to Peer Review Findings

This section provides the DOE's Water Power Technologies Office's (WPTO's) response to the findings and results of the 2017 Peer Review. This response considers the entire breadth of peer review results, including the project-level results, but does so in direct response to the program-level evaluation metrics: Program Objectives; R&D Portfolio; Management and Operations; and Communications and Outreach. See Section 2 for more information about these metrics.

## 4.1 Summary: Water Power Technologies Office Response to Reviewer Feedback

The Water Power Technologies Office makes strategic investments that support key technology innovations, mitigate risks, and provide technologies and information that drive cost reductions and improved performance of American marine energy and hydropower. Program leadership and staff are extremely grateful to the reviewers for undertaking a thorough examination of the program's initiatives. The review comments and recommendations were candid and constructive.

Peer reviews increase public transparency into WPTO's research efforts.[8] Further, it provides an important opportunity to pause from work, evaluate the research portfolio, and make adjustments that will maximize the program's positive impact on the MHK industry. The 2014 Peer Review provided valuable recommendations, which WPTO integrated successfully. In 2014, reviewers noted a need for more active engagement among national labs and other industry stakeholders to better align activities and ensure that roles for each project were filled by the most appropriate organization. Since that time, communication and operational improvements (e.g.,, monthly presentations to the Marine Energy Council, dedicated workshops with hydropower leaders, the Small Business Voucher initiative) have led to greater successes. During the last year, and continuing into the future, partnerships have increased between the labs and industry—in many cases, these partnerships were proposed by device developers. The program also initiated a lab research transparency series that provides monthly presentations to the Marine Energy Council to highlight publicly available research results and products that industry can leverage.

The water power industry faces a broad range of challenges, and WPTO has placed emphasis on developing strategies for both marine energy and hydropower that include input from diverse stakeholder groups and clearly communicate and target key objectives. As suggested in the 2014 Peer Review, consideration is given to the timing of research activities, so projects with limited near-term impact can be initiated at a later time, when appropriate, and projects addressing more urgent, near-term needs can be prioritized sooner. The 2017 Peer Review has produced valuable comments, observations and constructive suggestions. WPTO will incorporate recommended approaches and considerations in managing its current portfolio and in making future funding decisions.

## 4.2 Hydropower Program Response to Peer Review Findings

This section details the response of the Hydropower program to the peer review findings. Under each programmatic evaluation metric below, reviewer comments from the tables in Section 3.3 are copied in bulleted, italicized lists. Office responses to each group of comments are then provided. Complete comments are provided in Volume II, Section 6 of this report. WPTO has reviewed all reviewer comments and incorporated lessons learned from them into their responses.

**EVALUATION METRIC: Program Objectives**

- *Overall, the DOE Hydropower Program is addressing crucial needs of the industry, particularly those identified in the Hydropower Vision.*

[8] The 2017 WPTO Peer Review presentations are available on the DOE website at https://energy.gov/eere/water/water-power-program-peer-reviews.

- *DOE should continue to focus on technology costs as well as opportunities that minimize civil costs such as small, low-head facilities.*
- *There seems to be a general need to focus more attention on regulatory issues related to hydropower, but it's not clear this responsibility should fall to DOE.*

**Hydropower Program Response for Program Objectives**

Reviewers confirmed that program objectives align well with crucial industry needs in specific areas, and that the Hydropower Vision played a key role in defining those objectives, though there is still more to be done to achieve important cost reductions. Moving forward, dialog with the industry will continue, as evidenced by the program's recent Executive Summit for Hydropower Research and Development, to ensure that its research portfolio addresses the crucial needs of the industry. The program will continue to focus on minimizing the costs associated with small hydropower as well as shift toward providing new information regarding the benefits of hydropower and pumped storage in the United States with respect to grid resiliency and stability. With respect to regulatory issues, DOE has no hydropower regulatory responsibilities. The Department has, however, historically played a role in providing scientific, unbiased information to inform regulatory processes and in convening/facilitating agreements among hydropower regulators (i.e., the program's efforts in the Memorandum of Understanding between the Federal Energy Regulatory Commission and the Army Corps of Engineers). DOE also continues to play a leadership role in the Federal Inland Hydropower Working Group. The program will continue to actively engage with hydropower industry and regulatory bodies as necessary to develop scientific information and analyses that can help regulators shorten and/or remove inefficiencies in the permitting process for new hydropower.

**EVALUATION METRIC: R&D Portfolio**

- *DOE's hydropower portfolio includes several projects with potential to advance the industry, such as research into fish-friendly turbines and instrument development.*
- *DOE should expand its focus on optimization and sustainability, and should consider engaging new private industry partners for its R&D efforts, particularly with a focus on manufacturability.*
- *Research should primarily comprise broadly applicable projects rather than site-specific studies.*

**Hydropower Program Response for R&D Portfolio**

The reviewers acknowledged the Hydropower Program's WPTO's efforts to advance industry knowledge with respect to biological design criteria for turbines and development of instrumentation for integrating small hydropower projects with energy storage systems. The program notes that these two efforts have resulted in industry partnerships with large private-sector turbine manufactures. WPTO staff will continue current efforts with respect to optimization and sustainability (asset management research/small modular hydropower) but, as noted above, will shift program focus slightly towards quantification of the value of hydropower and pumped storage particularly with respect to impacts on the existing fleet from increasing grid demand for operational flexibility. This effort will also require a certain level of industry engagement and partnering especially with respect proposed techno-economic pumped-storage hydropower analysis.

While site-specific studies are often necessary with respect to deployment of new hydropower technologies, it is always the goal of WPTO to ensure that the results of such studies have broad applicability across the hydropower industry.

**EVALUATION METRIC: Management and Operations**

- *The overall management of the DOE Hydropower Program is strong and led by a dedicated team of professionals.*

- *This peer review was a well-executed event.*
- *Most projects appear to be advancing well, although regulatory issues remain a gap in the overall portfolio.*

**Hydropower Program Response for Management and Operations**

The WPTO Hydropower Program appreciates the reviewers' complementary remarks with respect to the management of the program and Peer Review event. The program is pleased as well with the advancement of the projects in the portfolio and will continue to ensure that this portfolio addresses the research needs of the hydropower industry. As noted above, with respect to regulatory issues, the program has historically played a role in providing scientific, unbiased information to inform regulatory processes.

**EVALUATION METRIC: Communication and Outreach**

- *Communication and outreach are important facets of the DOE Hydropower Program.*
- *The Program should continually enhance its outreach efforts and ensure that research results and other information are readily available to stakeholders and easy to find.*
- *The Hydropower Vision is a strong point in the Program's outreach efforts and has the potential to have real impact on the industry. It should be revisited at regular intervals for maximum effectiveness.*

**Hydropower Program Response for Communication and Outreach**

WPTO agrees with the reviewers that existing outreach efforts need enhancement, with the goal of improving program work and thus the value of DOE investments to the U.S. taxpayer. While it is not the program's role to provide communication or marketing efforts on behalf of industry, it is essential that the program have effective engagement with stakeholders to ensure feedback and insight that increase the relevancy of WPTO projects, disseminate products in a way that maximizes the impact of WPTO projects, provide transparency in utilization of taxpayer funds, and provide accurate and objective information and data that inform the development of the industry and decision makers. Specific to hydropower, the program held an Executive Summit on Hydropower Research and Development that was attended by over 75 leaders in the hydropower industry. At that event, WPTO staff learned that, in general, the industry had limited awareness of the work of DOE national laboratories. As a result, the program initiated a campaign to attend all five National Hydropower Association regional meetings and the Northwest Hydropower Association annual meeting to inform the industry of WPTO research efforts and gather information about industry research needs. In addition, WPTO developed and released an online information portal, HydroWise, an easy-to-use "kiosk" that can direct users to the latest hydropower research activities of the national laboratories and other DOE-funded research. The program also launched an online projects database and map, which lets users easily search and learn more about projects. The project database and map includes basic information like project cost, locations, and partners, as well as more detailed information, such as peer review presentations, images, and other documents.

With respect to revisiting the *Hydropower Vision*, WPTO initiated an effort, with the national laboratories, to catalog all of the activities throughout the hydropower community relating to the 64 action items identified in the Vision's Roadmap. This information will be leveraged to identify gaps in activities among the action areas and engage with the hydropower community to seek ways of filling those gaps. Finally, in 2021, the program will revisit the Vision's hydropower growth scenarios to determine how the Vision Roadmap activities are affecting the projected Vision growth trajectory.

**EVALUATION METRIC: Strengths**

- *The Hydropower Program research portfolio covers solid depth and breadth.*
- *The diverse topics addressed by the projects are aligned with Program objectives and the Hydropower Vision.*

- *The Program is showing good results, especially considering funding that is low relative to other energy technologies.*

**Hydropower Program Response for Strengths**

The reviewers acknowledge that the Hydropower portfolio is diverse and aligned with stated objectives. In the coming years, the goal is to ensure that the program maintains this alignment by clearly articulating program objectives and strategies in the form of a comprehensive strategic plan. In addition, WPTO will maintain rigor in its project selection process through the merit review program, which will ensure that results continue to be impactful to the hydropower community.

**EVALUATION METRIC: Weaknesses**

- *Although the Hydropower Program's portfolio is overall strong, there are still topics that need more attention, especially small hydropower, permitting, workforce development, and FERC's [the Federal Energy Regulatory Commission's] role in hydropower development.*

- *The Program should also fight for more funding to invest in developed technologies, not just new technologies. Topics to consider include R&D in mature markets and ways to realize gigawatt-hour gains in power produced from existing facilities.*

- *Lack of project management measures led to insufficient handle on performance of national laboratory projects.*

**Hydropower Program Response for Weaknesses**

The reviewers point out that the program would benefit by more work in the small hydropower field. Program staff acknowledges that this area deserves attention, but also notes that the current portfolio includes $2.4M worth of research to directly benefit small hydropower. Plans for FY18 continue this trend. With respect to hydropower permitting, DOE has no hydropower regulatory responsibilities but will continue to actively engage with regulators such as FERC to provide the scientific and accurate action necessary to inform any reform efforts in the permitting and regulatory processes.

The WPTO Hydropower Program has historically supported and funded the Hydropower Research Foundation's fellowship program that has provided opportunities for graduate students to conduct research into some of the hydropower industries' most pressing issues. Many of these fellows have now joined the hydropower workforce and are providing valuable knowledge. With respect to continued work in the area of workforce development, the program is considering options, taking into account the priorities of the current Administration, and will use the soon-to-be-released hydropower workforce report to chart future activities.

WPTO recognizes that optimization of existing hydropower facilities is a key pillar of the Hydropower Program strategy. In FY17, WPTO will complete studies at the national laboratories with respect to advancing intake flow measuring technologies that should lead to optimized operations as existing facilities. Budgetary plans for FY19 and beyond will include strong consideration for requesting funds to advance technologies for existing projects.

One reviewer noted an apparent lack of overall project management leading to insufficient constraints on certain national laboratory projects. WPTO staff are trained technical project managers and there is extensive dialog with the labs with respect to project budgetary and technical milestones, including review of quarterly reports. However, WPTO staff are committed to continuous development and staying current with project management best practices. As a result, the program is in the process of implementing new project management and cost reporting procedures that will ensure WPTO staff can track budgetary issues on a more real-time basis. These practices will improve project managers' abilities to anticipate potential challenges and most effectively address deviations from project plans.

With respect to reviewer suggestions that national laboratory projects lack attention to market- or end-user needs, WPTO is focused on improving its bi-directional communication with stakeholders to ensure that the labs receive and respond to the feedback and insights necessary to both establish the relevance of technical research to industry, and to effectively inform decision makers.

## 4.3 Marine and Hydrokinetics Program Response to Peer Review Findings

This section details the response of the Marine and Hydrokinetics (MHK) program to the peer review findings. Note that key reviewer comments for each metric are provided in italics (verbatim).

**EVALUATION METRIC: Program Objectives**

- *The objectives of the WPTO are aligned with DOE's overall mission.*
- *WPTO's MHK progress to date has been overall successful across a range of goals, including technology advancement and reduction of deployment barriers.*
- *Future work should include cross-cutting approaches, use of multiple test sites, and support for more capital intensive and longer term technology development.*

**MHK Program Response for Program Objectives**

Reviewers confirmed that the program objectives align with the overall mission of the DOE and that progress to date on both technology advancement and deployment barrier reduction has again been successful. The program appreciates the comments regarding incorporating use of multiple test sites in future work and continues to collaborate with other entities when practical—such as testing at the Navy's Wave Energy Test Site (WETS) and the European Marine Energy Centre (EMEC). The program plans to continue these collaborations as it supports the construction and use of the Pacific Marine Energy Center-South Energy Test Site (PMEC-SETS). Additionally, the program recognizes that U.S. industry would benefit from a testing program similar to the European Union's Marine Renewables Infrastructure Network (MARINET) program. This type of program would provide access to tank testing at various locations, currently a major barrier for fast and iterative technology improvement, as well as expertise on how to better complete experiments and numerical modeling in operational and extreme conditions.

**EVALUATION METRIC: R&D Portfolio**

- *While WPTO-funded MHK projects have achieved solid results across a useful and relevant body of topics, looking at ways to rebalance the research portfolio could be beneficial to the industry. This includes ensuring that DOE funds research for MHK projects and technologies that are viable and that address industry needs.*
- *WPTO can leverage its resources and support industry growth by funding technologies that are close to commercialization as well as timing funding opportunities in a way that helps industry avoid the "drag and delay" between DOE funding and private investment.*
- *DOE should consult with interested private sector manufacturing, marine servicing, and state/regional innovation and economic development partners to evaluate a partnered approach to investing in more mature technologies that can accelerate the timeframe for MHK technology development.*

**MHK Program Response for R&D Portfolio**

DOE is in a unique position to assist in research and development to advance the MHK industry by making strategic investments that spur innovation and propel United States leadership in the sector. WPTO recognizes the value of funding research that addresses industry needs and supports industry growth. To meet other industry challenges, the WPTO invests in testing and infrastructure, specifications and standards, and performance assessments. The WPTO supports research to help understand and address engineering challenges and risks associated with MHK technologies, with the ultimate goal of transferring the bulk of investments to the private sector. The WPTO supports the international consensus based IEC TC 114 specifications that will enable future commercial certifications of devices and projects. The WPTO coordinates closely with other organizations and agencies whose missions are enabled by access to MHK energy, such as the U.S. Navy, the U.S. Fish and Wildlife Service, the Marine Energy Council, and the Pacific Ocean Energy Trust. The WPTO actively communicates with these and other partners to investigate opportunities to accelerate market development. As the industry matures, more data are available and the WPTO tracks metrics related to cost, energy capture, and other attributes. The office makes this information available to investors for financing purposes and to the industry for benchmarking and goal setting.

**EVALUATION METRIC: Management and Operations**

- *The DOE WPTO staff are bright, capable, dedicated individuals who exhibit high levels of professionalism and have the respect of the MHK industry.*
- *The WPTO has and should continue to exhibit leadership in innovation and collaboration in MHK research. Maintaining this role will require communicating and coordinating with industry as well as other federal agency partners.*

**MHK Program Response for Management and Operations**

WPTO's MHK team appreciates the positive feedback from reviewers regarding the capabilities of current staff. The program consistently challenges all staff to continually develop as individuals and as an organization. The WPTO agrees that the management and operations of the program's research and development activities require close partnerships with the MHK industry and other federal agency partners. The program is collaborating with the U.S. Navy, U.S. Coast Guard, Federal Communication Commission, National Oceanic and Atmospheric Administration, the Federal Energy Regulatory Commission, the Army Corps of Engineers, and the Bureau of Ocean Energy Management on various programmatic and project-specific initiatives. The office is proactively engaging industry through multiple channels outside of collaborative agreements, including regular telephone conferences with the Marine Industry Council to highlight the work of DOE's national laboratories and National Marine Renewable Energy Centers, and actively engaging international partners and participating in technical conferences around the globe.

**EVALUATION METRIC: Communication and Outreach**

- *WPTO has generally been successful in its communication and outreach to stakeholders. The DOE-funded tool Tethys is a primary example of this success.*
- *The Program should continue to expand its engagement with industry and stakeholders, with particular concentration on working with other federal and state agencies as well as international organizations.*
- *WPTO should improve the availability of and ease of access to of publications and findings on its website—e.g., through social media—in order to increase the impact of its taxpayer-funded work.*

**MHK Program Response for Communication and Outreach**

Reviewers acknowledged success in WPTO's communication efforts, but noted room for growth—particularly in coordinating communications with federal and state agencies and international organizations. Reviewers also recommended improving access to publications and research products. The program is focused on improving its engagement with stakeholders to ensure we listen to the industry and other users of our research and incorporate their insight to increase the relevancy of WPTO projects, maximize their impact, provide transparency in use of taxpayer funds, and provide accurate and objective information and data that inform decision makers and the development of the industry. In addition, WPTO recently launched an online projects database and map, which lets users easily search and learn more about projects. The project database and map include basic information such as project cost, locations, and partners, as well as more detailed information, such as peer review presentations, images, and other documents.

