U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WATER POWER TECHNOLOGIES OFFICE

LETTER FROM THE DIRECTOR

Dear Colleague:

On behalf of the U.S. Department of Energy's Water Power Technologies Office (WPTO), I am happy to release the 2019 WPTO Peer Review report. This report is the product of a comprehensive review of the Marine and Hydrokinetics (MHK) and Hydropower Programs, including evaluations of both programs' strategies, as well as individual projects and new initiatives. The review covered 77 individual projects funded by the office, including 41 projects funded by the MHK Program and 36 by the Hydropower Program. These projects represent the majority of WPTO's active portfolio between fiscal years (FY) 2017 and 2018, though some projects were funded and initiated as early as FY 2014, before WPTO was an independent office. The projects reviewed represent about $230 million in executed funding, which includes funds appropriated in prior fiscal years and non-federal cost share.

WPTO is required to conduct an office-wide review every two years in accordance with departmental guidance; we in WPTO consider this an important responsibility and opportunity, as it is the most comprehensive mechanism that we have for gathering feedback on our programs and projects. We could not do our jobs without the help and input of our stakeholders, which is why the objectives in our office's Outreach and Engagement Strategy are embedded in everything we do, including how we planned and executed this review. We were deliberate in planning this review to achieve the key goals outlined in the strategy: (1) demonstrate transparency, (2) elicit feedback, (3) disseminate results and tools developed through R&D, and (4) provide objective and accurate information to the public. We also sought to provide all attendees—not only the reviewers—a variety of opportunities to provide feedback and engage WPTO staff, whether comment boxes to anonymously submit feedback or a "Town Hall" with WPTO staff at the end of the review to provide an opportunity for open-ended feedback and discussion. The engagement opportunities and input provided through this type of comprehensive review is invaluable to our programs.

This year's review was particularly important to WPTO for a few reasons. Primarily, this was the first Peer Review of WPTO's portfolio as an independent office, separate from the Wind Energy Technologies Office. It also reflected the new programmatic structure and strategies put in place since 2017, including some expansion to new areas where hydropower and MHK technologies can have a significant impact, such as leveraging hydropower's full range of grid benefits (HydroWIRES Initiative / Grid Reliability, Resilience, and Storage) and marine energy applications in the Blue Economy (Powering the Blue Economy). In addition, during the period under review, WPTO leveraged new funding and partnership mechanisms—some of which were novel for DOE at large. These funding mechanisms are helping WPTO attract a diverse set of innovators to support our mission of reducing costs and improving the reliability of water power technologies. Lastly, significant budget increases over the last few years made 2019 an even more critical time to independently review our work and discuss how to most effectively use public funds to drive the greatest R&D impacts.

Only a few months after the review, I can already say the feedback we received is proving useful. At an office-level, we received encouraging feedback on our strategies, including both the R&D activities we fund and the mechanisms by which we fund them. One trend we noticed is the average scores for both the MHK and Hydropower Program strategies were higher than the average weighted scores of all projects reviewed under the respective programs. This indicates that our current program objectives—which have been updated since some of the reviewed projects were initiated—are well aligned with industry needs, even if these strategic objectives may not have always been executed perfectly in individual projects. The reviewers were particularly supportive of the new HydroWIRES and Powering the Blue Economy initiatives. We also received overwhelming support from both reviewers and general attendees for WPTO's efforts in leveraging a variety of funding mechanisms, beyond traditional lab contracts and cooperative agreements. We will continue to think critically about diverse R&D challenges and the appropriate funding structure to address each one, whether that means a funding opportunity announcement, a prize competition, a notice of technical assistance, or some other mechanism we have not yet created.

While WPTO appreciates the positive feedback, we are also very grateful for the constructive suggestions, particularly related to our stakeholder engagement, use of performance metrics, and our approach to the collection, management, and dissemination of data. With respect to stakeholder engagement, we heard that some areas of our programs are doing this well, while others need improvement. For example, we learned earlier and more frequent industry engagement could have benefitted several projects, in particular our new small hydropower projects. We also received specific feedback on organizations we should collaborate with more closely on shared marine energy research interests, such as the Bureau of Ocean Energy Management. We cannot overstate how important meaningful stakeholder engagement and impactful dissemination is to our mission. We plan to work more closely with our colleagues and project teams to ensure their plans for stakeholder engagement are appropriate throughout the entire project cycle, and that they have an impactful strategy to disseminate results, tools, and lessons learned. Second, we heard that both the MHK and Hydropower Programs have more work to do in the area of performance metrics, both at a project level (i.e., how do we define success) and at a program level (specifically in quantifying WPTO's impact, return on investment, and commercialization successes). The office has been working hard over the past year to define performance metrics for marine energy devices as part of our new Testing Expertise and Access for Marine Energy Research (TEAMER) program, and we plan to pilot new program-wide impact assessment in FY 2020. Third, we learned we need to strengthen our data efforts. We recognize that we are collecting large amounts of valuable data, but our current structures for accessing these data don't adequately ensure quality and ease of use. Finally, we received useful feedback on the structure of the review. Most notably, we heard time and time again that reviewers would have benefitted from having more information on WPTO's go/no-go decisions and how funded projects move forward. We will incorporate this feedback into our planning for the next Peer Review.

To all who contributed to our office's 2019 Peer Review, thank you. To all the attendees, thank you for taking an interest in our programs and offering your feedback. To the project teams and principal investigators that presented, thank you for the time you have invested in this review, as well as in the important work you do every day. To our invited speakers, thank you for offering your perspectives and challenging our community to think differently about our approaches to innovation and the impact of our work. And last but most certainly not least, thank you to our reviewers. On behalf of WPTO, I am deeply grateful for the significant time and energy you put into this review. The team was honored by your willingness to share your expertise with us and dive deeply into our portfolio. We know the marine energy and hydropower communities will benefit for years to come thanks to your strategic advice on the direction of our R&D programs.

Sincerely,

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

EXECUTIVE SUMMARY

Introduction

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy's (EERE's) Water Power Technologies Office (WPTO, or "the office") 2019 Peer Review was held on October 8–10, 2019, in Alexandria, Virginia. The purpose of the peer review was to evaluate 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. All programs within EERE are required to undertake rigorous, objective peer reviews covering their key projects, as well as 80%–90% of their funded active project portfolio every two years.

Review Process

Most projects in WPTO's fiscal year (FY) 2017–2018 research and development (R&D) portfolio were presented to the public and systematically reviewed by 24 external subject-matter experts from industry, academia, and federal agencies. During the event, principal investigators (PIs) presented on 77 projects in WPTO's R&D portfolio, and WPTO staff presented on each program's strategy and high-priority initiatives. See Table 1 for a list of the programs, the activity areas, and the number of projects in each.

Table 1. WPTO's Peer Reviewed Projects and Strategic Initiatives.

Program	Activity Area	Number of Projects
Hydropower	Technology R&D for Low-Impact Hydropower Growth	8
	Grid Reliability, Resilience, and Storage	9
	Modernization, Upgrades, and Security	2
	Environmental R&D and Hydrologic System Science	10
	Big-Data Access and Management	7
	*HydroWIRES Initiative**	
Marine and Hydrokinetics	Foundational and Crosscutting R&D	12
	Technology-Specific Design and Validation	8
	Reducing Barriers to Testing	15
	Data Sharing and Analysis	6
	*Powering the Blue Economy**	
	Total Number of Projects	**77**

*Strategic initiatives

These projects and program strategies were organized into four groups, referred to as "tracks" for the peer review. There were two tracks for the Hydropower Program and two tracks for the Marine and Hydrokinetics (MHK) Program. Each track included one or more activity areas. See the agenda in Appendix A for a list of tracks and associated activity areas. Two review chairpersons were selected to oversee the peer review tracks and review process: Greg Lewis, formerly of Duke Energy, presided over the Hydropower tracks and Elaine Buck, of the European Marine Energy Centre, presided over the MHK tracks.

Evaluation Criteria

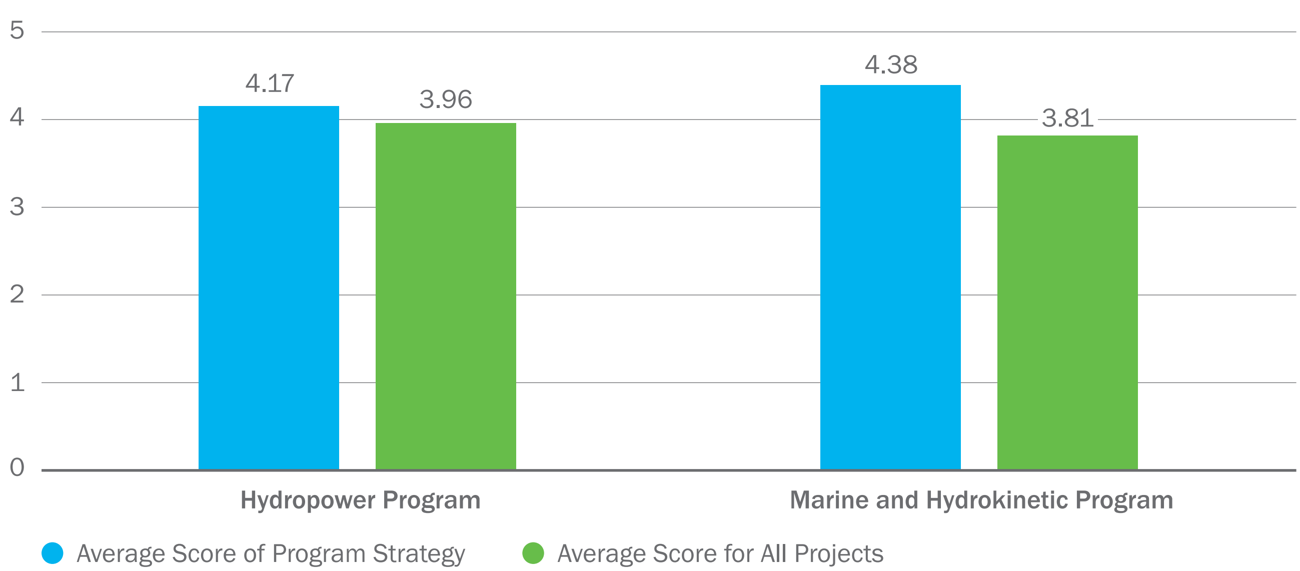
Reviewers were asked to evaluate WPTO's major R&D programs and significant initiatives (i.e., Powering the Blue Economy and HydroWIRES [Water Hydropower and Water Innovation for a Resilient Electricity System]) at a strategic level, both numerically and with specific, concise comments to support each evaluation. Reviewers evaluated each program or strategic initiative on the following equally weighted criteria: (1) program strategy and objectives; (2) program portfolio; (3) program management approach; and (4) stakeholder engagement, outreach, and dissemination. Reviewers provided scores on a scale of 1 ("unsatisfactory") to 5 ("superior") for each criterion and were also asked to answer unscored, supplemental questions for each program or strategic initiative, which are outlined in Appendix A.

In addition, reviewers were asked to evaluate a set of WPTO's projects, both numerically and with specific, concise comments to support each evaluation. Reviewers evaluated each project on the following specific criteria: (1) project objectives, impacts, and alignment with the program strategy; (2) end user engagement and dissemination strategy; (3) management and technical approach; (4) technical accomplishments and progress; and (5) future work. Project scoring involved weighting the evaluation criteria based on each project's category—sunsetting/completed, ongoing, or new—which was based on the project's start and/or end date. Reviewers were asked to comment on the strengths and weaknesses behind their scoring and to provide recommendations that they felt that the office should consider.

Scoring Overview

Figure 1 summarizes reviewers' quantitative assessments of how WPTO's programs are performing overall, including the average score of each program's strategy and the average score of all projects reviewed per program.

Figure 1. Average score per program



Overall, the average scores in Figure 1 indicate that reviewers rated each program's strategy higher than the average score for all individual projects. This shows that our current program objectives—which were updated after some of the earliest projects were initiated—align well with evolving industry needs. Reviewers agreed that the strategies are sound, and they were particularly supportive of the new HydroWIRES and Powering the Blue Economy initiatives.

WPTO's Key Objectives for the 2019 Peer Review

WPTO staff and management considered the 2019 Peer Review a significant milestone and opportunity for the portfolio given this was the first comprehensive evaluation of WPTO as a standalone office. WPTO established key objectives that guided how the review process was planned and executed before, during, and after the event. With the overarching goal that all participants should leave feeling like their time was well spent, our additional objectives included the following:

- Give reviewers a transparent and comprehensive view of the portfolio and WPTO's vision for marine energy and hydropower R&D.
- Gather valuable feedback on funded R&D, technical accomplishments, and management approach, and leverage this feedback to inform future decision making.
- Enable all participants (not just reviewers) to provide feedback on the future of WPTO and the programs' strategic directions.
- Complement the review sessions with presentations from inspiring and insightful thought leaders offering outside perspectives to stimulate thoughtful discussion.
- Provide opportunities for networking, so all attendees can leverage and learn from the expertise of others.

The objectives above were set to ensure the peer review aligned with WPTO's Outreach and Engagement Strategy, which includes four key goals:

1. **Transparency**: Demonstrate good stewardship of taxpayer funds by persistently and transparently communicating how WPTO funds are utilized and evaluate project impacts.
2. **Feedback**: Gather feedback from stakeholders to inform and improve WPTO projects and strategy.
3. **Dissemination**: Maximize the impact of WPTO-supported research by effectively disseminating results of projects and tracking usage of various products.
4. **Objective and accurate information**: Provide access to accurate and objective information and data that can help to accelerate industry development and inform decision makers.

While WPTO has identified opportunities for improvement, the office concluded the experience was highly successful in meeting the stated key objectives for the 2019 Peer Review. For the overarching goal of ensuring participants' time was well spent, the results from a post-event survey suggest that the office was largely successful on this metric, and 84% of post-event survey respondents said that they would consider attending a future WPTO peer review, even if their participation was not requested (i.e., not serving as a reviewer or presenting as a PI).

A summary of WPTO's lessons learned, recommendations for other peer reviews, as well as the feedback collected from all non-reviewers can be found in General Feedback and Lessons Learned.

LIST OF ACRONYMS

AEP	Annual Electricity Production
BOEM	Bureau of Ocean Energy Management
CEATI	Centre for Energy Advancement through Technological Innovation
CFD	computational fluid dynamics
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EMEC	European Marine Energy Centre
EPAct	Energy Policy Act of 2005
EPRI	Electric Power Research Institute
FERC	Federal Energy Regulatory Commission
FMEA	failure modes and effects analysis
FOA	funding opportunity announcement
FY	fiscal year
GLIDES	Ground-Level Integrated Diverse Energy Storage
HFI	Hydropower Fleet Intelligence
IEA	International Energy Agency
IEA-OES	International Energy Agency Ocean Energy Systems
IEC	International Electrotechnical Commission
IECRE	IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications
IFRMER	French Research Institute for Exploitation of the Sea
IO&M	installation, operations, and maintenance
IP	intellectual property
ISO	independent system operator
LCOE	levelized cost of energy
MHK	marine and hydrokinetic
MHKDR	Marine and Hydrokinetic Data Repository
MPC	model predictive control
MRE	marine renewable energy
NGOs	non-governmental organizations
NHA	National Hydropower Association
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
NWEI	Northwest Energy Innovations
O&M	operations and maintenance
OE	Ocean Energy
OES	Ocean Energy Systems

OPI	Oscilla Power Inc.
ORNL	Oak Ridge National Laboratory
ORPC	Ocean Renewable Power Company, Inc
OSU	Oregon State University
PBE	Powering the Blue Economy
PI	principal investigator
PNNL	Pacific Northwest National Laboratory
PRIMRE	Portal and Repository for Information on Marine Renewable Energy
PSH	pumped-storage hydropower
PTO	Power Take off
Q&A	question and answer
QA	quality assurance
QC	quality control
R&D	research and development
RAPID	Regulatory and Permitting Information Desktop
RMA	reliability maintainability and availability
ROI	return on investment
RTO	regional transmission organization
SAM	System Advisor Model
SBIR	Small Business Innovation Research
SBV	Small Business Vouchers
SMH	standard modular hydropower
SNL	Sandia National Laboratories
STTR	Small Business Technology Transfer
SWA	Secure Water Act
TC	Technical Committee
TCF	Technology Commercialization Fund
TEAMER	Testing Expertise and Access for Marine Energy Research
TPL	technology performance level
TRC	Technical Review Committee
TRL	technology readiness level
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WBS	work breakdown structure
WEC	wave energy converter
WEC-SIM	Wave Energy Converter SIMulator
WES	Wave Energy Scotland
WETS	Wave Energy Test Site
WPTO	Water Power Technologies Office

CONTENTS

INTRODUCTION

Purpose of Peer Review

A peer review is a standard best practice for assessing highly technical, complex projects and programs and is widely used by industry, government, and academia. Peer reviews elicit objective reviews and advice from independent experts to provide the U.S. Department of Energy (DOE) managers, staff, and researchers with a powerful and effective tool for informing the management, relevance, and productivity of government-funded projects. The 2016 Office of Energy Efficiency and Renewable Energy (EERE) Peer Review Guide defines a peer review 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 programs and/or projects.**

This definition distinguishes in-progress peer review from other types of reviews, such as merit reviews, which are used to evaluate technical proposals for competitive solicitations; "stage gate" or "go/no-go" reviews, which determine whether a project is ready to move to the next phase of development; and other review activities such as quarterly milestone reviews or budget reviews.

A peer review is based on the premise that enlisting third-party experts to objectively evaluate the progress and impact of a technical project and/or program adds a valuable layer to technical program and project management. Peer reviews are essential in providing robust, documented feedback to EERE leadership to inform program planning. They also provide management with independent validation of the effectiveness and impact of its funded projects and program scopes. Knowledge about the quality and effectiveness of current projects and programs is essential in directing (or redirecting) new and existing efforts.

WPTO 2019 Peer Review

EERE's Water Power Technologies Office's (WPTO's) 2019 Peer Review was held on October 8–10, 2019, in Alexandria, Virginia. During the public event, principal investigators (PIs) presented on 77 projects in WPTO's research and development (R&D) portfolio (41 MHK, 36 Hydro), and WPTO staff presented on each program's strategy and key initiatives. These projects and program strategies were systematically reviewed by 24 external subject matter experts from industry, academia, non-governmental organizations (NGOs), and federal agencies. The 2019 Peer Review included tracks across all the Marine and Hydrokinetics (MHK) and Hydropower Programs' activity areas (see Figure 2).

Results of the 2019 Peer Review will be used to help inform programmatic decision making, modify existing projects, guide future funding opportunities, and support other strategic planning objectives. The time period for the 2019 Peer Review included the first three years of WPTO as an independent office.

Figure 2. WPTO program activity areas

MHK Program

- Foundational and Crosscutting R&D
- Technology-Specific System Design and Validation
- Reducing Barriers to Testing
- Data Sharing and Analysis

Hydropower Program

- Technology R&D for Low-Impact Hydropower Growth
- R&D to Support Modernization, Upgrades, and Security for Existing Hydropower Fleet
- Grid Reliability, Resilience, and Storage
- Environmental R&D and Hydrologic Systems Science
- Big-Data Access and Management

Peer Review Panels

Review Panels consisted of four to six external experts who were selected based on their technical expertise and high-level qualifications in their designated technology area. WPTO made efforts to ensure there was a balance within each Review Panel by including a mix of reviewers from industry, academia, NGOs, and federal agencies, with a range of expertise. Reviewers were required to sign legal agreements stipulating an absence of a conflict of interest with the projects they reviewed. Each set of reviewers was guided by a Program Review Chair, as well as a Review Panel Lead, whom in most cases had previous experience as a reviewer. Table 1 lists the members and affiliations of the Program Review Chairs and Review Panel Leads. Members of each Review Panel are listed within each individual program sections.

Table 2. Program Review Chairs and Panel Leads

HYDROPOWER PROGRAM			
Name	**Role**	**Review Panel**	**Affiliation**
Greg Lewis	Review Chair and Panel Lead	New Technology and Moderniza-tion	Duke Energy
Scott Flake	Panel Lead	Grid Reliability	Independent Consultant
Tim Brush	Panel Lead	Environmental R&D and Data Management	Inter-Fluve
MHK PROGRAM			
Name	**Role**	**Review Panel**	**Affiliation**
Elaine Buck	Review Chair and Panel Lead	Foundational R&D, Technology Design, and Validation	European Marine Energy Centre
Chris Bassett	Panel Lead	Reducing Barriers to Testing and Data Sharing	University of Washington

Reviewers were responsible for consolidating and summarizing all reviewer comments on assigned projects and submitting draft project evaluation summaries to WPTO and Chairs/Panel Leads. Panel Leads were responsible for drafting activity area evaluation summaries and submitting to WPTO and Review Chairs. Review Chairs were responsible for drafting a program-level evaluation summary, reviewing key parts of the draft report, and submitting to WPTO.

Program Evaluation Criteria

Reviewers were asked to evaluate WPTO's major R&D Programs and significant initiatives at a strategic level, both numerically and with specific, concise comments, to support each evaluation. Reviewers evaluated each program or strategic initiative on the following, equally weighted criteria: (1) program strategy and objectives; (2) program portfolio; (3) program management approach; and (4) stakeholder engagement, outreach, and dissemination. These evaluation criteria, as described below, served as the standard template for the scores and comments provided to each program or strategic initiative. In addition, reviewers were asked to answer unscored, supplemental questions for each program or strategic initiative, which are outlined in Appendix B.

Table 3. Program Evaluation Criteria Weighting

Program Evaluation Criteria	Weights
Program Strategy and Objectives	25%
Program Portfolio	25%
Program Management Approach	25%
Stakeholder Engagement, Outreach, and Dissemination	25%
Recommendations/Supplemental Questions	0%

- **Program Strategy and Objectives**—programs or strategic initiatives were evaluated on the degree to which:
  - The program's long-term strategy, strategic approaches, and future direction were effectively conveyed during the peer review.
  - The program's strategy reflects an understanding of the near and long-term challenges facing industry and other stakeholders.
  - The program invests in early-stage research to accelerate the development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed.
  - The program supports efforts to validate performance and grid reliability for new technologies, develop and increase accessibility to necessary testing infrastructure, and evaluate systems-level opportunities and risks.
  - The program invests taxpayer funds wisely to drive the greatest impact.

- **Program Portfolio**—programs or strategic initiatives were evaluated on the degree to which:
  - The projects within this program portfolio contribute to meeting the program's strategy and objectives.
  - The projects within this program portfolio are addressing key challenges and reducing barriers to advance water power technologies.
  - The rationale for and organization of the funded projects and program approaches have been effectively conveyed during the peer review.
  - The program portfolio effectively balances research priorities and allocates resources appropriately.
  - The projects within this program portfolio are appropriate for WPTO's role as a public R&D organization.
- **Program Management Approach**—programs or strategic initiatives were evaluated on the degree to which:
  - The program team effectively manages and directs the activities needed to meet its objectives.
  - The program team focuses on priority research areas that create the greatest impact on new technology and industry advancement.
  - The program team effectively communicates priority research areas and the allocation of resources.
  - The program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects.
  - The program team has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees.
- **Stakeholder Engagement, Outreach, and Dissemination**—programs or strategic initiatives were evaluated on the degree to which:
  - The program demonstrates good stewardship of taxpayer funds by persistently and transparently communicating how WPTO funds are being utilized and evaluates project impacts.
  - The program gathers feedback from stakeholders to inform and improve WPTO projects and strategy.
  - The program maximizes the impact of WPTO-supported research by effectively disseminating results of projects and tracking usage of various products.
  - The program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision makers.

Project Evaluation Criteria

Each project in the WPTO portfolio was categorized based on its start and/or end date. To capture projects that have been active since the last peer review, which took place in 2017, the three project categories are as follows:

- **Sunsetting and Completed Projects** – projects with a planned end date prior to January 1, 2020 and completed projects.
- **Ongoing Projects** – projects with start dates before October 1, 2017 and end dates after January 1, 2020.
- **New Projects** – projects with start dates after October 1, 2017.

Project scoring involved weighting the evaluation criteria based on each project's category. The weighting for project categories and evaluation criteria is illustrated in Table 4.

Table 4. Project Evaluation Criteria Weighting

		Project Categories		
		Sunsetting and Completed Projects	Ongoing Projects	New Projects
Evaluation Criteria Weights	Project Objectives, Impacts, and Programmatic Alignment	20%	20%	20%
	End User Engagement and Dissemination Strategy	20%	20%	20%
	Management and Technical Approach	20%	20%	20%
	Technical Accomplishments and Progress	40%	20%	0%
	Future Work	0%	20%	40%

Reviewers were asked to evaluate each project on specific criteria: (1) project objectives, impacts, and alignment with the program strategy; (2) end user engagement and dissemination strategy; (3) management and technical approach; (4) technical accomplishments and progress; and (5) future work. These evaluation criteria, as described below, served as the standard template for the scores and comments provided to each project.

- **Project Objectives, Impacts, and Alignment with the Program Strategy**—projects were evaluated on the degree to which:
  - The project performers have described how the project contributes to the program's strategy/ approaches.
  - The project performers have considered and described the use/applications of their expected products and outputs.
  - The project performers have presented the relevance of this project and how successful completion of the project will advance the state of technology, meaningful impacts, and/or the viability of any commercial applications.
- **End User Engagement and Dissemination Strategy**—projects were evaluated on the degree to which:
  - The project performers have identified who will benefit from this project and how the success of the project will advance the industry or meet the needs of specific stakeholder/end user groups.
  - The project performers have explained whether specific industry or end users were engaged/are planned to be engaged and at which points in the project, (i.e., whether an advisory group was set up, whether end user needs were surveyed/assessed, if and how progress/preliminary results are communicated).
  - The project performers have clearly described the rationale for the stakeholder/end user engagement strategy and how project results and information have been/are planned to be disseminated.
- **Management and Technical Approach**—projects were evaluated on the degree to which:
  - The project performers have implemented technically sound R&D approaches and have demonstrated/validated the results needed to meet their targets.

    - The project performers have identified a project management plan that includes well-defined milestones and adequate methods for addressing potential risks.
    - The project performers have clearly described critical success factors, which will define technical viability, and they have explained and understand the challenges they must overcome to achieve success.
- **Technical Accomplishments and Progress**—projects were evaluated on the degree to which:
    - The project performers have made progress in reaching their objectives based on their project management plan.
    - The project performers have described their most important accomplishments in achieving milestones, reaching technical targets, and overcoming technical barriers.
    - The project performers have clearly described the progress since any last review period.
- **Future Work (New and Ongoing Projects Only)**—projects were evaluated on the degree to which:
    - The project performers have outlined adequate plans for future work, including key milestones and go/no-go decision points.
    - The project performers have communicated key planned milestones and addressed how they plan to deal with upcoming decision points and any remaining issues.

WPTO OVERVIEW

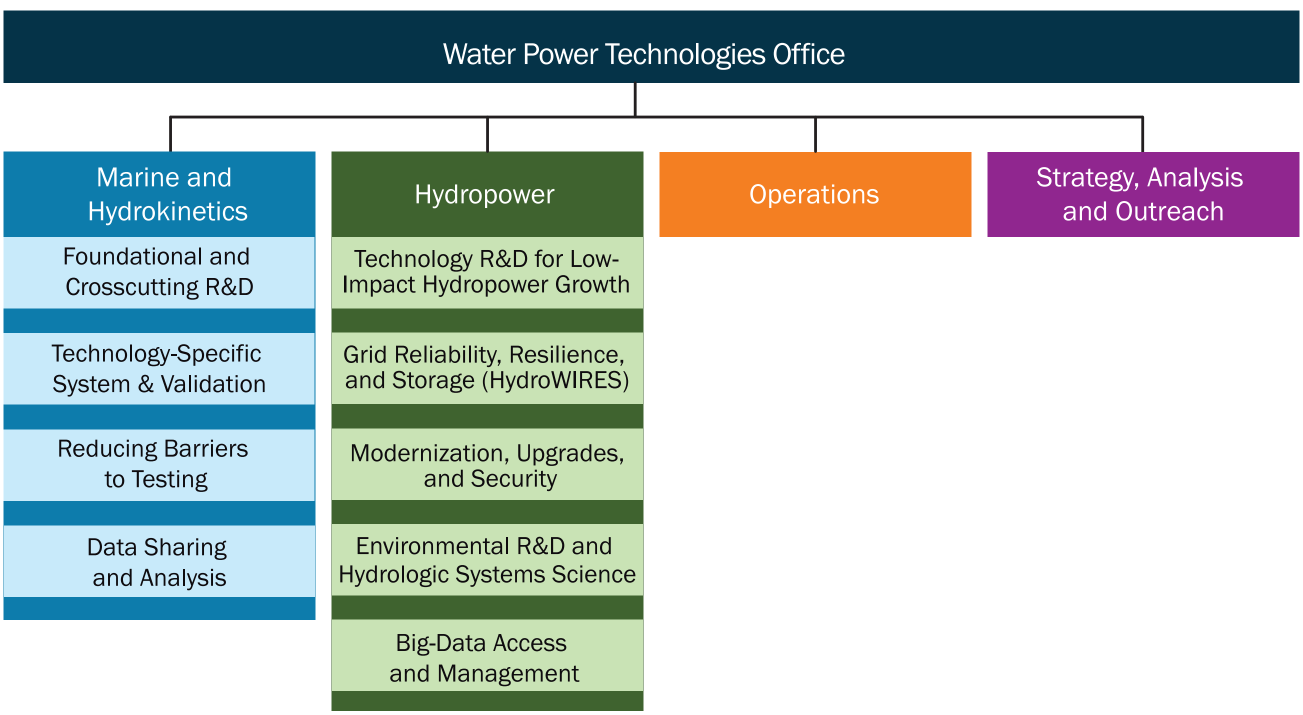
Mission, Values, and Structure

WPTO enables research, development, and testing of emerging technologies to advance marine energy and next-generation hydropower and pumped storage systems for a flexible, reliable grid. WPTO works with national laboratories, industry, universities, and other federal agencies to conduct R&D activities through competitively selected, directly funded, and cost-shared projects. In pursuing these objectives, WPTO always endeavors to:

- Catalyze innovation in technology and science
- Steward natural resources and support the public good
- Expand access to affordable, reliable, and secure energy
- Invest taxpayer funds wisely and to drive the greatest impact
- Collaborate and actively seek input from stakeholders and partners
- Demonstrate transparency and share results widely.

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. WPTO consists of two R&D programs: the MHK Program and the Hydropower Program. The office also has two teams who work across the two programs: the Operations team and the Strategy, Analysis, and Outreach team (Figure 3).

Figure 3. WPTO's Organizational Structure



WPTO considers stakeholder engagement a top priority and strives to engage a diverse array of stakeholders, such as researchers, technology developers, regulators, and the public. Active collaboration and communication among key stakeholders enable WPTO to more effectively achieve its mission by identifying critical challenges in water power research, outlining opportunities for accelerating industry development, and informing the strategy and direction of the office's portfolio. WPTO's Outreach and Engagement Strategy represents values that are essential to WPTO's success, such as appropriately incorporating expert feedback into our R&D and maximizing the impact of DOE's investments.

The WPTO Outreach and Engagement Strategy includes four key goals:

1. **Transparency**: Demonstrate good stewardship of taxpayer funds by persistently and transparently communicating how WPTO funds are utilized and evaluating project impacts.
2. **Feedback**: Gather feedback from stakeholders to inform and improve WPTO projects and strategy.
3. **Dissemination**: Maximize the impact of WPTO-supported research by effectively disseminating results of projects and tracking usage of various products.
4. **Objective and accurate information**: Provide access to accurate and objective information and data that can help to accelerate industry development and inform decision makers.

Outreach and engagement, as well as management and operations, were incorporated into the evaluation criteria for both the program elements and individual projects, as outlined in the previous sections.

Budget

Water power R&D has taken place at DOE consistently since fiscal year (FY) 2008 after the Energy Independence and Security Act of 2007 directed DOE to establish the "Water Power Program." Prior to FY 2016, water power research was conducted in the former Wind and Water Power Technologies Office. In FY 2016, in response to congressional direction, WPTO was established as a standalone office dedicated to marine energy and hydropower R&D. The time period for the 2019 Peer Review included the first three years of WPTO as an independent office.

Funding for DOE's water power R&D has increased considerably since FY 2008, as shown in Figure 4. Congressional appropriations have usually kept the water power portfolio split with roughly two-thirds of the budget focused on marine energy R&D and one-third on hydropower. Figure 5 shows EERE's Office of Renewable Power budget since FY 2008, with WPTO currently representing about 5% of the portfolio.

Figure 4. Water Power Technologies Office budget from FY 2008 to FY 2020

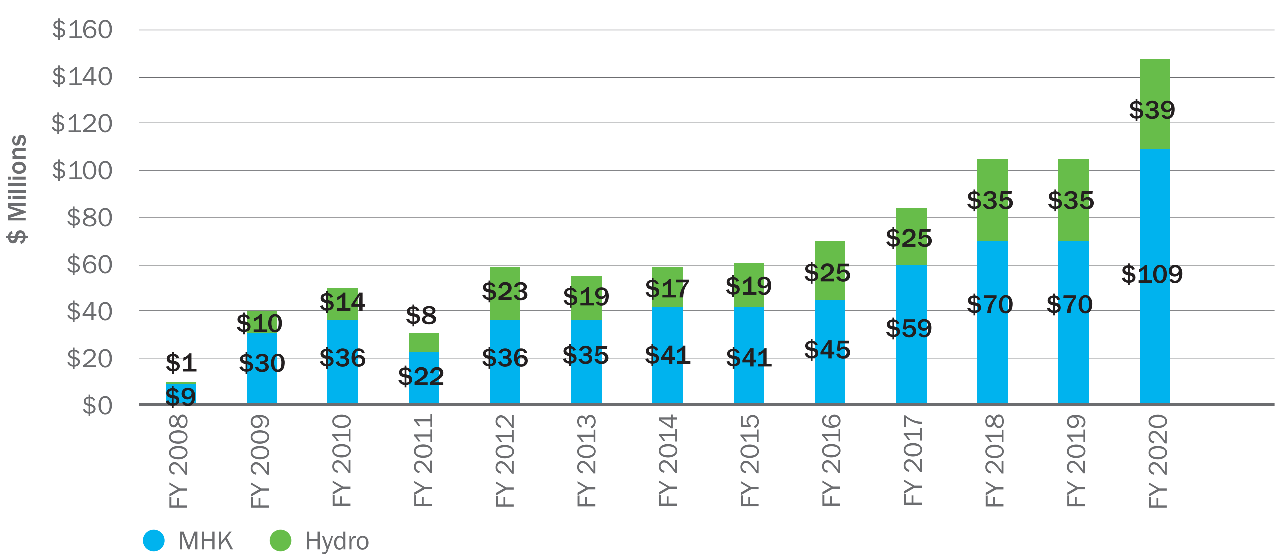
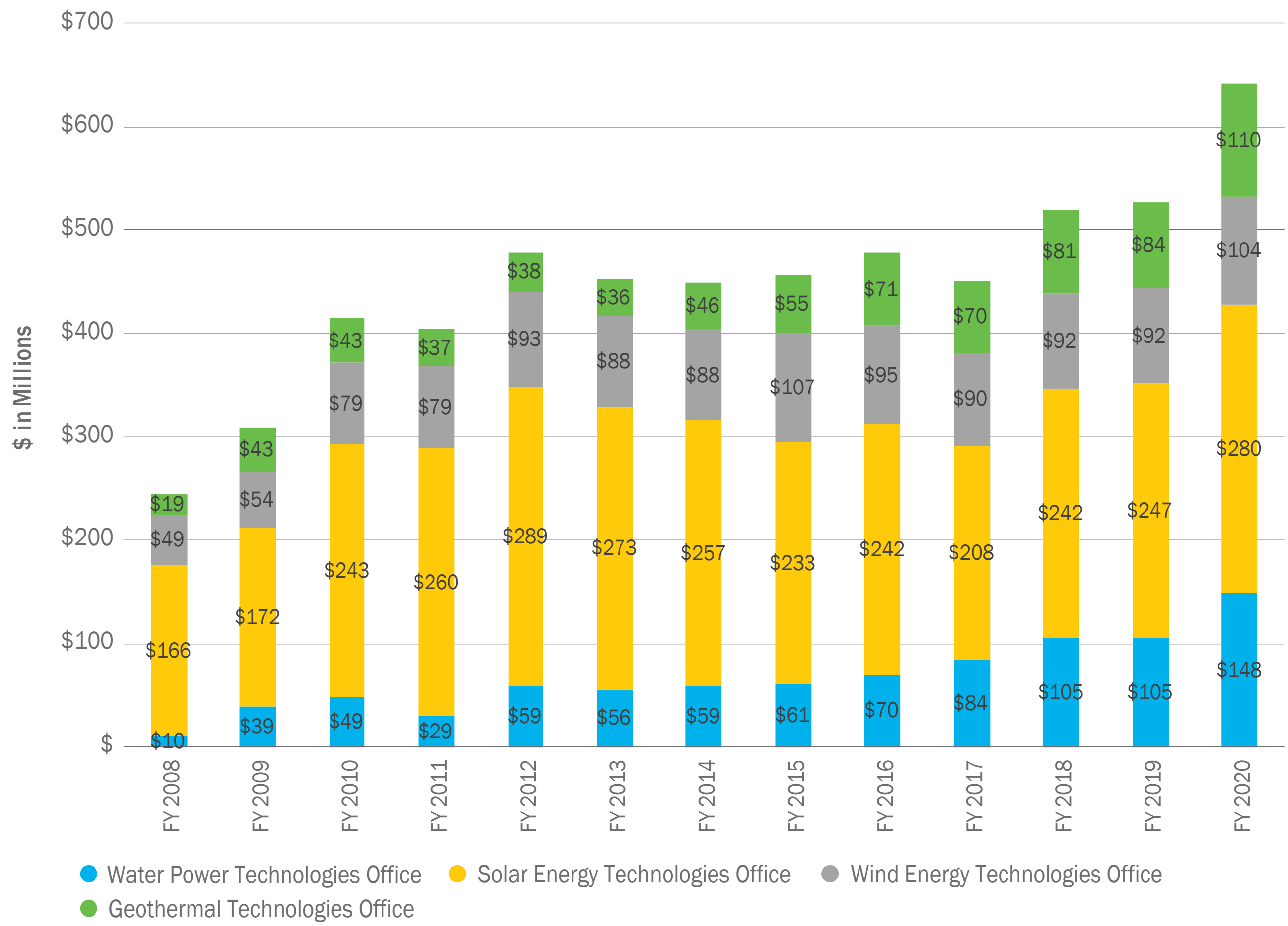


Figure 5. Office of Renewable Power budget from FY 2008 to FY 2020

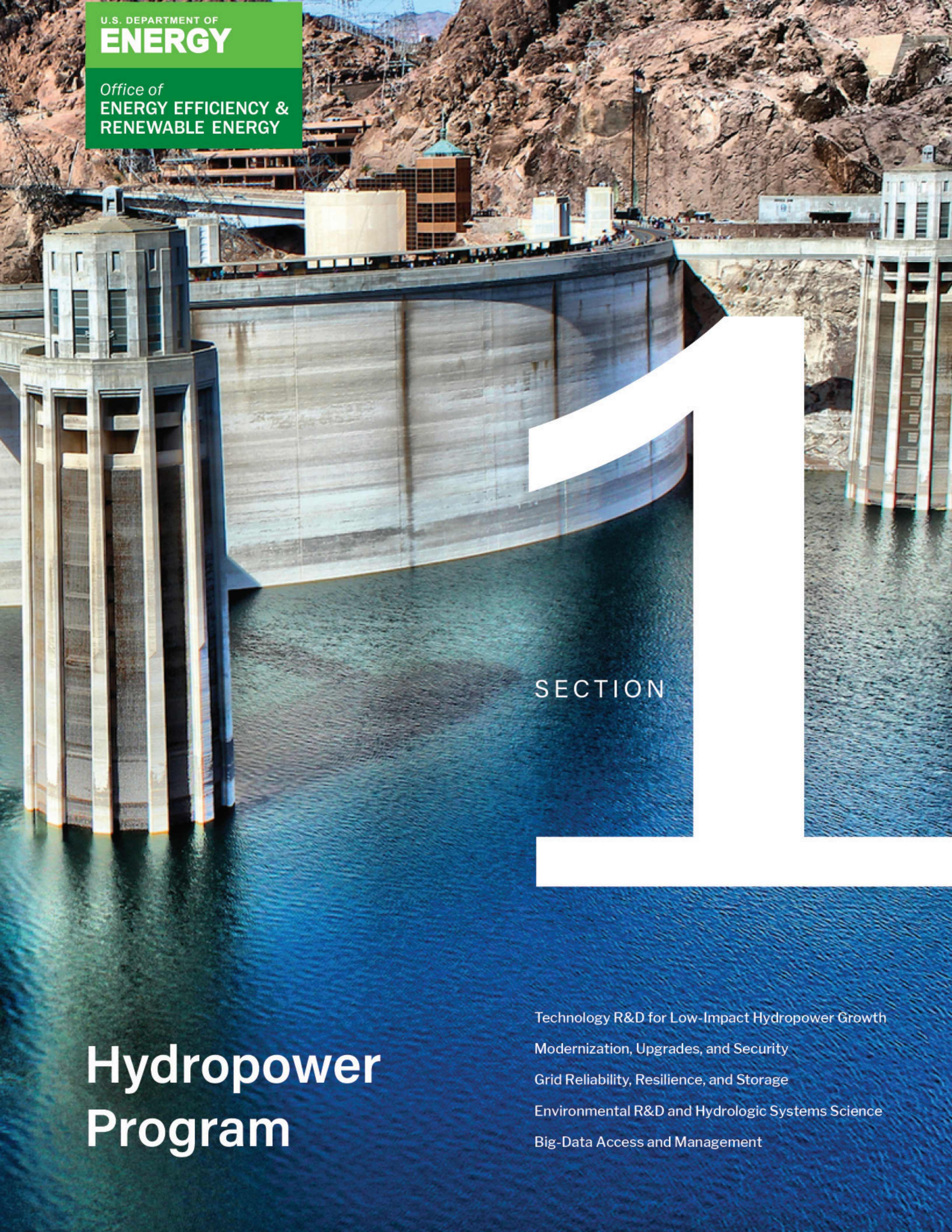


Funding Mechanisms

WPTO leverages a variety of funding mechanisms and increasingly focuses on developing innovative programs and funding mechanisms to support R&D. The following describes the main mechanisms WPTO leverages to fund R&D. The budget breakdown showing how much the MHK and Hydropower Programs executed in each category for FY 2017–FY 2019 can be found in the Program-specific sections of this report.

- **Financial Assistance (public, competitive funding opportunities**) is a vehicle to fund competitive solicitations that aim to identify and fund solutions or ideas that are developed by private industry or academia.
  - Through a **Funding Opportunity Announcement (FOA)**, WPTO provides notice of available funding for R&D projects that address areas of interest identified by the office. Applications submitted through FOAs are evaluated based on publicly shared criteria. Selected applications result in cooperative agreements through which DOE provides multi-year funding with a cost-share commitment from the awardee (though some applicants are exempt from the EERE cost-share requirement, like academic institutions). Cooperative agreements are similar to grants but provide for more involvement between the federal awarding agency and the awardee.
  - The **Small Business Innovations Research (SBIR) and Small Business Technology Transfer (STTR) Programs** are competitive programs targeted to small businesses to support prototyping and commercialization activities. Both programs offer zero cost-share grants through a three-phased approach focused on products and services with commercial potential.

- **Prizes and competitions** use financial awards and other incentives to tap into the ingenuity and creativity of crowds. Prizes are organized with defined goals and within a defined timeframe. Compared to funding made available through DOE FOAs, prizes usually offer smaller funding awards within a faster timeline.
- **National lab-led R&D funded through Annual Operating Plans (AOPs)** are annual contracts with DOE national labs that define the scope, schedule, milestones, and cost for work. This is how WPTO funds national lab partners to conduct research and analysis, as well as to develop tools and resources for the benefit of the water power field. Ongoing, multi-year efforts require merit review.
- **WPTO-funded lab support to industry** are mechanisms that leverage the expertise and resources of the national laboratories, with the intended recipient being industry or academia.
    - **"FOA support"** occurs when labs receive funds to support a FOA awardee. Labs are currently ineligible to apply for WPTO FOAs, but they may be requested by a FOA recipient (from industry or academia) to partner on an awarded project. In these cases, WPTO pays the lab directly.
    - **Small Business Vouchers (SBV)** has funded national labs' support to small businesses to help test, develop, and validate their innovative products.
    - **The Technology Commercialization Fund (TCF)** enables industry to obtain a license to lab-developed technologies. This is a congressionally mandated program which comprises .9% of annual program budgets and requires cost share.
- **The Energy Policy Act (EPAct) 2005 Section 242 Hydro Incentive Program** provides funding for projects adding hydroelectric power generating capabilities to existing dams throughout the United States. This is a congressionally mandated program appropriated to the Hydropower Program.
- All other funded work that does not fall within one of the categories above and involves additional program-led work, including analysis, communications, stakeholder engagement, and dissemination activities.



U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SECTION 1

Hydropower Program

- Technology R&D for Low-Impact Hydropower Growth
- Modernization, Upgrades, and Security
- Grid Reliability, Resilience, and Storage
- Environmental R&D and Hydrologic Systems Science
- Big-Data Access and Management

HYDROPOWER PROGRAM OVERVIEW

Hydropower is America's oldest renewable and currently makes up nearly 7% of U.S. generation. Hydropower has long remained the largest source of renewable electricity generation, accounting for roughly 40% of U.S. renewable electricity generation in 2018; pumped storage hydropower (PSH) remains the largest contributor to U.S. energy storage, with an installed capacity of 21.6 GW or roughly 95% of all commercial storage capacity in the United States.

Vision

A U.S. hydropower and pumped storage industry that is fully utilized to support grid reliability and the integration of other energy resources; capitalizes on new, low-impact opportunities for growth; maintains and optimizes existing assets; and continues to improve the environmental sustainability of hydropower systems.

Mission

To conduct early-stage R&D and applied science to further the development of transformative, cost-effective, reliable, and environmentally sustainable hydropower and pumped storage technologies; to better understand and capitalize on opportunities for hydropower and pumped storage to support a rapidly evolving grid; and to support the use of hydro to improve U.S. energy-water infrastructure and water security.

To achieve the mission and realize the vision of the Hydropower Program, WPTO has identified five core research and development (R&D) activity areas:

1. Technology R&D for Low-Impact Hydropower Growth
2. R&D to Support Modernization, Upgrades, and Security for Existing Hydropower Fleet
3. Grid Reliability, Resilience, and Storage
4. Environmental R&D and Hydrologic Systems Science
5. Big-Data Access and Management.

The Hydropower Program plans to launch a public Request for Information to solicit feedback from stakeholders on its revised programmatic strategy in fiscal year (FY) 2020. Through the revised hydropower strategy, WPTO aims to clearly communicate the rationale for and organization of possible DOE-supported hydropower R&D from now to 2030. The tables below summarize the foundation of the revised strategy—WPTO's description of U.S. hydropower's challenges and the Hydropower Program's approaches to address such challenges.

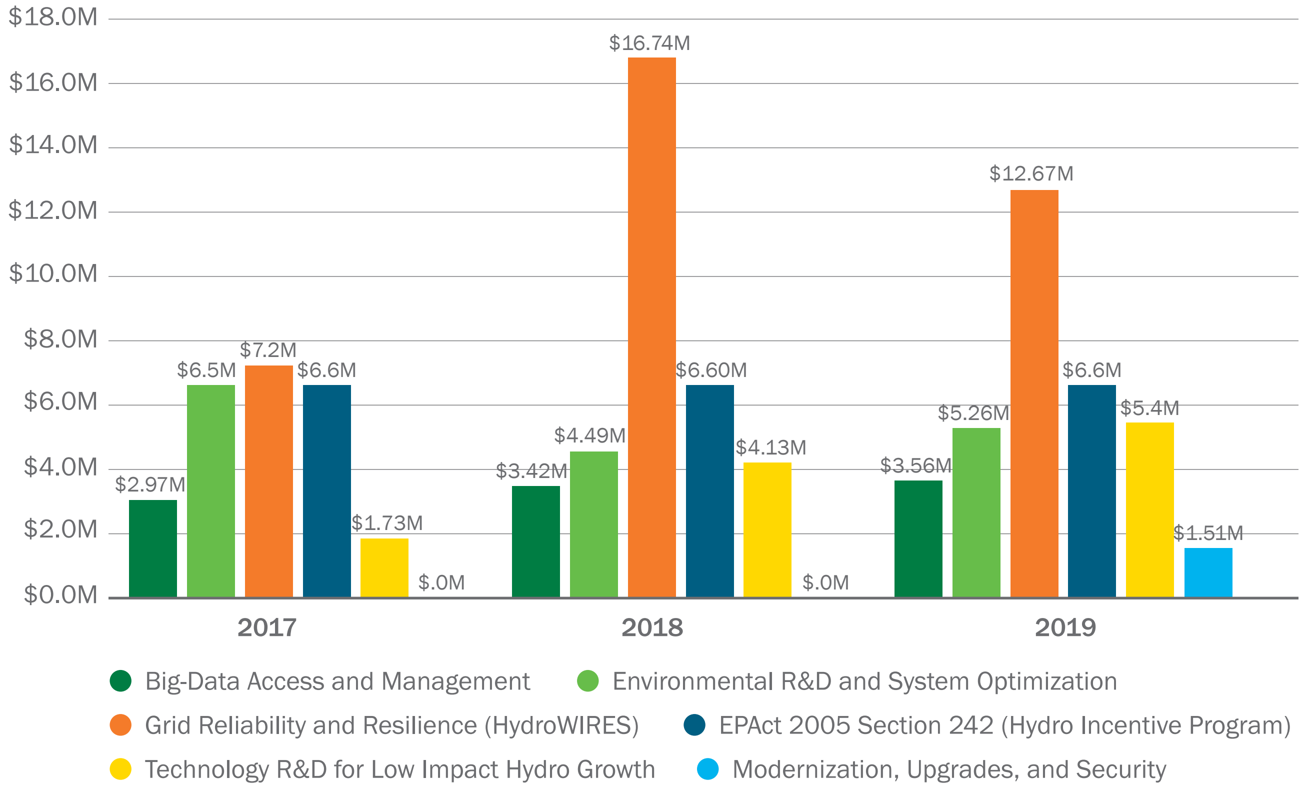
Challenges for Hydropower and Pumped Storage in the U.S.				
Untapped Potential for Hydro & PSH to Better Support Grid Reliability & Integration of Other Energy Resources	**Limited Opportunities for New, Affordable Generation Growth Given Existing Hydro Technologies**	**Maintaining Cost-Competitiveness and Security of Existing Hydropower Assets Given Fleet Age**	**Addressing Environmental Impacts and Balancing Multiple Uses for Water**	**Lack of Access to Information Necessary to Support Decision-Making**
• The electric system is changing rapidly, and existing hydropower and PSH systems were originally optimized to operate under very different conditions. • Significant gaps in information about the costs to hydro and PSH in providing grid reliability and resiliency services. • Hydropower flexibility is constrained by a range of variables including licensing requirements and other water uses. • There has been relatively little attention or research into these areas, especially on the development of new PSH systems.	• Remaining new hydro resources (including non-powered dams and new stream-reaches) are smaller, lower-head, more diverse and distributed, and require new technologies to be cost-competitive. • There can be significant environmental impacts with existing hydro designs/systems; is has been difficult to develop more hydro using existing technologies and meet ecological objectives. • There is a lack of infrastructure and capabilities to test and validate new technologies and designs.	• Introduction on new technologies and upgrades of the existing fleet occur over long time periods given longevity of assets. • Hydropower facilities are extremely different from one another, with wide ranges of operational and physical characteristics and limited information availability. • Hydropower and PSH plants are increasingly connected to information technology systems which heighten cybersecurity risks. • Effective application of digitization requires a heretofore unestablished “right sized” focus on information and analytics.	• The many uses of/for water itself make development and operation of hydropower complicated, with many different variables and sensitives to be considered. • There are analytical challenges in evaluating tradeoffs, and management objectives (environmental recreational, irrigation, etc.) that are changing, and sometimes unclear and difficult to reconcile • Hydropower plants and the environments they are deployed in are both extremely diverse. • There are remaining scientific knowledge gaps around biology, behavior and interaction of many species with hydropower facilities (including limitations in instrumentation and monitoring technologies).	• Information on technologies, available resources, species distribution, markets, etc. is widely dispersed, of differing qualities, and difficult to identity and gain access to. • Regulatory processes are cost and time-intensive, and there is poor information and data available/accessible on regulatory process outcomes and drivers.

WPTO's Approaches to Address Challenges				
Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration	**Technology R&D for Low-Impact Hydropower Growth**	**R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet**	**Environmental R&D and Hydrologic Systems Science**	**Big-Data Access and Management**
• Understand the needs of the rapidly evolving grid and how they create opportunities for hydropower and PSH. • Investigate the full range of hydropower's capabilities to provide grid services, as well as the machine, hydrologic, and institutional constraints to fully utilizing those capabilities to provide grid services. • Invest in innovative technologies that improve hydropower capabilities to provide grid services.	• Enable the development of new technologies for both existing water infrastructure and new stream-reach applications that incorporate ecological and social objectives. • Leverage new advancements in manufacturing and materials to dramatically lower costs of components and systems designs. • Support testing of new technologies, including development of necessary testing infrastructure.	• Create mechanisms to classify hydropower plants by mechanical and cyber-physical systems, providing better characterization of the fleet and allowing identification of exemplary facilities or practices. • Advanced technology solutions and data evolution to improve equipment longevity and condition-based repair. • Creation of cybersecurity tools and studies which help enhance the security of critical dam infrastructure by articulating the cybersecurity target, risk and recovery landscape. • Develop cross-cutting digitalization systems and advanced sensor suites to empower data driven decisions on O&M and asset management.	• Develop better monitoring technologies to evaluate environmental impacts. • Develop technologies and strategies that avoid, minimize, to mitigate ecological impacts. • Support development of metrics for better evaluating environmental sustainability for new hydropower developments. • Assess potential impacts of long-term hydrologic variations to hydropower generation and flexibility. • Improve abilities to assess potential methane emissions from reservoirs. • Better identify opportunities and weigh potential trade-offs across multiple objectives at basin-scales.	• Help industry to manage large, disparate and dissimilar datasets relevant for performance, operations, costs, maintenance, permitting, and environmental mitigation. • Support comprehensive reviews of historical regulatory process drivers and outcomes. • Identify information-sharing mechanisms that could increase coordination among permitting agencies. • Develop effective methods of communicating process complexities to non-technical stakeholders.

Overview of the Hydropower Program during this Peer Review Period

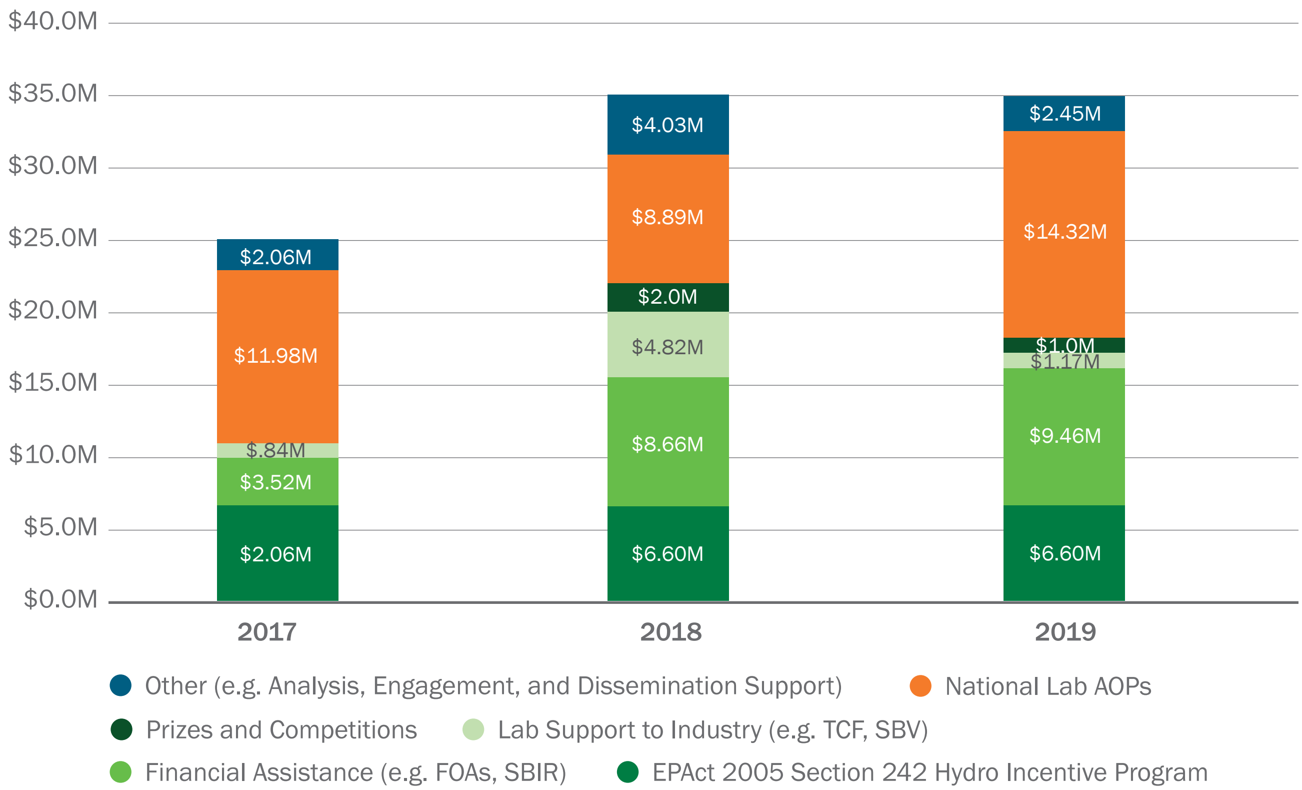
Figure 6 shows the Hydropower Program's spending by activity area over recent years (FY 2017, 2018, and 2019). It should be noted that some of the projects reviewed during the 2019 WPTO Peer Review period were funded with prior year dollars (such as from FY 2016 or before). However, when viewed as a whole, the figure best represents current and recent program funding. Due to the multiyear nature of DOE R&D program planning, some aspects of the portfolio were more heavily emphasized in a particular year. For example, the spike in funding for grid reliability and resilience can be explained by the launch of the HydroWIRES initiative in FY 2018. Though the program had previously invested in this area of research, WPTO set forth new priorities and a targeted approach to an issue that is now more important than ever.

Figure 6. Hydropower Program FY17–FY19 portfolio—total budget by activity area



The Hydropower Program leverages a variety of funding mechanisms, and the distribution by funding mechanism for FY 2017–2019 can be seen in the chart below. For descriptions of each funding mechanism, please see the Funding Mechanisms section of the WPTO Overview. Note that the Hydropower Incentive Program is a mandated program for which Congress specifies the exact funding level each year.

Figure 7. Hydropower Program FY17–FY19 portfolio—total by budget by funding mechanism



The 2019 Peer Review looked at the first three years of WPTO as an independent office, and there were several program developments during this time period:

- **A new grid research initiative**: During this peer review period, WPTO officially the launched the HydroWIRES initiative—a new research initiative to understand, enable, and improve hydropower and PSH's contributions to grid reliability, resilience, and integration in a rapidly evolving electricity system. Though the program had previously invested in this area of research, WPTO set forth new priorities and a targeted approach to an issue that is now more important than ever. The initiative leverages expertise from industry and DOE's national laboratories to understand the value drivers for hydropower, to quantify its unique capabilities and constraints, to improve operations and planning for hydropower alongside other resources, and to invest in technology innovation to improve hydropower capabilities. Key efforts in FY 2019 included industry support for quantifying hydropower flexibility and national lab work to improve hydropower modeling capabilities.
- **Support to the Department's Advanced Energy Storage Initiative**: Through the Advanced Energy Storage Initiative, DOE coordinates research from across all of its applied offices to drive advancements in bi-directional electrical storage, thermal storage, chemical storage, and flexible generation and loads. WPTO, with the HydroWIRES initiative and funding to PSH R&D, is an integral part of DOE's work on innovations in energy storage and grid flexibility. The Hydropower Program supports the Advanced Energy Storage Initiative and continues its focus on hydropower and PSH's roles in grid reliability and resiliency by continuing to support innovative PSH technologies and conducting new research to evaluate and improve the flexibility and grid services provided by hydropower and/or PSH.

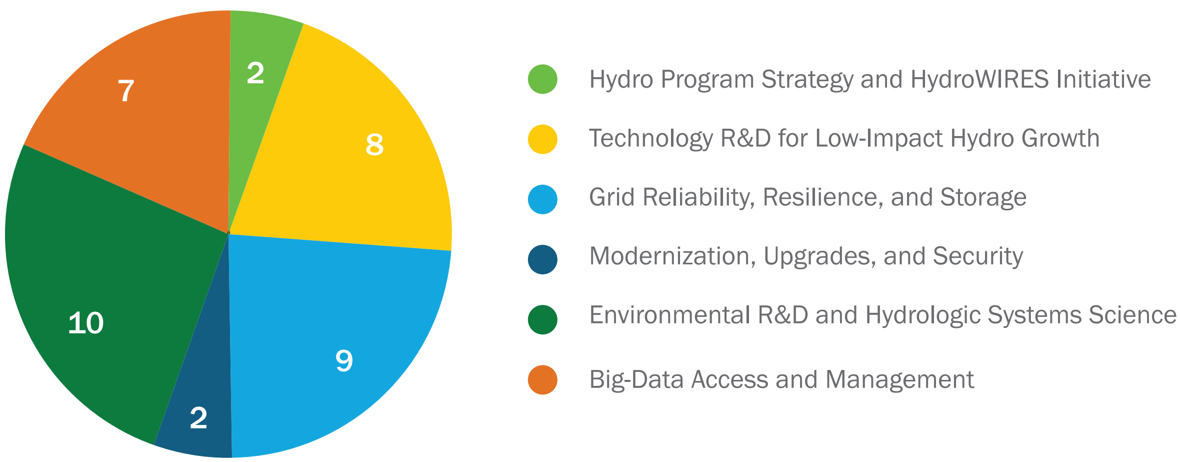
- **Increased efforts to leverage a variety of funding and partnering mechanisms**: For example, in FY 2019, the Hydropower Program launched its first prize competitions. One was in support of HydroWIRES, the FAST prize, which stands for "Furthering Advancements to Shorten Time." Through FAST, WPTO gathered innovative ideas for technology solutions to cut down the time for commissioning pumped storage from 10 years to 5, all while reducing both cost and risk. Finalists participated in a pitch contest the day before peer review, and the winners received up to $550,000 in national laboratory vouchers and cash prize. Also, in FY 2019, WPTO partnered with the Department of Interior's Bureau of Reclamation and other federal agencies to launch a prize seeking innovative methods for excluding fish from water diversions and intakes, the Fish Protection Prize.
    - A Notice of Technical Assistance is another example of a novel partnering mechanism leveraged by the Hydropower Program. In FY 2018, WPTO issued a NOTA to perform techno-economic studies for two selected PSH projects. Project developers applied for the opportunity for the DOE national laboratories to evaluate the long-term value of their potential project. Two sites were selected, and the evaluation methodology applied will be tested and refined, after which, the guidance and valuation tools will be made publicly available for use by the hydropower industry.
- **New design concepts for Standard Modular Hydropower (SMH)**: The program advanced new approaches to hydropower design and, in FY 2018, launched the first FOA to support industry to develop SMH components and site designs. SMH takes a completely new approach to designing hydropower facilities by shifting the design philosophy from custom designing each facility to extract the greatest amount of energy possible and then mitigating environmental impacts, to designing a system with a key goal of sustaining the existing environment. By focusing the design process on sustaining the important hydrologic, hydraulic, geomorphic, physiochemical, and ecologic processes that occur in streams and watersheds, SMH can deliver the benefits of hydropower at lower cost and with greater environmental benefits, while leveraging standardized and modular component designs that are more easily and cheaply manufactured.
- **Small hydropower valuation in alternative markets**: In FY 2019, the Hydropower Program began looking into new areas where hydropower could have major impact (e.g., in irrigation modernization). WPTO funded an initial case study that demonstrated that hydropower co-development can be a key enabler of irrigation modernization while also providing agricultural, economic, environmental, and resiliency benefits to communities across the United States. Thus, WPTO sees irrigation modernization as an example of a business case for developing small hydropower in which generation is not the sole driving factor, which is an alternative market for hydropower. Much like hydropower can unlock greater benefits for an irrigation district trying to improve its infrastructure, there are more markets in which hydropower can enable desired outcomes. WPTO intends to investigate some of these potential markets in FY 2020. Other examples of potential value streams that WPTO may study include water and wastewater treatment, ecosystem and river health, flood control, and historic preservation. Though this is a new area of research that was too new to be reviewed during the 2019 review, it may lead to new areas of work for WPTO in coming years and result in projects for review in a future WPTO peer review.

This bulleted list not only provides context for some of the newer approaches WPTO took during the years under review, but also what to expect from WPTO in future years and in the next WPTO peer review.

Organization of Tracks and Review Panels

Both the Hydropower Program Strategy and individual projects were reviewed and scored during the 2019 WPTO Peer Review. Additionally, the reviewers scored and provided specific feedback on the future direction of HydroWIRES. Three panels of reviewers reviewed these program elements, as well as individual projects across all of the Hydropower Program's technology areas. Figure 8 depicts the total number of hydropower presentations reviewed by program and activity area.

Figure 8. Hydropower Program Portfolio—number of presentations by activity area



The following external experts served as reviewers for the Hydropower Program during the 2019 Peer Review.

Table 5. Hydropower Reviewers

Name	Organization	Review Panel
Greg Lewis*	Duke Energy	New Technology and Modernization
David Hanson	Retired	New Technology and Modernization
David Sinclair	Advanced Hydro Solutions	New Technology and Modernization
Steve Lewis	Sapere Consulting	New Technology and Modernization
Scott Flake**	Independent Consultant	Grid Reliability and Resilience
John Simonelli	Retired	Grid Reliability and Resilience
Charlton Clark	formerly DOE	Grid Reliability and Resilience
Tom Acker	Northern Arizona University	Grid Reliability and Resilience
Tim Brush**	Inter-Fluve	Environmental R&D and Data Management
Colleen McNally-Murphy	American Rivers	Environmental R&D and Data Management
Edith Zagona	University of Colorado-Boulder	Environmental R&D and Data Management
Juliusz Kirejczyk	Independent Consultant	Environmental R&D and Data Management

* Program Review Chair
** Review Panel Lead

Organization of the Results

The quantitative and qualitative results are summarized at the program, activity area, and project level. Information in this section has been compiled based on the following sources and is organized as follows:

1. *Hydropower Program Evaluation Summary*: A summary of all hydropower reviewers' comments that provides insight into the program's strengths and weaknesses or potential issues and specific recommendations. The Program Review Chair was responsible for drafting the program summary report in consultation with each Review Panel Lead and all hydropower reviewers.
2. *Hydropower Programmatic Response*: The program's official response to the recommendations provided in the Review Chair's program evaluation summary.
3. *Hydropower Program Score Results*: The results of the peer reviewers' scores, organized by the activity areas where individual projects were grouped for the 2019 Peer Review. Each subsection includes each activity area's score results, an evaluation summary prepared by the Review Panel Lead, and individual project evaluations.

HYDROPOWER PROGRAM EVALUATION SUMMARY

Prepared by Greg D. Lewis, Hydropower Program Chair

Key Takeaways

WPTO's Hydropower Program is conducting broad, complex, innovative R&D that enhances hydropower's attributes as an increasingly environmentally friendly, flexible, reliable, and sustainable renewable resource for our country's energy and water supply needs. In the spirit of continuous improvement, the fully transparent peer review process used input from experts in the hydropower community to objectively assess the R&D projects within the program's portfolio and provided recommendations for future program improvement. The program staff is dedicated and well qualified and did an excellent job coordinating the peer review. The Hydropower Program assembled a superb peer review panel with extensive knowledge and expertise to gather critical feedback and suggestions. This year's peer review process successfully offered assessments, guidance, and future recommendations that will continue to ensure high-level value and impact from WPTO-supported research.

Feedback from the Review Chair to WPTO

Reviewers were supportive of the overall direction of the Hydropower Program and noted the program's adaptability to the ever-changing energy, environmental, and societal landscapes. The program is investigating some excellent areas of work that have the potential to become transformative, "game changing" innovations. However, as might be realistically expected, there were very wide-ranging project outcomes within this broad and complex portfolio. Reviewers observed some excellent project concepts, with solid project management and well-documented findings included in final reports, but there were also some poorly vetted project concepts, with weak project management and poor accomplishments in relation to the initial objectives. These general observations have led the reviewers to suggest several opportunities for improvement:

1. *Industry expertise and involvement*

While the reviewers acknowledge that some project failures are expected within any R&D portfolio, the reviewers agreed that several of the projects would have benefitted greatly from more engagement with industry stakeholders in the early stages of the project. Reviewers suggested that the program enlist peer reviewers and/or other industry experts, as well as potential end users, earlier and continuously throughout the project process to assist with design reviews and project management oversight, as well as to provide technical advisement. Stronger upfront scrutiny of concepts and designs, using industry and community expertise, would have significantly altered the direction on a few projects and greatly enhanced the stewardship of taxpayer funds as a result. Reviewers agreed that incorporating industry expertise continuously from the beginning to the end of a project could assist WPTO and the project team. Industry experts could support and inform the direction of the program by offering connections to industry partners for disseminating information. Incorporating additional industry expertise, advisement, and end user support earlier in the project process would be a relatively small cost that could significantly reduce project risks and ensure maximum impact of WPTO-supported research.

2. *Additional project management emphasis*

Reviewers agreed that the project management skills exhibited by PIs varied widely. Some projects produced quality summaries for review, delivered extensive final reports, and adhered to a set schedule and budget. Conversely, other projects produced ineffective summaries for review, experienced significant delays in schedule, exceeded budgets, and failed to adequately convey accomplishments in comparison to initial objectives. Reviewers agreed that more attention to the go/no-go frameworks, the decisions that were made, and why they were made during a project's timeline would be helpful. A clearer explanation of expenditures during all previous years, as well as anticipated future budgets, would also be helpful for multi-year and ongoing projects. These observations highlight an opportunity for a stronger emphasis on project management principles and enforcing consistent expectations.

While not every project requires a full-time project manager, the reviewers thought that some PIs had a poor understanding of project management principles. An introductory webinar on project management and WPTO's expectations could help deliver more consistent results for the peer review. Solid project management should include:

- Clear objectives, well-defined scope, and deliverables
- Schedule outline, including critical path activities, milestones, and decision gates or hold points with clear go/no-go criteria
- Complete budget status, including cash flows and contingency amounts spent to date and remaining to be spent
- Regular communications, status meetings, and progress reports
- Risk assessments, performance metrics, and success criteria.

Developing more consistency in the project management approach would benefit the projects, as well as simplify DOE oversight and greatly reduce the unknowns included in the sometimes inconsistent and incomplete information being communicated to reviewers.

3. *Clarify, emphasize, and monitor expectations of PIs*

Reviewers noted that some projects made lofty but unsubstantiated claims of anticipated initial cost reductions, efficiency improvements, or reduced levelized cost of energy (LCOE). Furthermore, there was often a complete lack of compelling evidence or calculation to support these assumptions and "hoped for" claims. A more detailed explanation of expectations upfront to the PIs may help reduce these assertions that appear unfounded. This could include a list of expectations to include final documentation of accomplishments as compared to initial objectives, expected deliverables in the form of presentation summaries and reports, and evidence supporting how their project will meet or has met objectives of lower LCOE, higher efficiency, and lower initial capital costs. Again, it is possible that WPTO may be communicating similar expectations and receiving some substantiating proof of these improved outcomes from the PIs. However, without continuity of reviewer involvement in earlier aspects of the process, reviewers can only judge the projects based on the information "snapshot" that is presented, and unfortunately, that information was often incomplete or lacking compelling evidence.

Several projects were considered monumental undertakings that require extensive amounts of data compilation and analysis. Reviewers acknowledge that there could be value in these tools if they are user friendly and completed successfully, but the volume, complexity, and long-term management of these databases present some concerns that need to be addressed. Large data intensive projects should require quality assurance/quality control (QA/QC) protocols for data, including sample selection and data validation processes. Additionally, a plan and budget for future updating of the databases should be included as an expected budget cost for these projects. Also, these projects must be undertaken with a clear initial focus on engaging the end user to determine how these data tools can be useful to avoid getting mired in superfluous analyses of voluminous available data.

Summary of all Reviewers' Comments

Overall Impressions

There are some solid, innovative projects that can advance the state of the technology within the hydropower portfolio, including some well thought out, planned, managed, executed, and documented projects. Unfortunately, this high level of project performance was not consistently observed for all projects. Based on the limited snapshot of information available to reviewers, opportunities for improvement exist in consistently engaging industry and stakeholder expertise, providing stronger upfront scrutiny of concepts and designs, emphasizing typical project management principles, and more clearly outlining, monitoring, and requiring compliance with Program expectations. Also, including more representation from non-industry stakeholders was suggested as being important to gathering diverse perspectives in the peer review process.