**EVALUATION METRIC: Strengths**

- *WPTO has excellent staff and solid leadership, which results in strong program and project oversight and implementation.*
- *The Program portfolio is well managed and provides clear expectations about project deliverables and the impacts on industry.*
- *Communication [engagement] with other federal agencies and MHK developers enhances DOE's investment value by sharing lessons learned and developing collaborative strategies.*

**MHK Program Response for Strengths**

WPTO appreciates the reviewers' acknowledgment of efforts to provide solid leadership to this important industry. WPTO is in a unique position to assist in research and development to advance the MHK industry toward commercialization by making strategic investments that spur innovation and propel United States leadership in the sector. WPTO holds significant value in collaboration and information sharing. Close working partnerships have been cultivated with other federal agencies, which has enabled each agency to leverage their investments and maximize the impact to the MHK Industry. As an example, WPTO has partnered with the U.S. Navy to jointly support testing of prototype MHK devices at the Navy's Wave Energy Test Site (WETS) in Kaneohe, HI.

**EVALUATION METRIC: Weaknesses**

- *WPTO funding provides solid support for technology research, but does not adequately support plans that can get new technologies to market. The program should consider playing a larger role as a catalyst to accelerate MHK to the point where it can secure private investment and as a facilitator for the federal agency collaboration necessary to support the permitting and testing of MHK technologies.*
- *WPTO needs to work with the national laboratories more closely to ensure that lab projects align with current industry needs.*
- *The base of players supported by DOE funding is too limited. DOE should consider other partners to drive more diversity in research and innovation.*

**MHK Program Response for Weaknesses**

Based on comments from its 2014 Peer Review, WPTO initiated a Marine Energy Council (MEC) lab transparency presentation series to increase stakeholder's awareness of lab capabilities that can be leveraged by device developers. The office is encouraged to see companies engaging with the labs to initiate partnerships. In FY18, three organizations have partnered with a lab to improve energy capture through advanced controls research and modeling, and four others have scheduled power take-off testing at the labs. One aspect of lab research is to provide testing and modeling capabilities, and another is to produce products that are 100% releasable to the public to maximize impacts. For example, one effort produced testing reports and test data that were downloaded more than 2,000 times, showing significant interest from industry and academia. WPTO seeks to maintain a balanced portfolio, where some funds go directly to industry-based research, which often produces proprietary results, and other funds go to lab research, which produces products available to the entire MHK industry. In addition, each national lab project is now merit reviewed to provide a means to evaluate industry impact of each project.

Regarding the suggestion that DOE should consider other partners, WPTO agrees and is proactively seeking advice on specific ways to increase the diversity of its research and development partners. The office's most recent success in this area was the Wave Energy Prize, which was a public competition that challenged organizations to double state-of-the-art energy capture in wave energy devices. WPTO was pleasantly surprised when 92 device developers submitted applications to enter the competition—including many that were new to WPTO.

The program agrees that thorough literature searches and reviews are a critical first step before initiating any R&D project. This point is covered in the standard kick-off presentation for each new project. As a best practice, WPTO intends to reiterate this action and clearly articulate the requirement to all selected awardees.

DOE seeks to support industry in bringing MHK energy technology costs in line with other sources of energy and achieve commercialization. The Administration has directed DOE to focus on early-stage research and development. The WPTO strategy is under review to ensure that it aligns properly with this direction while addressing the technological challenges and programmatic barriers that impede commercialization.

# 5 Summary of Project-level Evaluations

## 5.1 Process Overview

Reviewers scored individual projects (project-level evaluations) on six separate evaluation metrics, using a numeric 5-point scale. Scores tabulations in this report include averages and standard deviations, providing relative as well as absolute assessments of WPTO and its projects.

The peer review evaluations focused on the following six evaluation metrics. Where applicable, the shortened name used in the project-level Scoring Tables in this report is shown in parentheses.

Metric #1, *Relevance*, is a stand-alone metric. Metrics #2–6 are combined to provide a single weighted *Performance* score. Applicable weights for these metrics are in the table below.

(1) *Relevance to water power industry needs and overall DOE objectives* (Relevance)—The degree to which the project aligns with objectives and goals of WPTO and meets the needs of the water power industry at large. This is a stand-alone metric reported separately in the scoring tables.
(2) *Methods / Approach*—The degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers.
(3) *Technical Accomplishments and Progress* (Accomplishments/Progress)—The degree to which the project has delivered results and/or progressed technically compared to the stated project schedule and goals.
(4) *Project Management*—The effectiveness of the project's management, including project planning, project execution, and allocation of resources to complete the project within scope, on-time, and within budget.
(5) *Research Integration, Collaboration, and Technology Transfer* (Collaboration/Tech Transfer)—The degree to which the project successfully interacts, interfaces, or coordinates with other institutions (e.g., industry, universities, other laboratories) and projects, and the degree to which projects are disseminating the results of the R&D.
(6) *Proposed Future Research (if applicable)* (Future Research)—The degree to which the future research proposed is relevant, well-planned, and worthwhile of continued funding.

The *Performance* score is the weighted average of metrics #s 2–6, with the weights shown in Table 5-1.

Table 5-1. Metrics and scores for project-level evaluations

| | | |
|---|---|---|
| Relevance | Stand-alone metric | Relevance to water power industry needs and overall DOE objectives |
| Weighted Average Performance | 30% | Methods / Approach |
| | 30% | Technical Accomplishments and Progress |
| | 20% | Project Management |
| | 10% | Research Integration, Collaboration, and Technology Transfer |
| | 10% | Proposed Future Research (if applicable) |

The equation used to calculate the *Weighted Average Performance* score is in Appendix E. The project **Scoring Tables** show the Relevance in the first scoring column and the (computed) *Performance* score in the second column. The remaining columns show the actual scores for each performance metric. Charts in the **Scoring Tables** plot **Relevance** on the Y axis and **Performance** on the X axis. The shading represents one or two standard deviations from the mean (darker center block is one standard deviation, lighter outer block is two standard deviations). Approximately 68% of the projects are within one standard deviation of the mean and 95% are within two standard deviations.

Numerical project scores are based on a 5-point scale: 5 – Outstanding; 4 – Good; 3 – Average; 2 – Fair; 1 – Poor. Qualitative descriptors apply to these numerical scores. These descriptors vary for each of the metrics and are included in the example scoring sheet in Appendix B.

In addition to scoring the evaluation criteria, peer reviewers were asked to provide qualitative assessment of the project in a written narrative. Reviewers were asked to comment on overall strengths and weaknesses, and to include recommendations for ways to improve the projects. Reviewers were not required to submit narrative comments for every project.

Qualitative descriptors apply to the numerical scores. These descriptors vary for each of the metrics and are included in the example scoring sheet in Appendix B. In addition to scoring the evaluation criteria, peer reviewers were asked to provide qualitative assessments of each project metric in a written narrative. Reviewers were also asked to comment on overall strengths and weaknesses, and to include recommendations for ways to improve the projects.

The following project scoring elements are provided for WPTO subprograms and topic areas:

**(1)** **Scoring Table**—summarizes the scores assigned by reviewers to all of the projects in each subprogram. This table includes the **Review Average,** which represents the average scores for all WPTO projects (i.e., across Hydropower and MHK). Each table also includes the average for that particular subprogram. Note that one subprogram has only one project.

**(2)** **Key Comments Themes and Examples**— includes a selection of summary comments intended to capture key points, best practices, or critical deficiencies noted by reviewers regarding the projects within each subprogram. The comments in these tables are not comprehensive, but are intended to provide a representative selection of both positive and negative input from reviewers. The goal is a balanced snapshot of the feedback provided about WPTO projects.

Bubble charts summarizing track scores relative to funding levels are also included in the subsequent sections.

The tracks and subprograms by which the project results are divided are:

Track: Hydropower
Subprograms:

- Growth
- Sustainability
- Optimization.

Track: MHK
Subprograms (bold) and topic areas:

- **MHK 2A – Environmental Research, Resource Characterization and Analysis**
  - Environmental
  - Market and Industry Development, Analysis, and Data Dissemination
- **MHK 2B – Technology Research and Development**
  - Components
  - Survivability
  - Systems
- **MHK 2C – Demonstration and Infrastructure**
  - Demonstration
  - Infrastructure
  - Sensors and Measurement.

## 5.2 Hydropower Track: Summary of Project Results

As a means of assessing the variability in scores among reviewers, Table 5-2 presents the average scores for each evaluation metric by reviewer, across all projects in the Hydropower track. Note that reviewers did not review projects for which they had an identified conflict of interest. Reviewer results are anonymized before results are calculated. The table lists reviewers in order of their **respective relevance and performance** scores, not in order by their identifying reviewer number.

Table 5-2. Average Score by Reviewer across All Hydropower Project Evaluations

| *Hydropower Track* | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Average Score across All Peer-Reviewed WPTO Projects* | *4.1* | *3.8* | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| *Average Score across All Hydropower Projects* | *4.0* | *3.6* | *3.7* | *3.6* | *3.7* | *3.6* | *3.5* |
| | | | *Metric Scores Used for Weighted Average Performance* | | | | |
| Reviewer | Relevance | Weighted Average Performance | Methods/ Approach | Accomplishments/Progress | Project Management | Collaboration/ Tech Transfer | Future Research |
| Reviewer1 | 4.4 | 4.3 | 4.4 | 4.3 | 4.1 | 4.2 | 4.1 |
| Reviewer 8 | 4.4 | 3.6 | 3.7 | 3.4 | 3.5 | 3.7 | 3.5 |
| Reviewer 7 | 4.2 | 3.2 | 3.3 | 3.2 | 3.2 | 3.1 | 3.2 |
| Reviewer 3 | 4.0 | 3.9 | 3.9 | 3.9 | 4.0 | 3.8 | 3.9 |
| Reviewer 5 | 4.0 | 3.6 | 3.7 | 3.5 | 3.6 | 3.5 | 3.4 |
| Reviewer 4 | 3.9 | 3.6 | 3.6 | 3.5 | 4.2 | 3.7 | 3.1 |
| Reviewer 2 | 3.9 | 3.8 | 3.8 | 3.8 | 4.1 | 3.6 | 3.5 |
| Reviewer 6 | 3.7 | 3.2 | 3.2 | 3.2 | 3.2 | 3.3 | 3.4 |

### 5.2.1 Funding to Scoring Comparison Charts—by Hydropower Subprogram

Figure 5-1 provides insight into funding amounts for each of the three Hydropower subprograms, relative to peer review scores for relevance and overall performance (weighted average score). The size of the solid bubbles for each subprogram indicates relative funding. The dashed bubble in the center illustrates total funding for the Hydropower track for each of the respective funding categories shown (DOE-only funding and DOE plus cost-share funding).

Note that relevance is on the Y axis and weighted average performance is on the X axis. The shading on the charts represents one (darker) or two (lighter) standard deviations from the mean scores.

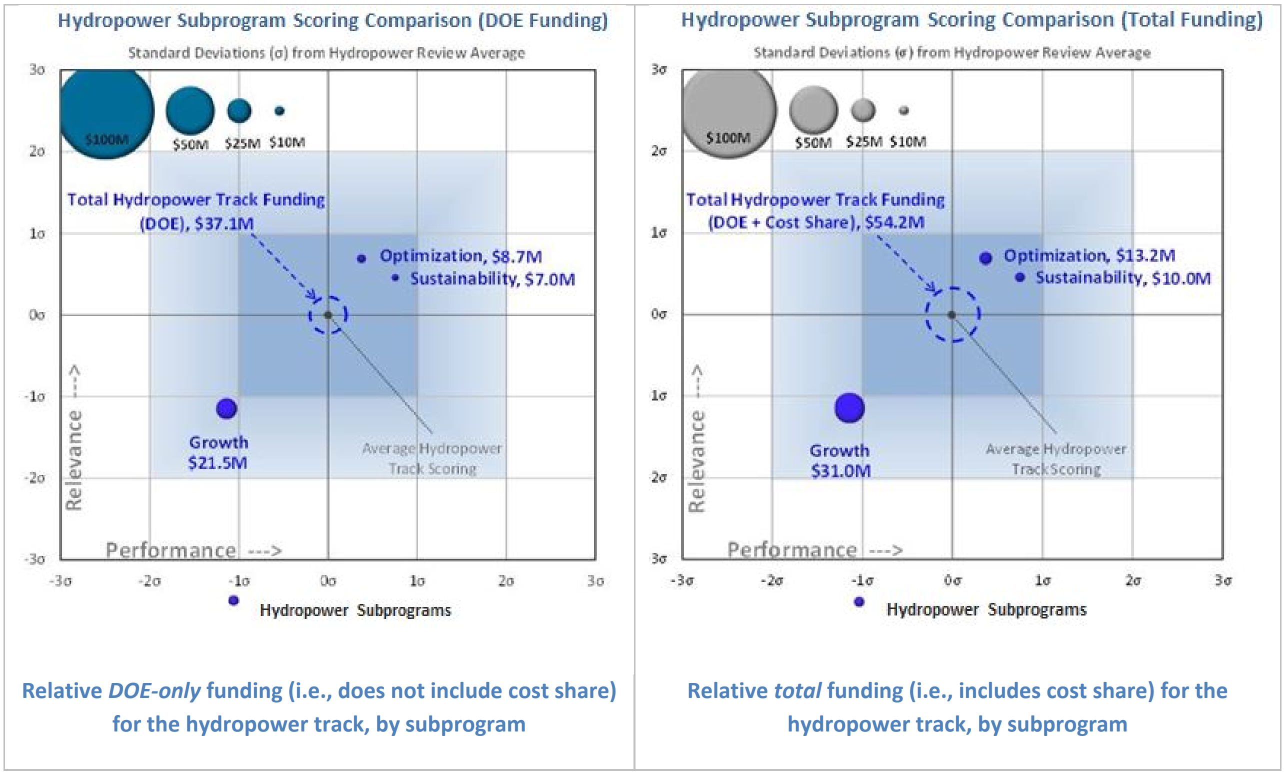
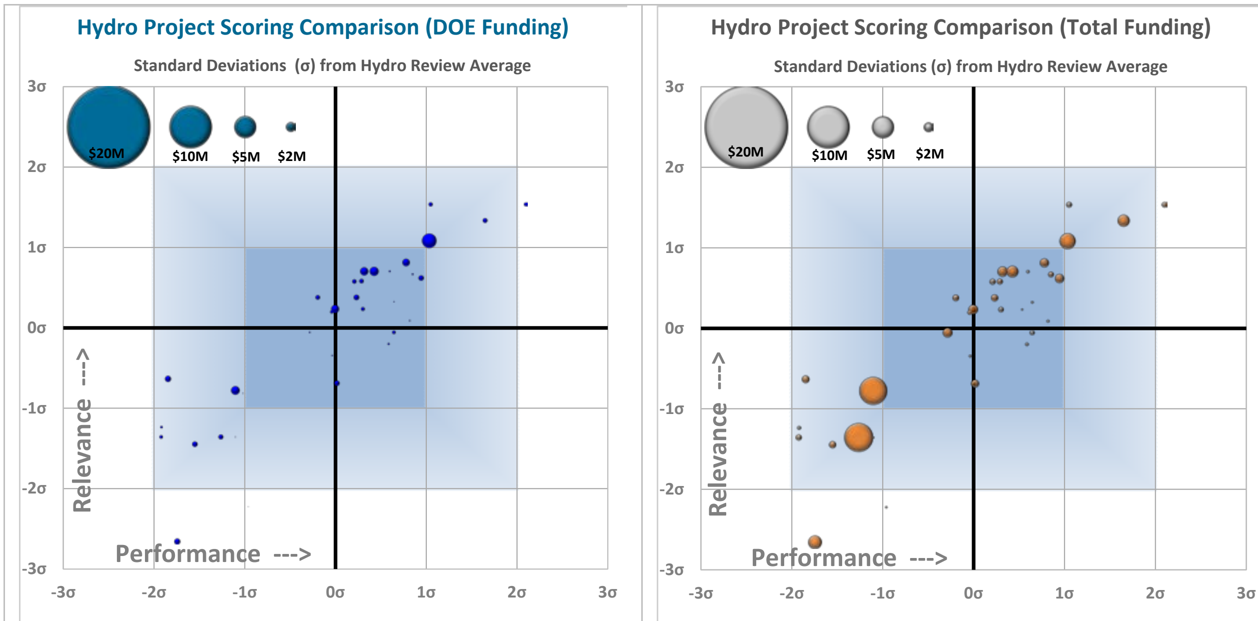



Figure 5-1: Funding amounts relative to Hydropower subprogram scores

### 5.2.2 Funding to Scoring Comparison Charts—by Hydropower Track

Figure 5-2 provides insight into funding amounts for the Hydropower track, by project, relative to peer review scores for relevance and overall performance (weighted average score). Note that relevance is on the Y axis and weighted average performance is on the X axis. The shading on the charts represents one (darker) or two (lighter) standard deviations from the mean scores.




**Relative *DOE-only* funding (i.e., does not include cost share) of the reviewed hydropower projects.**

**Relative *total* funding (i.e., includes cost share) of the reviewed hydropower projects.**

Figure 5-2: Hydropower subprogram scores and relative funding amounts

### 5.2.3 Project-Level Summary Chart Explanation

Section 4.2.4 provides scoring and comment summaries for each of the Hydropower subprograms (Table 5-3).

Table 5-3. Water Power Technologies Office Hydropower Subprograms

| |
|---|
| **Growth**<br>*Facilitate realization of long-term deployment scenarios for responsible hydropower growth.* |
| **Optimization**<br>*Optimize the value and the power generation contribution of the existing hydropower fleet.* |
| **Sustainability**<br>*Ensure that hydropower's contributions toward meeting the nation's energy needs are consistent with environmental stewardship and responsible water use management.* |

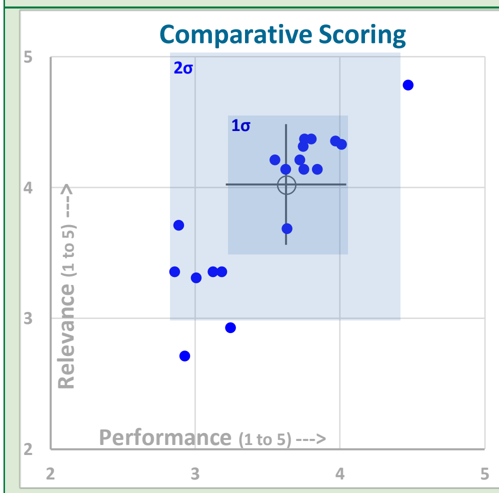
These results are shown in two tables for each subprogram:

1) **Project Scores**—summarizes the scores assigned by reviewers to all of the projects in each subprogram. This table includes the **Review Average,** which represents the average scores for all WPTO projects (i.e., across Hydropower and MHK). Each table also includes the average for the associated subprogram. The project score tables include graphs illustrating scores on the relevance/performance continuum. The smaller shaded box in the chart represents one [1] standard deviation from the mean; the larger shaded box is two [2] standard deviations from the mean. Note that the graphs use an abbreviated scale (origin = 3) in order to provide a zoomed-in view.

2) **Key Comments**—summarizes a selection of comments from reviewers for each subprogram. The comments in these tables are not comprehensive, but are intended to provide a representative selection of both positive and negative input from reviewers. The goal is a balanced snapshot of the feedback provided about Hydropower projects.

### 5.2.4 Results by Subprogram

*Hydropower: Growth*




Total Projects: 19

Avg. Funding: $1.13M DOE / $1.63M total

Avg. Project Duration: 3.0 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance (WAP) | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for Hydropower—Growth** | **3.7** | **3.9** | **3.5** | 3.6 | 3.5 | 3.7 | 3.4 | 3.3 |
| Magnetic Gears for Hydropower Drivetrains (184)[9]<br>Emily Morris, Emrgy Hydro, LLC | 4.6 | 4.8 | 4.5 | 4.4 | 4.3 | 4.6 | 4.6 | 4.7 |
| Hydro Research Foundation University Research Awards Program (132)<br>Brenna Vaughn, Hydro Research Foundation | 4.2 | 4.3 | 4.0 | 3.8 | 4.1 | 4.3 | 4.2 | 3.9 |
| SLH100 Demonstration Project at Monroe Hydro (139)<br>Abe Schneider, Natel Energy, Inc. | 4.2 | 4.4 | 4.0 | 4.0 | 3.9 | 4.0 | 3.9 | 4.1 |
| Rapidly Deployable Advanced Integrated Low Head Hydropower Turbine Prototype (175)<br>Arnie Fontaine, Pennsylvania State University | 4.1 | 4.4 | 3.8 | 4.0 | 3.8 | 3.7 | 3.4 | 3.8 |
| Cost-Optimization Modular Helical Rotor Turbine-Generator System for Small Hydro Power Plants (174)<br>David Yee, Eaton Corporation | 4.1 | 4.4 | 3.8 | 3.9 | 3.7 | 3.8 | 3.4 | 3.7 |
| Standard Modular Hydropower (SMH) (97)<br>Brennan Smith, ORNL | 4.0 | 4.3 | 3.7 | 3.8 | 3.5 | 4.0 | 3.7 | 3.9 |

[9] Numbers in parentheses after the project names are peer review identification numbers (PRIDs). These were used to organize projects for the peer review. The PRIDs are not in any specific order.

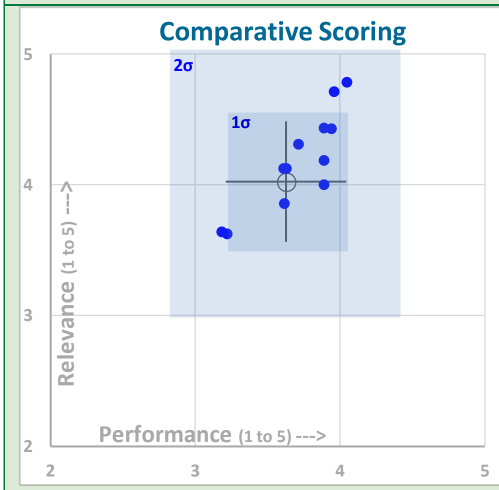
| *Hydropower: Growth* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site (141)<br>David Brown Kinloch, Weisenberger Mills, Inc | 4.0 | 4.1 | 3.8 | 3.9 | 3.9 | 3.8 | 3.6 | 3.7 |
| Modular Pumped Storage Hydropower Feasibility and Economic Analysis (76)<br>Boualem Hadjerioua, ORNL | 4.0 | 4.2 | 3.7 | 3.9 | 3.6 | 3.9 | 3.6 | 3.4 |
| The Design and Development of a Composite Hydropower Turbine Runner (194)<br>Pat Hipp, Composite Technology Development, Inc. | 3.9 | 4.1 | 3.8 | 4.1 | 3.3 | 3.9 | 3.6 | 3.8 |
| Workforce, Education, and Training Needs Assessment for U.S. Hydropower (159)<br>Jay Paidipati, Navigant Consulting, Inc. | 3.9 | 4.1 | 3.6 | 3.8 | 3.4 | 4.0 | 3.4 | 3.3 |
| Optimized Composite Prototype for Archimedes Turbine Manufacture (193)<br>Jerry Straalsund, Percheron Power, LLC | 3.9 | 4.2 | 3.6 | 3.8 | 3.6 | 3.4 | 3.1 | 3.4 |
| French Modular Impoundment (181)<br>Bill French, French Development Enterprises, LLC | 3.7 | 3.7 | 3.6 | 3.4 | 3.8 | 3.9 | 3.3 | 3.5 |
| Demonstration of a New Low-Head Hydropower Unit (143)<br>Wayne Krouse, Hydro Green Energy, LLC | 3.3 | 3.7 | 2.9 | 3.2 | 2.9 | 2.9 | 2.4 | 2.5 |
| Cellular Cofferdam for Hydropower Use (182)<br>Marte Gutierrez, Trustees of the Colorado School of Mines | 3.3 | 3.4 | 3.2 | 3.2 | 3.3 | 3.3 | 3.0 | 2.8 |
| The 45 Mile Hydroelectric Project (142)<br>Jim Gordon, Earth by Design Inc. | 3.2 | 3.4 | 3.1 | 3.3 | 3.2 | 3.0 | 3.1 | 2.6 |
| Modular Low-Head Hydropower System (180)<br>David Duquette, Littoral Power Systems, Inc. | 3.2 | 3.3 | 3.0 | 2.9 | 3.1 | 3.1 | 3.1 | 2.9 |
| Harnessing the Hydroelectric Potential of Engineered Drops (140)<br>Jerry Straalsund, Percheron Power, LLC | 3.1 | 3.4 | 2.9 | 2.7 | 2.7 | 3.3 | 3.1 | 2.6 |
| Cement Changes and Solutions to the Industry (183)<br>Todd Sirotiak, North Dakota State University | 3.1 | 2.9 | 3.2 | 3.1 | 3.3 | 3.7 | 3.1 | 2.6 |
| South Fork Powerhouse Project (137)<br>David Hanson, Sacramento Municipal Utility District | 2.8 | 2.7 | 2.9 | 2.9 | 3.0 | 3.6 | 2.6 | 2.0 |

**Hydropower—Growth**
**Key Comments**

- Within the portfolio, there are excellent examples of collaboration with industry, agencies and non-governmental organizations. Further engagement is urged on technical topics of mutual interest with (for instance) the DOE Wind Program, the auto and marine industries, and other established research programs.
- The modular pumped storage research is important to 1) determining the feasibility of specific technical concepts on which to focus further R&D; 2) addressing the necessary cost reductions; and 3) assessing the impact of environmental factors on potential growth.
- Continuing to target cost reduction through both initial capital costs and levelized cost of energy (LCOE) is a priority. Ensuring consistency of LCOE calculations is critical to comparative analysis of technologies.
- Continuing R&D that enables reductions in the cost and the environmental footprint of civil works at hydropower projects is critical to growth.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Magnetic Gears for Hydropower Drivetrains* project (PRID 184) is promising work that should be prioritized. The approach is well designed and technically feasible, with clearly defined performance targets and a real-world application.<br>• In the *Cost-Optimization Modular Helical Rotor Turbine-Generator System for Small Hydro Power Plants* project (PRID 174), the approach of targeting cost reduction through both initial capital costs and LCOE is a priority. This method could serve as a model for other projects.<br>• Application of modular structures utilizing, for instance, prefabricated concrete components (widely used in other types of major civil-works construction) for dam construction is an excellent idea.<br>• The *Hydro Research Foundation University Research Awards Program* (PRID 132) has provided a valuable tool to promote professional technical employees in the hydropower industry. In the long term these fellowships will result in a number of qualified and skilled technical professionals in the industry.<br>• Great job encouraging the Center for Applied Energy Research to expand beyond coal research. This is significant because it is a break through accomplishment, convincing an organization previously uninvolved in hydropower to expand their work and focus on hydropower.<br>• Continue to blend industry, universities, and labs to get strong results.<br>• The AHS [Archimedes Hydrodynamic Screw] technology appears to be a fish-friendly and relatively low cost methodology to capture the hydro-potential at existing low head sites. Since there are a large number of these sites throughout the United States, this technology could be a valuable part of future hydro-generation, developed by smaller investors not requiring large institutional financing.<br>• The range of PSH [pumped storage hydropower] options reviewed was excellent and should be used as an example of how a stable of technical solutions to a challenge should be identified upfront before a project commences. | • The South Fork Powerhouse Project (PRID 137) appears to be a "one-off" project with only limited relevance to the majority of future developments.<br>• Modular systems may have significant dam safety concerns, which should be a topic of investigation.<br>• The *Hydro Research Foundation University Research Awards Program* (PRID 132) does not provide any benefits for the blue-collar operators required to support the operation of hydropower facilities. DOE should look at programs in this area in addition to college scholarships to support future industry needs.<br>• The estimated costs of $2000/KW referenced in the *Modular Helical Rotor Turbine-Generator System* (PRID 174) may be on the high side for small hydropower development. Also, a water delivery system utilizing a siphon system may not be practical.<br>• The proposed cost limit of $0.80/watt in the magnetic gears project is very high and would not be economical for most small hydro installations. Cost of this technology needs to be driven down to make it commercially viable.<br>• To achieve the objective of wide stakeholder acceptance of new stream reach development will be difficult without meaningful input and collaboration from environmental NGOs. More strategic thinking in this area is encouraged.<br>• DOE should make an effort to remove inconsistencies in LCOE calculations made by project awardees.<br>• Examples of technical areas in which the DOE Wind Energy and Water Power offices should be collaborating closely include materials research, composites manufacturing, variable frequency drives, and additive manufacturing. |

*Hydropower: Optimization*




Total Projects: 12

Avg. Funding: $0.73M DOE / $1.10M total

Avg. Project Duration: 3.1 years

| Project | Average of Relevance and WAP | Relevance | Weighted Average Performance (WAP) | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for Hydropower—Optimization** | **4.0** | **4.2** | **3.7** | 3.8 | 3.6 | 3.7 | 3.8 | 3.6 |
| Integrated Hydropower and Storage Systems Operation for Enhanced Grid Services (58)[10] Rob Hovsapian, INL | 4.4 | 4.8 | 4.1 | 3.9 | 4.0 | 4.1 | 4.1 | 4.4 |
| Facilitating Regulatory Process Improvements (Federal Interagency Collaborative) (90) Shelaine Curd, ORNL | 4.3 | 4.7 | 4.0 | 4.0 | 3.7 | 4.1 | 4.1 | 4.0 |
| National Hydropower Asset Assessment Program (NHAAP) (77) Shih-Chieh Kao, ORNL | 4.2 | 4.4 | 3.9 | 4.0 | 4.0 | 3.9 | 3.9 | 3.7 |
| Hydropower Regulatory and Permitting Information Desktop (RAPID) Toolkit (116) Aaron Levine, NREL | 4.2 | 4.4 | 3.9 | 4.0 | 3.8 | 4.0 | 3.9 | 3.8 |
| U.S. Hydropower Market and Trends Report (112) Rocio Uria Martinez, ORNL | 4.0 | 4.2 | 3.9 | 3.9 | 3.8 | 3.8 | 4.1 | 4.1 |
| Basin Scale Opportunity Assessment Initiative (111) Kyle Larson, PNNL | 4.0 | 4.3 | 3.7 | 3.8 | 3.6 | 3.9 | 3.6 | 3.7 |
| Cost Data Collection and Modeling for Hydropower (64) Patrick O'Connor, ORNL | 3.9 | 4.0 | 3.9 | 3.9 | 3.8 | 3.8 | 4.3 | 3.9 |
| PSH Transient Simulation Modeling (49) Edward Muljadi, NREL | 3.9 | 4.1 | 3.6 | 3.7 | 3.7 | 3.6 | 3.3 | 3.6 |
| Hydropower Asset Management Research (61) Brennan Smith, ORNL | 3.9 | 4.1 | 3.6 | 3.8 | 3.7 | 3.5 | 3.7 | 3.1 |
| Low-Head, Short-Intake Flow Measurement Research (62) Marshall Richmond, PNNL | 3.7 | 3.9 | 3.6 | 3.8 | 3.6 | 3.4 | 3.6 | 3.5 |
| Hydropower Manufacturing and Supply Chain Analysis (43) Jason Cotrell, NREL | 3.4 | 3.6 | 3.2 | 3.2 | 3.3 | 3.4 | 3.1 | 2.7 |
| Iowa Hill Pumped-storage Project Investigations (138) David Hanson, Sacramento Municipal Utility District | 3.4 | 3.6 | 3.2 | 3.6 | 2.7 | 3.5 | 3.4 | 2.4 |

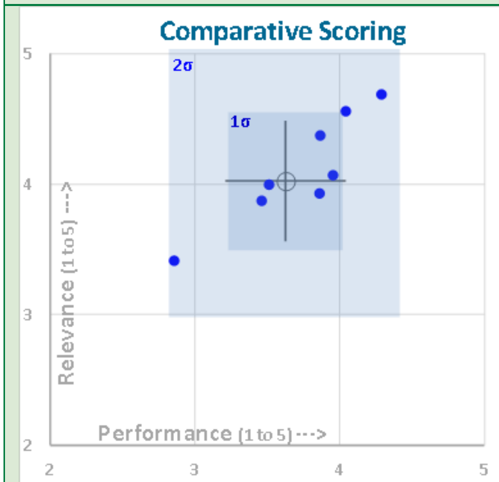
[10] Numbers in parentheses after the project names are peer review identification numbers (PRIDs). These were used to organize projects for the peer review. The PRIDs are not in any specific order.