Program Strategy and Objectives

Reviewers agreed that the program did an excellent job of ensuring that all presenters described how their projects aligned with DOE objectives. The consistent introductory slides and generally consistent required summaries were helpful to reviewers. The program's vision and mission statements, as well as the mix of projects, demonstrate an excellent understanding of the near and long-term challenges within the hydropower community. The diverse selection of projects shows investment in early-stage research to accelerate the development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed. Evidence of this innovation was observed in projects that could potentially deliver cost-effective, environmentally friendly advancements in new turbine technology. While there is always room for improvement in a few specific projects within a broad portfolio, reviewers generally agree, that on an overall basis, taxpayer funds have been invested wisely.

Program Portfolio

Reviewers agreed that the projects in the hydropower portfolio contribute to meeting the program's strategy and objectives, though not all projects contributed equally. The diverse projects within this program portfolio are addressing key challenges and reducing barriers to advancing water power technologies, and they are appropriate for WPTO's role as a public R&D organization. As might be expected in a broad and complex portfolio, some projects could benefit from the suggested improvements outlined in the prior sections.

Reviewers were provided a 'snapshot' of information that attempted to capture project accomplishments from several years of investigation. For ongoing projects, a conclusive assessment of the impacts was not always possible since much work remains, so the end effectiveness could not be predicted. In addition, there may have been background information that reviewers did not see or have adequate time to review and digest. Given these circumstances, constructive comments were offered with these limitations in mind.

Program Management Approach

Reviewers agreed that that the projects focused on priority research. In addition, the reviewers agreed that the program team is well qualified and generally effective at directing the activities needed to meet its objectives, but the team could be most effective with occasional support from the hydropower community. Similarly, the program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects, but they could benefit from greater industry and stakeholder input and expertise that could assist with additional project oversight and serve as supporting thought leaders to inform the direction of the program. Reviewers generally agreed that, based on the very narrow time window and limited resulting evidence that peer reviewers can observe, it would be presumptuous to say that the operations and oversight procedures were fully utilized and sufficient.

Stakeholder Engagement, Outreach, and Dissemination

While the engagement, outreach, dissemination, and resulting effectiveness vary by project across the portfolio, reviewers generally agreed that the program transparently communicates how WPTO funds are being utilized and evaluates project impacts internally and externally using the peer review process. This year, the peer review cast a much broader net across the hydropower community and gathered feedback from within the industry and from stakeholders and NGOs in the larger hydropower community. Multiple feedback opportunities were offered in addition to the peer reviews, including the Town Hall feedback forum, suggestion boxes, and websites. All of these can be used to inform and improve WPTO projects and strategy.

Additionally, the early engagement of potential end users, as well as industry and stakeholder experts, could enable earlier, more widespread communication of work underway. These same end users and experts could also fill support roles as thought leaders to inform the direction of the program and offer additional connections to industry partners for disseminating information.

Effective dissemination of information is challenging because many recipients are already suffering from information overload. Sharing a high-level status of the Hydropower Program's various projects at key conferences such as HydroVision International, Waterpower Week, The Centre for Energy Advancement through Technological Innovation (CEATI), and Electric Power Research Institute (EPRI) events provides significant coverage and reaches many potential end users in the industry. Additional communication in Hydro Review Weekly, DOE newsletters and webinars, and other electronic media can also reach a high percentage of hydropower community stakeholders (if they take the time to read it). Other information sharing and gathering opportunities could include periodic engagement of an R&D focus group via meeting or webinar. It was noted that publication of results in journals that are relatively obscure to the hydropower industry will probably not be seen and will have little value to most end users.

HYDROPOWER PROGRAMMATIC RESPONSE

Prepared by Tim Welch, Hydropower Program Manager

Overview

The Hydropower Program would like to thank the reviewers for their time and effort to evaluate our program strategy and R&D portfolio. The program will continue to benefit from external feedback from the hydropower community regarding our strategic direction and the investment of taxpayer funds. The program thanks the reviewers for acknowledging that our mission and vision and diverse portfolio of projects demonstrates an understanding of the near- and long-term challenges facing the hydropower industry. Reviewers noted that the program did an excellent job of ensuring that projects were aligned with strategic objectives and remarked that some projects were "transformative" with "game changing" innovations. We appreciate the recognition of our program staff, whom reviewers described as "dedicated," "well qualified," and "supportive of the overall direction of the program." Overall, reviewers recognized that they only received a limited snapshot of information on each project and outlined several opportunities for improvement in (1) consistently engaging industry and stakeholder expertise to provide stronger upfront scrutiny of concepts and designs, (2) emphasizing typical project management principles, and (3) more clearly outlining, monitoring, and requiring compliance with program expectations. The following sections outline the program's official response to the recommendations provided in the review chair's program evaluation summary, as well as responses to potential issues or specific recommendations noted by the review panel for each individual activity area.

Recommendation 1: Industry expertise and involvement

The reviewers' key recommendation to the program is to focus on increasing direct hydropower industry involvement in the program's R&D portfolio. Reviewers recommended that projects would greatly benefit from continuous industry engagement throughout the life of the project, particularly in the technology R&D portfolio. Though all projects are subject to a comprehensive external merit review prior to funding, we agree that the program would benefit from ongoing involvement of experienced industry reviewers, especially in establishing performance metrics for go/no-go decisions. This ongoing industry engagement would provide necessary expertise to ensure that any technical difficulties encountered during a project could be overcome in a way that would increase the likelihood of success. However, the level of industry engagement should be proportionate to the type and scale of a project.

Recommendation 2: Additional project management emphasis

Reviewers noted an opportunity for the program to improve project management by adding more technical rigor to the go/no-go decision process. We agree with this suggestion and will work to add more rigor to our required milestones and these reviews to focus on results rather than simply project progression. As mentioned above, we are interested in collaborating with the hydropower industry on the performance metrics to use at these go/no-go decision points. Additionally, the reviewers suggested WPTO and PIs provide more details on these milestones in future peer reviews, and noted that some project summaries did not include information on these milestones and failed to describe accomplishments with respect to objectives. Moreover, reviewers noted that some projects were over budget and behind schedule, which raised doubts that oversight procedures were fully utilized and sufficient. However, reviewers recognized that they only received a limited snapshot of information on each project but thought that more background information may have been needed in some cases. The program acknowledges that not all relevant milestones were included in the project summaries and presentations, which may not have given reviewers the necessary insight into the project management process.

The program recognizes the benefit in providing additional project details to reviewers and will work to adjust project templates and guidance and ensure rigorous internal review of materials in future peer reviews. We will work to ensure that PIs put greater emphasis on major project milestones, particularly go/no-go decisions, in project summaries and presentations to give peer reviewers a more complete picture of how the project was managed. In addition, the program is developing a standard framework for a logic model designed to help PIs clearly define and articulate project activities, outputs, outcomes, and impacts, as well as how these align with the program's strategy and approach. WPTO envisions this logic model to serve as both a project management and communication tool that can inform project plans and help better identify meaningful and appropriate data and metrics to monitor and measure. We will pilot the logic model with several project teams in FY 2021 and further encourage PIs to integrate impact-focused thinking into the project lifecycle. Finally, we concur with the recommendation that a training or webinar would be beneficial to lab PIs and new FOA awardees to outline the program's project management expectations.

Recommendation 3: Clarify, emphasize, and monitor expectations of PIs

Reviewers suggested that the program provide more clarity on expectations for PIs, along with more external reviewer involvement. In the individual project evaluations, reviewer comments indicated that this recommendation was primarily focused on two low-scoring projects in the technology R&D portfolio. These projects were selected in 2015 as part of a funding opportunity announcement for research into small turbines for low-head hydropower. From the beginning, we recognized that both projects were high risk endeavors, with an objective focused on cost reductions and greater operational flexibility in low-head hydropower. These projects were carefully monitored throughout the process and ultimately moved forward through the go/no-go decision based to their potential to provide valuable information that could inform future R&D efforts. Though we did not succeed in the potential development/deployment of these new technologies, our research into small turbines for low-head hydropower provided important lessons learned, including:

- Use of advanced manufacturing and composite materials is possible to enable standardization of hydropower components, allowing most parts and tooling to be reused across all units.
- Multi-body dynamic models in a hydropower application can easily simulate and test virtual turbine prototypes of various mechanical designs in a fraction of the time and cost required for physical build and test.
- If a new low-head turbine technology cannot pass fish with near-zero mortality rates, inclusion of fish screens is likely cost prohibitive for standard modular hydropower.

We recognize that continuous industry expertise and involvement may help to manage expectations for future technology R&D projects. To ensure that project goals and objectives are clearly met, the program will work to more clearly develop and define project and program-level metrics to measure successes.

Technology R&D for Low-Impact Hydropower Growth

Reviewers agreed that the program's technology R&D portfolio demonstrates an understanding of the challenges for small hydropower development. The program funds small hydropower R&D projects with an overall goal of lowering the capital costs and reducing the environmental impacts of new development. Across a few projects, reviewers expressed concern that the innovations achieved would be insufficient to ensure small hydropower could compete with current low-cost generation options. For low-impact hydropower growth to become a reality, the program acknowledges that transformational changes must be made in the way hydropower projects are conceived and built. This is the rationale behind the program's standardized, modular approach to hydropower design and development, which can reduce per unit costs and also effectively incorporate ecological and social objectives for river systems earlier in the design process. In addition, hydropower can provide unique value propositions due to synergies with other renewables (e.g., complementary load profiles), system flexibility (for reservoir hydropower), and water system benefits. There is an opportunity to advance the small hydropower value proposition by investigating alternative markets in which non-energy drivers create opportunities for small-scale hydropower development. Moving beyond our program's traditional focus, we will investigate other drivers and markets to illuminate co-benefits, business cases, and specialized markets in order to articulate other systems and environments that may increase the value proposition for small hydropower.

Grid Reliability, Resilience, and Storage/HydroWIRES Initiative

Reviewers were very supportive of the HydroWIRES Initiative, stating that this highly valuable program will offer critical guidance for projects supporting the hydropower industry. One recommendation was for the program to consider reviewing any overlapping study areas among the portfolio to avoid duplication of research, such as overlapping bulk market studies. We acknowledge the concerns of the reviewers and note that part of our motivation for aggregating diverse projects into a unified HydroWIRES portfolio was to manage projects in a comprehensive way to avoid duplication of research. In fact, as a result of the diverse valuation approaches, we are comprehensively evaluating sixteen ongoing FOA projects under a valuation harmonization protocol to understand strengths, weaknesses, and applicability of each approach.

In addition, reviewers recommended that we focus more on end users through engagement with regional industry experts and regulatory experts. Specifically, reviewers recommended that we reach out to independent system operators (ISOs) and regional transmission organizations (RTOs) directly, rather than relying solely on data-based research. We wholeheartedly agree and plan to implement new protocols, such as the use of logic models across the portfolio, to ensure that every PI has a comprehensive and effective plan for disseminating project results to potential end users. In addition, we will work to develop a detailed HydroWIRES engagement strategy that includes a tiered structure of potential end users, including the communities they belong to, their specific organizations, and a targeted assessment of how the goals and objectives of our initiative aligns with their needs. Our HydroWIRES engagement strategy will reach beyond the traditional hydropower community (i.e. National Hydropower Association, (NHA) Northwest Hydroelectric Association, CEATI, utilities, and hydropower OEMs) to engage the broader power system or "grid" community (e.g. Energy Systems Integration Group, Electric Power Research Institute, CEATI Strategic Options for Integrating Emerging Technologies and Distributed Energy Interest Group, ISO/RTOs, National Association of Regulatory Utility Commissioners, etc.). We agree that direct engagement with ISOs is important for effective insight into the evolving U.S. grid; therefore, the HydroWIRES team will meet with a variety ISOs in the immediate future.

Regarding the Hydropower Value Study, reviewers expressed concerns with relying on public data for the value analyses. We understand this concern but recognize that analyzing public data allows the entire community to further investigate and analyze the same data, even if some of the community (e.g. ISOs) will already be aware of it. On the other hand, analyzing private data—when sharing agreements can be established—may unearth new insights but may not allow for deeper investigation by others across the community. We believe that both approaches are necessary for a clear understanding of hydropower value.

Finally, reviewers recommended that HydroWIRES examine the role of hydropower in distribution sector. We agree that a deeper examination into the roles for hydropower and PSH at the distribution scale is warranted, at least with respect to microgrids, and will consider ways to evaluate the most appropriate use cases for hydropower and PSH as well as batteries. More generally, HydroWIRES and the broader DOE portfolio includes investigation of hydropower hybrid configurations (e.g. hydropower/PSH paired with batteries), which could include both microgrid and or residential applications.

Modernization, Upgrades, and Security

Though only two projects were reviewed this year, the reviewers agreed that the modernization, upgrades, and security portfolio contributes to meeting the Hydropower Program's strategy and objectives. Reviewers overwhelming agreed that the Solid-State Processing project was a clear example of investing in early-stage research to accelerate the development of innovative water power technologies, and that this project was worthy of continued investment, considering its low-risk, high-reward potential. Reviewers thought that the Short Intake Flow Measurement Research project exemplified an attempt to overcome long-standing difficulties to validate unit performance and could be used to deliver efficiency gains for many small and medium sized hydro stations.

Reviewers praised the Solid-State Processing project for its breakthrough potential in increasing cavitation resistance of newly manufactured turbines, which is a key challenge that could dramatically lower maintenance costs and reduce outage durations in a high percentage of hydro stations. The program concurs with the reviewers' assessment that the results from this project are promising and represent a major step forward for protection of turbines from cavitation damage. Currently, we are seeking an industry partner to conduct field testing and demonstrate the value of this research.

Regarding the Short-Intake Flow Measurement project, reviewers were most concerned that achieved error levels will likely not lead to significant improvements in intake flow measurements. Reviewers thought that the project should better articulate how flow measurement accuracy will lead to improved hydropower performance, as well as create a process for transmittal of any significant results to the hydropower community. We share the reviewers concerns that the performance of the flow measurement techniques developed in this project do not achieve the stringent accuracy requirements of performance test standards for flow measurement. However, flow measurement in short converging intakes has been a long-standing problem within the industry, and this project presents an improvement to the status quo of existing flow measurement technologies, regarding both timing and measurement accuracy. The project results chart a pathway to reducing the deployment time and effort of flow measurement sensors, as well as enabling non-invasive continuous measurement, which cannot currently be done in short converging intakes. Finally, while we have worked extensively with the U.S. Army Corps of Engineers in field testing, we agree that more extensive and far reaching industry engagement would be valuable to test the higher resolution alternatives and ensure repeatability of the solution in the field.

Environmental R&D and Hydrologic Systems Science

The Environmental R&D portfolio received the highest scores out of all the activity areas. Reviewers agreed that the portfolio of projects is well aligned with the program's objectives and needs of the industry. Reviewers commended our efforts to develop innovative technologies and tools, particularly fish tags. Though a reviewer noted a first-hand negative experience with commercialization of fish tags, that same reviewer also applauded the program for its improvements in this area. Finally, reviewers recognized that the projects included in the Environmental R&D portfolio are clearly addressing key challenges posed by the hydropower industry. With the power of current computers, reviewers stated that the modeling projects will produce very useful results and tools. Similarly, with the advances in materials science, battery miniaturization, and computational fluid dynamics (CFD) tools, reviewers recognized the program's large strides in addressing fish passage and monitoring issues.

Big-Data Access and Management

Overall, reviewers expressed concern with the volume and complexity of our big data management efforts. Reviewers recommended that our data management protocols include QA/QC procedures, such as sample selection and data validation, a plan and budget for future updating, and an initial focus on end users to determine how these datasets can be useful to the hydropower community. We recognize the volume and complexity concerns in our efforts to homogenize and consolidate a diverse range of large hydropower datasets; however, the benefits of this endeavor will confer a wide range of benefits. We will continue to work with ORNL to revisit our data QA/QC practices, including validation, to ensure that we have a solid plan and budget for identifying aberrant data and revising in the future. Additionally, we are reassessing our data strategy overall, while working to strengthen our team's data science expertise. In the near term, we plan to develop a more formal outreach strategy to ensure that our data products meet the needs of end users, both currently and going forward.

Regarding the Hydropower Fleet Intelligence (HFI) project, reviewers expressed concerns about the quality of data and converting data to actionable information. Reviewers recommended additional engagement with the hydropower industry, in particular project operators, and identification and use of other sources of hydropower operational data. We recognize that several of the industry data sources for the HFI project, such as HydroAmp condition data, suffered from significant accuracy issues. We identified the QA/QC issues associated with HydroAmp data and provided recommendations to enable HydroAmp to become a viable source of hydropower condition data in the future. To ensure a reliable source of more current hydropower condition data, we have engaged directly with some major industry utilities for access to more reliable hydropower condition data. In addition, we would like to note our successful efforts with respect to other primary sources of data for reliability and cost (e.g. North American Electric Reliability Corporation's Generating Availability Data System and the Electric Utilities Cost Group) to identify means by which QA/QC procedures can be incorporated into these datasets, with the end goal of identifying aberrant data. Finally, we agree that additional industry engagement is needed for the HFI project to ensure that our results are germane to the needs of the industry with respect to improved O&M cost savings. As part of our future efforts, we will partner with the Hydropower Research Institute and its industry members—U.S. Army Corps of Engineers, Chelan County Public Utility District, and Southern Company—which will provide unprecedented access to reliable hydropower operational data.

Another area of concern for reviewers was related to the objectives and proposed outcomes of the licensing project—An Examination of the Hydropower Licensing and Federal Authorization Process. This project collects both quantitative and qualitative data to identify the costs and uncertainties associated with the U.S. federal regulatory process for non-federal hydropower projects. The reviewers strongly felt that it is not enough just to understand the reasons for regulatory delays, but that the project should make definitive recommendations for how to improve the hydropower regulatory process. For years, delays in the federal hydropower authorization process have been cited as a chilling effect on the growth of hydropower in the U.S. However, the reasons for these delays have been based primarily on anecdotal information from a variety of divergent viewpoints (e.g. the hydropower industry, regulators, and environmental NGOs). To date, there has been no attempt at a science-based, objective, and quantitative analysis of the federal hydropower authorization process. Through our Stakeholder Working Group—a diverse group of hydropower stakeholders from across the hydropower community—we intend to develop a report that comprehensively and objectively examines the full spectrum of federal and state hydropower authorization processes. The report will not include recommendations for regulatory reform because it is not within DOE's mandate to make such recommendations; however, a comprehensive report of this nature provides objective, unbiased information that any parties can consider as part of any efforts to update regulatory processes.

HYDROPOWER PROGRAM SCORE RESULTS

This section provides an overview of the scoring for the Hydropower Program strategy, all projects within the Hydropower Program, and the HydroWIRES Initiative. Reviewers evaluated the Hydropower Program strategy and HydroWIRES on the following, equally weighted criteria: (1) program strategy and objectives; (2) program portfolio; (3) program management approach; and (4) stakeholder engagement, outreach, and dissemination. Reviewers provided scores on a scale of 1 ("unsatisfactory") to 5 ("superior") for each criterion and were also asked to answer unscored, supplemental questions for each program or strategic initiative, which are outlined in Appendix B. A summary of the reviewers' responses to the unscored, supplemental questions were incorporated into the Hydropower Program Evaluation Summary. Figure 9 summarizes the weighted score of the Hydropower Program strategy and average reviewer score according to each program evaluation criteria.

In addition, reviewers were asked to evaluate a set of WPTO's projects, both numerically and with specific, concise comments to support each evaluation. Reviewers evaluated each project on the following specific criteria: (1) project objectives, impacts, and alignment with the program strategy; (2) end user engagement and dissemination strategy; (3) management and technical approach; (4) technical accomplishments and progress; and (5) future work. Project scoring involved weighting the evaluation criteria based upon each project's category—sunsetting/completed, ongoing, or new—which was based on a project's start and/or end date. Reviewers were asked to comment on the strengths and weaknesses behind their scoring and to provide recommendations that they felt that the office should consider. Figure 10 summarizes the average score of all projects within each activity area, the average score of all hydropower projects, the average HydroWIRES strategy score, and the average program strategy score.

Figure 9. Average reviewer score of the Hydropower Program Strategy by program evaluation criteria

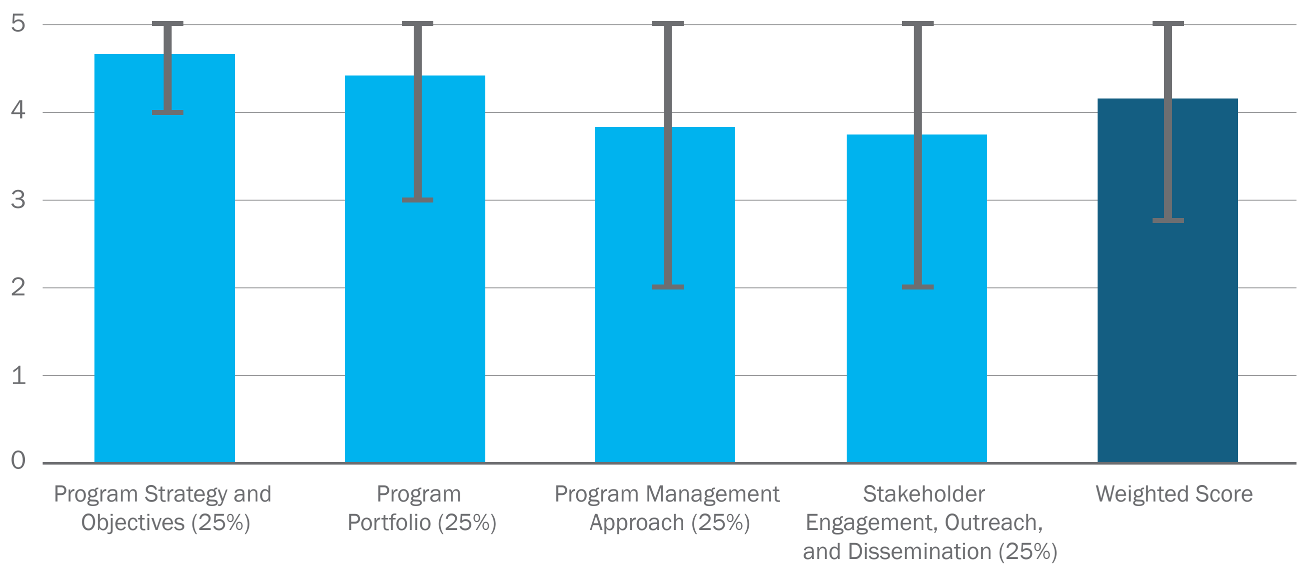
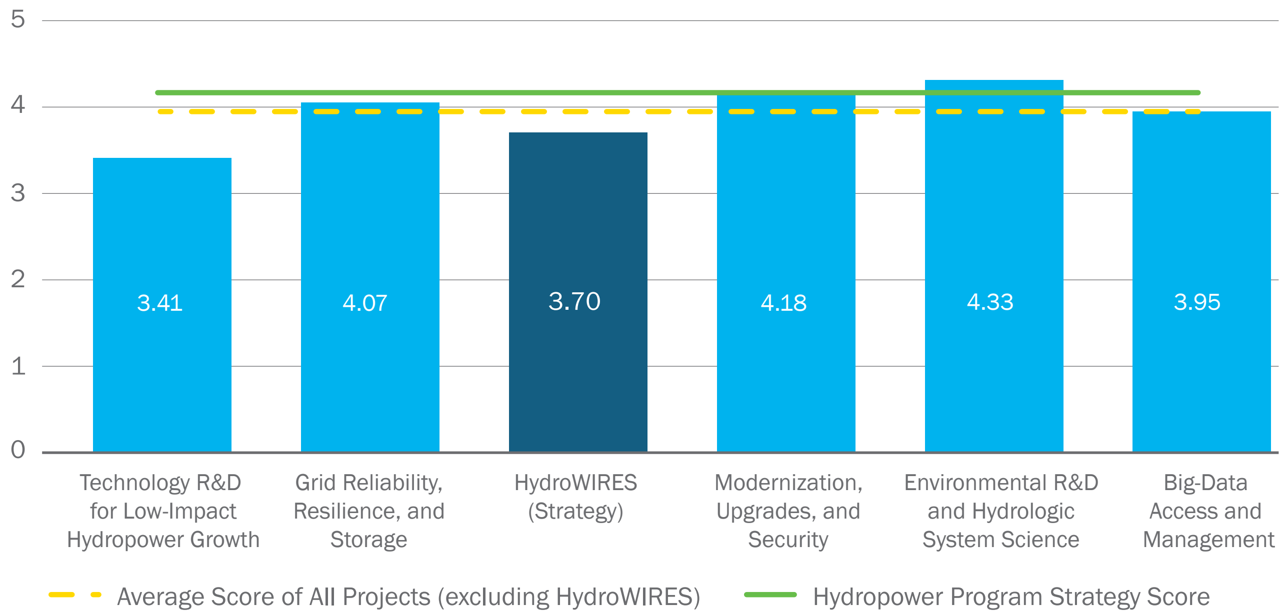


Figure 10. Average weighted score by Hydropower Program activity area



Note: Of the 36 projects reviewed in the Hydropower portfolio, the number of projects reviewed per activity area include: Technology R&D—8 (22%); Grid Reliability—9 (25%); Modernization—2 (6%); Environmental R&D—10 (28%); Big-Data—7 (19%).

Organization of Activity Area and Project Results

The 2019 Peer Review results are organized by the activity areas into which individual projects were grouped for the review. Each subsection (i.e., activity area) includes the following components:

1. *Activity Area Score Results*: This chart depicts the average weighted score for each project in each activity area.
2. *Activity Area Summary Report*: This consists of a summary of the review panel's comments that provides insight into each activity area's strengths and weaknesses or potential issues and specific recommendations. Review panel leads were responsible for drafting activity area evaluation summaries in consultation with the full review panel and program review chair. Consensus among the reviewers was not required, and reviewers were asked to include differences of opinion and dissenting views within the report.
3. *Project Evaluations*: These are individual project reports, which constitute 2–3-page reports summarizing the results of each project evaluated during the review process. Each report includes the following elements:
   a. *Project Name and Work Breakdown Structure (WBS) Number or Award Agreement*: The full project name is listed as the heading, with the identifying code underneath in parentheses. Project evaluations for each activity area are ordered by WBS number, followed by award agreement number, from lowest to highest.
   b. *Weighted Project Score*: Each project's average weighted score is stated numerically. A bar chart depicts the average scores for each evaluation criterion, as well as the range of scores given to the project by the individuals within the review panel. The chart also indicates the average value for each evaluation criterion across all projects within the activity area.

c. *Summary Table*: Each report provides reference information about the project, including the recipient organization, PI name, project dates, project type, and funding values.
   i. *Recipient*: The recipient indicates the organization tasked with leading the project (this may include multiple organizations in situations where the project has more than one recipient).
   ii. *Principal Investigator:* The PI is the individual affiliated with the recipient organization who is assigned to lead the project.
   iii. *Project Category*: Each project is categorized as sunsetting, ongoing, or new, based on its start/end date.
   iv. *Project Type*: There are many types of projects within the WPTO portfolio, but this review focused primarily on two types of projects: (1) AOPs, which are core R&D projects performed by DOE's national laboratories, and (2) projects awarded through a FOA, which are indicated in this table by listing the FOA's name or number.
   v. *Funding*: Each project includes total costed and total authorized. Total costed is the budget executed during the full peer review period (from FY17 through Q2 of FY19). Total authorized for AOPs is the sum of prior year (FY16) carryover and budget authorized during the full peer review period (from FY17 through Q2 of FY19). Total authorized for FOAs is the total DOE negotiated award amount, including amounts allocated to sub-recipients.
   vi. *Project Descriptions*: Project descriptions are compiled from the project summaries that the PIs submitted for each project.

vii. *Summary of All Reviewers' Comments*: Reviewers were responsible for consolidating and summarizing all reviewer comments on their assigned projects, in consultation with the review panel leads and program chairs. These project evaluation summaries were edited only for grammar and clarity. In a limited number of cases, reviewer remarks deemed inappropriate or irrelevant were excluded from the final report.

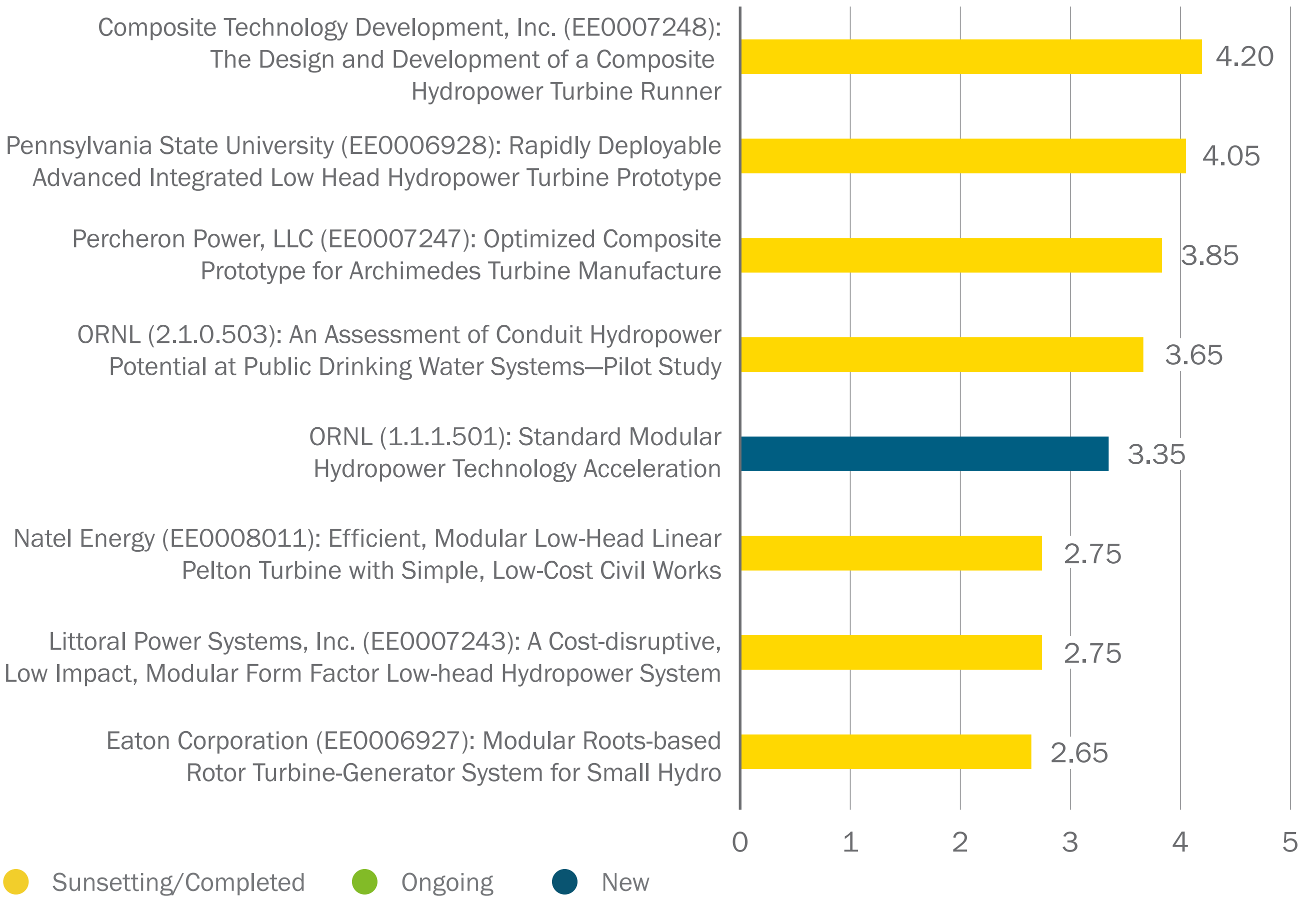
Technology R&D for Low-Impact Hydropower Growth

This section provides an overview of the scoring for all projects within the Technology R&D for Low-Impact Hydropower Growth activity area (see Figure 11); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Technology R&D for Low-Impact Hydropower Growth	**3.41**

Figure 11. Technology R&D for Low-Impact Hydropower Growth activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

There were very wide-ranging project outcomes in the Technology R&D for Low-Impact Hydropower Growth (Tech R&D) portfolio. Reviewers observed some excellent project concepts with solid project management and documented findings in final reports, but also some poorly vetted project concepts with weak project management and poor accomplishments in relation to the initial objectives.

Summary of all Reviewers' Comments

Overall Impressions

There were some solid, innovative projects that can advance the state of the technology within the Tech R&D portfolio, including some well executed, managed, and documented projects. Unfortunately, this was not consistent from project to project. Opportunities for improvement exist in consistently engaging industry expertise, providing stronger upfront scrutiny of concepts and designs, emphasizing project management principles, and more clearly outlining, monitoring, and requiring compliance with expectations.

Program Strategy and Objectives

The reviewers generally agreed that the program did an excellent job of ensuring that all presenters described how their projects aligned with DOE objectives. The consistent introductory slides and generally consistent required summaries were helpful to reviewers. The mix of Tech R&D projects demonstrate an understanding of the near and long-term challenges facing industry and other stakeholders for low-impact hydro growth to have any chance to occur. A couple projects also displayed innovative potential that could possibly help some struggling existing locations through future use of more cost-effective, environmentally friendly technology advancements. The diverse selection of Tech R&D projects shows investment in early-stage research to accelerate the development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed.

Program Portfolio

Reviewers generally agreed that, while not all projects contributed equally to the results within this program portfolio, overall, the projects contribute to meeting the program's strategy and objectives. The projects within this program portfolio are addressing key challenges and reducing barriers to advance water power technologies and are appropriate for WPTO's role as a public R&D organization, but could benefit by the improvements outlined in the "Feedback from the Review Panel to WPTO" section above.

Program Management Approach

Tech R&D reviewers generally agreed that the program team effectively manages and directs the activities needed to meet its objectives but could use a little help from industry to be most effective. Similarly, the program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects, but they could benefit from greater input from industry experts, who could provide additional project oversight and serve as supporting thought leaders to inform the direction of the program. Reviewers agreed that, based on the very narrow time window and limited resulting evidence that peer reviewers can observe, it would be difficult to say that the operations and oversight procedures were fully utilized and sufficient. See suggested improvements above.

Stakeholder Engagement, Outreach, and Dissemination

While the engagement, outreach, dissemination, and resulting effectiveness vary by project in the Tech R&D portfolio, reviewers generally agreed that the program transparently communicates how WPTO funds are being utilized and evaluates project impacts internally and also externally using the peer review process. This year, the peer review meeting cast a much broader net across the hydro community and gathered feedback from within the industry and from stakeholders and NGOs in the larger hydro community. Multiple feedback opportunities were offered in addition to the peer reviews and included the Town Hall feedback forum, suggestion boxes, and websites. All of these can be used to inform and improve WPTO projects and strategy. Finally, the engagement of industry experts could also fill a support role as thought leaders to inform the direction of the program and offer connections to industry partners for disseminating information.

STANDARD MODULAR HYDROPOWER TECHNOLOGY ACCELERATION

(WBS #: 1.1.1.501)

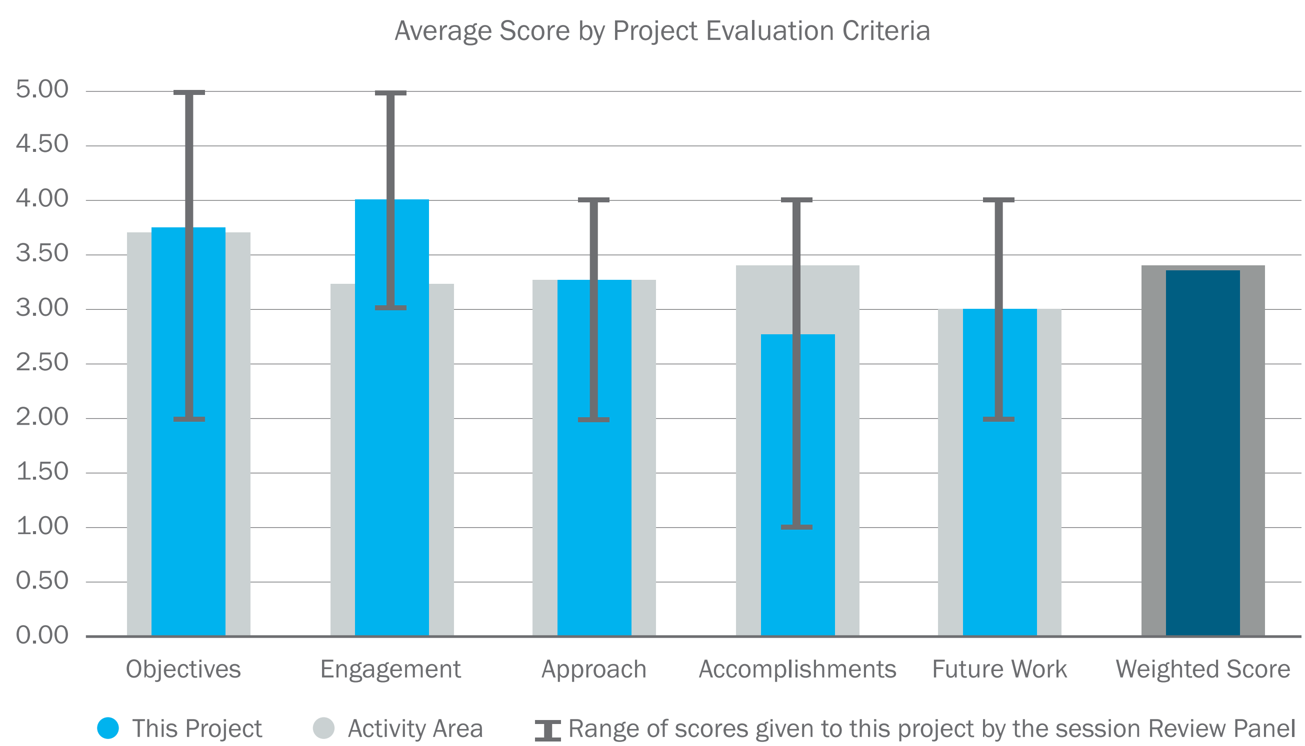
Recipient:	ORNL
Principal Investigator:	Brennan Smith
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$3,260K
Total Costed:	$2,679K

Project Description

This project's objective is to explore new ways to site, design, develop, and operate small hydropower facilities in the United States at lower costs with greater environmental compatibility. SMH R&D focuses on three areas: (1) standardization of design, review, manufacturing, and other features to reduce site specificity and project costs; (2) modularity of a hydropower facility into discrete functional units, allowing scalability to deliver energy and environmental benefits at many different sites; and (3) priority design objectives for environmental compatibility to maintain stream functionality and ecosystem health.