| Hydropower—Optimization<br>Key Comments |
| --- |
| • Quantification of ancillary services and potential revenue streams, particularly from PSH, is critical to optimizing overall industry performance and long term success.<br>• Open-source performance data gathering and analysis is an extremely effective way to optimize existing fleet technology.<br>• Reviewers stressed the value of collaboration with other organizations in the hydropower community during projects, as well as the importance of effective dissemination of results.<br>• Case studies are an effective tool to assist industry with understanding how to navigate the regulatory process. |

| Successes<br>(Representative Comments) | Critiques & Recommendations<br>(Representative Comments) |
| --- | --- |
| • Continued support of *Integrated Hydropower and Storage Systems* (PRID 58) is recommended. The project really captures how the future of our industry is transitioning and can be valued, for instance by addressing new uses for proven technology like the Siemens “Smart Energy Box”.<br>• The effective use of existing generation resources is important in maximizing the value of hydropower production. New technology R&D enables better real-time decisions regarding dispatching and operational efficiency of multiple units.<br>• Protecting and potentially improving environmental conditions through basin-scale solutions is an excellent initiative.<br>• Understanding the reason that the *Iowa Hill Pumped-storage Project Investigations* work (PRID 138) was terminated is useful information for other potential pump storage projects. The fact that a large municipal utility with tax-exempt financing could not justify this project is important to understand in today's marketplace.<br>• Holding the 2015 Cost Reduction Workshop is an example of best practice in getting the value of these studies communicated back to the industry.<br>• The tool for navigating regulatory procedures is extremely valuable for both optimization and growth. Soft cost barriers are very intimidating, especially for small owners.<br>• Quantification of ancillary services is a key component of optimization.<br>• The goal of having the *National Hydropower Asset Assessment Program* (PRID 77) data base as a “one-stop-hydro-shop” is excellent.<br>• The completion of the revised Memorandum of Understanding with FERC [Federal Energy Regulatory Commission] and the U.S. Army Corps of Engineers is a real accomplishment. It will be valuable to see how it actually impacts a representative licensing process. | • While understanding of manufacturing and supply chain factors is important, it is not clear what the project (PRID 43) set out to do and what it accomplished or did not accomplish. Needs better communication with the National Hydropower Association on how this data can effect policy and benefit the industry.<br>• The *Cost Data Collection and Modeling for Hydropower* project (PRID 64) should include an assessment of interconnection and transmission issues since hydropower competes against other renewable sources of energy often requiring major system upgrades and/or new transmission to reach market.<br>• It is recommended that consideration be given to studying the technical review section of the 408 process to verify that this is being performed in an efficient manner that minimizes the development time for new hydroelectric projects.<br>• Technology innovation in pumped storage may be getting ahead of market. If we have solutions looking for locations, can more be done to ensure that investors and bankers understand the superior investment returns?<br>• Although there appeared to be significant coordination with fisheries groups, the results of the *Basin Scale Opportunity Assessment Initiative* (PRID 111) were apparently not shared with any potential development groups to date. If this study is to prove useful in the long term, utility groups and developers need to be better aware of the tools and how to apply them. |

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Federal Interagency Collaborative* (PRID 90) successfully focused on a discrete regulatory problem that was known to be holding back development at a number of sites and set out to solve it - without legislation or rule change. The use of a conference with developers and other users was very effective in providing the U.S. Army Corps of Engineers a better sense of the developer's perspective and the hurdles they face. | • The RAPID project [*Hydropower Regulatory and Permitting Information Desktop (RAPID) Toolkit*, PRID 116] has really done a fantastic job of communicating their project and its outcomes to certain stakeholder groups. However, given the potential value of the toolkit in development of new hydroelectric potential and relicensing, the outreach to actual developers has not been as widespread as it could be.<br>• If the *Integrated Hydropower and Storage Systems Operation for Enhanced Grid Services* (PRID 58) study results in methodology that can use run-of-river facilities to provide enhanced grid support and ancillary services, a follow-up study could involve how these facilities could be compensated for providing these services to the grid.<br>• The value to the industry of the *PSH Transient Simulation Modeling* (PRID 49) study needs to be more clearly established since they already know that new pumped storage technologies can provide a variety of ancillary services. How can this work help actually get new pumped storage built? |

***Hydropower: Sustainability***




Total Projects: 8

Avg. Funding: $0.87M DOE / $1.25M total

Avg. Project Duration: 3.9 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance (WAP) | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for Hydropower—Sustainability** | **3.9** | **4.1** | **3.7** | 3.8 | 3.7 | 3.7 | 3.8 | 3.6 |
| Monitoring Technology Development for Sensitive Species (Juvenile Eel / Lamprey Tag Development) (54)[11]<br>Daniel Deng, PNNL | 4.5 | 4.7 | 4.3 | 4.4 | 4.5 | 4.0 | 4.2 | 4.1 |
| Biologically-Based Design and Evaluation of Hydro-Turbines (BioDE) (125)<br>Gary Johnson, PNNL | 4.3 | 4.5 | 4.0 | 4.1 | 4.1 | 3.9 | 4.3 | 3.9 |
| Report to Congress-Potential Climate Change Impacts on Federal Hydropower (115)<br>Shih-Chieh Kao, ORNL | 4.1 | 4.4 | 3.9 | 4.0 | 3.8 | 3.9 | 3.9 | 3.6 |
| Environmental Performance Analysis and Testing Campaign for New Technologies (92)<br>Alison Colotelo, PNNL | 4.0 | 4.1 | 4.0 | 4.0 | 3.9 | 4.1 | 3.9 | 3.8 |
| Water Quality Modeling Improvements at Columbia and Cumberland River Basins (32)<br>Boualem Hadjerioua, ORNL | 3.9 | 3.9 | 3.9 | 4.0 | 3.6 | 3.9 | 4.0 | 4.0 |
| CERC-WET Topic 3: Improving Sustainable Hydropower Design and Operations (195)<br>Ashok Gadgil, University of California, Berkeley (Consortium Lead) | 3.8 | 4.0 | 3.5 | 3.6 | 3.4 | 3.6 | 3.7 | 3.3 |
| Informing Hydropower Investment and Operational Decisions Under Changing Hydrologic Conditions (93)<br>Mark Wigmosta, PNNL | 3.7 | 3.9 | 3.5 | 3.5 | 3.4 | 3.5 | 3.6 | 3.4 |
| Environmental Metrics for Hydropower (95)<br>Shelaine Curd, ORNL | 3.1 | 3.4 | 2.9 | 3.0 | 2.7 | 3.0 | 2.8 | 2.8 |

[11] Numbers in parentheses after the project names are peer review identification numbers (PRIDs). These were used to organize projects for the peer review. The PRIDs are not in any specific order.

**Hydropower—Sustainability**
**Key Comments**

- Biologically-based design research activities to-date are seen as both highly successful and a long-term research need with strong relevance to DOE objectives.
- The ambitious goals and broadly inclusive approach of the *Environmental Metrics for Hydropower* project (PRID 95) could diminish its chances for positive impact.
- The assessments conducted under the *Informing Hydropower Investment and Operational Decisions Under Changing Hydrologic Conditions* project (PRID 93) and the *Report to Congress on Potential Climate Change Impacts on Federal Hydropower* (PRID 95) promise to provide both optimization and sustainability benefits for the industry by evaluating possible long-term scenarios for use in planning.
- The challenge of commercializing the promising prototype tags developed under *Monitoring Technology Development for Sensitive Species (Juvenile Eel / Lamprey Tag Development)* (PRID 54) will be in achieving cost reduction.
- Thinking outside the box to evaluate innovation and address challenges, such as in the *Environmental Performance Analysis and Testing Campaign for New Technologies* project (PRID 92), makes the industry aware of how creative thinking and new approaches can be applied successfully.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Monitoring Technology Development for Sensitive Species* project (PRID 54) has resulted in an exciting innovation with the potential to be successfully promoted to the general public as an indication of the commitment to fish protection by the hydropower industry.<br>• The *Biologically-Based Design and Evaluation of Hydro-Turbines (BioDe*) project (PRID 125) is very multidisciplinary in approach and is using a technical methodology that is delivering success. In a real-world situation Grant County PUD [Public Utility District] used the BioPA model as a filter for part of Priest Rapids procurement process: all manufacturers had to have their turbine scored and do better than the old unit.<br>• The [Obama] White House-directed joint United States/China *CERC-WET Topic 3* effort (PRID 93) on improving sustainable hydropower design and operations has strong goals, team and approach and technical results to date.<br>• *Environmental Performance Analysis and Testing Campaign for New Technologies* (PRID 92) is an excellent example of an innovative technology successfully achieving goals (e.g., acceptance by resource agencies) using DOE funds, rather than imposing the high cost of achieving that acceptance on hydro operators who need to install fish passage.<br>• Of the climate-related hydropower studies, *Informing Hydropower Investment and Operational Decisions Under Changing Hydrologic Conditions* (PRID 93) has the most to do with actually improving the ecological sustainability of hydropower by linking climate modeling with local ecological needs (water temperature for habitat).<br>• The congressionally mandated report to Congress assessing the potential impacts of climate change on the federal hydropower fleet has developed information that is very important to future national-scale energy planning. It is valuable to have most of the federal hydropower family (Power Marketing Administrations, Bureau of Reclamation, Army Corps of Engineers) participating. | • The large representation on the advisory boards of the *Environmental Metrics for Hydropower* initiative (PRID 95) may limit their ability to narrow the scope and accomplish specific deliverable results, other than identifying needs for new research.<br>• Going forward, biologically-based design research should not just identify problems but work on solutions in conjunction with manufacturers while coordinating with labs like Alden, as well as with resource agencies.<br>• Long term success of the *CERC-WET Topic 3* project (PRID 93) is tied to United States/China coordination and performance of the Chinese team, which are beyond the control of WPTO.<br>• The *Environmental Performance Analysis and Testing Campaign for New Technologies* project (PRID 92) may have higher future viability if a suitable and effective fish attraction scheme can be developed.<br>• It is important that the relevance of the *Informing Hydropower Investment and Operational Decisions Under Changing Hydrologic Conditions* project (PRID 93) to the overall hydropower industry in the United States be established.<br>• Future R&D on the monitoring device for sensitive species should focus on cost reduction to enable commercialization. |

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Water Quality Modeling Improvements at Columbia and Cumberland River Basins* (PRID 32) modeling "optimize and check" approach allows operators to safely meet water quality requirements at lower cost while squeezing additional generation out of the system. They are using very strong methods and technical tools to address this complex task. | • Going forward, the *Water Quality Modeling Improvements at Columbia and Cumberland River Basins* project (PRID 32) should focus on incremental improvements, verification, technology transfer, and application at a larger scale, which are logical next steps for a model that performed well. |

## 5.3 Marine and Hydrokinetics Track: Summary of Project Results

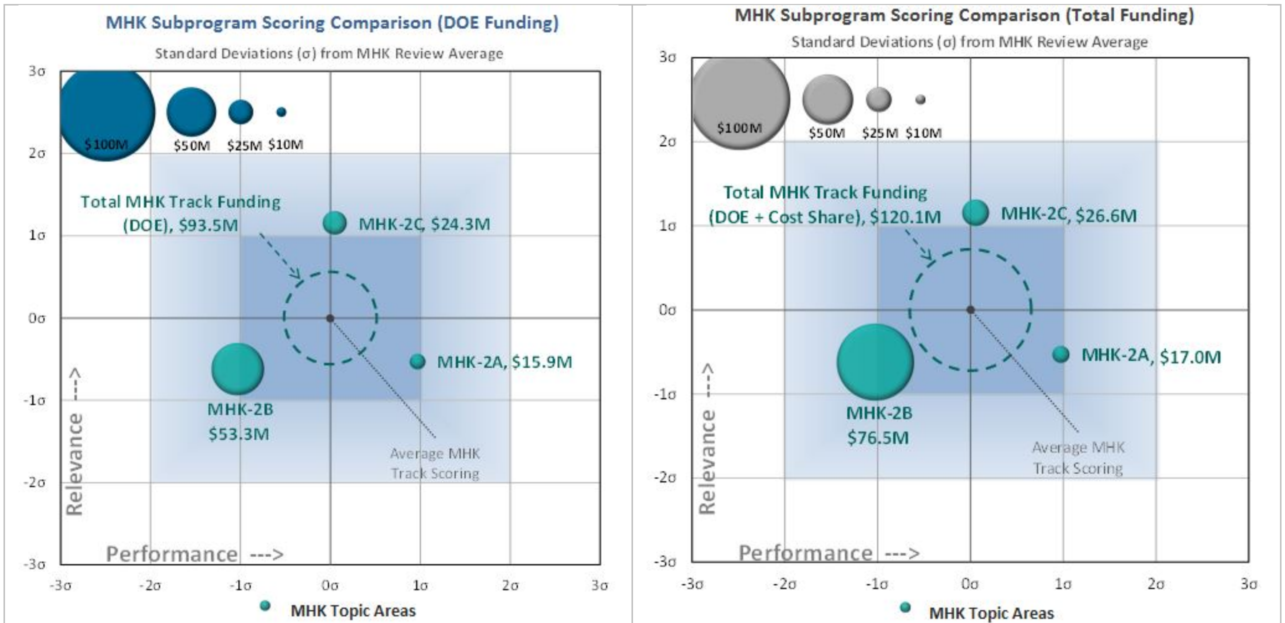
As a means of assessing the variability in scores among reviewers, Table 5-3 presents the average scores for each evaluation metric by reviewer, across all projects in the Marine and Hydrokinetics (MHK) track. Note that reviewers did not review projects for which they had an identified conflict of interest. Reviewer results are anonymized before results are calculated. The table lists reviewers in order of their **respective relevance and performance** scores, not in order by their identifying reviewer number. Note that reviewers were split into the MHK-2A and MHK-2B subprograms on Tuesday and Wednesday of the review: Reviewers 10, 16, 12, and 15 served in MHK-2A as well as MHK-2C; reviewers 11, 13, 9, and 14 served in MHK-2B as well as MHK-2C.

Table 5-3. Average score by reviewer across all Marine and Hydrokinetics project evaluations

| *MHK Track* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Average Score across All Peer-Reviewed WPTO Projects* | | *4.1* | *3.8* | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| *Average Score across All Hydropower Projects* | | *4.2* | *4.0* | *4.0* | *4.0* | *3.9* | *4.0* | *3.7* |
| Reviewer | Subprogram | Relevance | Weighted Average Performance | *Metric Scores Used for Weighted Average Performance* | | | | |
| | | | | Methods/ Approach | Accomplishments/ Progress | Project Management | Collaboration/ Tech Transfer | Future Research |
| Reviewer 10 | MHK-2A and MHK-2C | 4.6 | 4.6 | 4.5 | 4.7 | 4.6 | 4.5 | 4.2 |
| Reviewer 16 | | 4.3 | 4.2 | 4.3 | 4.3 | 4.1 | 4.2 | 3.9 |
| Reviewer 12 | | 4.0 | 3.9 | 4.0 | 3.9 | 3.8 | 3.9 | 3.6 |
| Reviewer 15 | | 3.9 | 3.7 | 3.8 | 3.8 | 3.6 | 3.9 | 3.3 |
| Reviewer 11 | MHK-2B and MHK-2C | 4.3 | 4.0 | 4.1 | 4.1 | 4.0 | 4.4 | 3.6 |
| Reviewer 13 | | 4.3 | 3.9 | 4.0 | 4.0 | 3.8 | 3.8 | 3.8 |
| Reviewer 9 | | 4.1 | 3.6 | 3.6 | 3.6 | 3.7 | 3.7 | 3.4 |
| Reviewer 14 | | 4.0 | 3.7 | 3.7 | 3.7 | 3.5 | 3.9 | 3.6 |

### 5.3.1 Funding to Scoring Comparison Charts—by Marine and Hydrokinetics Subprogram

Figure 5-3 provides insight into funding amounts for each of the three MHK subprograms, relative to peer review scores for relevance and overall performance (weighted average score). Note that relevance is on the Y axis and weighted average performance is on the X axis. The shading on the charts represents one (darker) or two (lighter) standard deviations from the mean scores.



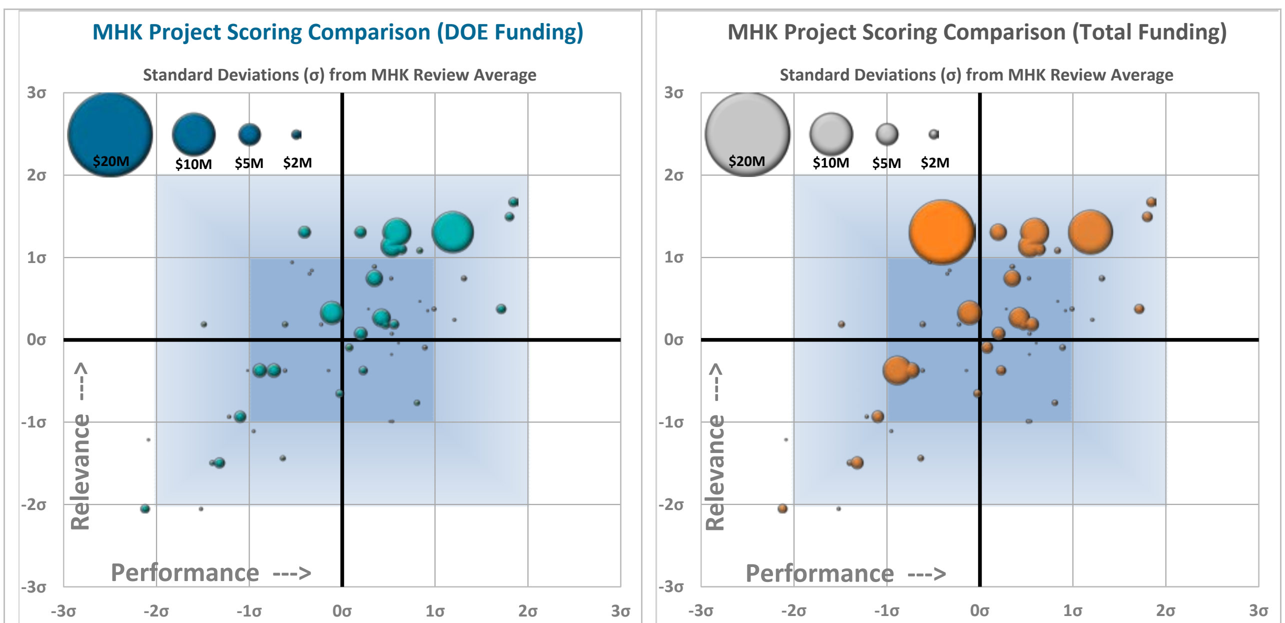

Relative *DOE-only* funding (i.e., does not include cost share) for the MHK track, by sub-track

Relative *total* funding (i.e., includes cost share) for the MHK track, by sub-track

Figure 5-3: Marine and Hydrokinetics subprogram scores and relative funding amounts

### 5.3.2 Funding to Scoring Comparison Charts—Marine and Hydrokinetics Track

Figure 5-4 provides insight into funding amounts for the Marine and Hydrokinetics track, by project, relative to peer review scores for relevance and overall performance (weighted average score). Note that relevance is on the Y axis and weighted average performance is on the X axis. The shading on the charts represents one (darker) or two (lighter) standard deviations from the mean scores.