Weighted Project Score: 3.4

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

This is a bold plan for the development of new stream reaches by starting with environmental and recreational improvements, then adding hydropower as an ancillary component, which reviewers found intriguing. The challenge will be two-fold: (1) seeking out funding sources for those primary elements, as the hydropower will not provide the economic driver, and (2) convincing non-governmental organizations (NGOs) and state agencies of the value of this approach.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project aims to change how the United States approaches hydropower development to strip away some of the site-specific planning requirements, regulatory hurdles, and environmental impacts that hinder development in the increasingly competitive energy generation space. It is not clear how the project approach accomplishes the goals of enabling the design and development of new SMH or how it leverages new advancements. It seems like the project is simply a quasi-advertising process for small modular approaches. The summary provides little information regarding what the end products will include, such as models, design tools, testing facilities, and assessment protocols. Researchers must focus on stakeholder engagement and the effort to shift the paradigm.

End User Engagement and Dissemination Strategy

The project presenter identified the primary end users of the new approach to be technology developers, environmental stakeholders, and hydropower project developers. The presenter's descriptions of how stakeholders have been engaged so far consist of U.S. Department of Energy (DOE)-funded projects involving manufacturing, facilitated stakeholder engagement, and a stakeholder review board. It is unclear if any plans are underway to demonstrate SMH at a site under development. Technical and academic resources have been utilized; however, industry manufacturers and developers have been less involved. The process of end user engagement was explained, but it is not clear if the end users who were targeted as part of the meetings and feedback from publications are the right audience.

Dissemination of progress is comprehensive—ranging from project website updates, publications in peer-reviewed journals, and conference presentations but underestimates the incredible task of convincing NGOs and state agencies of the value of SMH. Reviewer's comments suggested they generally agreed that a lot of unique work has been accomplished and information disseminated to those that have an interest in small hydropower development, and that information on smh.ornl.gov website is pretty extensive and useful.

Management and Technical Approach

The project management approach primarily states that the work is fully orchestrated by Oak Ridge National Laboratory (ORNL), utilizing a wide variety of expertise from researchers and staff with hydropower backgrounds, as well as a host of subcontractors ranging from design engineers, sediment transport/ geomorphology experts, and outside facilitation. The project is on schedule and under budget, but there is no supporting information.

The project has a conceptual goal but does not really have concrete success criteria or metrics in place. The stated areas of technical advancement do not appear to have results at this time. It is unclear whether standard project management practices are in place for the project, which will be important given the relatively large scope of the project. The basic premise that modularity reduces cost while increasing flexibility has not been proven, yet it is treated as a given in this project. Every stream and non-powered dam in the United States has its own peculiarities, which no amount of standardization can address. Secondly, no matter how much one can standardize components, the cost of new stream development yields no adequate return on investment with today's wholesale electrical pricing.

Technical Accomplishments and Progress

The technical progress and accomplishments made so far for this project are primarily a reiteration of the same material presented throughout the presentation, consisting of a list of publications issued for the SMH program. It is unclear what technical accomplishments have been made.

ORNL is engaging at several fronts: (1) partnering with other grant awardees related to new turbine designs and modular concepts and (2) supporting DOE in the formulation of funding opportunity announcements. This project is the hub of a concerted effort by DOE/ORNL to change the way small untapped hydropower opportunities are evaluated and implemented. However, feedback received from stakeholder engagement seems to be missing. It is unclear whether the environmental community has embraced this new paradigm for new hydropower development, and whether they expressed an interest in working with hydropower developers within the new paradigm to promote SMH.

The processes and framing have been developed, but the proof will be when SMH deployments start to happen. There are many challenges that are inherent in such a complex undertaking. While the goal of standardizing modular small hydropower deployments is admirable, it seems doubtful—given the variability of river and stream environments, as well as local interests—that standardization is a realistic goal.

Future Work

Future work for this project is contingent on wider stakeholder engagement. Researchers should focus less on ideas for modules and more on describing the benefits of stream reach development to NGOs, local governments, and other stakeholders outside of hydro. Current turbine/generator programs have been unsuccessful and should not be included in this effort. Future work would benefit greatly from a process to ensure that (1) the project has a clear, succinct, and well-stated goal, and (2) the work supports the objectives of such goal.

As stated by the PI, the approach to the development of new hydropower facilities in the U.S. should be based on the concept of river functionality, which essentially means work with the river rather than tame the river. Convening stakeholder focus groups to help guide and inform the development of these new concepts is imperative, particularly from the environmental/recreational community that are key players in licensing new hydropower facilities. There are doubts whether one can remove the site-specificity of environmental issues, but on generic issues such as fish passage and sediment transport through the new facility, the approach may be successful.

AN ASSESSMENT OF CONDUIT HYDROPOWER POTENTIAL AT PUBLIC DRINKING WATER SYSTEMS—PILOT STUDY

(WBS #: 2.1.0.503)

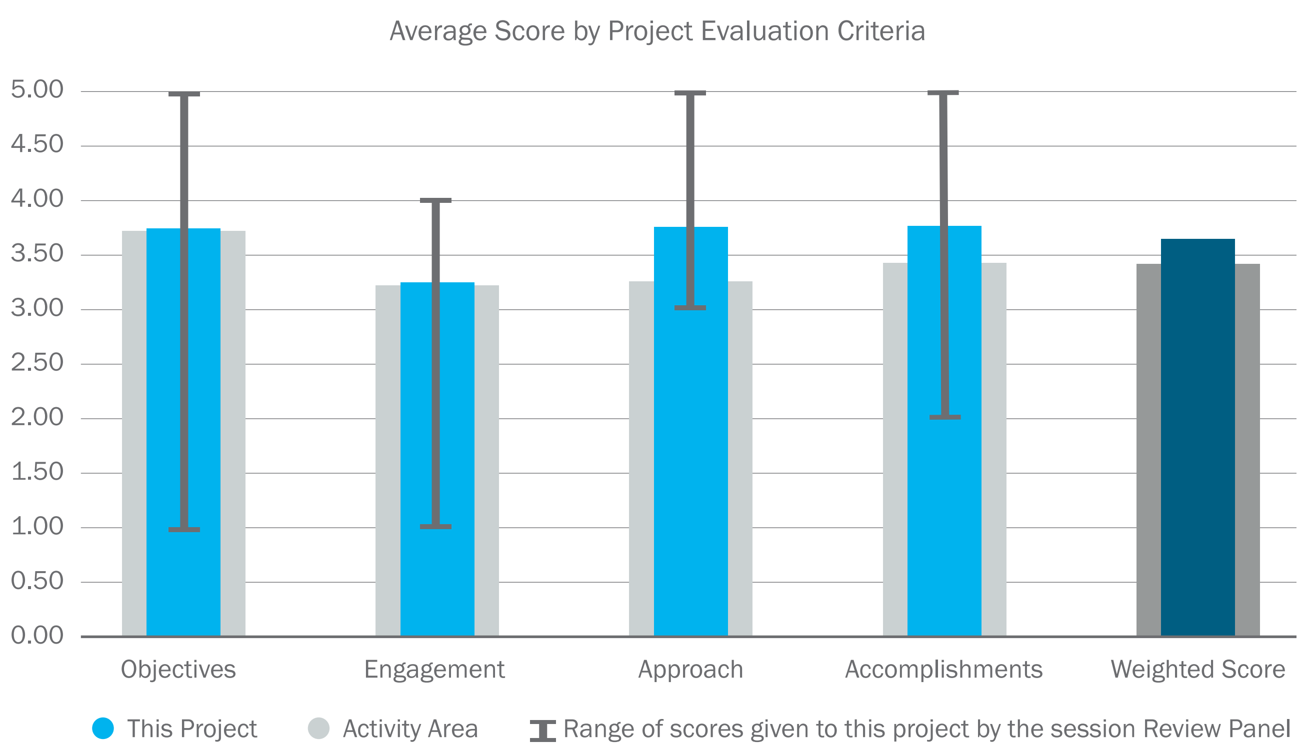
Recipient:	ORNL
Principal Investigator:	Shih-Chieh Kao
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$75K
Total Costed:	$75K

Project Description

This project was awarded to Telluride Energy and ORNL by the DOE SBV Pilot Program in FY 2017. Under a cooperative research and development agreement, Telluride Energy and ORNL designed a geospatial assessment approach to estimate the total undeveloped conduit hydropower potential at public water systems, which might be retrofitted with hydropower to take advantage of the expedited permitting process through the Hydropower Regulatory Efficiency Act of 2013. The project team collected and analyzed multiple public and nonpublic datasets in this pilot study for the states of Oregon and Colorado. The assessment can be further expanded to quantify the national public water systems conduit hydropower potential and their interregional differences across the country.

Weighted Project Score: 3.7

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

This project represents a focused and well-executed pilot study that illuminates the potential for conduit hydropower in public drinking water supplies of two key states. Whether the investigation should be expanded to other states is uncertain given the relatively small amounts of energy predicted by the pilot study. As acknowledged by the PI, most water districts/agencies are well aware of the pressure-reducing valve opportunities for hydropower development in their systems, which suggests that enumerating the potential generation throughout the country may not significantly alter current DOE policy. The team should consider focusing future efforts on developing a user application package of benefits and analysis models, as well as promoting the value of undertaking these conversions, such as the addition of battery storage that could be integrated into their water supply operations.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers all agreed that the project was based on clearly stated objectives; potential benefits are straightforward; and the project is inexpensive. The project clearly lays out the value of exploring this area given the advent of legislation that eases licensing of conduit hydropower and the opportunities to gain economic benefit via net metering.

End User Engagement and Dissemination Strategy

The end users are defined as water districts and water agencies. The primary engagement and dissemination of information described has been passive via SBV, which closely collaborates with national laboratories. This seems appropriate as this is a pilot project with little need for external input. If this effort expands to other states, it would be useful for ORNL researchers to examine the level of use of the ORNL website by water districts throughout the country and determine whether or not a more focused outreach strategy is needed

Management and Technical Approach

The reviewers agreed that the technical approach is sound and thorough, and many were surprised given the limited budget of this project. The technical approach demonstrates a clear algorithm for estimating generation potential, the sources of information that were gathered (including the need for non-disclosure agreements to garner data on intake locations), as well as a discussion of why pumped groundwater added to the conduit system was not used. The only improvement suggested by one reviewer was that the project could have identified specific sites to do more thorough engineering reviews as a test against the generalized approach to validate the capacity and energy potential for Oregon and Colorado.

Technical Accomplishments and Progress

The reviewers generally agreed that the technical accomplishments of this project align with the original objectives of investigating: (1) the number of potential sites in Oregon and Colorado, (2) their cumulative capacity, and (3) their cumulative estimated annual energy production. These results are valuable as an initial reconnaissance-level evaluation of the potential hydropower generation at conduits operated by municipal water agencies and districts in two states with favorable topography, surface water resources, and population levels. Overall, progress appears to be very good, but the opportunity appears to be very small.

MODULAR ROOTS-BASED ROTOR TURBINE-GENERATOR SYSTEM FOR SMALL HYDRO

(WBS #: EE0006927)

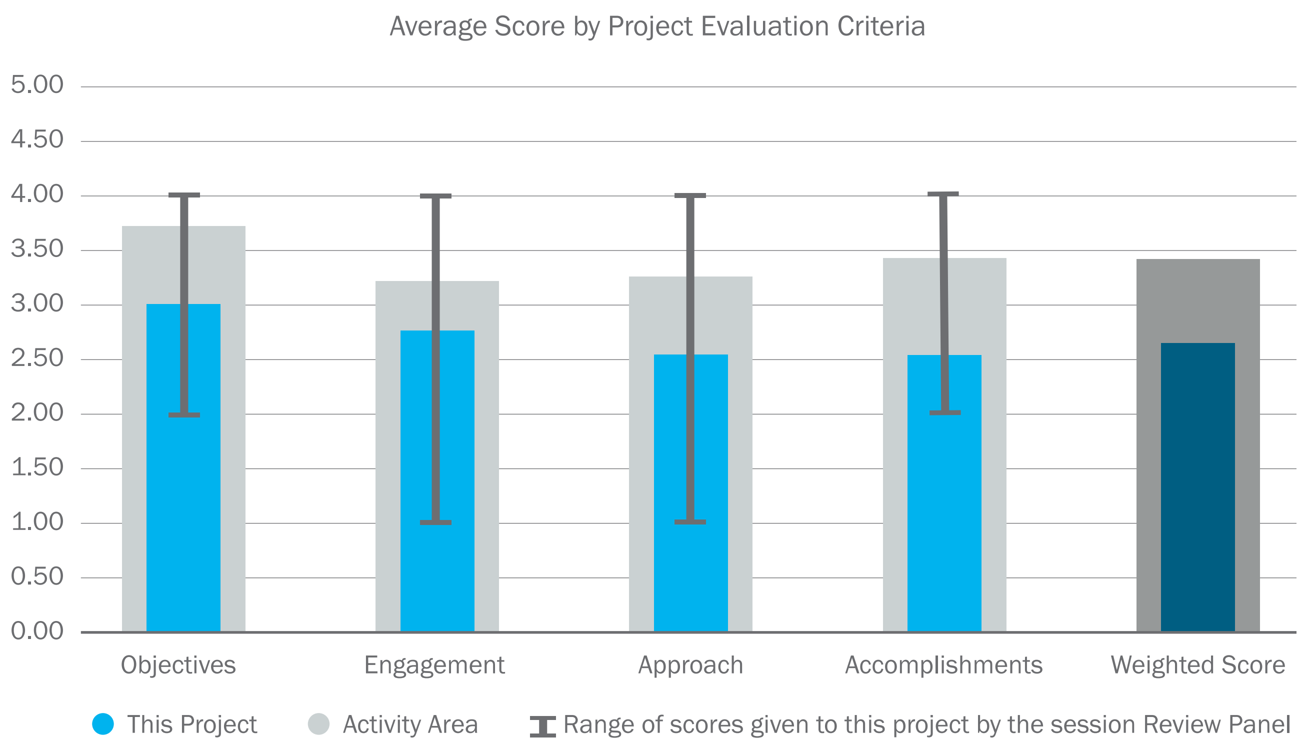
Recipient:	Eaton Corporation
Principal Investigator:	David Yee
Project Type:	FOA 1006: Water Power Manufacturing
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$2,549K
Total Costed:	$1,549K

Project Description

Approximately 50 GW of potential renewable power is residing in more than 25,000 U.S. non-powered dams having low head and flow. This resource remains untapped because it is not cost effective to scale-down and deploy traditional large hydro turbine systems into these applications. This project's objective is to develop and demonstrate a Roots-based turbine-generator system that can cost-effectively deliver power from these existing non-powered dams. The Roots device is uniquely qualified to meet the application needs because it has a broader efficiency window when compared to traditional turbine runners.

Weighted Project Score: 2.7

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

In general, the research at this stage does not provide a compelling case that modular turbine designs of the Roots-based turbine-generator can be installed at non-power dams at sufficient low cost and/or improved efficiencies to achieve the LCOE values needed to make low-head, small hydropower competitive with solar and wind development. This project could have benefitted by a rigorous design review in the early stages with input from other industry experts. A design review would better guide the PI away from challenging hard spots and also better inform the DOE regarding the risks that need to be overcome prior to the go/no-go decision point. Providing additional industry expertise as part of the oversight team to follow along each project throughout its full lifecycle would have been money well spent to assist both the PI and DOE.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were in general agreement that the objectives were clearly stated as to how the project aligns itself with the DOE program objectives. However, the reviewers generally expressed concerns regarding unresolved challenges, including the need for a gearbox/variable speed system that would potentially double costs, close gaps between the rotors and body that would make the system unstable under conditions of high silt and debris.

End User Engagement and Dissemination Strategy

The reviewers generally agreed that the end users of the research were well described as dam owners (utilities, water agencies, etc.); engineering, procurement, and construction firms; manufacturing companies; and ultimately, consumers benefiting from a lower LCOE value project. The reviewers also concluded that the researchers engaged a variety of entities in conversations to receive preliminary feedback on design elements of the project. However, reviewers generally felt that the project could have benefitted greatly by an industry advisory group (or design review) since the PI may not have been familiar with typical operational challenges in hydro waterways and relied on subcontractors that apparently did not raise appropriate risk concerns with the PI.

Management and Technical Approach

There was general agreement among the reviewers regarding how well the project was planned, including a clear description of the roles and responsibilities of different members of the research program. However, the core team of the program does not appear to have specific expertise in turbine design or practical in-field operations and maintenance (O&M) issues. Project management has struggled to deliver a working device and has fallen behind schedule by a year or more. A good design review early on should have determined that the close clearances of this Roots-type device were not very compatible with real-world waterborne debris loading and fish turbine mortality issues that would be present in the majority of applications with this device. Additionally, debris removal systems, which would be necessary to eliminate all but the very small contaminants, would be extremely maintenance intensive in most waterways and would add significantly to the cost challenges of this system. As a result, this device would have limited opportunities for economically viable hydropower installations

Technical Accomplishments and Progress

With respect to the technical accomplishments, there were mixed comments among the reviewers. While reviewers thought the use of laminated rotors was creative and the Roots-type design was credible and well established, there were concerns raised regarding the technical accomplishments, including the concern that the turbine design package represented a poor choice for most small hydropower applications that have debris, silt, sand, leaves, and other waterborne contaminants. These operational and maintenance risks would likely outweigh any small efficiency gains, if any, over other existing tried and true turbine technologies.

RAPIDLY DEPLOYABLE ADVANCED INTEGRATED LOW HEAD HYDROPOWER TURBINE PROTOTYPE

(WBS #: EE0006928)

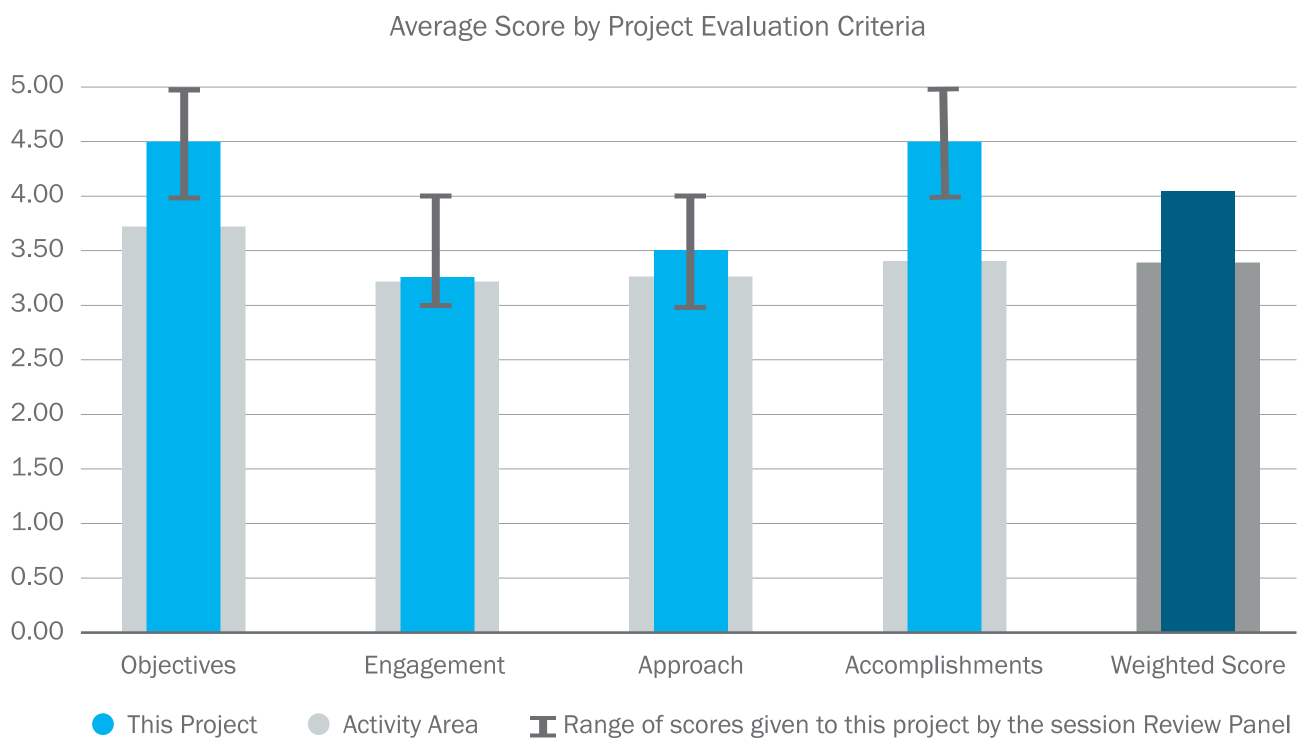
Recipient:	Pennsylvania State University
Principal Investigator:	Arnold Fontaine
Project Type:	FOA 1006: Water Power Manufacturing
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$2,750K
Total Costed:	$2,200K

Project Description

Develop and test a rapidly deployable advanced hydropower turbine-generator targeting low LCOE. The project includes the following innovative features: (1) modular, multi-blade row, hub-less (ecological friendly, self-cleaning, low maintenance) hydro turbine providing high-efficiency, low-head, variable-flow energy extraction; (2) design for advanced manufacturing; (3) condition-based health monitoring; and (4) direct-rim-drive, variable speed generator design, minimizing drivetrain and casing geometry enhancing modularity. The project team fabricated and performance-tested a 0.2-m prototype model in Pennsylvania State University's Applied Research Laboratory's 0.305-m diameter water tunnel facility under variable flow conditions. The project also had additive manufacturing capability and included a cost-assessment feasibility study, which featured a 0.9-m diameter scale inlet guide vane and rotor blade builds.

Weighted Project Score: 4.1

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

Overall, this project demonstrated an interesting and innovative turbine concept worthy of DOE funding. While the additive manufacturing of blades does not appear to be a promising avenue of further research, the program team is encouraged to work with a turbine manufacturer to create a larger machine that can be deployed in the field for evaluation. A practical application for such a device could be in pressure-reducing valve replacement at water treatment plants.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that the project objectives were clearly identified and aligned with DOE program strategy. They clearly describe an innovative approach to turbine-generator design using the rim drive concept, targeting the primary objective of lowering LCOE by reducing manufacturing costs, installation costs, and O&M costs, as well as designing an environmentally friendly turbine. The project summary aptly describes what they are working on and how the hub-less runner and direct-drive generator could lower LCOE and help drive development in low-head scenarios.

End User Engagement and Dissemination Strategy

The reviewers were in general agreement that the project leaders did not pursue an aggressive program to engage potential end users in their project. The basic conclusion is that the success of the project will speak for itself and convince potential user groups to develop similar designs. Nevertheless, the work performed demonstrates a good pursuit and engagement of potential ultimate end users via ongoing discussions with Voith turbine manufacturing.

Management and Technical Approach

The project contributors both coordinated with each other and led their individual aspects of the project successfully, which signifies a solid project management approach. However, reviewers stated that they would have appreciated more specific details regarding the decision gates and project management principles applied. The six-task technical approach, extending from initial turbine design to validation testing, demonstrated a sound and logical progression of steps. However, there is little discussion of critical success factors, such as how they know the turbine generator design will achieve the LCOE reduction goals they set out to accomplish.

Technical Accomplishments and Progress

The reviewers agree that the project has been mostly successful, essentially meeting their objectives and demonstrating excellent progress on an innovative small-flow turbine concept. However, while it is clear a new turbine generator was successfully designed, built, and tested, the project does not provide sufficient evidence that lowering hydroelectric development LCOE has been accomplished. The self-cleaning nature of the hub-less design and its expected fish-passage friendly nature appears promising, but not proven or discussed with researchers familiar with fish-friendly turbines.

A COST-DISRUPTIVE, LOW IMPACT, MODULAR FORM FACTOR LOW-HEAD HYDROPOWER SYSTEM

(WBS #: EE0007243)

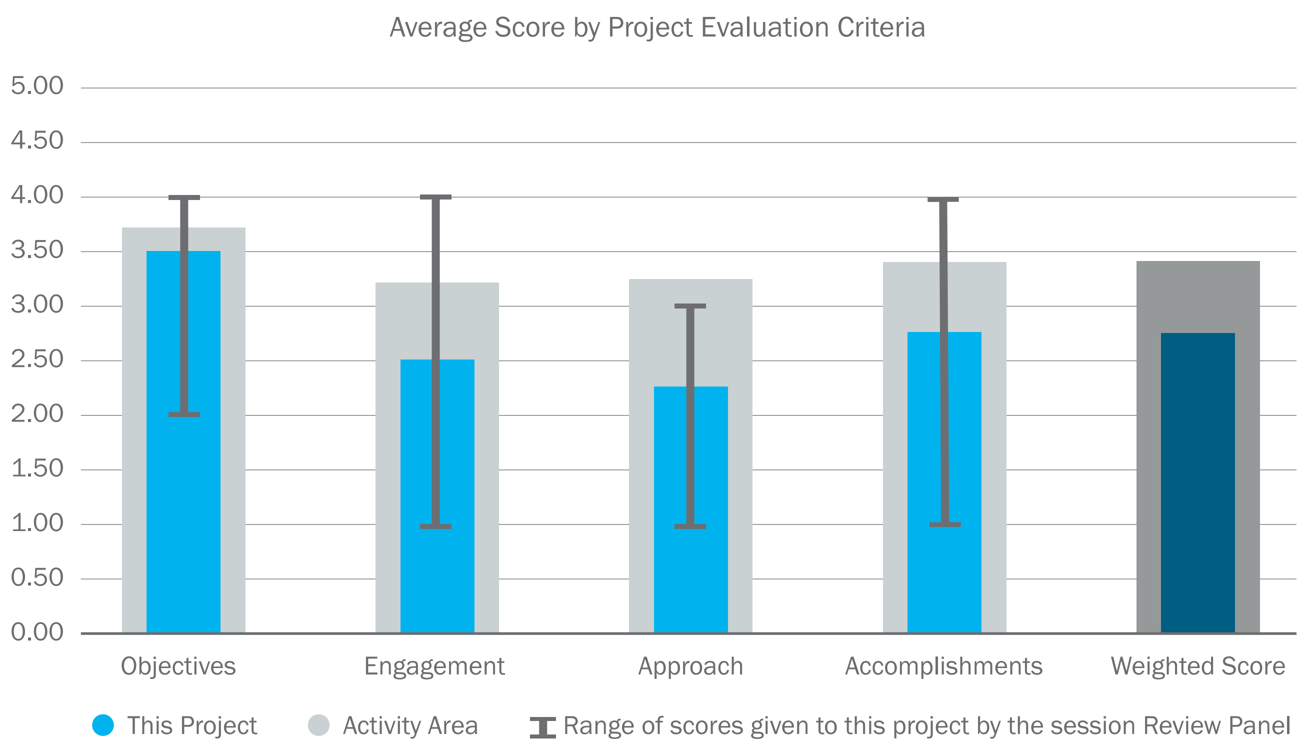
Recipient:	Littoral Power Systems, Inc.
Principal Investigator:	David Duquette
Project Type:	FOA 1286: Innovative Technologies for Low Impact Hydropower Develop-ment
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,792K
Total Costed:	$1,023K

Project Description

Small hydropower facilities—defined for this purpose as those of under 10 MW in installed capacity—have a relatively low impact on the environment as evidenced by favorable licensing regulations, particularly when configured as run-of-the-river plants. However, they face severe cost challenges. Addressing these cost challenges, Littoral Power Systems conceived a new type of hydropower equipment. It is a kit of standard, prefabricated modular parts based on the form factor of intermodal shipping containers. When assembled, the kit provides dam safety, power generation, spill control and other hydropower facility functions. The Littoral Power Systems system can be used to build and maintain a hydropower facility at substantially lower costs than traditional cast in place concrete, while optimizing generation. This project developed the module designs and analyzed the most critical dam safety functions to prove the feasibility of the system. The project exceeded the original goals and delivered designs beyond the proof-of concept stage backed up by thorough professional engineering analysis of stability, seepage, and structural integrity. Construction plans and professional engineering cost estimates indicated an LCOE half of the original LCOE goal.

Weighted Project Score: 2.8

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

The project represents an innovative approach to advancing new hydropower projects that could have a significant impact on the development of new stream reach opportunities. It offers the potential to reduce civil construction costs with the modular design, but before this particular technology can move any further, it must overcome significant hurdles. Primary among these is the issue of site-specific geotechnical conditions. The underlying problem is that issues such as seepage and stability involve foundation characteristics that are site-specific and not amenable to modular construction. Ultimately, the most formidable hurdles associated with this technology will be cost related, as new modular hydropower development will need to be competitive with wind and solar LCOE values that are well below the targeted values for this technology.

Project Objectives, Impacts, and Alignment with the Program Strategy

In general, the reviewers agreed that the objectives and success criteria of the project were clearly stated and align well with the Standard Modular Hydro program objective. This project is clearly an innovative approach for construction in new stream reaches and potentially at non-power dams, particularly in instances where there is an existing dam structure that is compatible with the addition of modular units. The researchers have explored a concept of modularity in construction with an eye on development in a real-world situation using defined industry and regulatory standards. The stated LCOE goal of the project is identified as $0.18/kwh, which would not be competitive with solar and wind development.

End User Engagement and Dissemination Strategy

Reviewers generally agreed that a broad spectrum of stakeholders were engaged as part of the project, and it appears their input was factored into the overall process. It is unclear what the dissemination strategy is on a go-forward basis as Littoral appears more inclined to pursue site licenses and construction. In that vein, much remains to be determined with acceptance by the Federal Energy Regulatory Commission (FERC) and U.S. Army Corps of Engineers' (USACE) from a dam safety perspective before a licensed project can proceed.

Management and Technical Approach

The reviewers agreed that the project management plan was described in minimal detail and lacked a description of the team's organizational structure. It appeared from the presentation that the team did not follow appropriate project management practices throughout the project. Specific details regarding the project development were not explained, and it appears that the project team may have spent their time pursuing a FERC license application without adequately vetting the technical issues associated with the project. The project has already been through four substantial design changes, which has undoubtedly made this more likely to be successful than the initial design out of the gate. However, it also suggests an incomplete design process and underscores the need for additional oversight and concept vetting in the early stages of a research project.

Technical Accomplishments and Progress

There was general agreement by the reviewers with regard to the uncertainty of the proven accomplishments of this project. Notwithstanding the ongoing licensing proceeding for the Scott's Dam Project on the James River, the reviewers expressed concern over the likelihood of this modular concept due to a variety of concerns such as (1) insufficient evidence that future capital development costs or O&M costs associated with these modules will be supportive of the $0.11/kWh LCOE forecast; (2) no proven, acceptable means of anchoring the structure to river bedrock; and (3) no current design for upstream or downstream fish passage modules, as well as for sediment transport modules.

OPTIMIZED COMPOSITE PROTOTYPE FOR ARCHIMEDES TURBINE MANUFACTURE

(WBS #: EE0007247)

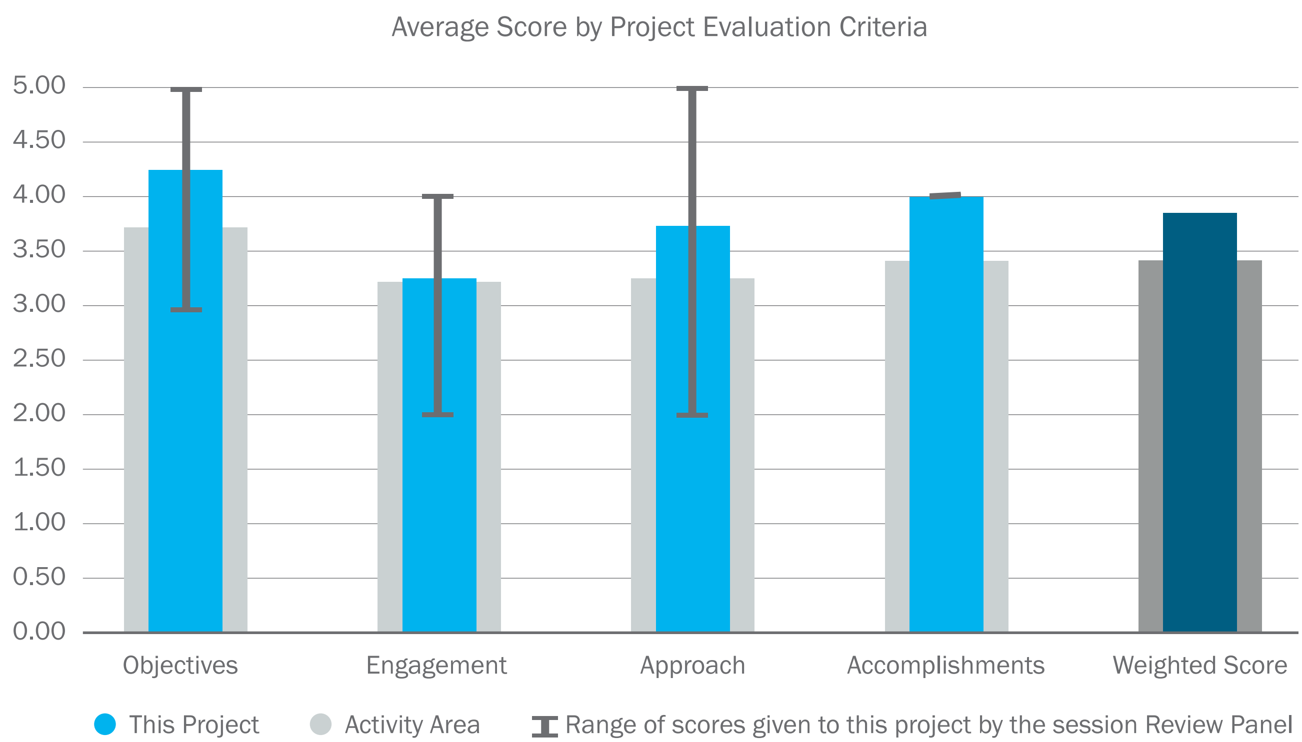
Recipient:	Percheron Power, LLC
Principal Investigator:	Jerry Straalsund
Project Type:	FOA 1286: Innovative Technologies for Low Im-pact Hydropower Develop-ment
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,389K
Total Costed:	$983K

Project Description

The goal of the Composite Archimedes Hydrodynamic Screw (CAHS) Project was to develop an optimized Archimedes Hydrodynamic Screw (AHS) turbine which is made of composite materials using advanced manufacturing methods. Conventional AHS turbines are made of steel and typically are shipped fully assembled from the factory. The turbines can be quite large, up to 16 feet in diameter and over 70 feet long, which requires oversize shipments and complicated and costly transportation logistics. The diameter of these turbines directly scales with the desired flow through the turbine, so the flow capacities per turbine also are currently restricted by the maximum transportable turbine diameter. The overall goals of this project were to reduce the LCOE for this relatively new low head hydropower technology, overcome the present barriers to steel AHS turbines, and demonstrate advanced U.S. manufacturing capability to produce the optimized turbine. Lowering the equipment and installation costs and producing the optimized turbines domestically should promote more rapid adoption of this promising low head technology across the U.S.

Weighted Project Score: 3.9

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

This project's progress demonstrates that is a promising area of research. Using composite materials to improve on a vintage hydropower design is creative and has potential beneficial ramifications in low-head and low-flow development opportunities. The potential to improve construction and maintenance costs are well understood, but the project team needs a better quantitative assessment of cost and value impacts, particularly as prevailing energy markets (driven by relatively cheap solar and wind projects) may form a significant barrier to the widespread adoption of composite Archimedes turbines. End user engagement could also be improved on this project. Addressing these concerns would improve upon a generally well-received and impressive project report and presentation.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that the potential benefit of the composite Archimedes design is well-defined in a qualitative sense and that the goals of the project align with those of the program. The benefits of reduced shipping, installation, and ongoing O&M costs are logical and benefit industry. It was also clear that the project was well-aligned with the program's desire to reduce costs in low-flow/low-head applications. Two of the reviewers did cite a lack of quantitative specificity around the project's objective of reducing cost.

End User Engagement and Dissemination Strategy

The project seemed to have input from technical experts, but the reviewers felt that outreach to developers or water agencies/districts who may actually purchase and install the system was lacking. There was a sense that Percheron Power may intend the project for their own commercial development and the lack of broader end user engagement may protect that plan. There was also concern that improving the cost to build from the current status of fabricating and shipping turbines from Europe is not a sufficient competitive benchmark and that benchmarking against solar and wind LCOE would provide a better metric for the technology's viability.

Management and Technical Approach

The management and technical approach were sufficient to support the accomplishments and progress to date, which have provided promising results. Two reviewers noted that the project management approach could be improved with clarity and details around project milestones and decision gates to guide continued work. As to the promising results, one reviewer noted that the 89% efficiency is remarkable for this device.

Technical Accomplishments and Progress

The reviewers completely agreed that the technical accomplishments and progress are impressive. The prototype's efficiency is impressive, and the logic for reduced installation and maintenance costs are well-understood from a qualitative standpoint. Reviewers presented the following concerns for this project:

- There is no definition of design, nor application limits in size, flow, and head
- Reductions in transportation and construction costs are not quantified
- The durability and longevity of the composite screw are concerning
- There is a lack of understanding regarding how prevailing low energy markets will present a significant barrier to adoption.

Overall, though, this is a promising area of research for the hydroelectric industry.

THE DESIGN AND DEVELOPMENT OF A COMPOSITE HYDROPOWER TURBINE RUNNER

(WBS #: EE0007248)

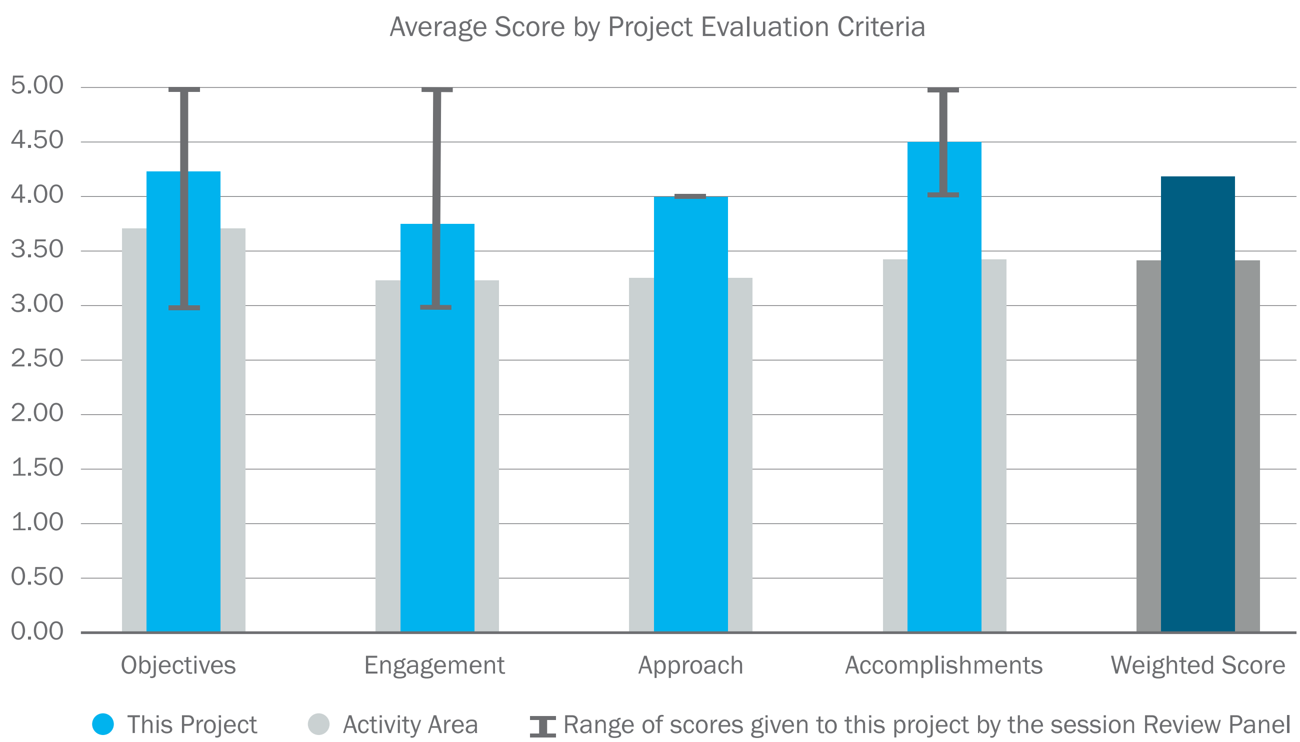
Recipient:	Composite Technology De-velopment, Inc.
Principal Investigator:	Paul Fabian
Project Type:	FOA 1286: Innovative Technologies for Low Im-pact Hydropower Develop-ment
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,347K
Total Costed:	$977K

Project Description

Through this project, Composite Technology Development, Inc. sought to design and laboratory test new and innovative conventional hydropower powertrain components, such as composite and replaceable blade technologies for turbine runners and/or materials and coatings for powertrain components. The overall goal of this project is to verify that composite materials are a reliable and economic alternative to traditional metallic runners and can provide designers with new design options to reduce operating costs and increase energy capture in a hydropower turbine system. The project objectives were to develop cavitation-resistant coatings and to prototype and test a composite runner system under real-world hydropower turbine operating conditions.

Weighted Project Score: 4.2

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The research shows promise, and the development of successful composite runners could significantly reduce the cost of hydroelectric development, particularly for smaller-scale projects. There is much work to be done to demonstrate the viability of the technology, particularly as it relates to the use of soft coatings to reduce cavitation, as well as the durability and longevity of the application. The delay in prototype testing is unfortunate, as it may have addressed some of these concerns. Continued work in this area is warranted, as the results to date are promising, and the potential benefits to the industry could be substantial.

Project Objectives, Impacts, and Alignment with the Program Strategy

The goal stated by the project performer in developing composite runners is well-articulated, and the potential impact to the industry could be significant. These impacts align with program objectives, particularly as they relate to improving the potential development of low-flow/low-head hydroelectric sites. One reviewer requested additional specificity regarding the potential impacts that could result from the work. Another was concerned that improved environmental impact was a stated objective, but no results in this area were cited.

End User Engagement and Dissemination Strategy

All reviewers responded positively to Voith's involvement as a project partner, stating that the company provided the project with an avenue to commercial development, as well as some real-world grounding. Two reviewers did note that outreach beyond Voith is desirable and that the project team needs to do a better job of engaging others in the industry, such as end users, hydropower operators, and developers. Additionally, the team should develop a plan to ensure the technology advancements are distributed throughout the industry.

Management and Technical Approach

All reviewers agree that the project performers deployed sound approaches to managing the project, including well-defined milestones and decision gates, which has contributed to the project's success. The metrics and criteria related to the management process and the decision gates would have improved the project report and provided a better understanding of the potential benefits of the technology. Also, it was noted that the project is currently behind schedule, and the application of the management approach to the delays is not well-described.

Technical Accomplishments and Progress

The accomplishments are clearly explained and understood, as were concerns about the commercial viability of the technology. The work related to the cavitation issue and the various soft coatings is also understood, although more detailed results in this area are desired. The progress being made toward prototype testing should help address concerns related to potential cavitation, as well as demonstrate the actual performance of the device in a simulated environment. Field testing of the technology ultimately will be needed but should not detract from the impressive accomplishments on this project to date.

EFFICIENT, MODULAR LOW-HEAD LINEAR PELTON TURBINE WITH SIMPLE, LOW-COST CIVIL WORKS

(WBS #: EE0008011)

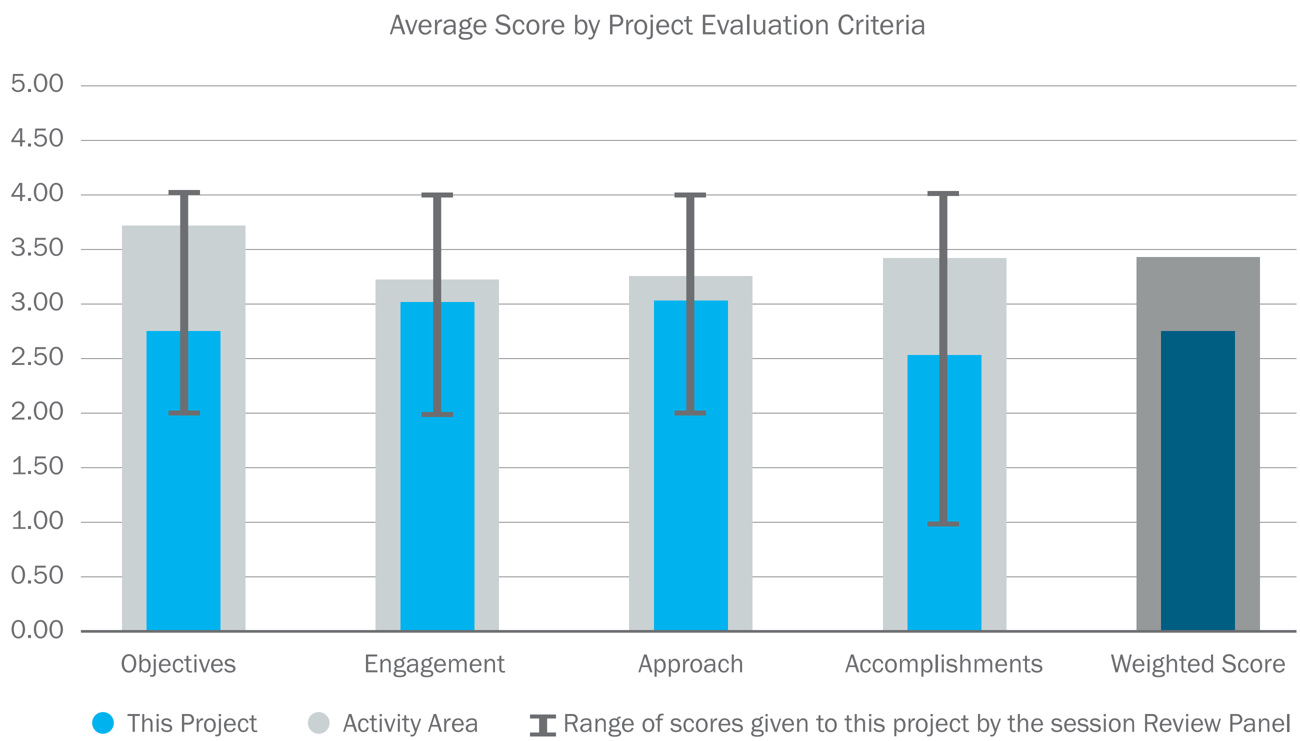
Recipient:	Natel Energy, Inc.
Principal Investigator:	Abe Schneider
Project Type:	FOA 1455: HydroNEXT: Innovative Technologies to Advance Non-Powered Dam and Pumped-Storage Hydropower Development
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$2,285K
Total Costed:	$1,703K

Project Description

In this project, Natel Energy and its team developed a completely new hydraulic turbine, called the Linear Pelton (LP), from concept to functional, tested hydraulic scale model. Natel also developed plans for two alternative civil works implementations (stationary and floating powerhouses), enabling the assessment of potential cost reductions of hydropower development at non-powered dams. The LP is an impulse turbine, which achieves large specific speed and good efficiency at low head. Operating above tailwater, the turbine allows reduction of submerged civil works. The project focused on powertrain dynamics and fatigue (including modeling and testing), design for manufacture, scalability, and hydraulic performance.

Weighted Project Score: 2.8

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

While this project involved radically new and innovative approaches to low-head turbine design, there were multiple foreseeable difficulties and constructability challenges that should have been uncovered earlier in the project process. The research into the LP device and other low-head concepts should not have necessitated costly exploratory manufacturing of a prototype or detailed engineering from consultants to identify the overwhelming obstacles to feasibility. The lessons learned from this project highlight the benefits of engaging additional technical oversight from industry experts that could assist the PI and offer support to DOE project management by using a thorough design review prior to the first go/no-go decision point.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers generally agreed that the project objectives were clear and aligned with program strategy. However, the reviewers also agreed that project performers should have recognized earlier in the project process that the technical hurdles associated with these innovative concepts would be too difficult to overcome.

End User Engagement and Dissemination Strategy

The reviewers generally agreed that the attempts to engage advisory groups were directionally correct, but the input from these selected in-house advisors did not result in the kind of objective, self-critiquing evaluations needed for a thorough, holistic design review and feasibility study. Hydro manufacturers and industry subject matter experts could have helped guide or change this project but did not appear to be engaged.

Management and Technical Approach

Reviewers agreed that the project team put forth out-of-the-box thinking and enthusiastic efforts to develop a new low-head, first-of-a-kind, LP turbine. Unfortunately, the concept design appeared to be overly complex compared to existing low-head turbine technologies. Furthermore, the demonstrated manufacturing difficulties, materials development challenges, real-world maintenance concerns, and undetermined costs and efficiency losses were all of greater concern than with existing technologies. Thus, the initial technical approach appeared to be inadequately vetted to enable significant success in a real-world environment. On the positive side, the numerous emerging problems seemed to be openly identified, optimistically pursued, and generally managed appropriately. This project offers lessons learned for the PI, as well as opportunities for DOE to fortify their support and oversight of projects.

Technical Accomplishments and Progress

Reviewers generally agreed that this became a series of subprojects to address the multitude of problems that the very complex overall concept presented. While some of the subprojects required new modeling techniques and areas of research that appeared to be handled well, the requirement for the total project to demonstrate and deliver benefits seemed to get lost in all the additional work scope. The result was that the project failed to deliver on its primary objective to produce a working 1-MW turbine within the time and funding available, and the team was unable to prove how this device would be more efficient, have lower LCOE, or possess any competitive advantage over existing turbines.

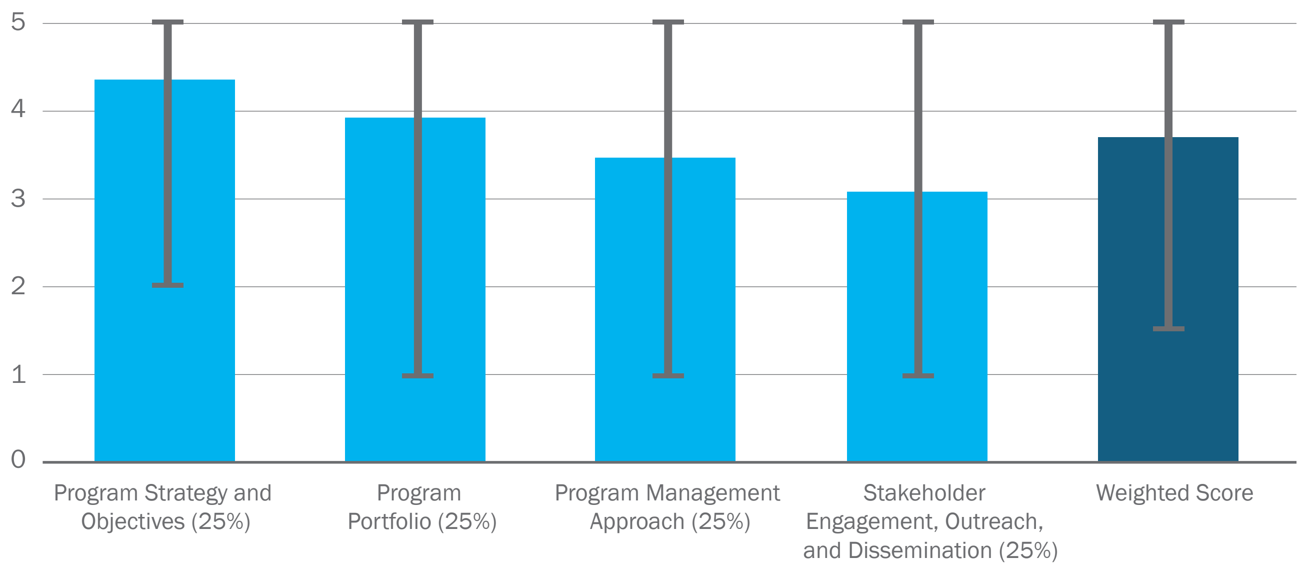
HydroWIRES Initiative / Grid Reliability, Resilience, and Storage

This section provides full evaluation results for the HydroWIRES Initiative and strategy; an overview of the scoring for all projects within the Grid Reliability, Resilience, and Storage activity area; the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

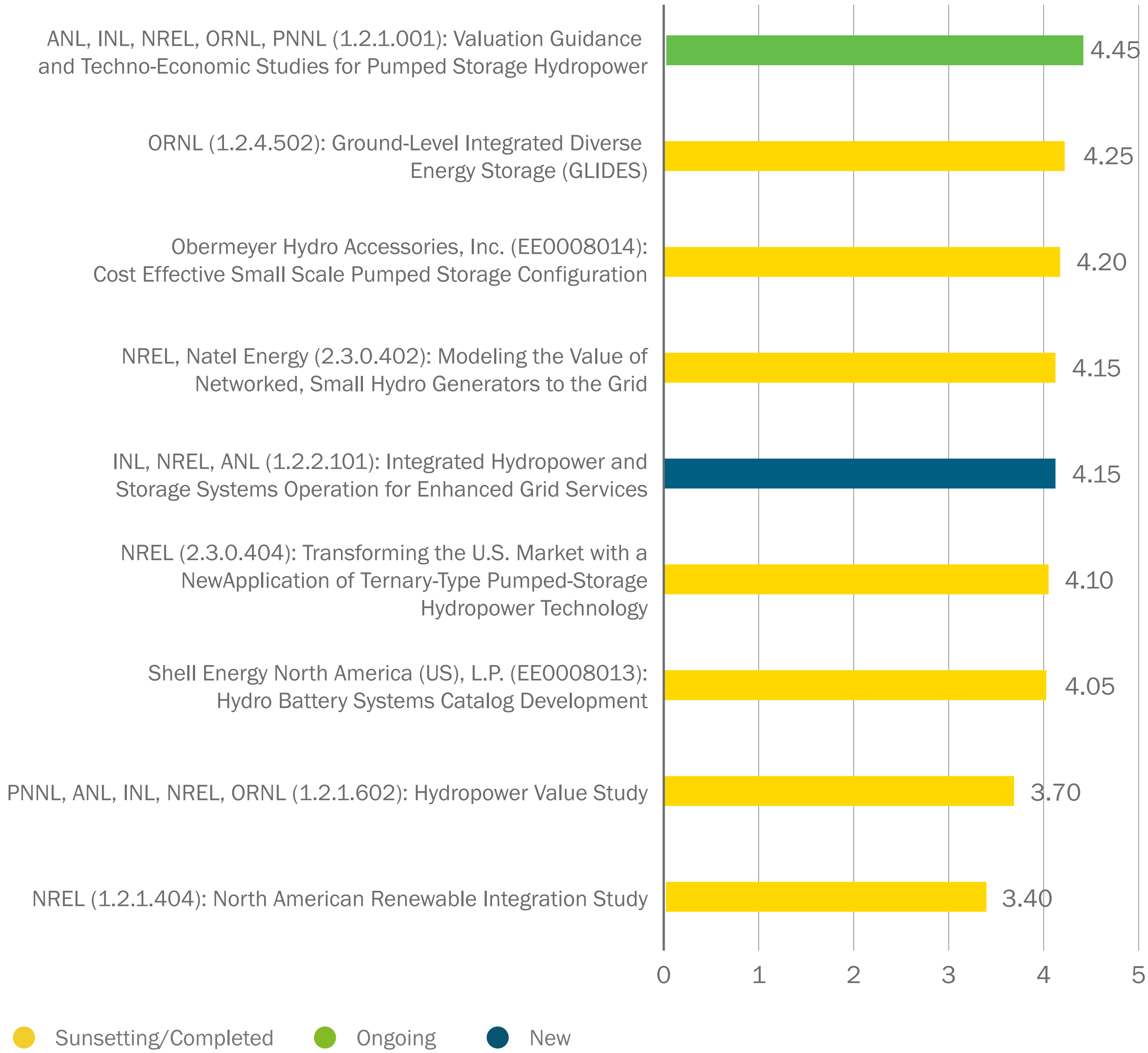
Figure 12 summarizes the weighted score of the HydroWIRES Initiative strategy and average reviewer score according to each program evaluation criterion. Figure 13 shows the average weighted score for each project in the Grid, Reliability, Resilience, and Storage activity area.

Figure 12. Average reviewer score of the HydroWIRES Strategy by program evaluation criteria



Name	Average Weighted Score of All Projects
Grid Reliability, Resilience, and Storage	**4.07**

Figure 13. Grid Reliability, Resilience, and Storage activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

The HydroWIRES program was viewed by each reviewer as a highly valuable program that will offer critical guidance for projects supporting the hydropower industry. The four key questions and supporting strategies provide an overall structure for the program and provide important guidance to the projects that are supported by this program. Support for this type of overall programmatic structure, to guide future research, is critical and should be supported into the future. WPTO should consider reviewing any overlapping study areas among the project portfolio to avoid duplication of research such as, overlapping bulk market studies. Other areas to consider are the role of hydropower in the distribution sector and the ability to manage "behind the meter" renewable resources. Several projects in the portfolio appear well suited for operation in a distribution system. The program should also consider providing additional project management guidance to the projects to ensure scope, schedule, and budget are effectively managed.

Summary of all Reviewers' Comments

Overall Impressions

Overwhelmingly, the reviewers supported and appreciated this program and the approach it has developed to focus research and guidance for the hydropower project portfolio. The structure of the program provides flexibility to allow projects to address new technology and evolution of the energy marketplace. As the program matures, it will be important to support leading research to help hydropower penetrate larger markets, including distribution systems, and integrate other technologies, including paring hydro with non-hydro technology.

Program Strategy and Objectives

The stated goal of the HydroWIRES program is to research untapped hydro resources to support a rapidly evolving gird. To do this, the HydroWIRES program has developed four research areas and strategic objectives. All of the reviewers appreciated this approach and the presentation of these strategies as part of each project overview. These four goals and research areas are important for a grid-focused knowledge base and are directly aligned with WPTO objectives for innovation, public good, access to affordable and reliable energy, wisely investing tax payers' funds, seeking input form stakeholders, and transparency.

Comments for each strategic area are:

- In the area of exploring value under evolving system conditions, there was a focus on the wholesale markets and bulk electric transmission system. As the grid evolves, it may be wise to also include review of opportunities to incorporate hydro into the distribution system.
- In the area of capabilities and constraints, the focus was on flexibility, modeling, and forecasting. It may be helpful to go further than the raw data and discuss the data inputs with the organizations collecting the information, use renewable inputs rather than grid upsets in analysis, and explore longer term energy storage for PSH technology.
- For operations and planning, the focus was on bulk electric grid projects. Reaching out to the ISOs and RTOs directly and not relying solely on data-based research can strengthen these areas. Also consider expanding the focus into the distribution system.

- The technology innovation area explored several types of innovative technology and provided an excellent overview of innovation in hydropower. Comments is this area included exploring different ways to combine various technologies with hydro to determine how each can benefit from the technology's different strengths. An example is the ternary technology and comparing this technology to conventional hydro and battery technology to help integrate renewables.

Program Portfolio
The HydroWIRES program has done a very good job organizing projects that align with WPTO's mission and vision statements. During the peer review, all of the projects presented aligned well with the HydroWIRES program objectives and with WPTO's mission statement. Specific recommendations for the HydroWIRES program going forward are to provide projects with guidance on expanded outreach and to reduce overlapping study objectives. Several reviewers noted that expanded outreach to ISOs would be helpful to better refine the objectives of the projects. WPTO should ensure that all projects provide transparency and accountability in publicly funded research.

A key challenge going forward for the program is to support "behind the meter" renewable integration and microgrids. To expand this research area, reviewers recommended that the program expand from wholesale markets and the bulk electric system to include the distribution system. Also, more direct involvement of the ISOs and RTOs could provide additional details to supplement the data-focused work presented during this peer review.

Program Management Approach
Many of the projects under the HydroWIRES program could have used better guidance on overall project management, including schedule development and presentation, overall project budgets, milestones, and risk management. Several peer reviewers recommended providing management guidance to include project schedules, budget overview for the entire project, project milestones, and go/no-go gates for the HydroWIRES program.

WPTO relies heavily on the exceptional technical capabilities and tools of the various national labs; WPTO should make a conscious effort to involve other industry technical experts to help with some of this effort. There are areas where there is no practical alternative to real world experience in planning and operating the bulk power system, which can help WPTO achieve the HydroWIRES goals.

Coordinating the research priorities of the projects at the program level to avoid overlapping research was another suggestion from several, but not all, peer reviewers. An example of overlapping research was noted when several of the HydroWIRES projects conducted studies on wholesale markets. In the future, the HydroWIRES program should consider one study of the wholesale markets that can be shared with other projects.

Stakeholder Engagement, Outreach, and Dissemination
The HydroWIRES presentation and material did not discuss a specific outreach objective or goal for this program. Most reviewers had a hard time assessing the effectiveness of the outreach program and of getting the word out about the program in general. During the peer review, many of the projects presented focused their outreach on typical industry conferences and publications. It would be helpful for the HydroWIRES program to provide guidance to the projects on outreach and how to expand the reach of the program beyond the usual industry conferences and publications.

While not specifically stated in the summary, it seems as if WPTO will rely on the national labs to handle the dissemination of information during the "hands-on" phase of the project. A more definitive dissemination plan to inform the industry of goals, milestones, and achievements would be beneficial.

Project Evaluations

VALUATION GUIDANCE AND TECHNO-ECONOMIC STUDIES FOR PUMPED STORAGE HYDROPOWER

(WBS #: 1.2.1.001)

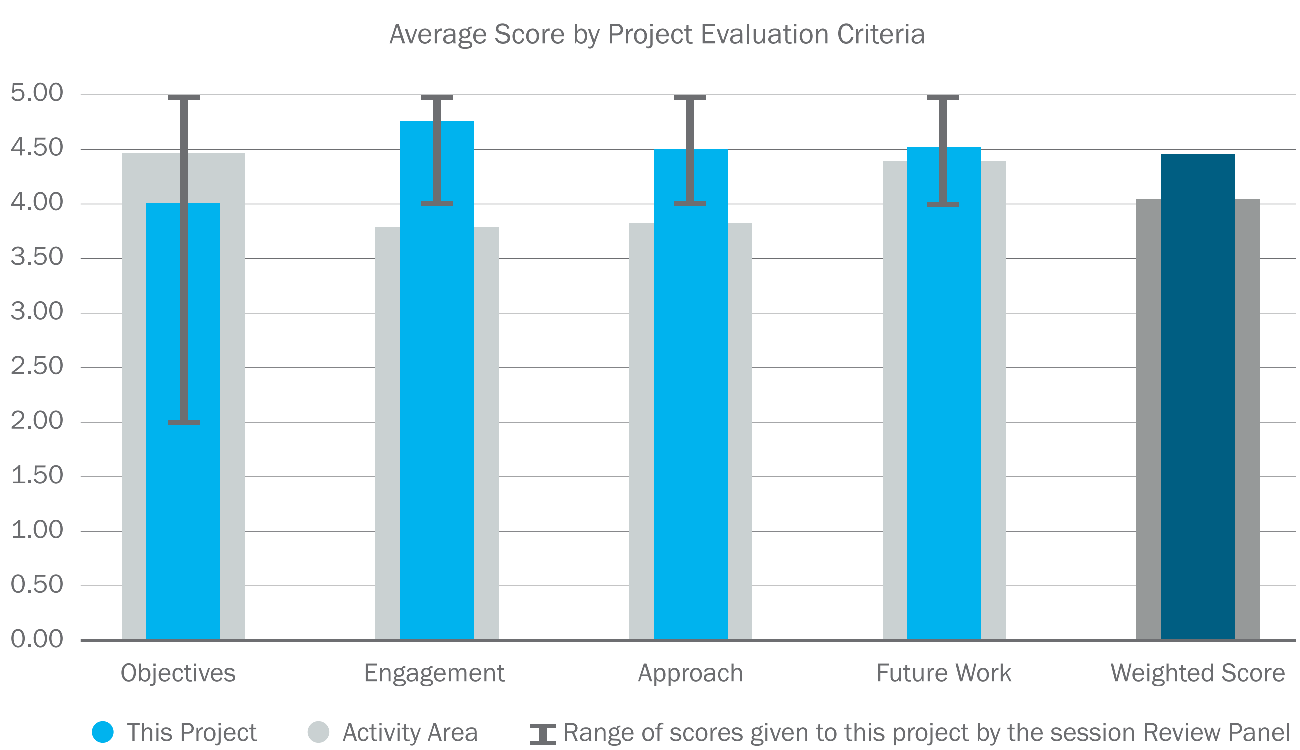
Recipient:	ANL, INL, NREL, ORNL, and PNNL
Principal Investigator:	Vladimir Koritarov
Project Type:	AOP
Project Category:	New Projects
Total Authorized:	$1,767K
Total Costed:	$1,193K

Project Description

As an energy storage technology, PSH supports all aspects of power system operations. However, determining the value of PSH plants and their many services and contributions to the grid has been a challenge. The objective of this project is to advance the state of the art in assessing the value of PSH plants and their role and contributions to the power system. The specific goal is to develop detailed, step-by-step valuation guidance that can be used by PSH developers, plant owners or operators, and other stakeholders to assess the value of existing or potential new PSH plants. This valuation guidance will be applied to two competitively selected proposed PSH sites to assist the developers in understanding the value streams available from the project. This technical assistance effort will inform the development of the final, public step-by-step valuation guidance.

Weighted Project Score: 4.5

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

This is a highly relevant project that builds on past work to develop a useful guide, which will aid industry in valuing PSH via the development and dissemination of a clearly articulated methodology. The most important part of this project will be continuing support of the tool after the guidebook is fully developed to continue to sell the capabilities and ensure industry adoption e. The information will need to be shared widely to industry and should be clearly focused on working with other related U.S. Department of Energy (DOE) activities.

Project Objectives, Impacts, and Alignment with the Program Strategy

This project goal is to develop a guidebook describing how to value PSH projects, which clearly aligns with the Hydropower Program's overall strategy. The project articulated how the final guidebook will be used by the stakeholder community to better understand the economic benefits of PSH, which can be very impactful, especially when combined with similar DOE efforts across other technologies. The review panel expressed concern that the study may focus too narrowly on economic evaluation given industry's current knowledge of the operating capabilities of PSH; however, the hope is that clear valuation guidance will help open further PSH development going forward.

End User Engagement and Dissemination Strategy

This project has a well-established engagement and dissemination strategy that reached all the vested stakeholders. The project performers have identified the project beneficiaries as electric utilities owning and operating PSH plants, PSH developers, grid and electricity market operators, public utility commissions and state energy offices, hydropower equipment manufacturers, engineering and consulting companies, as well as investment banks and other financial institutions. These end users will benefit from a better understanding of the actual value of PSH on the grid. By involving those currently looking to develop PSH facilities, state regulatory bodies, federal agencies, as well as other industry experts, the team has the technical know-how and access to multiple communication paths to disseminate critical information to those that need to know. The National Association of Regulatory Utility Commissioners is a uniquely positioned partner to contribute to the project via the Technical Advisory Group.

Management and Technical Approach

The project performers have implemented a technically sound R&D approach to developing the PSH valuation guidebook and are working to demonstrate it in two case studies. The project management plan includes detailed tasks and a well-defined set of milestones. Project risks were not specifically addressed. The report described critical success factors, the challenges involved, and a rational plan to achieve success. The communication between the responsible parties and the dissemination of data back and forth is well documented. The team has put the technical values into seven cogent buckets, and within those particular buckets, they will look at parallel services, those provided at the same time, and individual services that can only be provided as singular values. This will allow them to attempt to quantify the value of each individual service. They will leverage the existing work of WPTO and the Electric Power Institute. This is a very organized and relevant approach to develop a methodology to quantify the value that PSH brings to the table.

Technical Accomplishments and Progress

The project team lists the eight deliverables that will signify completion of the project. They further state that the project is on schedule and on budget. The most significant deliverable is going to be the PSH valuation guidebook. The project appears to be on schedule, having produced intermediate results consistent with the project team's management plan. While the specific project analysis is not innovative (similar work was conducted by Argonne National Laboratory in past years), the development of a clear and concise valuation guidebook is a great step in clarifying how to create an apples-to-apples analysis methodology.

Future Work

It appears all future work is confined to two major efforts: (1) continued development of the software tool that will allow stakeholders to better utilize the valuation guidebook and (2) dealing with the economic evaluation relative to markets. It would have been beneficial to see more detail on exactly what the project proposed to do relative to the market value of PSH capabilities. The plan to develop a tool to aid in the final process is innovative and should be very useful. The key to ensuring the project's overall success will be in continuing support of the tool after project completion to continue to sell the capabilities and ensure industry adoption.

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NORTH AMERICAN RENEWABLE INTEGRATION STUDY

(WBS #: 1.2.1.404)

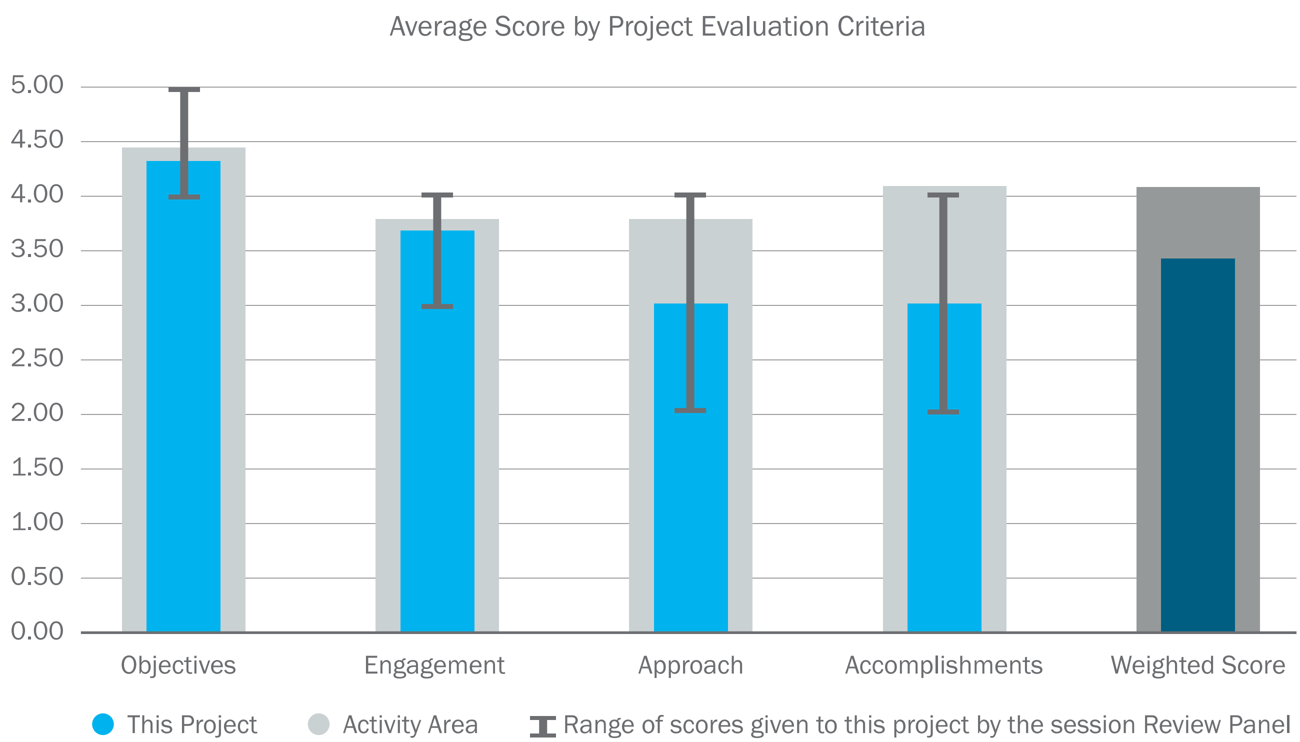
Recipient:	NREL
Principal Investigator:	Greg Brinkman
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,433K
Total Costed:	$986K

Project Description

The North American power system is evolving—how we generate and consume electricity is changing and becoming increasingly meteorologically dependent. A modern power system can take advantage of the diversity of resources and consumption to provide reliable, affordable, sustainable power to everyone. Opportunities will exist for new and existing grid technologies, including hydropower and PSH. The North American Renewable Integration Study will analyze the challenges and opportunities of transitioning to a modern power system in North America through the year 2050. It is a partnership between DOE, the Mexican Ministry of Energy, and Natural Resources Canada.