Relative *DOE-only* funding (i.e., does not include cost share) of the reviewed MHK projects.

Relative *total* funding (i.e., includes cost share) of the reviewed MHK projects.

Figure 5-4. Funding amounts relative to all Marine and Hydrokinetics project scores

### 5.3.3 Project-Level Summary Chart Explanation

Section 5.3.4 provides scoring summaries for each of the MHK subprograms and topic areas. These results are shown in two tables for each subprogram:

**(1) Project Scores**—summarizes the scores assigned by reviewers to all of the projects in each subprogram. This table includes the **Review Average,** which represents the average scores for all WPTO projects (i.e., across Hydropower and MHK). Each table also includes the average for the associated subprogram. The project score tables include graphs illustrating scores on the relevance/performance continuum. The smaller shaded box in the chart represents one [1] standard deviation from the mean; the larger shaded box is two [2] standard deviations from the mean. Note that the graphs use an abbreviated scale (origin = 3) in order to provide a zoomed-in view.

**(2) Key Comments**—summarizes a selection of comments from reviewers for each subprogram. The comments in these tables are not comprehensive, but are intended to provide a representative selection of both positive and negative input from reviewers. The goal is a balanced snapshot of the feedback provided about MHK projects.

### 5.3.4 Results by Subprogram and Topic Area

*MHK-2A Results: Score Distribution*

Figure 5-5 represents the overall distribution of scores for projects in the MHK-2A subtrack. The MHK-2A subtrack featured three topic areas related to addressing deployment barriers and facilitating commercial market development:

- Environmental Research and Monitoring
- Market and Industry Development, Analysis, and Data Dissemination
- Site and Resource Characterization.

Project-level Scoring Tables and Key Comments for each of the three subprograms and related topic areas are included subsequently.

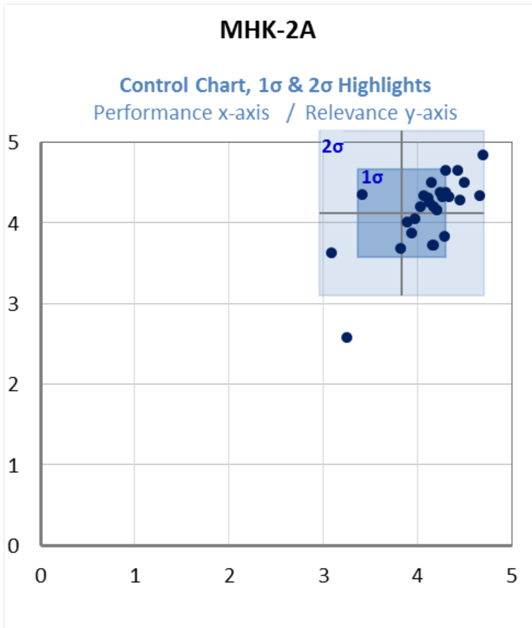
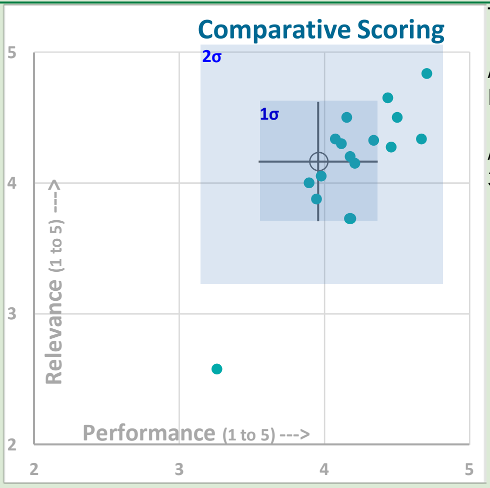



Figure 5-5. Score distribution for projects in the Marine and Hydrokinetics 2A subtrack

*MHK 2A: Environmental*




Total Projects: 17

Avg. Funding: $0.59M DOE / $1.06M total

Avg. Project Duration: 3.3 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for MHK-2A: Environmental** | **4.2** | **4.1** | **4.2** | 4.3 | 4.3 | 4.2 | 4.1 | 3.9 |
| Annex IV and Tethys: International Environmental Data Sharing Initiative (PRID: 118)[12] Andrea Copping, PNNL | 4.8 | 4.8 | 4.7 | 4.7 | 4.7 | 4.7 | 4.9 | 4.7 |
| MHK Regulator Trainings (PRID: 60) Ian Baring Gould, NREL | 4.5 | 4.7 | 4.4 | 4.4 | 4.3 | 4.4 | 4.7 | 4.7 |
| An Intelligent Adaptable Monitoring Package for Marine Renewable Energy (PRID: 169) Brian Polagye, University of Washington | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Triton Initiative (PRID: 63) Genevra Harker-Klimes, PNNL | 4.5 | 4.3 | 4.7 | 4.7 | 5.0 | 4.7 | 4.0 | 4.3 |
| Unobtrusive Multi-static Serial LiDAR Imager (UMSLI) for Wide-area Surveillance and Identification of Marine Life at MHK Installations (PRID: 168) Gabriel Alsenas, Florida Atlantic University Board of Trustees | 4.4 | 4.3 | 4.5 | 4.7 | 4.6 | 4.3 | 3.8 | 4.5 |
| Automatic Optical Detection and Classification of Marine Animals around MHK Converters using Machine Vision (PRID: 166) Steven Brunton, University of Washington | 4.3 | 4.3 | 4.3 | 4.6 | 4.3 | 4.0 | 4.6 | 4.3 |
| FY16 FOA [Funding Opportunity Announcement] Awards: Innovation, Testing and Validation of MHK Environmental Monitoring Instrumentation (PRID: 198) Samantha Eaves, DOE | 4.3 | 4.5 | 4.2 | 4.4 | 4.0 | 3.5 | 4.3 | 5.0 |
| Interactions of Aquatic Animals with the ORPC [Ocean Renewable Power Company] OCGen® in Cobscook Bay, Maine (PRID: 147) Gayle Zydlewski, University of Maine | 4.2 | 4.3 | 4.1 | 4.2 | 4.2 | 4.1 | 4.2 | 3.6 |
| Evaluating Potential for Impacts from Seal Collisions with Tidal Turbines (PRID: 98) Andrea Copping, PNNL | 4.2 | 4.3 | 4.1 | 3.7 | 4.3 | 4.2 | 4.3 | 4.0 |
| Nekton Interaction Monitoring System (PRID: 44) Kenneth Ham, PNNL | 4.2 | 4.2 | 4.2 | 4.3 | 4.2 | 4.0 | 4.4 | 4.0 |
| Informing a Tidal Turbine Strike Probability Model through Characterization of Fish Behavioral Response using Multibeam Sonar Output (PRID: 65) Mark Bevelhimer, ORNL | 4.2 | 4.2 | 4.2 | 4.5 | 4.5 | 4.3 | 4.3 | 2.3 |

[12] Numbers in parentheses after the project names are peer review identification numbers (PRIDs). These were used to organize projects for the peer review. The PRIDs are not in any specific order.

| MHK 2A: Environmental | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Evaluating the Potential for Marine and Hydrokinetic Devices to Act as Artificial Reefs or Fish Aggregating Devices (PRID: 150)<br>Dr. Sharon Kramer, H.T. Harvey and Associates | 4.0 | 4.1 | 4.0 | 3.8 | 4.0 | 4.4 | 4.1 | 3.8 |
| Effects of EMF Emissions from Cables and Junction Boxes on Marine Species (PRID: 149)<br>Manhar Dhanak, Florida Atlantic University | 4.0 | 3.7 | 4.2 | 4.4 | 4.1 | 4.4 | 4.3 | 3.4 |
| Acoustics Exposure Experimentation for Sensitive Fish Species (PRID: 114)<br>Mark Bevelhimer, ORNL | 3.9 | 4.0 | 3.9 | 4.2 | 4.1 | 4.0 | 2.4 | 3.9 |
| Assessment of Potential Impact of Electromagnetic Fields from Undersea Cable on Migratory Fish Behavior PR-146 (PRID: 146)<br>Ximena Vergara, Electric Power Research Institute, Inc. | 3.9 | 3.7 | 4.2 | 4.5 | 4.3 | 4.0 | 4.3 | 3.1 |
| Improvements to Hydrodynamic and Acoustic Models for Environmental Prediction (PRID: 73)<br>Jesse Roberts, SNL | 3.9 | 3.9 | 3.9 | 3.9 | 4.0 | 3.8 | 4.6 | 3.7 |
| Current Ability to Assess Impacts of Electro Magnetic Fields Associated with MHK Technologies on Marine Fishes in Hawaii (PRID: 151)<br>Jeremy Claisse, Vantuna Research Group | 2.9 | 2.6 | 3.3 | 3.1 | 3.5 | 3.9 | 2.6 | 2.5 |

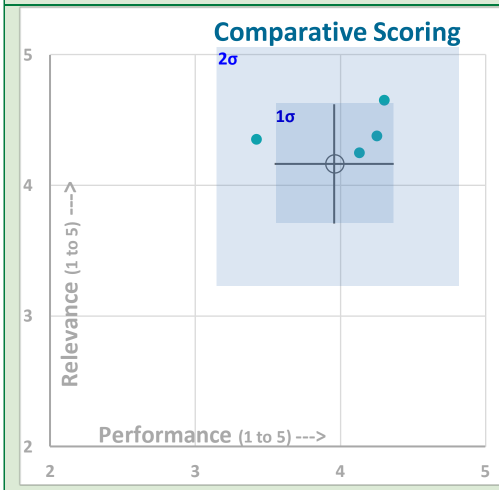
**MHK 2A—Environmental**
**Key Comments**

- The type of project represented by the *MHK Regulator Training* (PRID 60) ranks equally with technology development as dual priorities for DOE funding. This type of project is crucial to build consensus among key decision makers, provide data on MHK project effects, and, ultimately, move the industry forward. Engaging regulators should remain a key focus for DOE to select projects conducting environmental research related to MHK deployment.
- Environmental research projects that use collaborative approaches, make use of existing data sets, and provide data as open source or through other outreach are important to advancing MHK. These benefits should be balanced with keeping research and investments focused on technologies that are far enough along the development chain to have some opportunity to be viable.
- Projects such as *Informing a Tidal Turbine Strike Probability Model through Characterization of Fish Behavioral Response using Multibeam Sonar Output* (PRID 65), *Interactions of Aquatic Animals with the ORPC OCGen in Cobscook Bay, Maine* (PRID 167), and *Marine Mammal Behavioral Response to Marine Energy Converter Sound* (PRID 148) are highly relevant. Funding work on monitoring deployments is a high priority, and understanding interactions between fish and aquatic life and MHK devices is a concern of both state and federal resource agencies.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Annex IV and Tethys: International Environmental Data Sharing Initiative* (PRID 118) project represents an excellent 13-nation collaborative effort to coordinate long-term inputs and publish a State of the Science report (2016) in seven languages. Tethys is an exceptional resource that puts the United States at the center of data collection and dissemination, and represents the key type of activity in which DOE should engage. | • The project, *Current Ability to Assess Impacts of Electro Magnetic Fields Associated with MHK Technologies on Marine Fishes in Hawaii* (PRID 151), illustrates the potential need for DOE to reframe its approach on EMF [electromagnetic field] issues. DOE should consider a more coordinated EMF permitting strategy that focuses on the true scale of the problem, realistic problem conditions, and the context of an international electricity grid with many subsea cables. This should include working with other regulatory agencies and mining information from Europe, Japan, New Zealand, and other countries. |

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • For the FY 2016 FOA [Funding Opportunity Announcement] awards, DOE required project managers contribute 20% cost share. This creates strong project manager investment in successful outcome of the project.<br>• The combined private, public, and academic project team for projects such as the *Improvements to Hydrodynamic and Acoustic Models for Environmental Prediction* (PRID 73) and the *Nekton Interaction Monitoring System* (PRID 44) project is a strength for DOE.<br>• Several of the MHK environmental research projects supported by DOE have made good strides in supporting development of user-friendly software, self-guided tutorials, open source software and data, workshops, databases, and other outreach tools.<br>• Finding good ways to monitor animal interactions with MHK is important to address the questions raised by regulators. This type of work is represented successfully by projects such as *Unobtrusive Multi-static Serial LiDAR Imager for Wide-area Surveillance and Identification of Marine Life at MHK Installations* (PRID 168) and *Interactions of Aquatic Animals with the ORPC OCGen® in Cobscook Bay, Maine* (PRID 147). | • If presenting a FOA (application) that will help support reduced cost of the permitting process, applicants for the funding should relate how their project relates to the permit process. What is the need and how will their project fulfil this need?<br>• DOE should participate in workshops as a provider of technical expertise and for sharing of information, but there are questions about whether DOE should be the lead. BOEM [the Bureau of Ocean Energy Management] has hosted many public opportunities and included DOE as a presenter. It is suggested that this may be a better use of resources, particularly if budgets are tight.<br>• Continue and extend outreach efforts by presenting Tethys updates and by developing regional filters on data and push to U.S. federal and state regulators.<br>• Development of cost-effective environmental monitoring devices to assess the potential environmental impacts of MHK devices is essential. Collection of this data is currently time-consuming and costly.<br>• The *Improvements to Hydrodynamic and Acoustic Models for Environmental Prediction*, PRID 73 project may be before its time. There is a need to have working [viable] technologies to fully understand the environmental effects and have regulators buy in to results. |

*MHK 2A: Market and Industry Development, Analysis, and Data Dissemination*




Total Projects: 4

Avg. Funding: $0.55M DOE / $0.55M total

Avg. Project Duration: 1.9 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| Average for All Peer-reviewed WPTO Projects | 4.0 | 4.1 | 3.8 | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| Average for MHK-2A: Market and Industry | **4.2** | **4.4** | **4.0** | 4.0 | 4.2 | 4.1 | 4.0 | 3.4 |
| MHK Data Repository and Instrumentation Database (PRID: 71)[13]<br>Rick Driscoll, NREL | 4.5 | 4.7 | 4.3 | 4.2 | 4.4 | 4.4 | 4.0 | 4.5 |
| MHK Risk Management Framework (PRID: 104)<br>Jochem Weber, NREL | 4.3 | 4.4 | 4.3 | 4.3 | 4.6 | 4.5 | 4.1 | 3.0 |
| MHK Levelized Cost of Energy (LCOE) Analysis (PRID: 11) Rick Driscoll, NREL | 4.2 | 4.3 | 4.1 | 4.0 | 4.0 | 4.3 | 4.6 | 4.3 |
| MHK Manufacturing and Supply Chain Needs Assessment (PRID: 70)<br>Jason Cotrell, NREL | 3.9 | 4.4 | 3.4 | 3.5 | 3.9 | 3.4 | 3.4 | 2.0 |

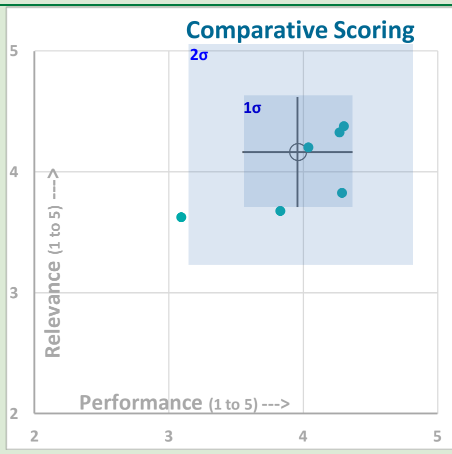
**MHK 2A— Market and Industry Development, Analysis, and Data Dissemination**
**Key Comments**

- The study conclusion in the *MHK Manufacturing and Supply Chain Needs Assessment* project (PRID 70) that a supply chain gap exists because MHK manufacturers are only interested in domestic demand for product significantly underestimates the global perspective and capacities of many large and even medium-size manufacturers who evaluate revenue potential on global market basis.
- DOE should evaluate whether projects in this sub-track sufficiently address near-to-market technologies. Projects prioritizing wave technology over current and tidal technologies fail to hit technologies that are ready to deploy in distributed generation scenarios on a cost-competitive basis.
- In studying and analyzing MHK markets, it is essential to clearly communicate MHK levelized cost of energy (LCOE) results in historical context of other historical cost reductions for renewable energy technologies, to explain/justify why MHK can be viable mid-term renewable energy technology for grid and alternative electricity sources, and to explain/prioritize R&D needed to lower costs.