Weighted Project Score: 3.4

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

This project is very large and complex, with many models employed. The report provided to the review committee did a good job of explaining the project's alignment with the Hydropower program objectives and strategies. Stakeholder engagement was good via the large and representative Technical Review Committee (TRC), with its semi-annual meetings for communications and feedback. It was evident that modern, cutting-edge modeling tools were both used and developed as part of this project; these tools required significant amounts of detailed future system data and assumptions. Based on the information presented in the project report, it was difficult to assess the technical soundness of the study. To do so would require an understanding of modeling details, validation activities, and TRC involvement. The project management plan was not clearly stated and did not show detailed objectives, milestones, and status in achieving the milestones and relevant go/no-go decision points. The dissemination plan was also not clearly presented. Overall, the committee was split on the usefulness of the project, with some of the members feeling it is essential to answer key questions that will allow development of a high renewables future, while others felt its conclusions are not surprising and could be expected by many in the industry.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project report indicated how the work aligns with DOE's goal to "Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration." The report showed that the project performers have considered the use/applications of their expected products and outputs, and they anticipate it will provide stakeholders with new methods, tools, and datasets to further their own understanding of planning and operations in a modern grid. Project relevance was described and is meritorious, including how successful completion of the project will advance the understanding of hydropower's impact and role in operations and reliability in the future, as well as the influence of wet and dry years.

End User Engagement and Dissemination Strategy

The project report described how specific stakeholders and end users have been engaged through the TRC. The list of grid operators and planners and other organizations involved is long and very impressive. The TRC meets twice annually and appears to be engaged, providing thoughtful critique and input. However, the type of information exchange and input from the TRC was not articulated in the report or presentation, and this would be helpful in assessing the effectiveness of the TRC and ultimately the project. The report described a logical approach to stakeholder/end user engagement strategy and targets the electric grid planners, operators, and stakeholders with an interest in studying the future grid. The dissemination plan upon project completion of the project is not clear. Because there are no publicly available reports and few details in the review report, it was difficult to tell if the study will be effective in meeting its goals.

Management and Technical Approach

The North American Renewable Integration Study is quite detailed and complex, with many datasets and assumptions necessary for its completion. Evaluating the project for its technical soundness would require a much more detailed description and/or presentation from the PI than what is available in the project report. From a high-level perspective, however, the project seems to be well set-up and using appropriate tools (ReEDS, dGEN, PLEXOS), as well as developing some useful new tools (PRAS and datasets). The project team is mainly using the capacity expansion model and the production cost model, both of which are appropriate for the study. However, without understanding the study set-up, assumptions, resolution, etc., along with the level of interaction and review of grid planners and operators, it is difficult to determine if the project results will be effective or not.

Within the brief report, the project management plan was described in general terms. The plan included a few high-level milestones but did not present detailed information about schedule and milestones. Thus, the reviewers could not determine if the management approach was well-designed or effective. Risks were not identified, though there were certainly many, such as the data exchange between countries, etc. There did not appear to be any go/no-go decision points in the project.

The report did not substantially address critical success factors or the challenges that must be overcome to achieve success.

Technical Accomplishments and Progress

The project report described the questions that will be answered by the study and, in general terms, the new tools and datasets that will be made publicly available to support future studies. The summary highlighted some of the assumptions involved in running the study, such as meteorological, distributed energy resources, capacity expansion, outages (generation and transmission), extreme events, nodal production costing, etc., but it did not provide details on the data. Related to hydropower, the report did not provide any specific detail about how modeling hydropower in wet and dry years was conducted. Additionally, no description was provided about existing limitations in modeling hydropower in the tools/techniques used, nor how this study will overcome those limitations. The decision to "cloister" results from the project until its completion made it very problematic to assess the accomplishments. During the review presentation, the PI did present some interesting results and answered numerous questions, but to truly assess the technical accomplishments, a longer presentation focused on the project goals, milestones, and outcomes would have been necessary.

Future Work

Future work was briefly mentioned in the report in terms of completing the remaining tasks. The review committee felt that stakeholders—especially those listed as beneficiaries of the work—should have a voice in identifying the direction of the other future work related to the North American Renewable Integration Study to ensure its usefulness.

HYDROPOWER VALUE STUDY

(WBS #:1.2.1.602)

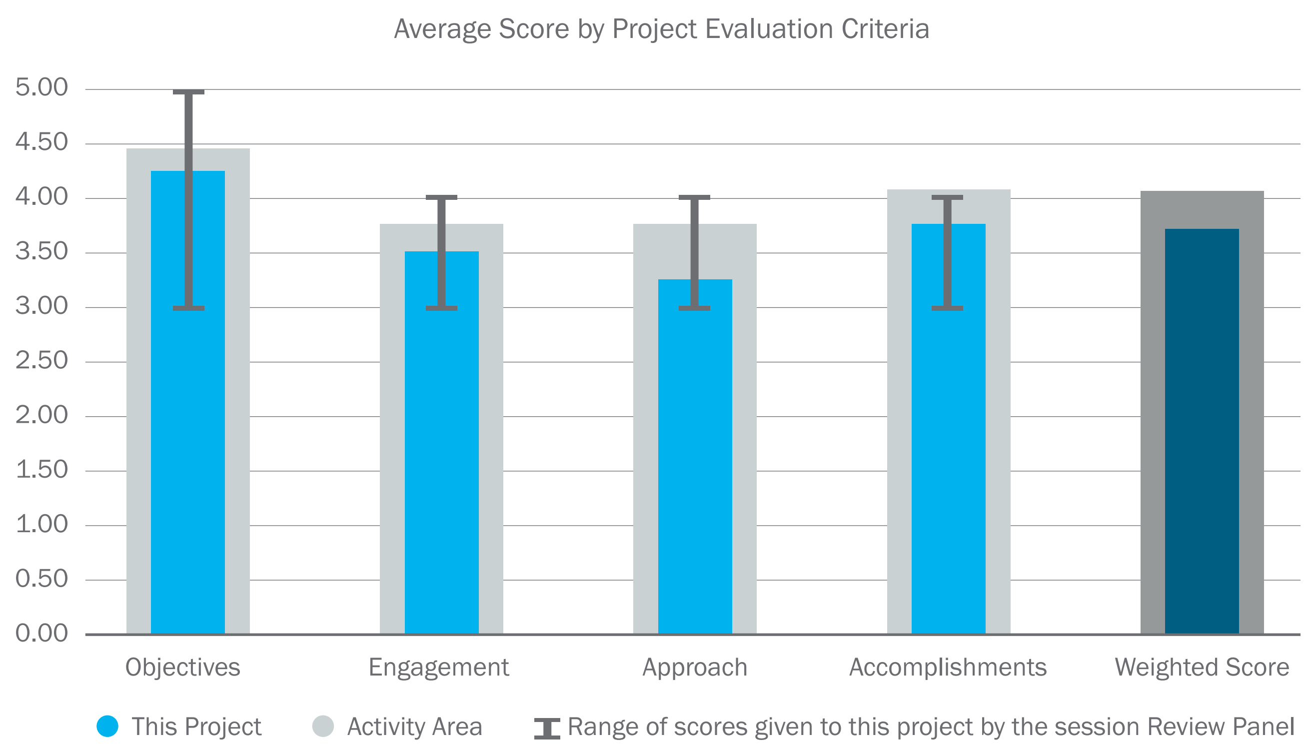
Recipient:	PNNL, ANL, INL, ORNL, and NREL
Principal Investigator:	Abhishek Somani
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,440K
Total Costed:	$1,395K

Project Description

The primary purpose of this project was to comprehensively understand the current landscape of hydropower operations and the resulting value of resources in power markets across the country. The project was designed to lay out the foundation for future research that enables the comprehensive understanding of the value of hydropower resources in a variety of future grid states.

Weighted Project Score: 3.7

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The project presented an interesting approach to understanding the potential hydropower has toward the reliability and resiliency of the grid based on past historical hydropower performance. However, as presented, producing large volumes of data based on historical information with the intent of doing some form of statistical trending may provide value to only a small subset of the overall general stakeholder body. The review team expressed some concerns about how the data would be used by the general stakeholder community and who would benefit.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project team described how this effort will contribute to the Water Power Technologies Office's overall resiliency and reliability goals and identified potential industry beneficiaries. Project goals would be accomplished through trending of existing hydropower operational performance. The historical data collected was gleaned from publicly available sources like FERC.

End User Engagement and Dissemination Strategy

The project team identified hydropower plant owners and operators, power system operators, marketing entities, and the ISO/RTO community as potential beneficiaries of this effort. These entities functioned in more of an advisory role because the operational data used in the analysis was primarily mined from public sources. While the report indicated results have been presented over time at various technical conferences, there were no details on what workshops and what feedback the project team received back at those workshops. Overall, the review team felt there were not enough details to determine exactly what the data entailed and how it was going to be used going forward.

Management and Technical Approach

The review team felt the project had a technically sound research approach using publicly available data and national laboratory expertise. There was concern that use of publicly available historical data may not have provided as much insight as using more detailed data, which could be obtained from operating entities (i.e., the ISO/RTO community), would. The review team questioned why the ISO/RTO community, who has more detailed data at their disposal, would they benefit from having it reported back to them in a less granular format through this effort. The summary presented some historical hydropower performance on the Chelan facility, but there were no accompanying details on exactly how the plant was operating during that period. There also was a general lack of data specificity (e.g., how much of the total U.S. hydropower resources were included in reporting, were all hydropower types included, how was the data broken down, what specific operating timeframes were considered, etc.). The summary report did not contain a detailed project management summary with individual milestones, assigned national laboratory responsibilities, associated accomplishments, go/no-go decision points, and budget/project controls.

Technical Accomplishments and Progress

The project team was able to present a limited subset of the results of their research. While the results did suggest some potentially insightful observations on various hydropower operations in certain areas of the United States, there appeared to be gaps in understanding exactly what data was used, how it was coordinated, and how representative of the overall hydropower industry it was. The review team recognized that there is a significant amount of data that has been collected; however, the difficult task is organizing that data so that significant and valuable trends can be obtained. The review team had concerns with the use of publicly available data rather than actual detailed operating data to drive an analysis of the value of hydropower toward grid resiliency and reliability. The review team further questioned the overall value of this effort to the greater stakeholder community.

Future Work

The project team did propose 10 additional areas as candidates for future research. Careful consideration should be given before advancing them forward. The review team does not think all of them merit continued research without additional detail on goals, objectives, and methods for research. Any future work must include key stakeholders, and the project team should not be proposing their own future scope without outside engagement.

INTEGRATED HYDROPOWER AND STORAGE SYSTEMS OPERATION FOR ENHANCED GRID SERVICES

(WBS #:1.2.2.101)

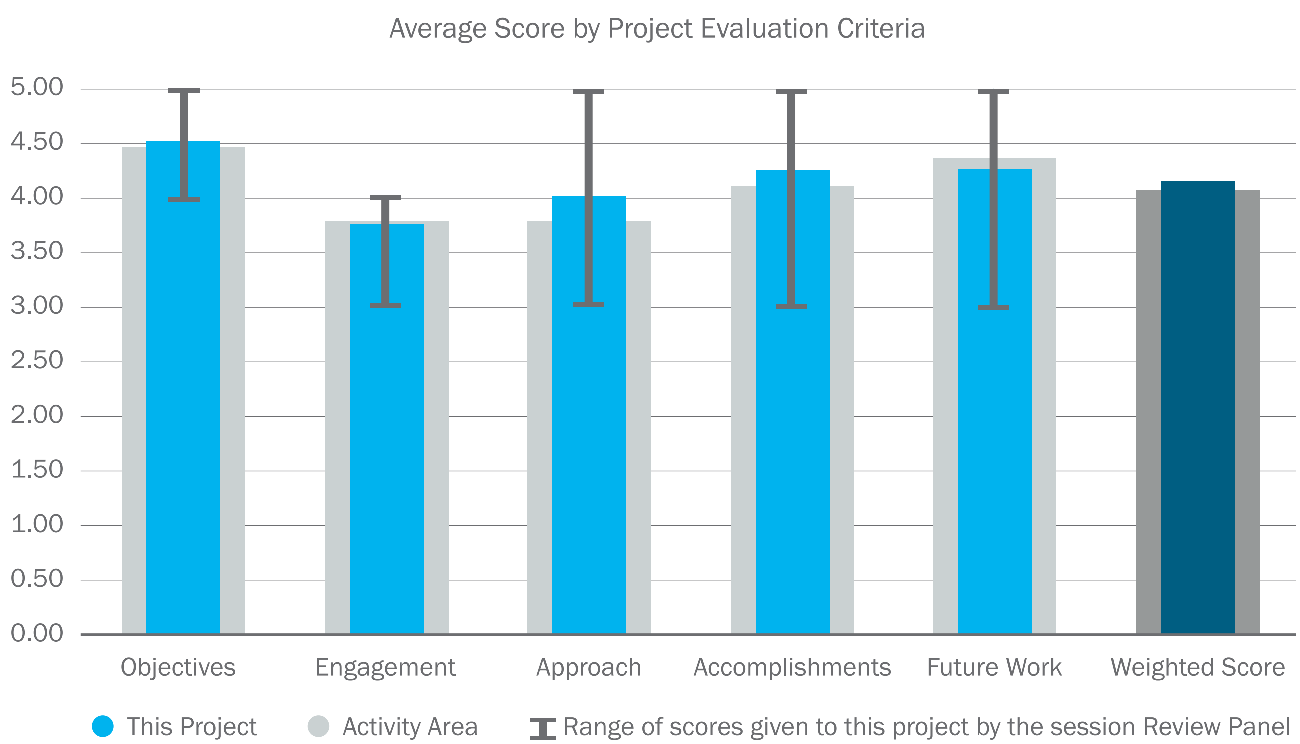
Recipient:	INL, NREL, and ANL
Principal Investigator:	Thomas Mosier
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$2,488K
Total Costed:	$2,217K

Project Description

This project demonstrates the technical potential and economic benefit of co-locating and coordinating hydropower plants with energy storage devices to create “virtual reservoirs.” These virtual reservoirs enable the integrated system to contribute essential reliability services and participate in ancillary services markets. The approach is agnostic to the type of energy storage and, in some cases, may benefit from a combination of energy storage technologies. For example, digital simulations demonstrate that hybrid systems composed of batteries, supercapacitors, and flywheels can leverage the unique performance characteristics of each storage technology, leading to better performance than systems employing only one energy storage type. The approach is also applicable to multiple types of hydropower plant characteristics. As a starting point, the project focused on demonstrating that energy storage can enable a run-of-river hydropower plant to perform like a hydropower plant with reservoir storage. In partnership with Siemens, the project team developed a centralized control scheme, the Smart Energy Box, to coordinate the operation of energy storage devices and one or more hydropower plants. The project also includes cost-benefit analyses that consider the increased ancillary services’ market performance and capital and operational costs of the storage system.

Weighted Project Score: 4.2

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work



Summary of all Reviewers' Comments

Overall Impressions

This project was viewed as a highly valuable research area that can better optimize existing infrastructure and also have the ability to incorporate new technology within existing hydropower resources to better integrate renewables and provide grid services. The peer reviewers appreciated that the project team used existing models and leveraged previous research. Overall, the project would benefit from a broader dissemination strategy.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project ties into the overall program goals very well by utilizing existing infrastructure and combining it with new technology to provide grid services and renewables integration. This is a good example of using existing infrastructure to meet new grid integration needs with technology. The panel thought that the project could be expanded beyond ancillary services and renewable integration to include energy storage and other services and technologies.

End User Engagement and Dissemination Strategy

End user engagement in this project has come via partnership with Idaho Falls Power, Siemens, and American Governor. Working with a host utility provides value and real-time operational experience to the project team. This approach ties into the identified end users who are owners and operators of existing hydropower facilities. To date, the project team has made presentations at industry conferences with others underway. Since the target audience is hydropower owners and operators, making presentations at industry-focused conferences and submitting content to industry-focused publications makes sense. The project needs a better plan on disseminating results to a broader stakeholder audience. For example, the project team should consider additional outreach to ISOs and RTOs on how they can utilize this study and also to better understand how they would interact with the "Smart Box" instead of each unit.

Management and Technical Approach

This project brings a wealth of technical background and knowledge to the table by coordinating three respected national labs, as well as practical hydropower plant operation and equipment by including Idaho Falls Power, Siemens and American Governor. This fits very well with the project objectives and target audience.

The technical approach for the project presentation included key project milestones and deliverables on an annual schedule, which was very helpful for an overview of the project. Additional detail on the project schedule and how the milestones are incorporated into a detailed project schedule would help reviewers understand how the project objectives would be achieved. Go/no-go gates were also provided for work that was completed.

The project's technical approach was well thought out, utilizing the virtual reservoir concept coupled with innovative control technology and existing infrastructure, including a cost-benefit analysis. The underlying premise of the "Smart Box" is its ability to optimize performance. The summary, however, did not explain what the optimization objective was, and optimization can mean many things (e.g., maximizing energy storage for future needs, maximizing reactive support, maximizing primary frequency response, etc.). At the presentation, it was clear that the optimization function would be user configurable, which is a desirable design capability. This approach took full advantage of the technical experience that was developed as part of the project's management approach.

Technical Accomplishments and Progress

To date, the project has met its goals and is below budget. The project created virtual reservoirs by modeling existing systems; it then used existing model, CHEERS, to show how the system can be integrated into markets. Additionally, the summary claims of other advantages to the grid, specifically in the areas of frequency response and black start. While these may be a technical accomplishment, it is unclear exactly how they were accomplished, and additional details should be provided. The project report demonstrated that the team has made progress in reaching their objectives. No information was provided from previous peer reviews or industry feedback.

Future Work

The project report did not clearly present the work plan that is remaining, beyond providing a couple bullets of upcoming work. From what was presented, future work includes expanding the services provided by the virtual reservoirs and performing a field demonstration of the capability to provide black start services in 2020. However, it was not clear if this future work will only focus on demonstrating black start or will also demonstrate in the field the results of their digital simulation of coordinating reservoirs to provide frequency regulation while enhancing revenues. The reviewers suggested that grid security and ISO outreach be included, and the project team should address grid cybersecurity or NERC standards review of the technology. Future work should include a go/no-go gate. Furthermore, the project would benefit from a clearer dissemination strategy that describes how the broader community will be informed about this project's successes and can potentially take advantage of them.

GROUND-LEVEL INTEGRATED DIVERSE ENERGY STORAGE (GLIDES)

(WBS #:1.2.4.502)

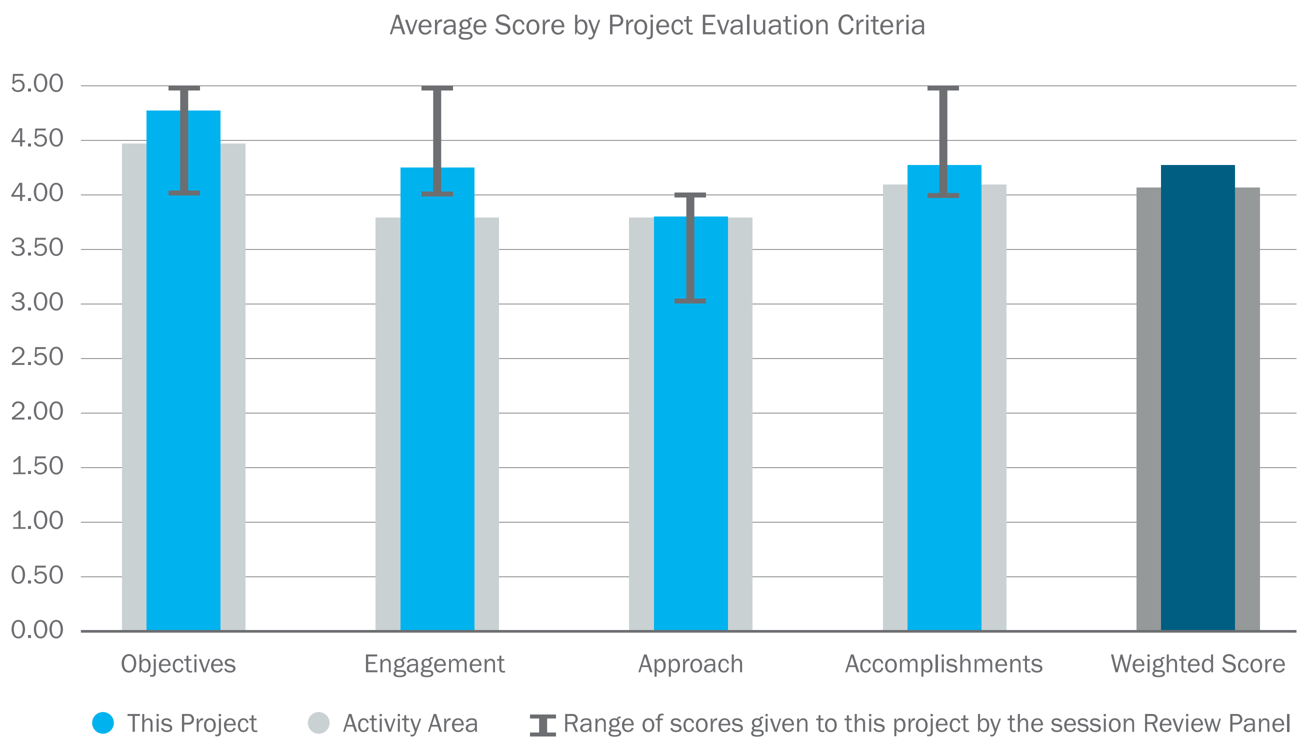
Recipient:	ORNL
Principal Investigator:	Ayyoub Momen
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,100K
Total Costed:	$830K

Project Description

This project explores the value proposition of a modular PSH technology with the potential to fill the technology gap between small-scale battery technology and large grid-scale PSH. ORNL researchers invented the Ground-Level Integrated Diverse Energy Storage (GLIDES) technology, a cost-effective, scalable, flexible storage system that can provide a broad range of ancillary services. GLIDES's modularity, energy density, scalability, and environmental benignity position it well to mitigate many of the market and regulatory barriers faced by large PSH.

Weighted Project Score: 4.3

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

This is a well-organized and highly relevant project that is working to develop a modular PSH system based on the use of pressure vessels rather than large water reservoirs. While still in an initial prototype phase, the project has considered a number of potential applications. The market analysis associated with the project seems very promising, although reviewers encourage the team to look beyond transmission level and analyze behind-the-meter applications. The review panel hopes to see the Hydropower program continue the development of this technology.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project clearly contributes to the program's strategy to understand, enable, and improve hydropower's contributions to grid reliability, resilience, and integration. The output of this project is to quantify the value proposition, identify cost reduction opportunities, and prioritize future research directions for the GLIDES modular PSH technology. This project is highly relevant and will advance the state of technology, as well as the viability of commercial applications by identifying and quantifying GLIDES's improvement over competing energy storage technologies. While the market analysis is a great addition to the project, the project team should consider distribution system market analysis rather than wholesale, as this is the more relevant market segment. GLIDES scalability allows it to be used at both grid and distributed scales, such as residential building applications.

End User Engagement and Dissemination Strategy

The project involved a wide stakeholder group, including various DOE departments, Tennessee Valley Authority, University of Tennessee, and ORNL's Manufacturing Demonstration Facility. However, the project team did not engage outside of the governmental organizations listed. The project performers identified that the beneficiaries from this project will be electric utilities and the electric sectors, residential buildings, military applications, and commercial buildings. Because this technology can be utilized in industrial setting and on sub-transmission level distribution systems, it may be wise to expand the outreach to include other folks who might be able to benefit outside the traditional utility and industry audience. The overall dissemination plan was briefly mentioned but is quite limited. ORNL indicated that it is still working on prototype development and working to expand engagement though attempts to partner with an outside entity to commercialize the technology, which the review panel strongly supports. It would be useful if the project dissemination plan included a technical report that documents the experimental mock-up and performance, the cost model that was developed, and the results of applying the cost model.

Management and Technical Approach

The reviewers agreed that the team had a strong overall approach to developing cost and performance modeling capability and implementing economic analysis, and, in general, a good management structure. The project was broken into three major efforts: (1) costing and designing the facility along with building a prototype; (2) determining the market value of having such storage resources available on the transmission and distribution systems; and (3) building a techno economic model that would allow for marketing the unit in various regions. Limited information was provided related to the specifics of the project management plan (i.e., specific milestones) or discussion of risks. The project should consider how this technology will operate in a distribution sub-transmission level system since this appears to be where the potential target customers are located. The reviewers believe performers showed a strong understanding of critical success factors.

Technical Accomplishments and Progress

The project team has made progress in reaching their objectives based on their project management plan, as articulated in their list of technical accomplishments. In particular, the project seems to be yielding great benefits and is developing a good overall understanding of the cost reduction pathways for future development. The evaluation of a number of potential pressure vessels is a great way to broaden the horizon for potential future applications of the overall concept, concluding that this project is feasible for both small-scale systems, as well as large grid-scale systems. The research in wholesale markets shows that this type of system has the potential to create a positive revenue stream. It was noted that the revenue stream would be very dependent on what ancillary markets the storage resource would participate in and that was all relative to where it was in the pressure cycle. More work is needed to identify how this system might create value in the distribution system.

Future Work

The program should continue to support the GLIDES concept. Potential application for commercial and residential building systems could be a game changer given the limited environmental impacts of GLIDES compared to lithium-ion battery technology. Furthermore, it would be beneficial to provide additional research for projects located at industrial and commercial sites served by the distribution system. This project will have a different economic evaluation and likely not participate directly in the organized wholesale markets. Evaluation of peak demand shaving, energy savings, and use of renewable energy, as well as distribution reliability services, would be helpful.

MODELING THE VALUE OF NETWORKED, SMALL HYDRO GENERATORS TO THE GRID

(WBS #:2.3.0.402)

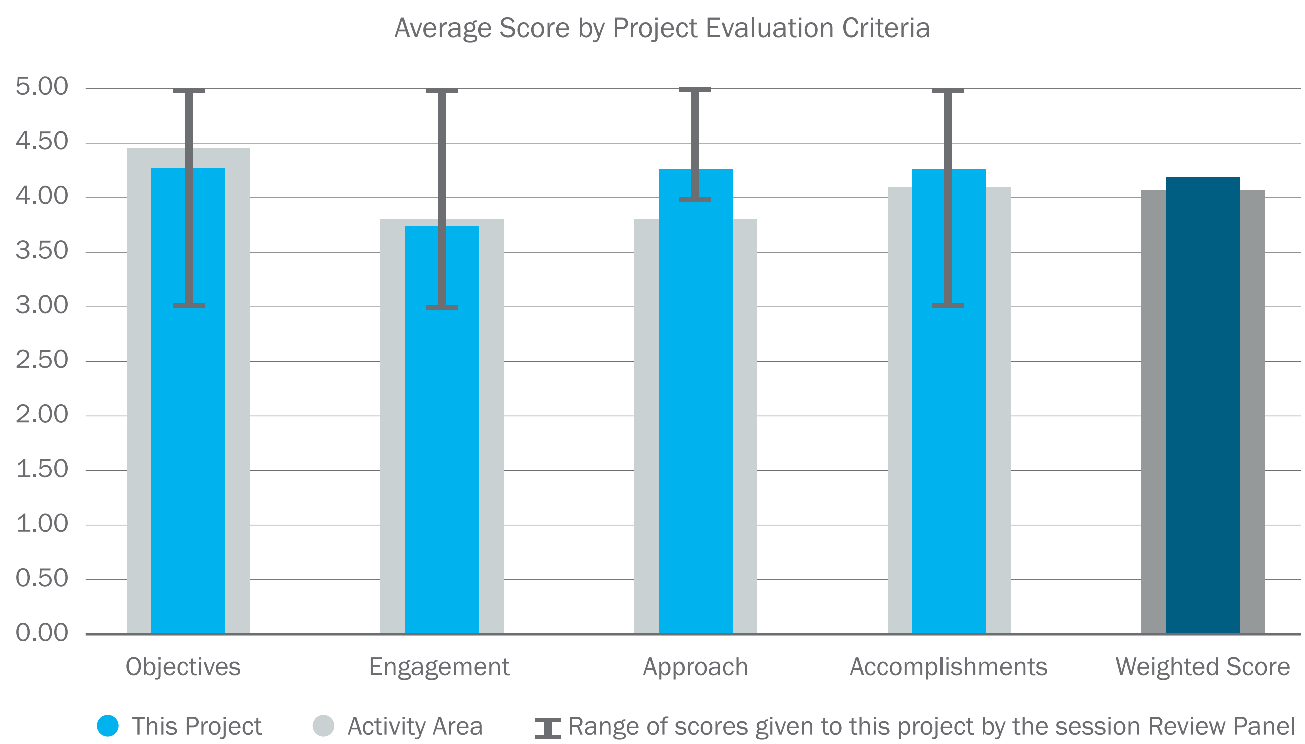
Recipient:	NREL and Natel
Principal Investigator:	Greg Stark
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$185K
Total Costed:	$144K

Project Description

DOE's SBV program provides U.S. small businesses access to DOE's national laboratories, helping them tap resources to overcome critical technology challenges for advanced energy products. Through this program, Natel utilized NREL's grid analysis capabilities to better understand the potential grid value of a cascading network of Natel's hydroEngine® turbines during dry, typical, and wet operating years. This project used operational optimization to quantify net revenue and the ability of the system to meet grid needs for varying hydrologic conditions. NREL also assessed operations under multiple operating cost scenarios, storage volumes, market types, and plant locations.

Weighted Project Score: 4.2

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The project report effectively described how this project, which was a successful example of the SBV program, contributed to the Hydropower program's strategies and approaches. The beneficiaries and end user engagement strategy were well described in this low-impact hydropower project. The project was completed on time and on budget. The project accomplished what it set out to do, ultimately providing an ability to understand the value of networked low-head hydro, its impact on downstream flows, and the effect of flow constraints on revenue.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project report effectively described how the SBV project contributes to the program's strategies and approaches. The report also described the use of the project outcomes, which included understanding the value of networked low-head hydro, its impact on downstream flows, and their relationship to revenue. The project report also addressed the relevance of the project and how it advances the state of technology for networked, low-head hydro, and demonstrated the viability of such a network in commercial applications. Another main tenant of the proposal was to demonstrate how optimized unit commitment of cascading hydropower can be used to respond to grid needs, which was not necessarily delineated in the summary.

End User Engagement and Dissemination Strategy

Beneficiaries of the project have been identified as the SBV applicant (Natel), other similar companies, and irrigation districts with potential for low-head hydropower applications (such as the Imperial Irrigation District) or river systems (such as the Yuba River). The project explained stakeholder (i.e., project partner) engagement. Project results were published in a journal article and a conference paper; however, the audience was primarily manufacturers and those participating in the study. Limited information was provided on the dissemination plan and how results will be shared beyond the project awardee. With such a positive environmental result, it seems like results should also be made more widely to environmental groups, as well as through their conferences and meetings.

Management and Technical Approach

The approach to perform the project analysis was technically sound. The management approach included researchers, modelers, utilities/end users, and the manufacturer. Additionally, the project accepted input from expert advisers. As a result, the project was able to overcome some technical difficulties and regroup using a different modeling approach, while staying on schedule and within budget. The modified analysis approach appears to have been appropriate given the inconsistencies encountered with the originally planned production cost model. This glitch required the team to use in-house software. From the way it is explained in the summary, that software did not allow some of the sensitivity testing that the group originally intended to do but did enable them to refine other aspects of the study such as environmental impact on river flow. The critical success factors were addressed, and a technically viable solution was achieved despite challenges.

Technical Accomplishments and Progress

The project performers met their objectives and completed the project. The most important accomplishments were identified, as well as the most important challenge. The results revealed that the hydro generators could operate in a manner to achieve grid and financial objectives, while also providing a positive environmental result. While the technical accomplishments of this study clearly show multiple benefits to small hydropower facilities that are configured in a cascading manner on a common waterway, it did not clearly demonstrate any of the value to grid reliability and resiliency.

TRANSFORMING THE U.S. MARKET WITH A NEW APPLICATION OF TERNARY-TYPE PUMPED-STORAGE HYDROPOWER TECHNOLOGY

(WBS #:2.3.0.404)

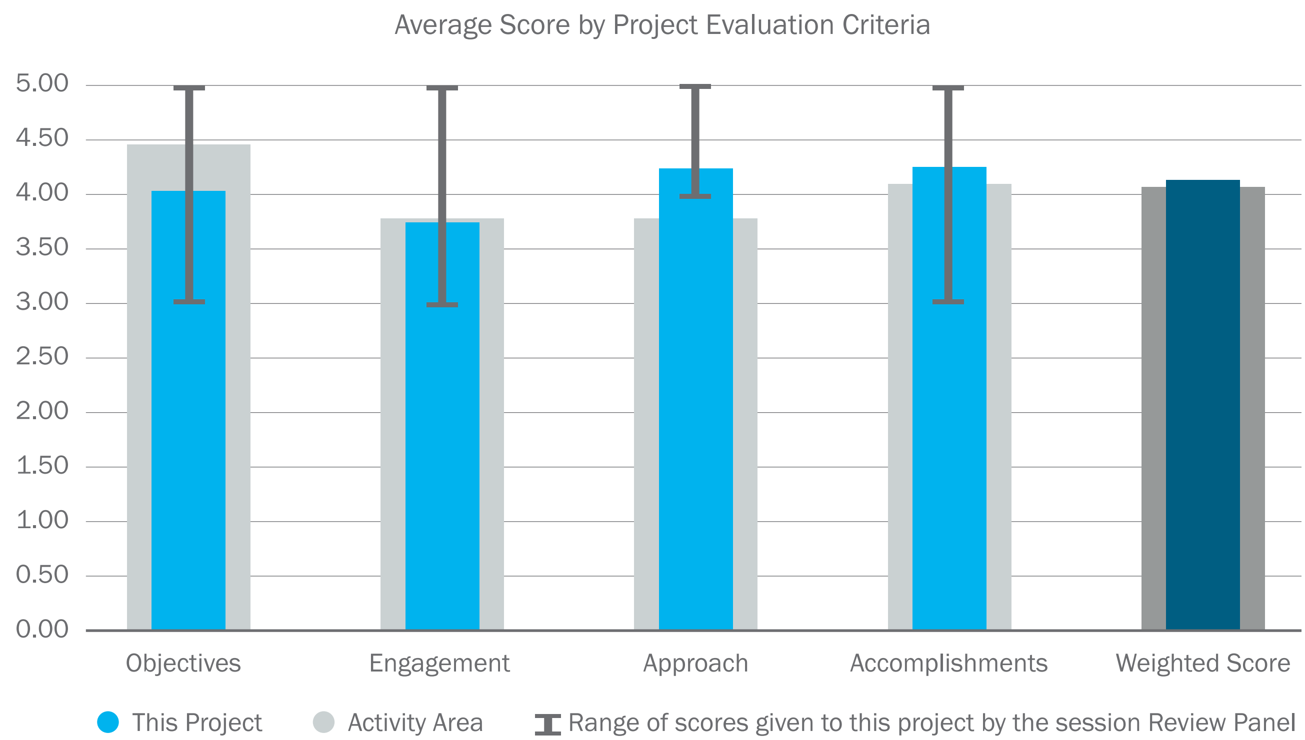
Recipient:	NREL
Principal Investigator:	Mark Jacobson
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,500K
Total Costed:	$827K

Project Description

The overarching goal of this project is to assess and quantify how innovative, fast-acting advanced PSH systems can solve the grid integration challenges facing U.S. renewables in the most cost-effective manner. This project focuses on ternary PSH technology, as well as quaternary PSH, and couples them with sophisticated transmission monitoring and control equipment (i.e., dynamic transmission) as a solution to the integration issues.

Weighted Project Score: 4.1

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The project team did a good job of modeling the ternary PSH technology and then adding the quaternary PSH technology midway through the project. The project presented a nice, detailed project management plan with many milestones enumerated. The project could have had more of a focus on, and explanation of, one of the primary project objectives, to determine how ternary PSH can aid in the integration of renewable energy into the grid rather than an analysis of response to grid disturbances.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project identified four major goals: (1) how ternary PSH pairs with renewable energy and the services it can provide for grid stability, (2) R&D support for this technology, (3) R&D for closed-loop PSH, and (4) big data access and management using a reference plant in Montana.

The project goals align with overall program objectives of improving grid resilience and reliability by better integrating renewables on the grid. To accomplish this, the team studied ternary PSH system paired with a phasor measurement unit, flexible alternating current transmission system device, and renewables that looked at revenue stream, system stability, and ancillary services in the Northwest power pool and CAISO. It was not clear how this project would achieve this goal due to the addition of a different technology midway into the project. The ternary technology seemed to be superseded by the quaternary technology without changing the project goals or objectives. Furthermore, it was not entirely clear how the state of the art will be significantly advanced, or the eventual impact of successfully meeting the project goals.