[13] Numbers in parentheses after the project names are peer review identification numbers (PRIDs). These were used to organize projects for the peer review. The PRIDs are not in any specific order.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *MHK Manufacturing and Supply Chain Needs Assessment* project (PRID 70) identified an overall extensive supply chain in the United States and brings good insights that can correct misconceptions.<br>• The *MHK Data Repository and Instrumentation Database* (PRID 71) is an effective tool that provides important information to developers.<br>• In addition to other benefits, the *MHK Risk Management Framework* (PRID 104) should help developers to use best practices to improve QA/QC in device design process and should help to maximize investment value for DOE WPTO by reducing project failure risks.<br>• The *MHK Levelized Cost of Energy (LCOE) Analysis* (PRID 11) is a strength of the Program that enables LCOE comparisons and both international and domestic partners. The focus on non-grid applications (desalinization; mini-grids) is important, given the urgent need for clean drinking water technology/military expeditionary power sources and mini-grid remote energy sources in both U.S. and global markets. | • While the *MHK Manufacturing and Supply Chain Needs Assessment* project (PRID 70) has strengths in terms of identifying and characterizing the supply chain, the research should have been more extensive in scope and included current/tidal technology. Using 12 total external contacts—five WEC manufacturers, four assembly/installation firms, and three advocacy/university research centers (total of 12 external contacts)—is insufficient for a market supply chain study.<br>• If DOE is overly prescriptive in insisting on the use of the risk reduction system identified in the *MHK Risk Management Framework* (PRID 104), to the exclusion of other equally effective best practices in risk reduction, the result could be duplicative planning costs for developers or inadvertent suppression of even better risk reduction practices. Leave room for flexibility in developer choice of equally effective risk reduction methodologies.<br>• While PRID 11 (*MHK Levelized Cost of Energy (LCOE) Analysis*) offers many strengths, using an approach that prioritizes wave over current technology fails to hit the priority near-to-market technology this is ready to deploy in distributed generation scenarios on a cost-competitive basis.<br>• DOE should make clear in the *MHK Data Repository and Instrumentation Database* (PRID 71) research how confidential data and intellectual property are handled in the process. |

*MHK 2A: Site and Resource*




Total Projects: 6

Avg. Funding: $0.74M DOE / $0.74M total

Avg. Project Duration: 2.3 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for MHK-2A: Site and Resource** | **4.0** | **4.0** | **4.0** | 4.2 | 4.1 | 3.8 | 3.9 | 3.3 |
| DoD MHK Deployment Opportunity Identification (PRID: 121)[14] Robi Robichaud, NREL | 4.3 | 4.4 | 4.3 | 4.5 | 4.2 | 4.1 | 4.4 | 4.2 |
| Wave Environmental Characterization at Wave Test Sites (PRID: 31) Vincent Neary, SNL | 4.3 | 4.3 | 4.3 | 4.3 | 4.7 | 4.4 | 4.7 | 2.3 |
| Model Validation and Site Characterization for Early Deployment MHK Sites and Establishment of Wave Classification Scheme (PRID: 55) Levi Kilcher, NREL | 4.1 | 4.2 | 4.0 | 4.4 | 3.9 | 3.8 | 4.0 | 4.0 |
| Wave Resource Model Integration (PRID: 14) Zhaoqing Yang, PNNL | 4.1 | 3.8 | 4.3 | 4.2 | 4.5 | 4.4 | 4.4 | 3.8 |
| National Wave Energy Resource Refinement Using 30-year Hindcast (PRID: 45) George Scott, NREL | 3.8 | 3.7 | 3.8 | 4.3 | 4.0 | 3.3 | 4.2 | 2.8 |
| Marine and Hydrokinetic Energy Metocean Data-use, Sources, and Instrumentation (PRID: 96) Senu Sirnivas, NREL | 3.4 | 3.6 | 3.1 | 3.2 | 3.4 | 3.1 | 2.0 | 3.0 |

**MHK 2A—Site and Resource**
**Key Comments**

- DOE should continue to work with NOAA [the National Oceanic and Atmospheric Administration] as a key partner and make use of NOAA data across hydropower research projects. Such data are high in quality and allow DOE to leverage additional federal resources. Use of such data, however, should still be subject to stringent DOE data standards and project design.
- Additional collaborative work with other federal agencies, e.g., DoD, as well as regional partners, could support expansion of MHK in two key ways: By facilitating the inclusion of MHK in renewable energy portfolio standards (e.g., DoD's renewable energy objectives), and by helping identify sites to locate MHK facilities and testing.
- The effect of permitting delays and concerns on MHK development is not entirely clear. DOE should continue to gather data and information to enhance understanding of the influence of permitting on current and future MHK projects.

[14] Numbers in parentheses after the project names are peer review identification numbers (PRIDs). These were used to organize projects for the peer review. The PRIDs are not in any specific order.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
| --- | --- |
| • Working with NOAA to shift from its operational mindset to the R&D and partnership approach needed for this joint R&D project is a success for DOE. NOAA is a critical partner with essential data for future projects.<br>• The *Wave Resource Model Integration* project (PRID 14) is an important project to improve local and global modeling efficiency and enable effective comparison of modeling. DOE's best modelers are on the project, plus a technical steering committee of experienced modelers to strengthen the project approach, protocols.<br>• The *Wave Environmental Characterization at Wave Test Sites* project (PRID 31) offers a useful tool with clear benefits to facilitate testing while reducing deployment risk. DOE should combine this work with infrastructure for testing. The product assists MHK developers with site selection, device design, and O&M [operations and maintenance] planning and risk reduction.<br>• The *DoD MHK Deployment Opportunity Identification* project (PRID 121) is a practical project that makes use of DOE's skills to help to identify new DOD [U.S. Department of Defense] users (e.g., U.S. Coast Guard) and define how these departments can utilize MHK to meet the departments' renewable energy targets. The project also supports critical national security efforts and resilient energy supplies for DOD bases and expeditionary forces.<br>• Product (*Wave Environmental Characterization at Wave Test Sites*, PRID 31) assists MHK developers with site selection, device design, and O&M planning and risk reduction.<br>• The methodology for calculating the wave energy is useful for identifying areas best suited for siting of wave converters. | • Proposed future research in the *National Wave Energy Resource Refinement Using 30-year Hindcast* project (PRID 45) to incorporate additional improvements to dataset package that might increase wave resource estimates is only marginally relevant and is not demonstrated to achieve the results. There is a question about whether the data set is sufficient for the high-level site selection purpose give that the resources are already significant.<br>• The *Wave Resource Model Integration* (PRID 14) was limited in location (Oregon), probably due to budgetary constraints. If possible, it would be useful to see how this project operates in other locations. Also, it is recommended that DOE pursue the intent of this project to look at extreme conditions. This is critical for the industry to design robust devices that can withstand the 100-year or 1,000-year storm.<br>• The *Marine and Hydrokinetic Energy Metocean Data-use, Sources, and Instrumentation* project (PRID 96) provides a thorough list of parameters and is completed, but it's unclear whether there are "blind spots" in the data. Collaboration with other agencies and integration with additional data sources (e.g., state GIS systems) could have improved results. The project could also benefit from additional outreach to communicate the results and make them available to the public.<br>• More focus is needed on expeditionary forces for power and water in remote, off-grid or no power zones. This can provide near-term application for MHK projects.<br>• Projects such as the *Wave Resource Model Integration* (PRID 14) note the potential for future research with international collaboration. This step could provide additional insight and help export technology for international projects. |

*MHK-2B Results: Score Distribution*

Figure 5-6 represents the overall distribution of scores for projects in the **MHK-2B** subtrack. The MHK-2B subprogram featured three topic areas, each focused on developing technical maturity through a specific subset of activities:

- Component Innovation and Refinement
- Survivability of Systems in Challenging Design Environments
- Systems Integration, Installation, and Operation.

Project-level Scoring Tables and Key Comments for each of the three subprograms are included subsequently.

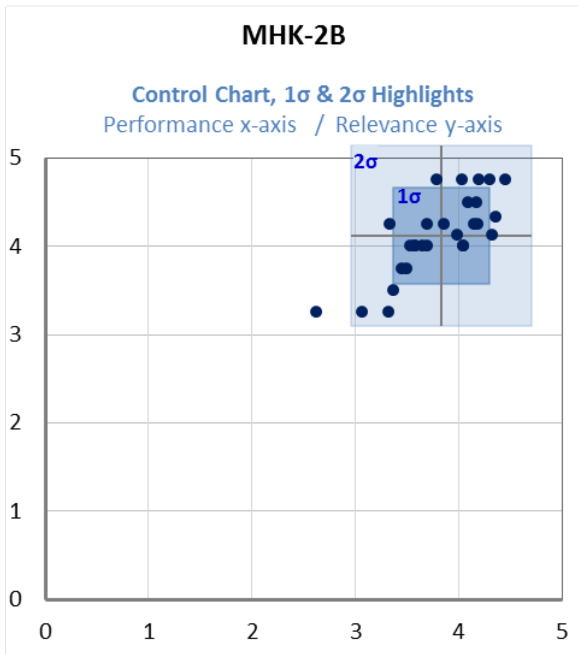
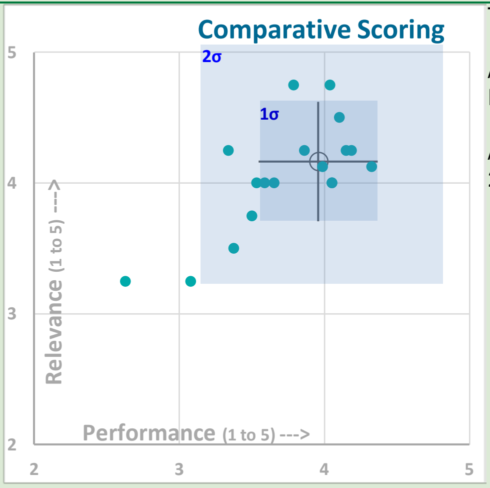



Figure 5-6. Score distribution for projects in the Marine and Hydrokinetics 2B subtrack

*MHK 2B: Components*




Total Projects: 18

Avg. Funding: $1.73M DOE / $2.98M total

Avg. Project Duration: 2.7 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| Average for All Peer-reviewed WPTO Projects | 4.0 | 4.1 | 3.8 | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| Average for MHK-2B: Components | 3.9 | 4.1 | 3.7 | 3.8 | 3.7 | 3.6 | 3.8 | 3.7 |
| HydroAir Power Take Off System (PRID: 162)<br>Gary Pearson, George Laird, Dresser-Rand Group, Inc. | 4.4 | 4.8 | 4.0 | 4.3 | 3.9 | 4.1 | 3.6 | 4.1 |
| Advanced WEC Controls (PRID: 78)<br>Ryan Coe, SNL | 4.3 | 4.5 | 4.1 | 4.0 | 4.3 | 3.6 | 4.5 | 4.5 |
| Advanced Technology Integration and Demonstration (FY16 FOA[15] 1418 Topic Area 1 Awards Overview) (PRID: 86)<br>Alison LaBonte, DOE Program Manager | 4.3 | 4.8 | 3.8 | 4.4 | 3.3 | 3.8 | 3.0 | 4.5 |
| Net Shape Fabricated Low Cost MHK Pass-Through-The-Hub Turbine Blades with Integrated Health Management Technology (PRID: 179)<br>Kevin Koudela, The Applied Research Laboratory (ARL) - The Pennsylvania State University | 4.2 | 4.1 | 4.3 | 4.4 | 4.6 | 4.1 | 4.0 | 4.0 |
| Advanced Direct-Drive Generator for Improved Availability of Oscillating Wave Surge Converter Power Generation Systems (PRID: 155)<br>Dr. V.R. Ramanan, ABB, Inc. | 4.2 | 4.3 | 4.2 | 4.1 | 4.5 | 4.1 | 4.1 | 3.6 |
| Advanced Energy Harvesting Control Schemes for Marine Renewable Energy Devices (PRID: 152)<br>Jarlath McEntee, Ocean Renewable Power Company, LLC | 4.2 | 4.3 | 4.2 | 4.0 | 4.3 | 4.0 | 4.8 | 4.0 |
| Assimilation of Wave Imaging Radar Observations for Real-Time Wave-by-Wave Forecasting (PRID: 170)<br>Merrick Haller, Oregon State University | 4.1 | 4.3 | 3.9 | 4.0 | 3.8 | 3.8 | 4.0 | 3.9 |
| Direct Drive Wave Energy Buoy (PRID: 144)<br>Ken Rhinefrank, Columbia Power Technologies, Inc. | 4.1 | 4.1 | 4.0 | 4.1 | 4.3 | 3.9 | 3.5 | 3.5 |
| Advanced Controls for the Multi-Pod Centipod WEC[16] Device (PRID: 158)<br>Alex Fleming, Dehlsen Associates, LLC | 4.0 | 4.0 | 4.1 | 3.8 | 4.0 | 3.8 | 4.8 | 5.0 |
| Efficient and Reliable Power Take-Off for Ocean Wave Energy Harvesting (PRID: 177)<br>Lei Zuo, Virginia Polytechnic Institute and State University | 4.0 | 4.0 | 4.1 | 4.1 | 4.0 | 4.0 | 4.1 | 4.0 |
| Power Take-off System for Marine Renewable Devices (PRID: 153)<br>Jarlath McEntee, Ocean Renewable Power Company, LLC | 3.8 | 4.0 | 3.7 | 3.8 | 3.4 | 3.5 | 4.5 | 3.6 |
| Wave Energy Converter Structural Optimization Through Engineering and Experimental Analysis (PRID: 163)<br>Ken Rhinefrank, Columbia Power Technologies | 3.8 | 4.3 | 3.3 | 3.3 | 3.1 | 3.4 | 3.8 | 3.8 |

[15] FOA = Funding Opportunity Announcement
[16] WEC = wave energy converter

| MHK 2B: Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Build and Test of a Novel, Commercial-Scale Wave Energy Direct-Drive Rotary Power Take-off Under Realistic Open-Ocean Conditions (PRID: 154)<br>Ken Rhinefrank, Columbia Power Technologies, Inc. | 3.8 | 4.0 | 3.6 | 3.8 | 4.0 | 2.8 | 4.0 | 3.1 |
| Passive Control for WECs (NASA CDOF)[17] (PRID: 79)<br>Vincent Neary, SNL | 3.8 | 4.0 | 3.5 | 3.8 | 3.3 | 3.8 | 3.5 | 3.3 |
| Controls Optimization of Three Different WEC Devices (PRID: 176)<br>Mirko Previsic, ReVision Consulting, LLC | 3.6 | 3.8 | 3.5 | 4.0 | 3.3 | 3.5 | 3.0 | 3.3 |
| Optimization of Hull Shape and Structural Design for OE [Ocean Energy] Buoy (PRID: 157)<br>Mirko Previsic, Ocean Energy USA LLC | 3.4 | 3.5 | 3.4 | 3.3 | 3.3 | 4.0 | 3.3 | 3.0 |
| System Agnostic Switched Reluctance Linear Generator for WECs (PRID: 178)<br>Alan McCall, Dehlsen Associates, LLC | 3.2 | 3.3 | 3.1 | 3.1 | 3.1 | 2.9 | 3.4 | 2.9 |
| Optimal Control of a Surge-Mode WEC in Random Waves (PRID: 156)<br>Allan Chertok, Resolute Marine Energy, Inc. | 2.9 | 3.3 | 2.6 | 3.3 | 2.5 | 2.0 | 3.0 | 2.0 |