End User Engagement and Dissemination Strategy

The project team has already done considerable outreach with several journal articles and presentations at industry conferences. Additional outreach is planned after the scheduled completion of the project in September. In addition, the project has targeted utilities that have significant renewable generation on their system to get specific feedback from end users and offtakes. The project team also discussed the results with CAISO. Additional outreach to ISOs is recommended.

Management and Technical Approach

The project management approach included several technical experts and engineers familiar with this technology. The narrative project summary included a project schedule and milestone activities with due dates; the project was well organized and clearly presented its goals, schedule, and milestones. Information about this project was disseminated at some conferences via technical journals. It is unclear if those technical journals were distributed only to the hydropower community or to the stakeholder community at large.

The technical approach included a full analysis of the cost and capacities of the technology and then modeling it in the market. Because of the very fast response from both the ternary and quaternary technology, the existing models did not fully capture the benefits. The project team did a very good job in adjusting to this new technology to fully capture the benefits of the project in the market. Project did not include evaluation of other technologies that can offer the same services (e.g., batteries).

Project risks were not specifically identified. Challenges were mentioned, but there was not enough detail on how they were overcome, or lessons learned.

Technical Accomplishments and Progress

The project team presented seven technical accomplishments that support the project objectives. All of these milestones demonstrate the value-add of T-PSH. They had to overcome several technical and modeling obstacles, but they were able to complete the project on time and within the approved budget. A new project analysis was added to the project, but there was no justification or adjustment to overall project goals when the new technology was added. It is unclear how the original project would have turned out if the new technology had not been added.

Future Work

The project is near completion. While the project demonstrated the value of adding T-PSH to the system, the summary lacked any specifics on exactly how the T-PSH can be integrated with a heavy penetration of renewables, dynamic transmission line ratings, and FACTs, which was alluded to in the earlier part of the paper. There should be more detailed reporting of details.

HYDRO BATTERY SYSTEMS CATALOG DEVELOPMENT

(WBS #: EE0008013)

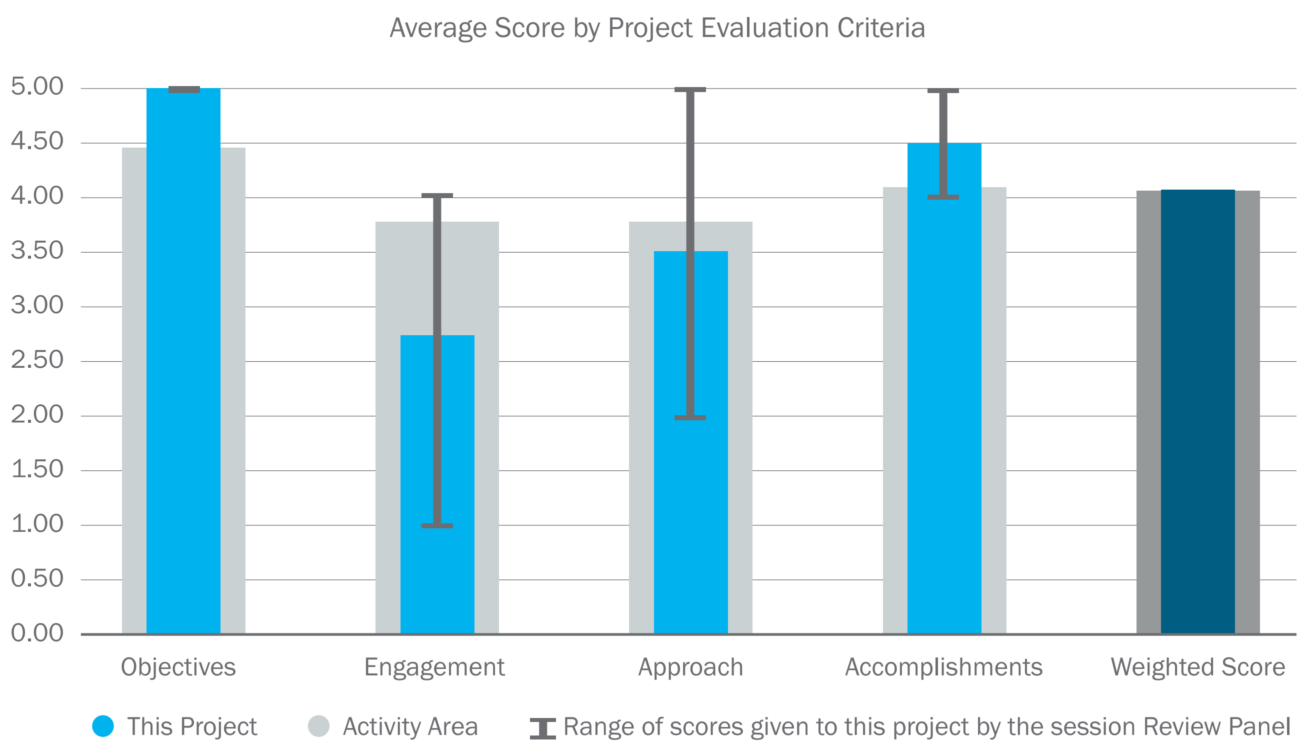
Recipient:	Shell Energy North America
Principal Investigator:	JT Steenkamp
Project Type:	FOA 1455: HydroNEXT: Innovative Technologies to Advance Non-Powered Dam and Pumped- Storage Hydropower Development
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$2,188K
Total Costed:	$958K

Project Description

Shell Energy North America is developing an innovative, completely modular 5-MW PSH system in which a floating membrane and a water storage tank comprise each reservoir for a closed-loop configuration. One project goal is to enable additional replication and additional configuration opportunities. The project will have a relatively small footprint, as the civil earthwork will be reduced as much as possible. Through this award, Shell Energy North America is determining the feasibility of the floating reservoir through design, modeling, and testing of a full-scale prototype. Shell Energy North America will also deliver a detailed engineering design of the balance of systems using Pearl Hill, Washington, as a reference site. The design includes the tank reservoir, modular pump and turbine sets, penstock, modular electrical substation, and auxiliaries. Lastly, a market analysis is being conducted for the system in five market regions to identify value streams within the context of larger renewable energy portfolios.

Weighted Project Score: 4.1

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The review team felt this project did bring forward some innovative approaches to improving the efficiencies and therefore the likelihood of small-scale PSH facilities being constructed. The ability to modularize the components and build them on this scale will be valuable especially in lieu of efforts to leverage existing oil and gas technologies. The review team did feel, however, that there was some degree of secrecy about certain aspects of the design components, innovation points, and potential information dissemination strategies in the project. There appeared to be some conflict between the developer who is looking to patent a product and go commercial and the engagement of the general stakeholder community. Overall, the reviewers had several questions about the viability and risks of the floating membrane component of the system that were not addressed in the summary.

Project Objectives, Impacts, and Alignment with the Program Strategy

The technical concepts and proposed advancements in this project align with WPTO goals, namely the development of an innovative, low-cost, modularized, PSH project that would provide a full range of grid services within existing markets. This project has identified several areas where it can contribute to the program's strategy and goals. The first is to better identify the services that a small modular PSH project can provide. These projects are unique in that they can connect in a more distributed manner rather than at grid scale, so they may offer different services. The project also proposed to identify a standard design to lower costs and a scalable solution for modular deployment. The use of commercially available industry membranes represents an interesting and innovative approach to building such facilities. By leveraging existing equipment and technology from the gas and oil industry, the project team simplified some aspects of the proposal and allowed them to effectively cost the project with a reasonable degree of certainty. This is a highly relevant project that could reduce huge cost and environmental concerns that have stalled the PSH industry.

End User Engagement and Dissemination Strategy

The project team consisted primarily of Shell Energy North America and DOE, with some ancillary technical support from other entities. While the summary identified entities that the project team thought would benefit from the proposal, there appeared to be a lack of follow-up in disseminating information to the stakeholder community. While the project partners were all involved in detailed discussions throughout the effort, the project team did not feel the need to update the general stakeholder community.

Management and Technical Approach

The project was broken down into four major tasks: (1) the floating membrane technology, (2) the balance of the PSH systems, (3) financial evaluation, and (4) lifecycle intensity assessment. Each task was assigned to a multidisciplinary team with expertise in technical design, modeling, and market analyses. Overall, the reviewers felt this was an innovative approach to small-scale, closed-loop PSH. The project has included a good check-and-balance type management approach, with a go/no-go gate between the two budget periods to mitigate project risks. While there was a clear approach to accomplishing the tasks in the project, there appeared to be a discrepancy between the actual budget and timeline. It was noted that the project had slipped with no accompanying explanation of why. More detailed milestones, timelines, go/no-go decision metrics, and accompanying budget updates would have made the review more thorough.

Technical Accomplishments and Progress

From a technical standpoint, the project demonstrated that the use of a prefabricated, corrugated metal, upper reservoir paired with a lower floating reservoir is a workable proposal for small-scale PSH. The project team did not address some valid projects risks such as environmental impacts of the large storage facility at a high elevation, destructive impact risks to a floating membrane, and siting of penstocks. The review team felt the project team should have explored some of these project risks and commented on them in the summary. Also, from a strategic implementation standpoint, the review team felt this project is more appropriate for distribution systems rather than the transmission system. It did not appear that the project team considered this aspect.

Future Work

The review team would like to see this project continue with the development of a workable prototype. Future market analysis on similar sized technologies should consider distribution-scale market evaluations. Additional detail on project materials and testing should be part of any future project funding.

COST EFFECTIVE SMALL-SCALE PUMPED STORAGE CONFIGURATION

(WBS #: EE0008014)

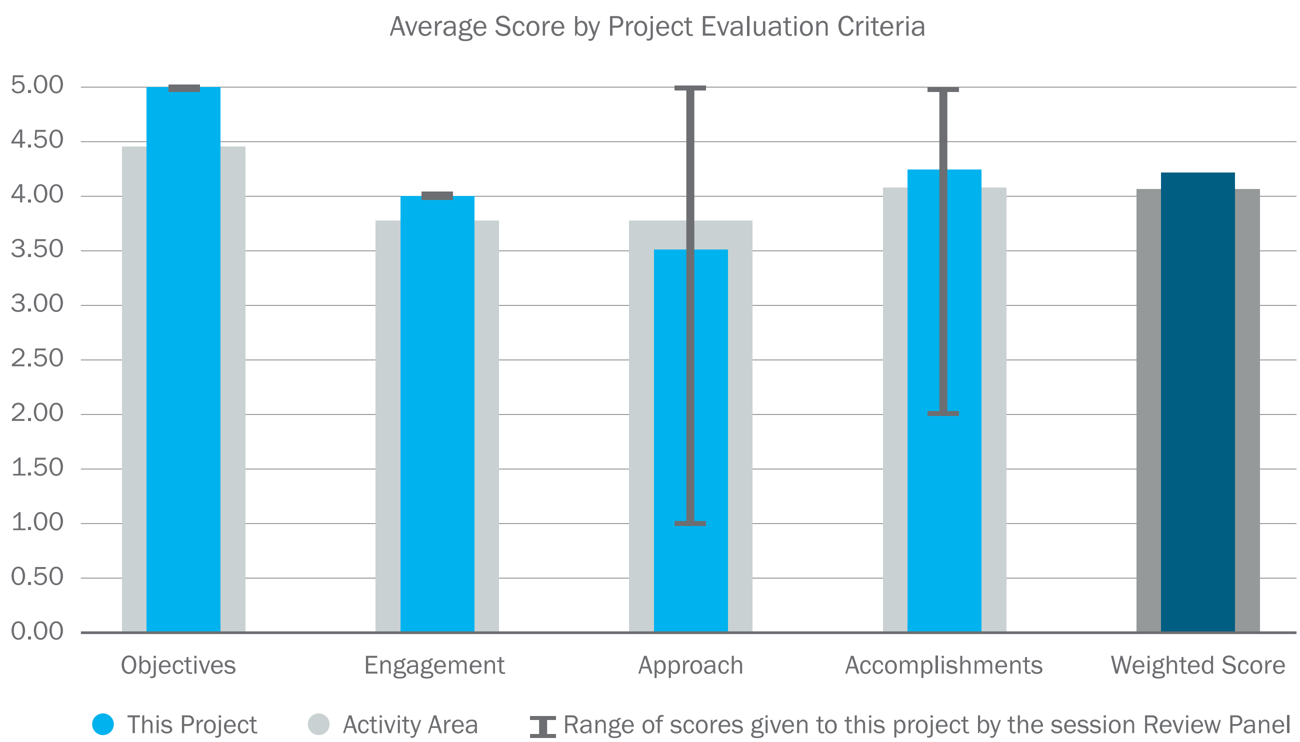
Recipient:	Obermeyer Hydro Accessories, Inc.
Principal Investigator:	Henry Obermeyer
Project Type:	FOA 1455: HydroNEXT: Innovative Technologies to Advance Non-Powered Dam and Pumped- Storage Hydropower Development
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,605K
Total Costed:	$879K

Project Description

The goal of this project is to design a cost-effective, small-scale, adjustable-speed PSH system optimized for the U.S. energy storage requirements. The technology is proven through concept design for exemplar sites, including estimated costs. The project demonstrates that the proposed technological innovation is commercially viable and that energy storage needs can be economically met with the proposed system. Using the developed project design, including cost estimates and ranges of application, the markets were analyzed to determine locations for installation opportunities.

Weighted Project Score: 4.2

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The reviewers generally had a very favorable impression of this project from a technical standpoint. The types of advancements in hydro turbine technology and design of the overall modularized storage facility has enormous industry potential. The review team did have some concerns about project management on this project. The concerns were not really related to the technical aspects of the project but more toward the lack of reporting about the budget, timelines, milestones, deliverables, and commercialization of the project.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers felt that this project fully aligned with the goals set by DOE. The proposal offered up some very innovative approaches to smaller scale PSH facilities. Turbine design proposals lead to an increase in efficiencies that may help justify building these facilities. Also, based on the vertical design, the reduced footprint may make these types of facilities more palatable for siting, as well as more palatable to the environmentalists. The reviewers believe the project should continue to be funded if future funding is available for this type of work.

End User Engagement and Dissemination Strategy

The review team felt that this project has a good cross section of various subject matter experts in the hydropower field. The approach to the study addressed mechanical, hydrological, and electrical aspects of the PSH facility. There did seem to be little information regarding potential environmental impacts (e.g., the potential impact on fish population). As progress was made, the pertinent information was disseminated to various entities within the hydropower community both in North America and internationally via workshops and technical publications. The review team believes that the project team kept the appropriate parties informed on this project.

Management and Technical Approach

The project brought in experts from Auburn University, Micro-tunneling, and Small Hydro Consulting to help with the technical work. NREL was brought in to evaluate some of the marketing and cost implications. There was no significant information about how this team was effectively managed nor was there concrete and detailed information on budgets, timelines, or milestones. It would have been more effective in reviewing this project if explicit milestones with progress summaries were included.

This collection of experts did bring the necessary knowledge to design, prototype, and evaluate this innovative approach to PSH. The team encountered some serious technical challenges with the concept of a vertically installed turbine/generator/pump configuration, which required very innovative solutions.

The review team also felt that there was an over emphasis on contributing to grid reliability. These facilities, because of their small size, may be more suited to interconnection on the distribution system rather than transmission system. The review team felt there may be more opportunities by considering the lower voltage distribution systems. The inclusion of project milestones and go/no-go gates would have aided in the review to better understand how the project was managed.

Technical Accomplishments and Progress

The review team felt this project accomplished several technical innovations across several different fronts on PSH. The project clearly demonstrated that the vertical PSH concept is workable and cost competitive. It was apparent the project team made some significant mechanical turbine design changes to make the vertical concept work; these were very innovative and proved very effective. Additionally, the technical advancements were not confined solely to turbine design; as an example, they developed an innovative approach for hoisting the turbine/generator/pump configuration up the shaft for maintenance. The project will continue to move forward and develop a 40-KW prototype, which the reviewers supported. Additional technical advancements may be forthcoming from validation of the prototype. There was mention in the summary of successfully pairing the facility with a solar photovoltaic plant, but there was no follow-up detail, which reviewers would have liked to see.

Future Work

The review team feels there are other potential applications and advancements that can be realized if this technology can be coupled with other projects, like GLIDES, and other DOE initiatives.

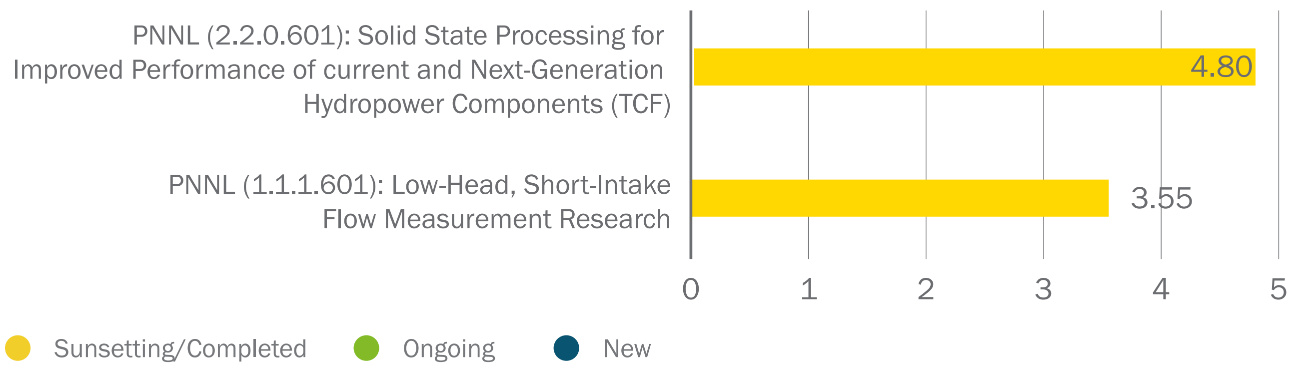
Modernization, Upgrades, and Security

This section provides an overview of the scoring for all projects within the Modernization, Upgrades, and Security (MUS) activity area (see Figure 14); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Modernization, Upgrades, and Security	**4.18**

Figure 14. Modernization, Upgrades, and Security activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

There are only two projects in this year's MUS portfolio; however, it is worth noting that the Solid-State Processing project by PNNL has breakthrough potential for the cavitation resistant manufacture and repair of hydro turbines. The reviewers were in full agreement that these efforts should continue at full speed and should explore combined use with robotic techniques, if (or when) the process is successfully demonstrated in field or manufacturing situations. This relatively low-risk investment but high potential payback was deemed as one of the best projects in the entire hydro portfolio. An excellent, model example of the potential benefits of R&D!

Summary of all Reviewers' Comments

Overall Impressions

In general, reviewers were "wowed" by the incredible potential of Solid-State Processing project's techniques for increasing the cavitation resistance of newly manufactured turbines and the potential for more cavitation resistant field repairs. The reviewers were less impressed with the results of the Short Intake Flow Measurement Research, which attempted to address a long-standing difficulty of getting cost-effective, yet accurate, flow measurements for short rectangular penstocks. The combined analytical and field-testing process required much less machine downtime for installing and completing flow testing, but unfortunately, the process fell short on the resulting final accuracy.

Program Strategy and Objectives

The reviewers generally agreed that the projects aligned with the objectives of the program. The Solid-State Processing project was a clear example of investing in early-stage research to accelerate the development of innovative water power technologies. The Short Intake Flow Measurement Research project was a clear example of a project that attempts to overcome long-standing difficulties to validate unit performance and could be used to deliver efficiency gains for many small and medium sized hydro stations.

Program Portfolio

While the sample size of projects in this category is very limited this year, reviewers agreed that these projects contribute to meeting the program's strategy and objectives. The Solid-State Processing project is focused on reducing the impacts of cavitation, which is a key challenge that could dramatically lower maintenance costs and reduce outage durations in a high percentage of hydro stations. This project has a low-risk, high-reward potential and is worthy of continued investment. Overall, the projects within this activity area are appropriate for WPTO's role as a public R&D organization.

Program Management Approach

For the limited projects in this year's MUS portfolio, it did not appear that much additional program team oversight was required for these projects to be reasonably smoothly executed and meet the intent of the program objectives. While the technical capabilities needed to monitor and guide these MUS projects appeared to be sufficient in these instances, the reviewers generally agreed that, in other activity areas, there is a much greater need for additional industry expertise and field experience to support the PIs and assist with DOE project management and technical oversight.

Stakeholder Engagement, Outreach, and Dissemination

While the engagement, outreach, dissemination, and resulting effectiveness vary by project in the MUS portfolio, reviewers generally agree that the program has demonstrated good stewardship of taxpayer funds by performing research on chronic barriers to improvement and high value, high potential impact areas. The reviewers also generally agreed that WPTO could be well served to engage peer reviewers and/or other industry experts earlier and continuously throughout the project process to assist with design reviews, project management oversight, and technical support. These experts could also fill a support role as thought leaders to inform the direction of the program and offer connections to industry partners for disseminating information. This would be a relatively small cost to insure maximum impact of WPTO-supported research.

Project Evaluations

LOW-HEAD, SHORT-INTAKE FLOW MEASUREMENT RESEARCH

(WBS #: 1.1.1.601)

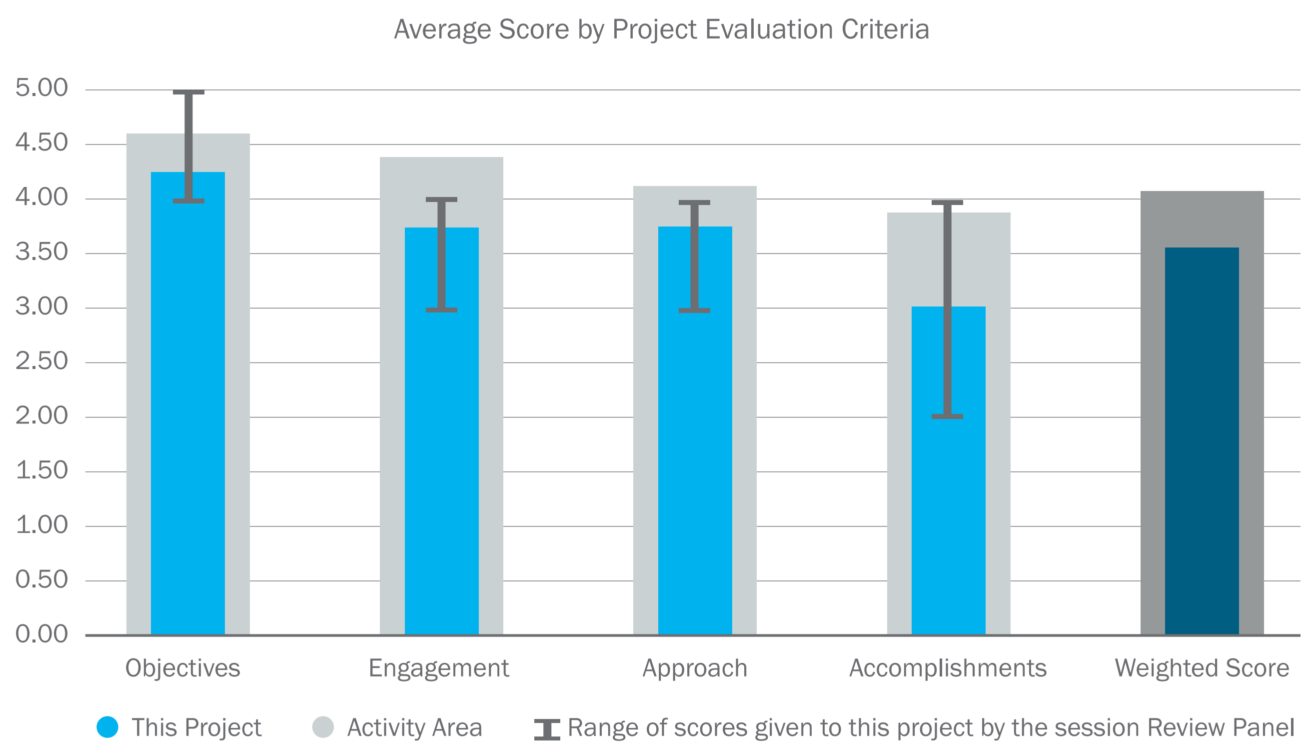
Recipient:	PNNL
Principal Investigator:	Marshall Richmond
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$524K
Total Costed:	$412K

Project Description

The overall objective of this project is to develop improved flow (discharge) measurement technology that will enable U.S. hydropower assets to produce more energy from available water. Achieving optimal generation, long-term water-use efficiency, asset monitoring, and sustainable water management objectives require active monitoring and control of hydropower unit operations. The availability of accurate flow-rate measurement technology is a primary factor in monitoring and controlling the instantaneous efficiency of hydropower energy production in the face of multiple constraints on hydropower asset operations. The ultimate outcome will be flow measurement technology and site-specific analysis methods that can be applied to a wide range of turbine types in the U.S. hydropower fleet that cannot be readily measured using existing technology.

Weighted Project Score: 3.6

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

This was an innovative attempt to improve absolute flow measurements for short rectangular penstocks using cost-effective methods. Unfortunately, the results of this method at this time do not provide sufficient accuracy (+/- 3%) to overcome this long-standing and difficult challenge.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that the explanation of project objectives was clear and aligned with DOE program objectives. The goal of this project was to reduce the cost and time required for absolute flow measurement in short rectangular penstocks, while delivering high accuracy. Cost-effective flow measurement is key to assessing true efficiency and performance but has been an insurmountable challenge in rectangular penstocks for many years.

End User Engagement and Dissemination Strategy

Reviewers agreed that there are a number of end users and hydropower units having this rectangular intake geometry that would benefit from this project's successful completion and accurate flow measurement delivery. Engagement of the U.S. Army Corps of Engineers' Hydroelectric Design Center and Chief Joseph Hydro Station as a deployment site were very useful to the project. It is not completely clear how this information will be disseminated or what the expected value proposition is for the end user.

Management and Technical Approach

The technical approach utilized a creative combination of analytical modeling and field test measurements to reduce the time for test set-up and to ultimately get accurate measurements more quickly. Reviewers generally agreed that the approach was innovative and reasonable, although the project management aspects (schedule, milestones, achievements, etc.) could have been more thoroughly described. Also, it was not completely clear how the analytical models from this initial effort could be used at other locations or if additional modeling would be needed for each site and what that cost and schedule might look like.

Technical Accomplishments and Progress

Reviewers generally agreed that this approach was innovative in attempting to overcome a problem that has been a performance measurement challenge at many old hydro stations for many years. Unfortunately, the results from the method in this pilot do not provide sufficient accuracy (+/- 3%) to use for turbine performance acceptance guarantees and would require significant improvement to match the best available (but labor intensive) existing technologies (+/- 1%). Reviewers agreed that this method, in its current state of accuracy, would probably not see widespread application and would likely have limited potential, but it was seen as a valiant attempt at a very challenging problem.

SOLID STATE PROCESSING FOR IMPROVED PERFORMANCE OF CURRENT AND NEXT-GENERATION HYDROPOWER COMPONENTS (TCF)

(WBS #: 2.2.0.601)

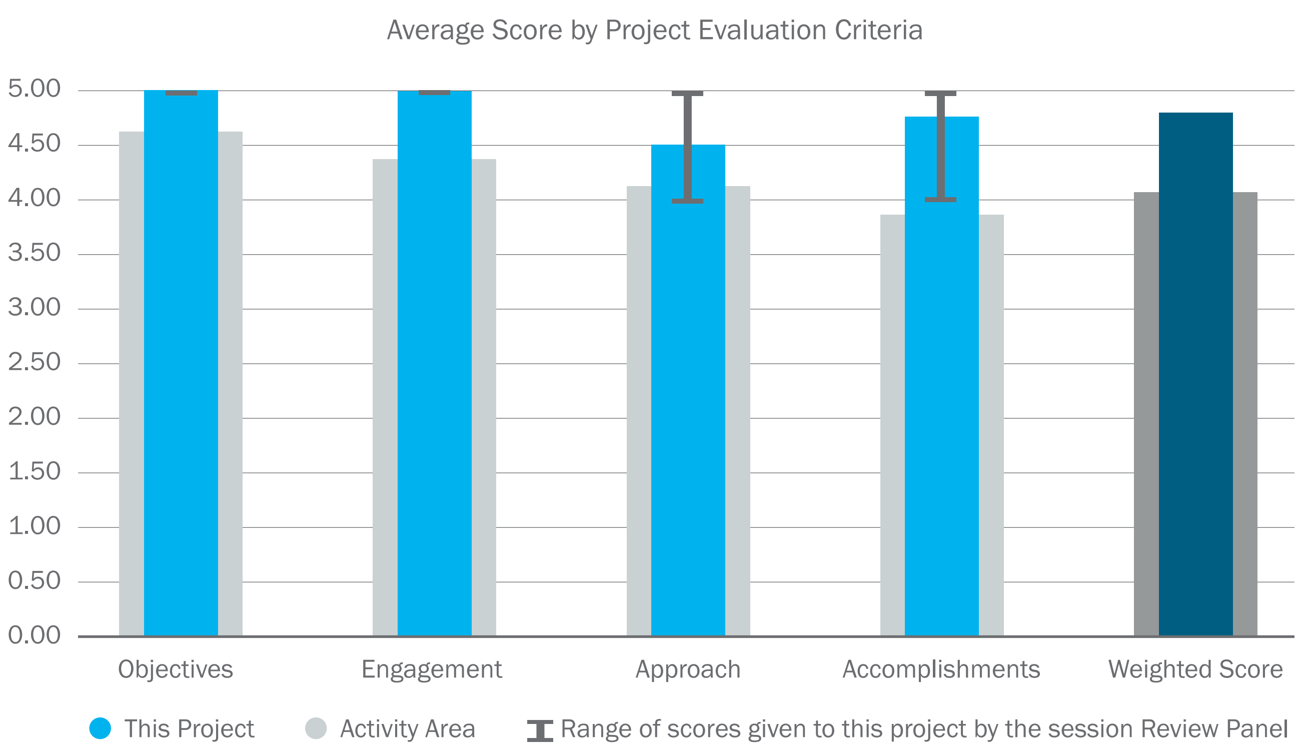
Recipient:	PNNL
Principal Investigator:	Ken Ross
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$200K
Total Costed:	$195K

Project Description

Component failures in hydraulic machinery, such as pumps, hydropower turbines, and propellers, are often caused by cavitation. In hydropower turbines, cavitation can also be harmful to fish passing, causing an increased fish mortality rate. To reduce the deleterious effect of cavitation, it is important to focus on mitigating material loss due to cavitation in the design and maintenance of hydraulic machines. The goal of this project was to demonstrate the feasibility of solid-state processing for cavitation repair of hydropower turbine runners, as well as to manufacture more cavitation resistant turbines. Solid-state processing is an emerging approach for producing a wide range of materials. It has the potential of delivering high-performing components with a low energy input. Solid-state processing produces controllable materials via high strain and plastic deformation. The specific solid-state processes investigated within the project duration are cold spray and friction stir welding. The project team evaluated the cavitation erosion resistance of sample plates, which they compared to unprocessed steel. Surface cavitation patterns and cavitation rates were characterized, and the mechanisms of material removal were discussed.

Weighted Project Score: 4.8

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The project supports the hydropower fleet by targeting significant cost reductions to reduce and repair cavitation damage and shortening outage times, which improves system reliability. The project seems to be moving in a logical fashion through testing and is at a stage where field deployment and testing are warranted. The project performers should be commended for their accomplishments and for focusing on an important issue to the hydroelectric industry. While technically sound and with appropriate input from end users, the project could benefit from improvements in project management and clarity in communications.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were in complete consensus that the project has the potential to provide significant benefits to the hydroelectric industry by delivering a new cost-effective approach to repair runner cavitation damage. This may become a bigger issue in the future as the hydroelectric system is increasingly used for flexibility purposes and units may experience increased cavitation. The project performers clearly described how the technology could be deployed commercially and advance the state of technology in the industry.

End User Engagement and Dissemination Strategy

The reviewers were in consensus that the project appropriately engaged potential end users as evidenced by the relevance of their work to the industry and as provided in their project information. The beneficiaries of their work were identified as well. The inclusion of project owner/operators (e.g., Army Corps of Engineers, Bureau of Reclamation, Idaho Power), as well as the Bonneville Power Administration, as collaborators provided a commercial sense to the activities and should provide the project performers with opportunities to field test their technology at projects experiencing cavitation issues.

Management and Technical Approach

The reviewers generally felt that the management and technical approach was appropriate for the work performed, which was demonstrating the properties of the different solid-state applications and the potential for improving cavitation repairs in a test environment before moving to field testing. Two of the reviewers cited minor shortcomings in the project summary related to this area—specifically that the project management approach could be improved and that the milestone descriptions were vague. Improved project management techniques may be warranted as the project moves to field testing in actual units. A better explanation of the technologies themselves (friction stir welding and cold spray applications) would have greatly improved the written summary.

Technical Accomplishments and Progress

The technical accomplishments are impressive and warrant continued work and deployment. Three of the reviewers noted that the progress was poorly communicated and that future written materials will need to address this shortcoming. This may be particularly important as the project moves toward field testing where project owners/operators will need to be convinced to take a significant step in using new technologies on expensive operating equipment. The project presentation addressed some of the shortcomings in the summary. It was clear from the presentation that progress had been made relative to the objectives and that the accomplishments warrant continued work in this area. A successful aspect of this research is the fact that all these tests were conducted at a very reasonable budget, highlighting the fact that this initial research into increasing cavitation erosion has paid great dividends and should continue into future phase of development and dissemination.

Future Work

The next step would be to implement these findings in the field and to evaluate the benefits for coating newly manufactured runners. Additionally, the team should explore the feasibility of combining solid-state processing methods with robotic repair and contouring techniques. If robotic repairs are possible, this would be even more valuable to the hydropower industry since confined space and poor accessibility pose significant problems for turbine repair workers. This is groundbreaking work of incredible importance to the industry.

agreed that the approach was innovative and reasonable, although the project management aspects (schedule, milestones, achievements, etc.) could have been more thoroughly described. Also, it was not completely clear how the analytical models from this initial effort could be used at other locations or if additional modeling would be needed for each site and what that cost and schedule might look like.

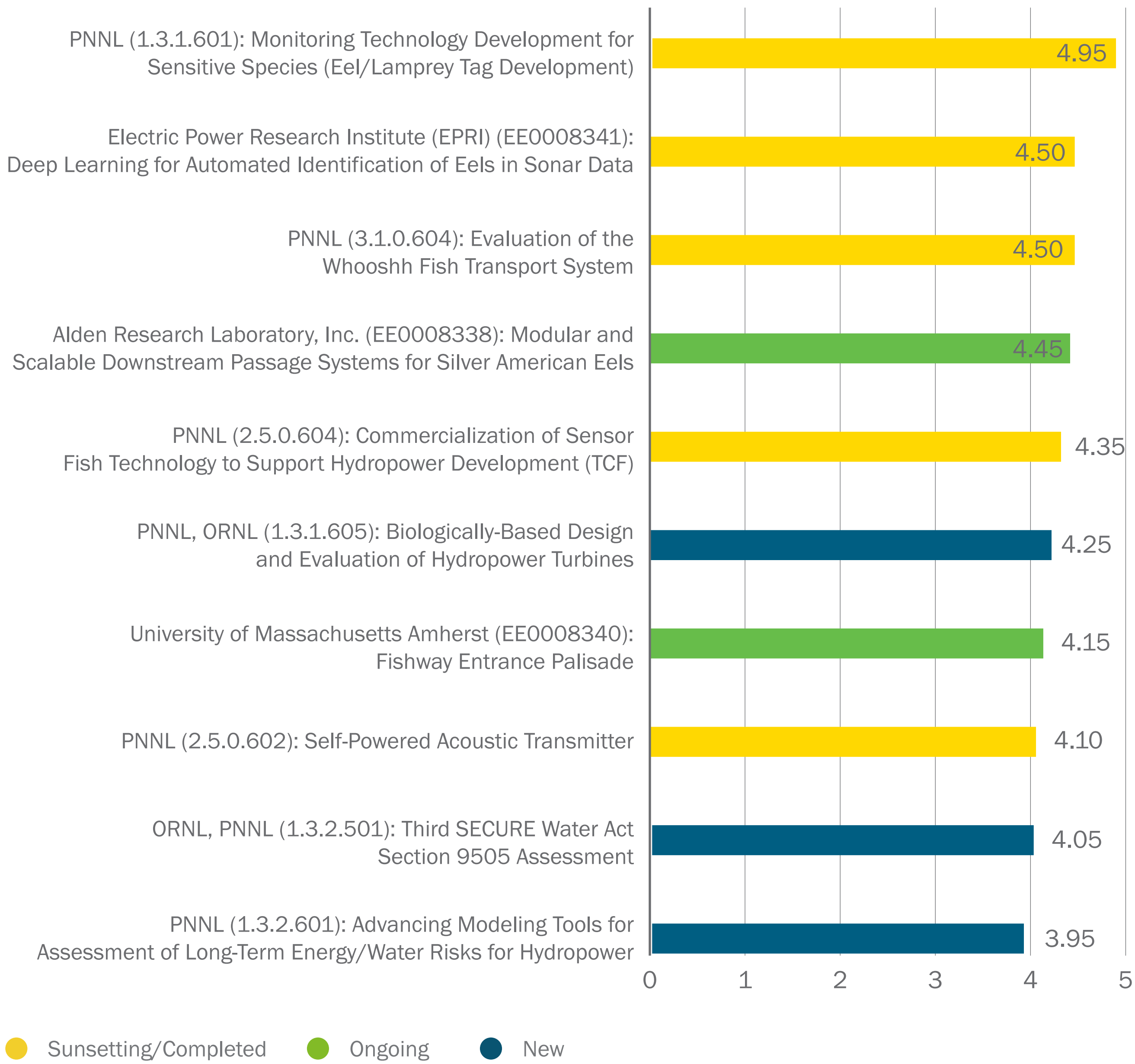
Environmental R&D and Hydrologic Systems Science

This section provides an overview of the scoring for all projects within the Environmental R&D and Hydrologic Systems Science activity area (see Figure 15); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Environmental R&D and Hydrologic Systems Science	4.33

Figure 15. Environmental R&D and Hydrologic Systems Science activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

Reviewers were strongly supportive of the projects in this program. There were a few suggestions for improvement and a few criticisms but, overall, there was strong support. The tools developed through this program should be very useful.