**MHK 2B—Components**
**Key Comments**

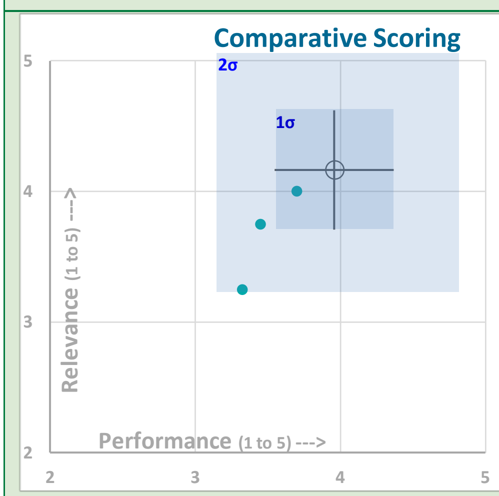
- There is concern that delays and unclear specifications in three projects—*Build and Test of a Novel, Commercial-Scale Wave Energy Direct-Drive Rotary Power Take-off Under Realistic Open-Ocean Conditions* (PRID 154), *HydroAir Power Take Off System* (PRID 162), and *Wave Energy Converter Structural Optimization Through Engineering and Experimental Analysis* (PRID 163) —have the potential to delay the schedule for the planned deployment of the U.S. Navy's Wave Energy Test Site (WETS).
- Further comparison to field data and improvement to wave prediction methodology, such as inclusion of second-order effects, would be beneficial for work such as that in the *Assimilation of Wave Imaging Radar Observations for Real-Time Wave-by-Wave Forecasting* project (PRID 170). Future work should include an investigation of existing and ongoing work of other investigators in academia and government. DOE could also evaluate different field data collection methodologies.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *HydroAir Power Take Off System* (PRID 162) project is well designed and in direct alignment with industry needs. The participation of two major manufacturers (Siemens and Dresser Rand) provides confidence in the demonstration project.<br>• The *Efficient and Reliable Power Take-Off for Ocean Wave Energy Harvesting* project (PRID 177) uses a unique and innovative approach to the problem of converting linear motion to rotating motion. In that regard, this approach offers a single step to capture linear wave motion and power and use it to drive an electric generator. The impact on overall efficiency and operational benefits of this approach need to be fully recognized. | • Although the *Power Take-off System for Marine Renewable Devices* project (PRID 153) is using a well-structured approach, it is an ambitious project that has suffered some delays and that suffers from the lack a manufacturer on the project.<br>• Need to determine the practicality of building a WEC device with a compressible degree of freedom component before putting additional funds into the *Passive Control for WECs (NASA CDOF)* project (PRID 79). |

[17] NASA = National Aeronautics and Space Administration; CDOF = compressible degrees of freedom

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Advanced WEC Controls* work (PRID 78) is a strong fit with the sector needs for control, and increased energy capture efficiency suggested by the research will be valuable to the MHK community.<br>• DOE-funded research on *Advanced Energy Harvesting Control Schemes for Marine Renewable Energy Devices* (PRID 152) has demonstrated clear progress against intended targets for annual energy production and levelized cost of energy, and has confirmed that the adaptive Kw2 feedforward controller has the ability to control the nonlinear system accurately.<br>• The *Advanced Direct-Drive Generator for Improved Availability of Oscillating Wave Surge Converter Power Generation Systems* (PRID 155) aligns with the sector industry needs and illustrates clear understanding of the challenge and identification of solutions for low-speed high-torque direct drive generator. | • The outcomes and how they directly impact the 17% LCOE reduction, as well as a comparison of the summary and accomplishments for *Optimal Control of a Surge-Mode WEC in Random Waves* (PRID 156) are not well explained. It is also not clear how the control strategy will be applied to the hardware.<br>• The *Direct Drive Wave Energy Buoy* (PRID 144) project aligns with the overall goals of the sector and has demonstrated progress towards a commercially viable device. More research is needed to demonstrate how these devices would achieve interconnection and align with subsystem development.<br>• If funding permits and/or appropriate manufacture cost share is available, it would be worthwhile to consider extending research to marine propulsion for *Advanced Direct-Drive Generator for Improved Availability of Oscillating Wave Surge Converter Power Generation Systems* (PRID 155). |

***MHK 2B: Survivability***




Total Projects: 3

Avg. Funding: $0.60M DOE / $0.61M total

Avg. Project Duration: 1.5 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | 4.0 | 4.1 | 3.8 | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for MHK-2B: Survivability** | **3.6** | **3.7** | **3.5** | 3.6 | 3.5 | 3.4 | 3.6 | 3.0 |
| Survivability Enhancement of a Multi-Mode Point Absorber (PRID: 187)<br>Tim Mundon, Oscilla Power, Inc. | 3.9 | 4.0 | 3.7 | 3.7 | 4.0 | 3.3 | 4.0 | 3.3 |
| Improved Survivability and Lower Cost in Submerged Wave Energy Device (PRID: 186)<br>Mike Morrow, M3 Wave LLC | 3.6 | 3.8 | 3.5 | 3.6 | 3.4 | 3.5 | 3.8 | 2.8 |

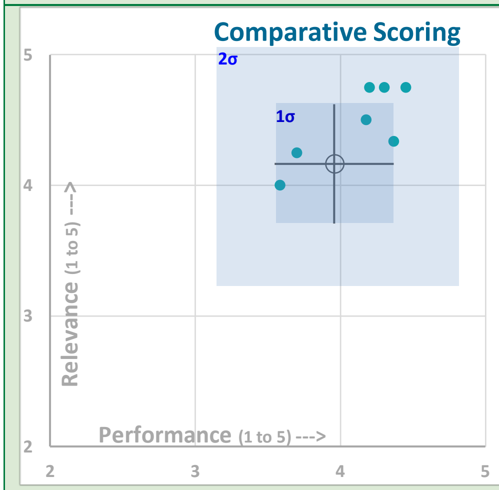
| *MHK 2B: Survivability* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Numerical Modeling and Experimental Validation of Extreme Conditions Response for the Centipod WEC [wave energy converter] (PRID: 185)<br>Alan McCall, Dehlsen Associates, LLC | 3.3 | 3.3 | 3.3 | 3.5 | 3.3 | 3.5 | 3.0 | 3.0 |

**MHK 2B—Survivability**
**Key Comments**

- Laboratory tests of scale models and sediment transport models to verify numerical models are good approaches. One DOE project using such approaches*, Improved Survivability and Lower Cost in Submerged Wave Energy Device* (PRID 186), offers an interesting device that—if successful—could make a step change in survivability for the wave sector.
- While collaborative teams in this sub-track are considered to be strong, they appear to be primarily with a few key companies and laboratories. DOE should consider support across a broader sector of the supply chain and research laboratories.
- The Centipod WEC concept has the potential to be a distraction from the other more mature technologies under development and especially against the WEP concept winner. The project has some fit with sector needs, but the overall direction and broader applicability are unclear.

| Successes<br>(Representative Comments) | Critiques & Recommendations<br>(Representative Comments) |
|---|---|
| • The *Survivability Enhancement of a Multi-Mode Point Absorber* project (PRID 187) is investigating how best to increase the survivability of the Triton WEC. However, lessons learned for the Triton will have application to some degree to all WECs.<br>• Strong collaborative teams are noted across several projects, with special note of members such as the National Renewable Energy Laboratory, Sandia National Laboratories, DNV GL, the U.S. Navy Surface Warfare Center, Carderock, Glosten, Oregon State University, and others. Some reviewers suggest that DOE consider adding a broader range of partners to further bolster and deepen these already strong partnerships. | • This project (*Numerical Modeling and Experimental Validation of Extreme Conditions Response for the Centipod WEC*, PRID 185) is investigating the survivability of the Centipod WEC. However, the Centipod is a unique device. Therefore, lessons learned will have narrow application to the MHK industry.<br>• This type of WEC (*Improved Survivability and Lower Cost in Submerged Wave Energy Device*, PRID 186) depends on two points of a wave profile. Therefore, it is particularly susceptible to interference from a confused or multi-modal wave field that will negatively affect the efficiency.<br>• *Numerical Modeling and Experimental Validation of Extreme Conditions Response for the Centipod WEC* (PRID 185) appears to be a reasonable fit with sector needs, but needs evidence of the baseline load cases, the impact of those results on the concept design, the winning load mitigation strategy, and the outreach strategy.<br>• The Army Corps of Engineers Coastal and Hydraulics Laboratory of the Engineer Research and Development Center are experts in the areas of scour and sediment transport. The *Improved Survivability and Lower Cost in Submerged Wave Energy Device* (PRID 186) project should reference this work.<br>• Researchers should be encouraged to submit papers and make presentations at appropriate professional society meetings, e.g., HydroVision. |

## *MHK 2B: Systems*




Total Projects: 7

Avg. Funding: $2.90M DOE / $2.99M total

Avg. Project Duration: 3.4 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for MHK-2B: Systems** | **4.3** | **4.5** | **4.1** | 4.0 | 4.3 | 4.0 | 4.3 | 4.0 |
| Wave Energy Prize: Testing and Data Analysis (PRID: 80)<br>Rick Driscoll, NREL | 4.6 | 4.8 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.0 |
| Administration of the Wave Energy Converter (WEC) Prize (PRID: 164)<br>Wesley Scharmen, Ricardo, Inc. | 4.5 | 4.8 | 4.3 | 4.0 | 4.5 | 4.5 | 4.5 | 4.0 |
| Wave Energy Converter Modeling (PRID: 67)<br>Yi-Hsiang Yu, NREL | 4.5 | 4.8 | 4.2 | 4.5 | 4.5 | 3.3 | 4.5 | 4.0 |
| DTOcean (Optimal Design Tools for Ocean Energy) (PRID: 75)<br>Jesse Roberts, SNL | 4.4 | 4.3 | 4.4 | 4.0 | 4.7 | 4.0 | 4.7 | 5.0 |
| Marine and Hydrokinetics Advanced Materials Program (PRID: 69)<br>Bernadette Hernandez-Sanchez, SNL | 4.3 | 4.5 | 4.2 | 4.0 | 4.5 | 4.0 | 4.3 | 4.0 |
| MHK Industry Support (PRID: 4)<br>Al Livecchi, NREL | 4.0 | 4.3 | 3.7 | 3.5 | 4.0 | 3.8 | 3.5 | 3.5 |
| Structured Innovation (PRID: 18)<br>Jochem Weber, NREL | 3.8 | 4.0 | 3.6 | 3.5 | 3.5 | 3.8 | 4.0 | 3.3 |

### MHK 2B—Systems
### Key Comments

- Overall, delivering an open source model and platform for WEC [wave energy converter] development is fundamental going forward for DOE, in order to compare results and narrow design consensus. Development of an accurate wave energy converter model, such as that researched in the *Wave Energy Converter Modeling* (PRID 67) will be a valuable contribution to the MHK community.
- Projects in this portfolio, such as the *Marine and Hydrokinetics Advanced Materials Program* (PRID 69), have relevance to DOE objectives and to industry. Future work could include developing structural integrity validation/verification methodologies for material composites; testing composite material components at full scale under load conditions; R&D on seals related to electric conductors and cables; substructure testing; saltwater effects; and corrosion between carbon fiber and metal interconnects.

| Successes<br>(Representative Comments) | Critiques & Recommendations<br>(Representative Comments) |
|---|---|
| • Tools developed under the *Wave Energy Converter Modeling* project (PRID 67) (open-source, WEC simulation tools; open-access validation datasets; and documentation) can be customized by WEC developers and are proving popular with the user community (e.g., 170+ unique visits per week). Ongoing software and development training help make it possible for R&D efforts to continue and be evaluated.<br>• The *Wave Energy Prize: Testing and Data Analysi*s (PRID 80) accomplished its goal of inspiring innovative WEC devices, which is a critical DOE objective.<br>• Use and application of models and approaches from wind-powered generation (e.g., in the *MHK Industry Support* project [PRID 4]) makes use of relevant approaches when adapted to WEC projects.<br>• Assistance to industry is essential to the success of MHK and WEC technology. The DOE labs have tremendous capabilities and it is positive to share those capabilities with industry.<br>• Wave energy concepts that offer high techno-economic performance, such as that being developed in the *Structured Innovation* project (PRID 18), provide valuable knowledge and technology to the MHK community. | • The DOE MHK Industry Support project (PRID 4) is a well-designed project that is relevant to the U.S. MHK sector. However, the limited number of developers and company-specific focus limits economies of scale and future industry impact.<br>• DOE should consider continued funding for the *Structure Innovation* project (PRID 18), as well as access for developers to be assessed and identify focused funding for their identified pain points. At this point, it isn't clear who would fund "structured innovation" and how they should be engaged.<br>• The lessons learned in the *MHK Industry Support* project (PRID 4) about Cooperative Research and Development Agreements (CRADAs) taking longer than anticipated should create a quality improvement process to address any barriers to CRADAs, which would impact other projects.<br>• The goal of the *DTOcean (Optimal Design Tools for Ocean Energy)* (PRID 75) project is to automate the design of an MHK array. This seems to be several years ahead of when it would be needed.<br>• How will the challenge of scaling and other lessons from the *Wave Energy Prize* (PRID 80) results be used against the barrier of infrastructure needs and possible approaches to bridge the gaps? |

*MHK-2C Results: Score Distribution*

Figure 5-7 represents the overall distribution of scores for projects in the **MHK-2C** subtrack. The MHK-2C subtrack featured three topic areas related to testing and demonstrating innovative technologies:

- Demonstrations of Technologies
- Infrastructure for Testing
- Sensors and Measurement for Data Collection, Performance Verification and Standards Compliance.

Project-level Scoring Tables and Key Comments Themes and Examples for each of the three subprograms are included subsequently.

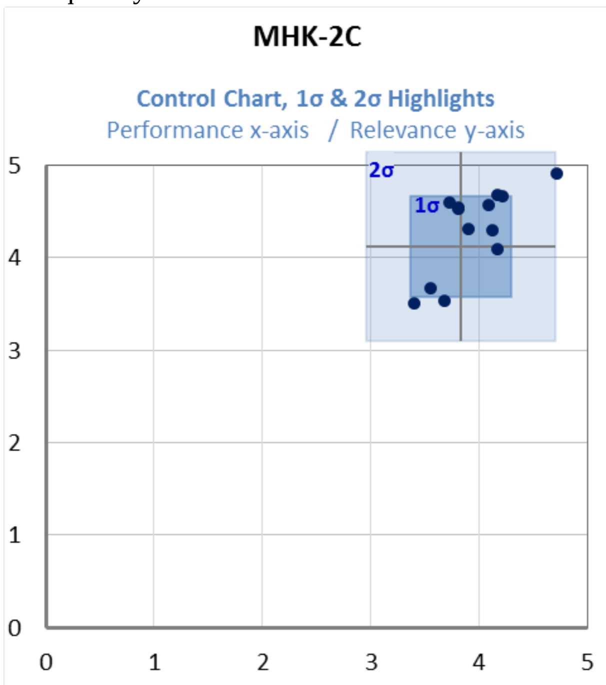
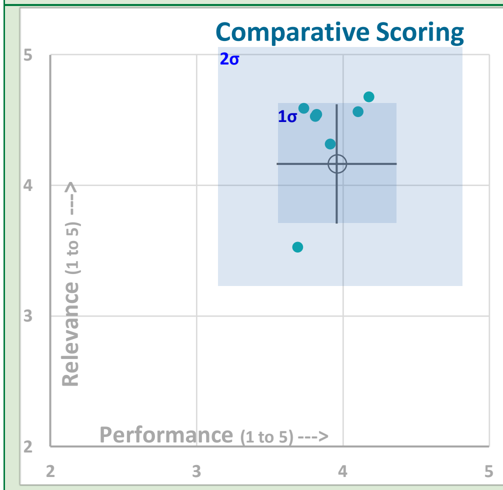



Figure 5-7. Score distribution for projects in the Marine and Hydrokinetics 2C subprogram

*MHK 2C: Demonstrations*




Total Projects: 7

Avg. Funding: $1.88M DOE / $1.99M total

Avg. Project Duration: 2.8 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for MHK-2C: Demonstrations** | **4.1** | **4.4** | **3.9** | 4.0 | 3.8 | 3.9 | 4.1 | 3.8 |
| Demonstration of the Ocean Energy (OE) Buoy at US Navy's Wave Energy Test Site (173)<br>Tony Lewis, Ocean Energy USA LLC | 4.4 | 4.7 | 4.2 | 4.3 | 4.1 | 4.1 | 4.3 | 4.0 |
| Wave Energy Test - New Zealand Multi-Mode Technology Demonstration at the US Navy's Wave Energy Test Site (145)<br>Steven Kopf, Northwest Energy Innovations | 4.3 | 4.6 | 4.1 | 3.8 | 4.3 | 4.0 | 4.6 | 4.2 |
| Next Generation MHK River Power System, Optimized for Performance, Durability and Survivability (189)<br>AlexAnna Salmon, Igiugig Village Council | 4.2 | 4.5 | 3.8 | 4.1 | 3.6 | 3.9 | 3.6 | 3.7 |
| Integrated Development and Comprehensive IO&M Testing at RITE of a KHPS TriFrame Mount[18] (190)<br>Dean Corren, Verdant Power Inc. | 4.2 | 4.5 | 3.8 | 3.7 | 3.9 | 4.0 | 3.8 | 3.6 |
| Reduction of System Cost Characteristics Through Innovative Solutions to Installation, Operations, and Maintenance (188)<br>Ken Rhinefrank, Columbia Power Technologies | 4.2 | 4.6 | 3.7 | 4.0 | 3.4 | 3.6 | 3.9 | 3.9 |
| Azura™ Demonstration at the Navy's Wave Energy Test Site (172)<br>Steven Kopf, Norhwest Energy Innovations | 4.1 | 4.3 | 3.9 | 3.9 | 4.0 | 3.7 | 4.1 | 3.8 |
| Current Energy Harnessing Using Synergistic Kinematics of Schools of Fish-Shaped Bodies (165)<br>Michael Bernitsas, Vortex Hydro Energy, LLC | 3.6 | 3.5 | 3.7 | 3.9 | 3.5 | 3.8 | 4.0 | 3.3 |

[18] IO&M = installation, operations and maintenance; RITE = Roosevelt Island Tidal Energy

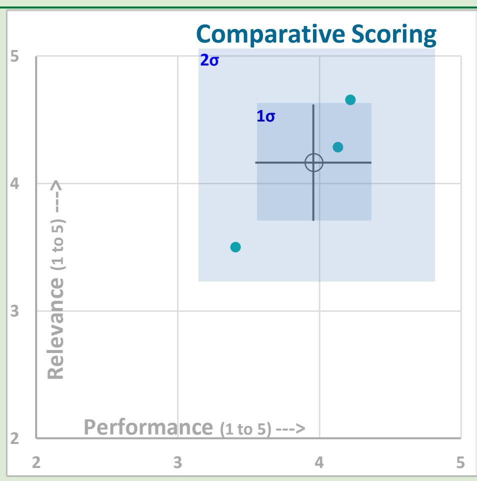
**MHK 2C—Demonstrations**
**Key Comments**

- Although outcomes of the *Wave Energy Test - New Zealand Multi-Mode Technology Demonstration at the U.S. Navy's Wave Energy Test Site* project (PRID 145) were overall positive and the project is considered relevant to DOE objectives, the failure to anticipate grid interconnection issue is a valuable learning that should be incorporated in future DOE grant calls to require detailed analysis of test site interconnection requirements.
- For advancing MHK, projects such as *Next Generation MHK River Power System, Optimized for Performance, Durability and Survivability* (PRID 189) are perfect because there is an end user of the electricity that reaps major benefits from reducing dependence on diesel generation. Also, the size of the project is appropriate for both demonstration and function. Successfully demonstrating small-scale, high-impact projects may be a good path forward.
- The deployment of near-full-scale Ocean Energy buoy (deep water oscillating water column device [PRID 173]) for one year at an open sea test site to validate performance predictions, reliability, and LCOE estimates will significantly advance WECs [wave energy converters] on the commercialization curve and demonstrate compatibility with grid operations.
- DOE should evaluate with project developers and supply chain vendors whether there is a low-cost, third-party platform that could serve as an effective virtual marketplace for talent/vendors with specialized skills needed by MHK.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Demonstration of the Ocean Energy (OE) Buoy at U.S. Navy's Wave Energy Test Site* project (PRID 173) exhibits impressive attention to detail, with steps including the implementation of risk reduction measures, use of third-party validation, equipment monitoring, and consideration for environmental concerns.<br>• The *Reduction of System Cost Characteristics Through Innovative Solutions to Installation, Operations, and Maintenance* project (PRID 188) is an important and relevant project as well as an excellent follow on to earlier R&D identifying needs to reduce costs, increase energy output, and assure safe and efficient IO&M. DOE should adopt lessons learned into its project evaluations, focusing on realistic time/$ estimates for company scale up to implement projects.<br>• The *Next Generation MHK River Power System, Optimized for Performance, Durability and Survivability* project (PRID 189) is a well-managed project that includes outstanding stakeholder engagement with the Igiugig village and local fishing industry.<br>• The focus on improving the IO&M costs and LCOE under the *Integrated Development and Comprehensive IO&M Testing at RITE of a KHPS TriFrame Mount* project (PRID 190) will benefit the entire MHK community. These costs are not always given the importance they deserve. | • Incorporate additional biological (fisheries-focused) studies into future deployments.<br>• *Current Energy Harnessing Using Synergistic Kinematics of Schools of Fish-Shaped Bodies* (PRID 165) appears to be a stand-alone project that doesn't contribute across all projects or achieve DOE objectives in terms of technology maturity.<br>• Each base in the *Integrated Development and Comprehensive IO&M Testing at RITE of a KHPS TriFrame Mount* project (PRID 190) will have to be made to fit the bathymetry. This may drive costs up, and it relies on both precise bathymetry knowledge and the ability to precisely deploy them multiple times. This may be much more challenging in deeper, more energetic sites.<br>• The *Wave Energy Test - New Zealand Multi-Mode Technology Demonstration at the U.S. Navy's Wave Energy Test Site* (PRID 145) is an interesting concept and a good example of getting technology (or "steel") in the water and tested over a long term (~18-month deployment). However, there is concern that the project may be limited in its potential impact and relevance to DOE objectives. |

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| | • Although the *Next Generation MHK River Power System, Optimized for Performance, Durability and Survivability* project (PRID 189) has good local partnerships, DOE should consider adding more local team members (e.g., the UA-F [University of Alaska Fairbanks] fisheries instead of the University of Maine). Such participants could offer additional local experience and knowledge. The project should also be completed before future research is considered, and external validation would bolster the findings.<br>• The *Reduction of System Cost Characteristics Through Innovative Solutions to Installation, Operations, and Maintenance* (PRID 188) project created strong lessons for full-scale deployments, including lessons related to design issues. These lessons need to be chronicled and prioritized in order to reduce costs and provide more input to O&M [operations and maintenance] best practices, and DOE should use these lessons for insight about appropriate timelines to advance through TRL [technology readiness level] stages to full scale. |

*MHK 2C: Infrastructure*




Total Projects: 3

Avg. Funding: $2.83M DOE / $3.35M total

Avg. Project Duration: 3.0 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for MHK-2C: Infrastructure** | **4.0** | **4.1** | **3.9** | 3.8 | 4.0 | 3.9 | 4.3 | 3.5 |
| Pacific-Marine Energy Center South Energy Test Site (PMEC-SETS) (161) - Belinda Batten, Oregon State University | 4.4 | 4.7 | 4.2 | 4.1 | 4.3 | 4.1 | 4.6 | 4.3 |
| Advanced Laboratory and Field Arrays (ALFA) (171) Belinda Batten, Oregon State University | 4.2 | 4.3 | 4.1 | 4.0 | 4.3 | 3.9 | 4.6 | 4.1 |
| California Wave Energy Test Center (CalWave) (160) Dr. Sam Blakeslee, Cal Poly Corporation | 3.5 | 3.5 | 3.4 | 3.3 | 3.5 | 3.8 | 3.7 | 2.2 |

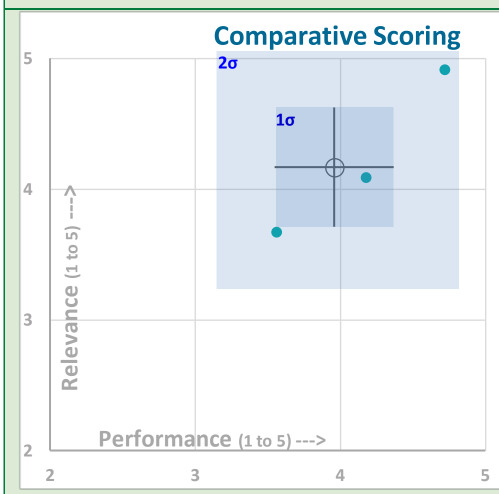
**MHK 2C—Infrastructure**
**Key Comments**

- At the Go/No Go critical phase of infrastructure projects such as *California Wave Energy Test Center (CalWave)* (PRID 160), it is recommended that DOE create the opportunity for second choice projects to re-scope their proposals so they can address other test demonstration opportunities.
- Although test sites are essential to advancing MHK/WEC [wave energy converter] technologies, there is some concern about whether it is an effective use of DOE technology development funds to fund two competing state applications for test sites (*California Wave Energy Test Center [CalWave]* [PRID 160] and *Pacific-Marine Energy Center South Energy Test Site* [PMEC-SETS] [PRID 161].
- Grid-connected test site projects such as those supported by DOE under this sub-track are critical to support device testing and advance MHK technologies to full commercialization. DOE could enhance such efforts by conducting a scoping study to gauge industry interest in testing slots to justify size and scale of testing sites (e.g., the 20-device project planned for the *Pacific-Marine Energy Center South Energy Test Site [PMEC-SETS]*).

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Pacific-Marine Energy Center South Energy Test Site* (PMEC-SETS) (PRID 161) is a competitive alternate to the Vandenberg Air Force base site on the California coast. It offers similar characteristics to the California site, but with advantages such as connection to an operating electric distribution system with interconnect to the BPA transmission grid, proximity to Pacific Northwest National labs, and an interconnection point that is not on a military base (i.e., no security barrier to access by contractors and construction equipment). The site also offers a potential cost savings in terms of reduced transport costs vs. shipping WEC devices to the Navy's WETS facility in Hawaii.<br>• A major strength of the *Pacific-Marine Energy Center South Energy Test Site* (PMEC-SETS) project (PRID 161) is its combined collaborative efforts. The project team coordinated with the community, international partners, academia, laboratories, industry, and the public. This large, diverse integration of stakeholders is essential to success of projects such as PMEC-SETS.<br>• The *Pacific-Marine Energy Center South Energy Test Site* (PMEC-SETS) project (PRID 161) captured lessons learned in earlier projects, including federal/state permitting agencies in permit planning process. There was a trade-off of a longer permitting timeframe that generally creates a more successful outcome with less opposition to permitting.<br>• The *Advanced Laboratory and Field Arrays (ALFA)* project (PRID 171) is an overall well-managed project that includes successful coordination with the University of Oregon and the grants awarded. | • The *California Wave Energy Test Center (CalWave)* project (PRID 160) was an average approach that does not appear to build off experiences from either Hawaii or Oregon. It was apparent there was a lot of stakeholder engagement up front, which is important, but this engagement dominated the project activities to the detriment of the technical approach and methods. The project also appears to be in direct competition of the OSU/NNMREC Test Center.<br>• The *Pacific-Marine Energy Center South Energy Test Site* (PMEC-SETS) project (PRID 161) sets a goal of "up to 20 utility-scale WECs, up to 20MW, within four berths". This is extremely ambitious and creates a complicated project with many moving parts. It is suggested that DOE consider a phased installation plan for this project and others like it.<br>• DOE needs to continue to ensure that funding for test sites is balanced with the funding necessary to support R&D that ensures there are new devices to test.<br>• There's a question as to whether the debris identification system in the *Advanced Laboratory and Field Arrays (ALFA)* project (PRID 171) can be used at conventional hydro plant reservoirs as a way to reduce risk of damage to turbines if the trash rack is not in place or has otherwise failed to do its job.<br>• The summary for the *California Wave Energy Test Center (CalWave)* project (PRID 160) indicates that the permitting process would eliminate regulatory burdens. This information was not elaborated on in detail, however, and should be summarized as a post-action lesson to inform California regulatory agencies for potential improvement to their permitting process. |

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| | • If there is opportunity for the *California Wave Energy Test Center (CalWave)* (PRID 160) site to be reevaluated as a commercial site, this might be a step from WETS to PMEC to CalWave as the first commercial site.<br>• Continued close management will be required to ensure the success of the multi-faceted work in the *Advanced Laboratory and Field Arrays (ALFA)* project (PRID 171). |

*MHK 2C: Sensors and Measurement*




Total Projects: 3

Avg. Funding: $0.88M DOE / $0.88M total

Avg. Project Duration: 4.4 years

| | Average of Relevance and WAP | Relevance | Weighted Average Performance | Methods/Approach | Accomplishments/Progress | Project Management | Collaboration/Tech Transfer | Future Research |
|---|---|---|---|---|---|---|---|---|
| **Average for All Peer-reviewed WPTO Projects** | **4.0** | **4.1** | **3.8** | 3.9 | 3.9 | 3.8 | 3.9 | 3.6 |
| **Average for MHK-2C: Sensors and Measurement** | **4.2** | **4.2** | **4.2** | 4.2 | 4.3 | 4.0 | 4.3 | 3.7 |
| Standards Development, IEC TC 114, IEA-OES Annual Contribution (33)[19]<br>Walt Musial, NREL | 4.8 | 4.9 | 4.7 | 4.7 | 4.8 | 4.6 | 4.9 | 4.7 |
| Modular Ocean Instrumentation System (MOIS) (88)<br>Eric Nelson, NREL | 4.1 | 4.1 | 4.2 | 4.2 | 4.3 | 4.1 | 4.3 | 3.7 |
| Tidal Device Field Measurement Campaign (FMC) (16)<br>Vincent Neary, SNL | 3.6 | 3.7 | 3.6 | 3.7 | 3.7 | 3.3 | 3.9 | 2.9 |

[19] IEC = International Electrotechnical Commission; IEA-OES = International Energy Agency-Ocean Energy Systems

**MHK 2C—Sensors and Measurement**
**Key Comments**

- Work such as that supported under the *Standards Development, IEC TC 114, IEA-OES Annual Contribution* (PRID 33) is a perfect example of international collaboration, especially given the importance of internationally recognized standards to the commercialization of marine energy. The United States should make efforts to remain the leader in standards development. Development of design, manufacturing, testing and safety standards is an essential part of the ultimate goal of getting MHK electric power and energy installations into commercial service.
- The *Modular Ocean Instrumentation System (MOIS)* project (PRID 88) illustrates the need for a commercialization plan for any additional MHK instrumentation funding to assure such technologies are not stranded and abandoned. MHK devices need to be prioritized over further instrument refinements.
- Testing and monitoring facilities such as those developed under the *Modular Ocean Instrumentation System (MOIS)* project (PRID 88) are essential to operation and maintenance of WEC units. It is also necessary to do analysis of why some designs fail or are damaged by storms and rouge waves.

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
|---|---|
| • The *Standards Development, IEC TC 114, IEA-OES Annual Contribution* (PRID 33) work has been exemplary in terms of its structure and outreach. The project has resulted in publication of multiple specifications and results disseminated through public workshops, forums, and the web. DOE selected strong representation and leadership for the project, leading to a structure that allows for QA/QC inputs and ongoing improvement of established standards.<br>• The development of the *Modular Ocean Instrumentation System (MOIS)* (PRID 88) for WEC on-device testing to characterize device performance, validate numerical models, and develop WEC testing methodologies will benefit the entire MHK community.<br>• The strong laboratory / private industry collaboration for the *Modular Ocean Instrumentation System (MOIS)* (PRID 88) work supports the viability and relevance of the project. Placement of the drawings and data into the MHK database is an important tool to support technology transfer and overall adoption by WEC developers.<br>• There were several "firsts" and accomplishments as a result of the *Tidal Device Field Measurement Campaign (FMC)* project (PRID 16), including fiber Bragg grating, improved CACTUS model, a published model validation data set, a successful wave tank system, and improved knowledge of turbulent flow in the coastal environment. Additional strengths include the development of a new cross ADV (Acoustic Doppler Velocimetry), strong analytic basis, collaboration with Ocean Renewable Power Company, effective technology transfer, and the resulting availability of CACTUS as an open-source program. | • Proposed future research for the *Tidal Device Field Measurement Campaign (FMC)* project (PRID 16) appears narrowly focused. There should be the integration of FMC with a tidal developer.<br>• For the *Standards Development, IEC TC 114, IEA-OES Annual Contribution* (PRID 33), coordinate with IEEE-Power Energy Society and relevant committees, subcommittees, working groups and task forces whose scope descriptions include actual MHK topics as well as associated equipment and apparatus essential to MHK development efforts.<br>• The project organization and international collaboration of the *Standards Development, IEC TC 114, IEA-OES Annual Contribution* (PRID 33) work is considered a strength. However, the work could potentially be improved by including representatives from other sectors such as O&G, and/or by investigating the possibility of getting other countries to contribute more cost share over time.<br>• With a team made up of experts from the national laboratories and academia, it is unfortunate that the research team could not identify an industry partner to support the CACTUS effort under the *Tidal Device Field Measurement Campaign (FMC)* project (PRID 16). The lack of an industry partner affected the budget and makes it difficult to determine whether additional work will directly and quickly benefit the target users and achieve the intended project objective to provide tidal industry with effective performance and load models. |

| Successes (Representative Comments) | Critiques & Recommendations (Representative Comments) |
| --- | --- |
| | • The *Modular Ocean Instrumentation System (MOIS)* (PRID 88) is a good fit with DOE program objectives and is critical to provide needed performance data to industry. There is some question, however, as to whether a "one-size-fits-all" approach will be widely adopted by developers.<br>• The focus of the *Standards Development, IEC TC 114, IEA-OES Annual Contribution* (PRID 33) effort is at the international level. When it comes to the interconnection of MHK-powered electric generation apparatus in the United States or North American grids, however, it will be necessary to have standards that are based in those regions. Such standards include NERC, IEEE, ASME, ASTM, NESC, RUS-REA, as well as ISO/RTO and FERC interconnection rules.[20] |

[20] NERC = North American Electric Reliability Corporation; ASME = American Society of Mechanical Engineers; ASTM = ASTM International; NESC = National Electrical Safety Code; RUS-REA = Rural Utilities Service- Rural Electrification Administration; ISO = independent service operator; RTO = regional transmission operator; FERC = Federal Energy Regulatory Commission

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