Summary of all Reviewers' Comments

Overall Impressions

The projects were strongly supported by reviewers for their objectives. There were some comments on the lack of information related to budgets and go/no-go decision-making frameworks, which was more a symptom of the peer review process and execution than of the projects' performance.

Program Strategy and Objectives

The presenters did a fine job with the objectives of their projects. In hindsight, perhaps a 1–2-page summary by WPTO for each program area would be helpful as context for reviewers (e.g., an explanation of how the three modeling focused projects fit with the seven fish passage/monitoring focused projects). WPTO should consider sharing an outline of each program to include the genesis of it, point along the program timeline at the time of the peer review, previous projects within the program, anticipated opportunities/focus areas for upcoming projects, and budget information (e.g., allocation for each project and spent to date for each, anticipated future funding).

Reviewers agreed that all the projects appeared to align well with the program objectives and needs of the industry. It is evident that this program invests in early stage research and develops innovative technologies. One of the criticisms specific to this lead has been the time to commercialization for some tools (e.g., Sensor Fish, and Juvenile Salmon Acoustic Telemetry System). It appears that WPTO is increasingly focused on timely commercialization, and if so, this criticism will no longer be waged. All reviewers agreed that the tools being developed are/will be useful to the industry.

This area of the Hydropower Program is not particularly focused on grid reliability, but the research complements other areas of the program that do support grid reliability. Through the various labs and outside facilities, industry has good access to testing infrastructure. Anecdotally, one reviewer suggested that WPTO should think critically about intellectual property (IP) ownership requirements at the labs and how this affects outside organizations and partners. Again, while anecdotal, one reviewer did not think it was clear why a lab should benefit through ownership of IP created in partnership with outside parties.

No reviewers explicitly stated that taxpayer funds have not been invested wisely. There were comments on the lack of attention (even though prompted by the review topics) to go/no-go decision points or frameworks. Given that the projects under peer review are in various stages along their timeline, it can be difficult to judge whether wise investments have been made. More attention to the go/no-go frameworks and presentation of what decisions were made (and why) during a project's timeline would be helpful.

Program Portfolio
All reviewers agreed that the projects presented contribute to the program's focus and objectives, and the projects included are addressing key challenges. With the power of current computers, the modeling projects will produce results and tools that will be very useful to the industry. Similarly, with the advances in materials science, battery miniaturization, and CFD tools, large strides in addressing fish passage and monitoring issues can be made.

The rationale for and organization of the funded projects and program approaches was adequately conveyed during the peer review. One aspect that would be helpful to reviewers is to have all materials (including slides) delivered as a single package well in advance of the presentations. Receiving slides the night after the first day of presentations was not helpful, as there was little time to review them. Complete budget information was not presented in many cases, and few effectively described those milestones in the timeline where go/no-go decisions were made and why.

In all cases, reviewers saw some or great merit in the projects, assuming they are completed in a cost-effective manner. With the 'snapshot' approach to this peer review process, it can be difficult to assess whether priorities and resources are appropriately allocated. One suggestion was to have a specific team of reviewers stay with a project (and perhaps program) from proposal to completion. There may be some difficulties in implementing such an approach, but reviewers offered it for consideration. It is evident from the strong support of reviewers that the projects in this program are appropriate for WPTO to support.

Program Management Approach
In most cases, reviewers scored the management of projects with high scores. However, there were some questions about how project teams might accomplish various aspects of their projects (e.g., whether existing efforts by others might be sufficient to inform the model development in PNNL's project titled "Advancing Modeling Tools for Assessment of Long-Term Energy/Water Risks for Hydropower" (1.3.2.601); whether the self-powered tag will come to fruition as a useful tool, especially as a commercialized tool; was an abundance of existing information of fish passage survival utilized in development of the tools in PNNL's project "Biologically-Based Design and Evaluation of Hydropower Turbines" (1.3.1.605)?

It was apparent that all projects reviewed focused on priority research areas that create the greatest impact on new technology and industry advancement. In general, the program team effectively communicated priority research areas and the allocation of resources. However, reviewers agreed that presentation of budget and future work aspects would have been more useful if complete project budgets were included. Dissemination of the technical information seemed to be well done.

In all cases, the reviewers agreed that the Hydropower Program team demonstrated the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects and thought that the project teams were well qualified. However, it is hard to assess that with any rigor or detail with the limited amount of time to observe the team in action.

Stakeholder Engagement, Outreach, and Dissemination
Regarding transparently communicating how WPTO funds are being utilized, reviewers agreed that more information on the budgets and their use would have appreciated. Some project presenters only presented budget used for the past two years and not the full project, so it was virtually impossible to assess whether funds were used efficiently over the course of the project.

In gathering feedback from stakeholders to inform and improve WPTO's projects and strategy, reviewers recommended continuing to consult with its current strong ties to the NHA, the Northwest Hydroelectric Association, and the Hydropower Foundation. The Hydropower Foundation is anxious to find the next program with WPTO to make a difference in the hydro industry. With Linda Ciocci as the new Executive Director, the organization is well positioned to tackle new initiatives. Reviewers recommended engaging in a series of regional meetings with high-level representatives of individual hydro, regulatory, consulting, and special interest groups. It is unclear whether such meetings would be more productive if you were to segregate or integrate groups based on their position along the hydro value spectrum, perhaps attempts at both would be informative. WPTO should pose questions and situations that test the representatives of each sector to justify their positions and broker meaningful conversations between articulate advocates for important issues/positions and policymakers.

Overall, reviewers thought that the dissemination of WPTO-supported research results was extensive. The panel lead questions the importance of focusing on primary literature publications in journals that are relatively obscure to the industry. Reviewers recommend that PIs should focus on better disseminating information to the end users.

Reviewers generally agreed that the program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision makers. One caveat, as mentioned before, is the time to commercialization, but if time to commercialization is a focus of WPTO moving forward, it will be applauded.

MONITORING TECHNOLOGY DEVELOPMENT FOR SENSITIVE SPECIES (EEL/LAMPREY TAG DEVELOPMENT)

(WBS #: 1.3.1.601)

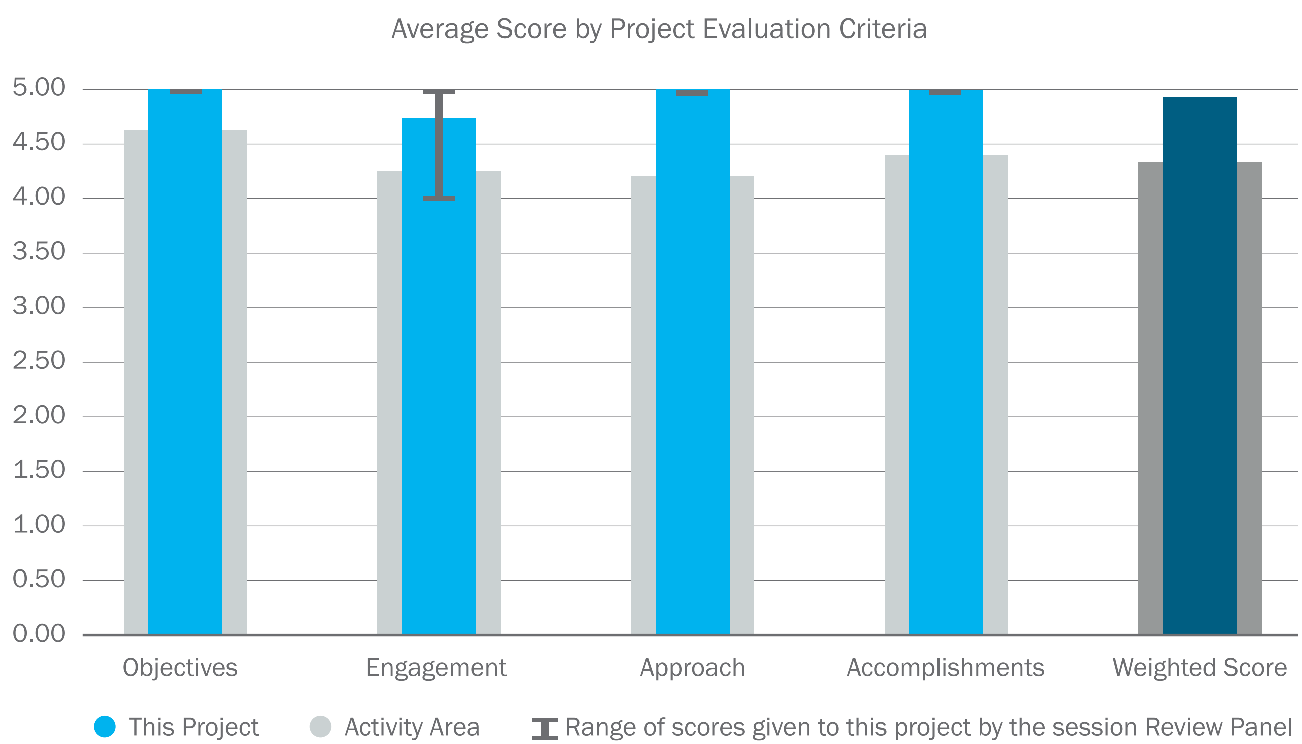
Recipient:	PNNL
Principal Investigator:	Daniel Deng
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,068K
Total Costed:	$1,068K

Project Description

The goals of this project were to design, prototype, and perform laboratory and field tests of an acoustic micro transmitter that can be used to study the behavior and survival of juvenile eel and lamprey. The ability to implant acoustic transmitters and track the movement of juvenile eels can help researchers better understand migration routes, habitat use, and hydropower dam survival rates to make more informed management decisions regarding new and existing hydroelectric facilities.

Weighted Project Score: 5.0

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%



Summary of all Reviewers' Comments

Overall Impressions

The project created a miniature monitoring device for implanting in juvenile eels and lampreys to better understand migration of these sensitive species through hydropower dams. The result is a remarkably small tag, capable to transmit data on a relatively long distance and tracking 3-D position of the fish in stream. All reviewers were impressed with this tag its potential application. It will likely be widely used to better understand fish movements and behavior.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project objectives are to better understand behavior of eels to protect them and ultimately make better hydropower management decisions. Reviewers agreed that the explanation of project objectives was clear and aligned with DOE program objectives. All reviewers offered a score of 5 for this aspect.

End User Engagement and Dissemination Strategy

Reviewers agreed that the project has successfully engaged end-users and has a substantial dissemination strategy with publications, presentations, media coverage, and more. A broad range of stakeholders might be interested in results of the proposed work. There was one reviewer question about the status of commercialization.

Management and Technical Approach

All reviewers scored this section with a 5 due to the strong team and performance. The management approach required multi-disciplinary collaborations that the project team managed well. Reviewers thought that the technical approach was robust and multi-faceted. One reviewer suggested including a commercialization schedule in the report.

Technical Accomplishments and Progress

Reviewers agreed that the technical accomplishments were substantial and that the acoustic micro-transmitter is a remarkable success. For its size, reviewers though that it has excellent longevity and offers potential of being widely used not only for targeted fish species, but in a much broader range of applications. This tag should be a very useful tool for better understanding fish movements and behavior. One reviewer suggested that the project team include more details on tag power and detection range.

BIOLOGICALLY-BASED DESIGN AND EVALUATION OF HYDROPOWER TURBINES

(WBS #: 1.3.1.605)

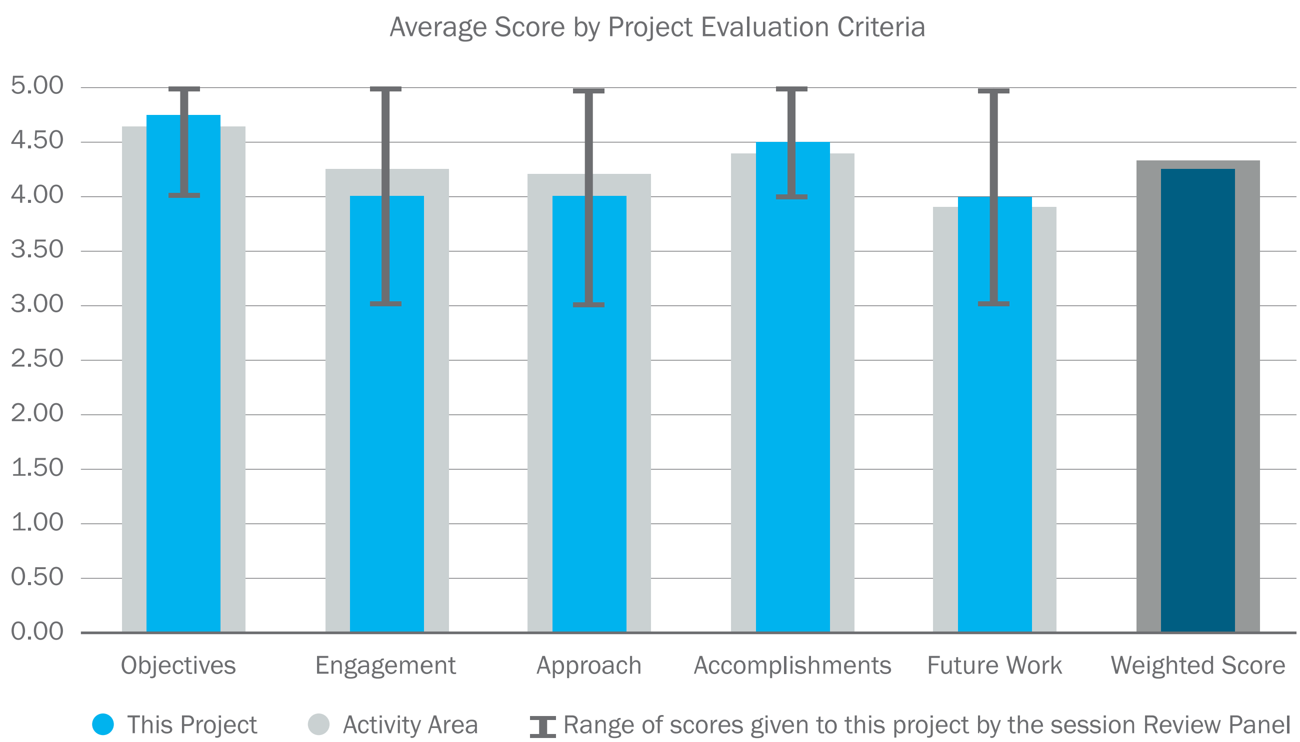
Recipient:	PNNL and ORNL
Principal Investigator:	Alison Colotelo
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$5,192K
Total Costed:	$3,566K

Project Description

This project is a multi-lab, long-term initiative between Pacific Northwest National Laboratory (PNNL) and ORNL. The goal of this project is to develop, demonstrate, and transfer a suite of tools and technologies that can be used by the hydropower community to evaluate the biological performance of proposed and existing hydropower turbines. The first tool, the Biological Performance Assessment toolset, provides a computational fluid dynamics (CFD) model overlay to relate in-turbine forces (e.g., strike, barotrauma, and shear) to impacts on fish and is derived from empirical data. The second tool, the Hydropower Biological Evaluation Toolset, is a software that supports similar analyses and works with field data collected by the Sensor Fish instrument, a neutrally buoyant juvenile salmon-sized sensor package that can be released through downstream fish passage routes (e.g., hydropower dam draft tubes). A third project product is dose-response data on a variety of U.S. fish species of concern. Fundamental experiments conducted at the DOE national laboratories provide data, information, and analyses on the impacts of in-turbine forces to fish to quantify passage survival indexes in the Biological Performance Assessment and the Hydropower Biological Evaluation Toolset.

Weighted Project Score: 4.3

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

All reviewers strongly supported this project and thought that the software package has broad potential applicability, including rivers with different kinds of fish and different environmental criteria. There seem to be significant commercial applications. Reviewers thought that it would have been helpful to see more information on the go/no-go decision making, as well as points along the way where such decisions were/will be made. The set of tools produced or in the works should be very useful to turbine designers.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project objective relates to a very important issue of assessing and improving fish survival during the turbine passage. The reviewers agreed that the explanation of project objectives was clear and aligned with DOE program objectives. Work accomplished so far is highly valued by the industry. All thought that the tools that will result from this project will be useful to many in the industry, assuming all tools will be commercialized in a timely manner. All reviewers supported this project.

End User Engagement and Dissemination Strategy

Reviewers agreed that the engagement and dissemination strategy is robust, with targeted market research into relevant hydropower operators/owners. Reviewers appreciated the emphasis on technology transfer to the end users, including identifying use cases to inform future research and to guide strategic engagement.

Management and Technical Approach

All reviewers agreed that the management and technical approaches were sound. It was not clear whether the project relied primarily or solely on data and information generated by the labs or whether the large body of peer reviewed and gray literature from the hydropower industry was used to inform this project. Information on milestones and go/no-go decision points along the timeline either were not conveyed.

Technical Accomplishments and Progress

Generally, reviewers were impressed by the substantial technical accomplishments. In fact, industry is already using some of the tools. A timeline for technology transfer of tools in development would have been helpful.

Future Work

Future work is well explained through FY 2020, although key milestones and go/no-go decision points were not included. This suite of tools should be well used by turbine manufacturers and perhaps others.

THIRD SECURE WATER ACT SECTION 9505 ASSESSMENT

(WBS #: 1.3.2.501)

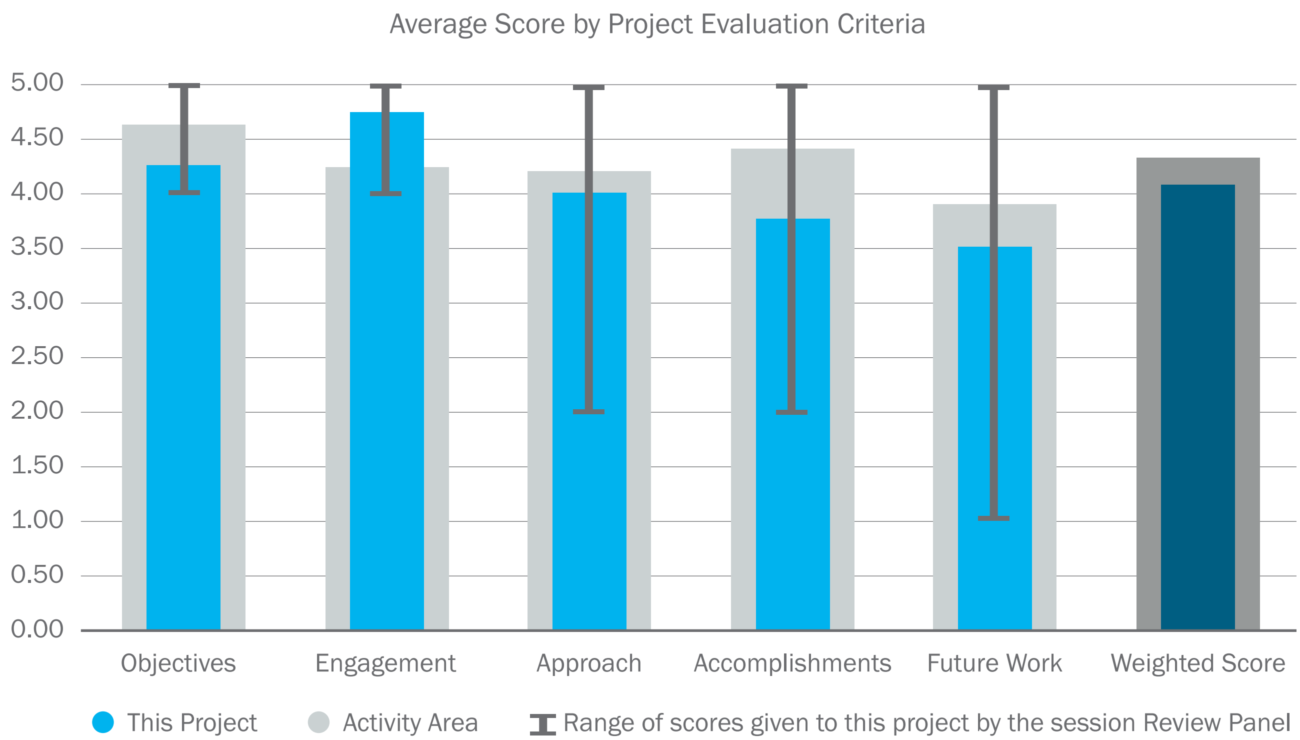
Recipient:	ORNL and PNNL
Principal Investigator:	Shih-Chieh Kao
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$809K
Total Costed:	$572K

Project Description

The objective of this project, as directed by Congress in Section 9505 of the SECURE Water Act (Public Law 111-11) of 2009, is to evaluate "each effect of, and risk resulting from, global climate change with respect to—(A) water supplies used for hydroelectric power generation; And (B) power supplies marketed by each Federal Power Marketing Administration." The Secretary of Energy is designated as the lead for this assessment, and it is to be conducted in consultation with the Power Marketing Administrations and other federal and state agencies every 5 years until 2023. The third 9505 (9505-V3) assessment started in 2018 and will provide the technical basis for the third DOE Report to Congress, which the SECURE Water Act requires.

Weighted Project Score: 4.1

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

Although the SWA mandates this project, the reviewers strongly agree that it is critically important to DOE and the hydropower industry to understand the effects of future hydrologic conditions on hydro generation, and thus highly aligned with the Program approaches and strategies. The project team is highly qualified, and the project has had a strong start in engaging the Power Marketing Administrations and other water management agencies in the methodology workshop. The plan to include the non-federal hydro industry through Hydropower Operations and Planning is also important. There are some concerns about the extensive technical work proposed without technical milestones or discussion of risk and critical success factors. Also, some concern about the technical focus on hydrologic techniques rather than hydropower analysis. The budget for this project should be analyzed with some comparison with the previous study to ensure a successful outcome.

Project Objectives, Impacts, and Alignment with the Program Strategy

This project is mandated by Section 9505 of the SECURE Water Act, which requires a study every 5 years to project potential effects of long-term hydrologic change on water availability for federal hydropower generation, hence the future of renewable energy and grid reliability. In addition to this congressional mandate, the reviewers agree the stated project aligns with the approach. Reviewers would welcome even more information on this Program alignment; they remarked on the importance of considering climate change on hydropower; and they encouraged including project benefits that go beyond federal hydropower projects.

End User Engagement and Dissemination Strategy

The project has reported on the extensive consultations that were held with Power Marketing Administrations, USACE, the Bureau of Reclamation, the U.S. Geological Survey, and the National Oceanographic and Atmospheric Administration (NOAA) to agree on a plan for methodology and assessment. The federal agency engagement is very strong and on track, and outreach to non-federal power stakeholders through Hydropower Operations and Planning is also useful and important. Reviewers recommend that the project should have more detailed plans for dissemination, especially to the non-federal stakeholders, in addition to the planned review by external experts of the final assessment.

Management and Technical Approach

The reviewers laud the expertise and collaboration among the project team members. Most reviewers are favorably impressed with the description of the technical plan of sequencing models from general circulation models to regional power projections. One reviewer was concerned that the very ambitious technical work plan is described only as tasks, without milestones or critical success factors or go/no-go decision points; the reviewer was also concerned that no risks have been identified. There are also some concerns about the technical focus of the work was on developing new hydrologic techniques (downscaling, multiple hydrologic models), but there was no mention of developing more sophisticated hydropower analysis, including flexibility and impact on grid analysis, which should be the main focus for DOE.

Technical Accomplishments and Progress

Progress to date includes the methodology workshops and likely some technical work, although without a schedule, milestones, or specific details, the progress cannot be accurately assessed. The reviewers applauded progress reported by the completion of the 2017 report but pointed out that this is not formally part of the current project.

Future Work

Most reviewers are satisfied with the outline of future work and “timely accomplishment of this important project.” One reviewer is concerned that the future work is described only in terms reports and meetings, and that there is not a schedule for the challenging and intense technical aspects of the work. Also, there are no budget numbers available to assess the future work.

ADVANCING MODELING TOOLS FOR ASSESSMENT OF LONG-TERM ENERGY/WATER RISKS FOR HYDROPOWER

(WBS #: 1.3.2.601)

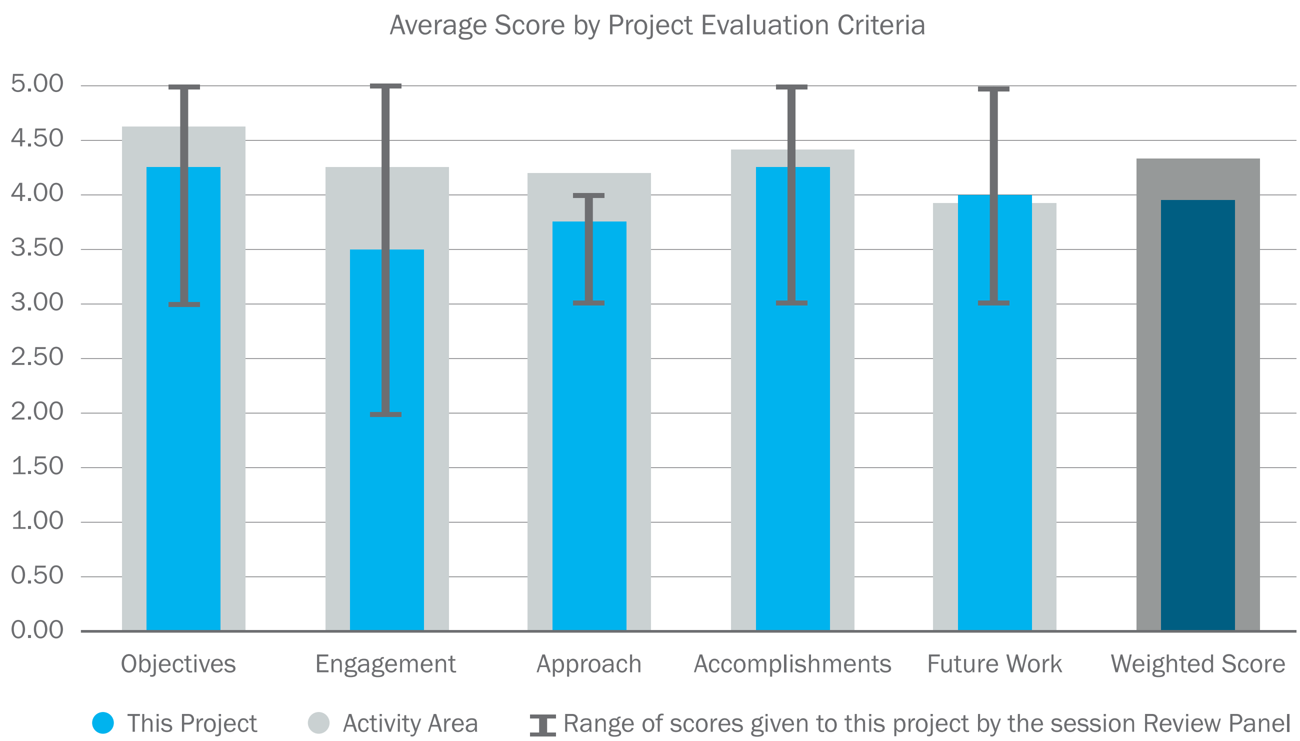
Recipient:	PNNL
Principal Investigator:	Mark Wigmosta
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$2,111K
Total Costed:	$1,800K

Project Description

This project is developing and demonstrating a scalable, physics-based modeling framework to better understand and evaluate hydropower investments and operational decisions in the face of changing hydrologic regimes. Of specific interest is the relationship among, and potential future risks regarding, changing water temperature regimes in rivers; electric power generation from hydropower; thermoelectric plant cooling and discharge; and water-quality and habitat needs for sensitive species. The project is developing and demonstrating an advanced modeling framework at the plant and system levels to evaluate the potential likelihood and severity of water temperature events under a range of possible future scenarios. The project will also evaluate alternative operations and infrastructure investments to mitigate such events.

Weighted Project Score: 4.0

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

Reviewers agreed with the value of improved (higher resolution) models for environmental analysis, although it is noted that specific need and use cases have not been identified as justification for the effort. The project leads are highly qualified, and early release of the improved model to the research community reflects substantive success. There is concern that the model cannot express hydropower operations or know about the grid, which may be a deficit in the ability to develop improved or optimized hydropower plant operations to support evolving grid needs. The plan to apply the model to a second basin in the eastern United States was considered potentially valuable by the reviewers, although there is concern about the enhancements that would be needed and about the lack of a general management plan guiding this and the work in general.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers unanimously agreed that project objectives are well described and aligned with the Hydropower Program's goals and strategies, and they agreed that the project is valuable and worth pursuing. Reviewers agreed that modeling river basins is a vital component of predicting future risks to hydropower generation and water quality due to the changing climate. High spatial resolution of the proposed approach, combined with the use of high-performance computing, will allow for a better understanding of multiple elements of system dynamics.

End User Engagement and Dissemination Strategy

All but one reviewer was satisfied with the description of the beneficiaries and end users identified, which includes "a broad cross section of the diverse interests in the hydropower arena," and also of the plans for dissemination. However, the only beneficiaries so far have been universities and research institutes, and there is some uncertainty expressed regarding future distribution and possible commercialization of the ultimate "product." One reviewer notes the lack of plan for stakeholder input to the process and notes that most hydropower stakeholders (such as hydropower plant owners/operators, tribes, NGOs, etc.) will not have the technical expertise or resources to benefit from this modeling platform.

Management and Technical Approach

The reviewers agreed that project managers are well qualified and capable of delivering the technical results. The main technical concern is that, although the physical process modeling seems sound and will be an improvement for environmental assessment, it is not clear how assessment of operating plans can be achieved. One reviewer thought that the models would also be improved by the inclusion of reservoirs, which have significant temperature implications. Critical success factors were not described.

Technical Accomplishments and Progress

Several technical accomplishments were reported: quantitative results presented indicate success of the modeling computations, computational performance is improved, and early transfer to external researchers reflects the acceptance and value of the computational work. Reviewers suggested that the project team include a comparison with the older modeling platform to demonstrate improvement.

Future Work

The project team indicated that the next steps are applying the framework to a second basin, likely the Connecticut River, for geographic and other differences. Most reviewers agreed with this project's value in that it would require model enhancements that are important to the hydropower industry;; although some pointed out that it does not fit into a described management plan, and specific work products are not described.

SELF-POWERED ACOUSTIC TRANSMITTER

(WBS #: 2.5.0.602)

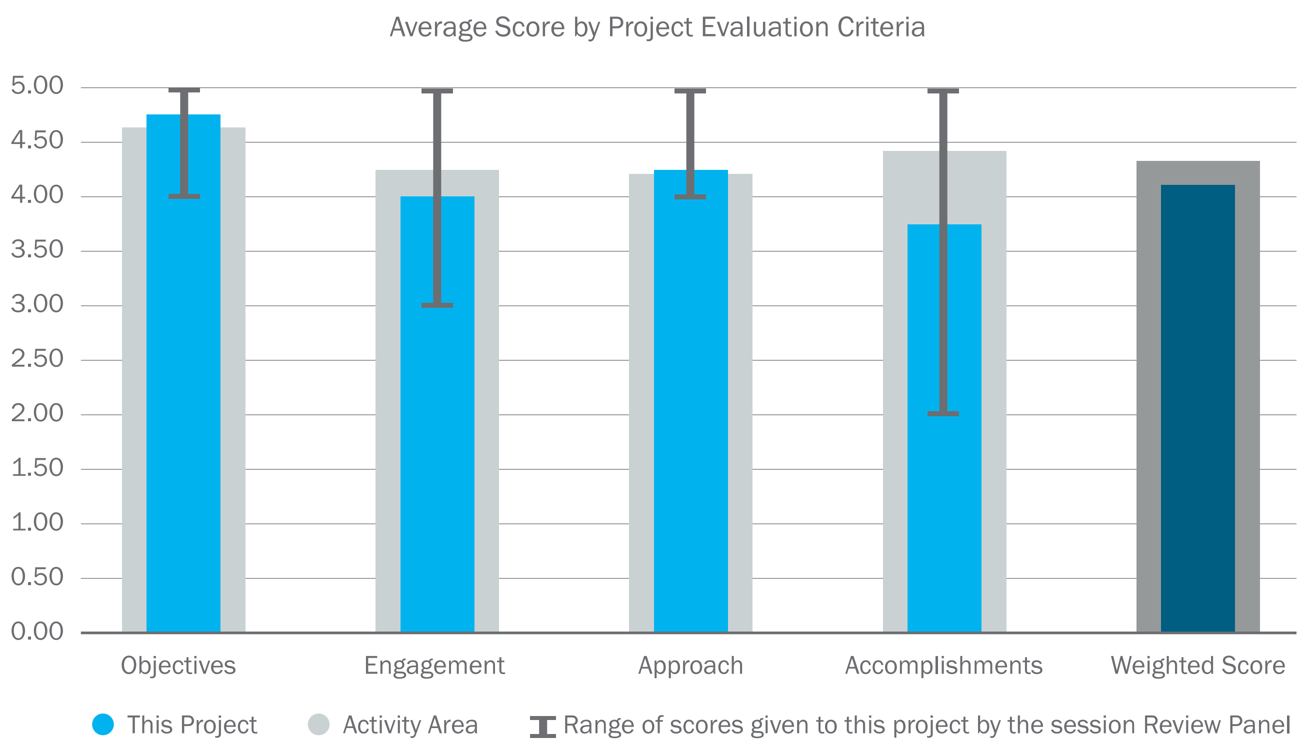
Recipient:	PNNL
Principal Investigator:	Daniel Deng
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$150K
Total Costed:	$125K

Project Description

The goal of this project is to prepare the self-powered transmitter for commercialization by demonstrating its viability and market impact in collaboration with private partners. The self-powered transmitter is a unique technology developed by PNNL and has generated interest from the private sector for application and technology transfer. This project is part of TCF Laboratory Call for Proposals in June 2016 and is extended without additional funds into 2019 to complete the field study component.

Weighted Project Score: **4.1**

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

All reviewers were very favorably impressed with this tag. It would likely be widely used to better understand fish movements and behavior if it can be developed for commercialization.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that the explanation of project objectives was clear and aligned with DOE program objectives. All agreed that this is a great idea, with substantial range of potential applications to facilitate tracking and protecting fish migration at hydroelectric facilities. One reviewer commented that, while objectives were well described, it was not clear if objectives will be met.

End User Engagement and Dissemination Strategy

In general, reviewers agreed that the engagement and dissemination efforts were good and included partnerships with a range of companies, presentations at conferences, and well-read articles published. One reviewer would have appreciated more details on how project partners were selected and how many licensees were queried regarding the utility of this tag.

Management and Technical Approach

In general, reviewers agreed that the management and technical approach was sound. In spite of some hurdles, good decisions have been made to date. It is not clear whether this tag will continue toward full development for use in the field.

Technical Accomplishments and Progress

All reviewers were impressed with the accomplishments in spite of some problems. Reviewers appreciated the candid description of problems. Some more details on tag specifications would have been appreciated. It is not clear whether this project will continue to fruition, which would be disappointing, as this tag has significant potential to be valuable in long-term monitoring of fish. Of course, it will only be useful if the price point for it is affordable; if that becomes an issue, then perhaps it should be shelved until other ideas come along. A description of the various go/no-go decision points (past and future) would have been helpful.

COMMERCIALIZATION OF SENSOR FISH TECHNOLOGY TO SUPPORT HYDROPOWER DEVELOPMENT (TCF)

(WBS #: 2.5.0.604)

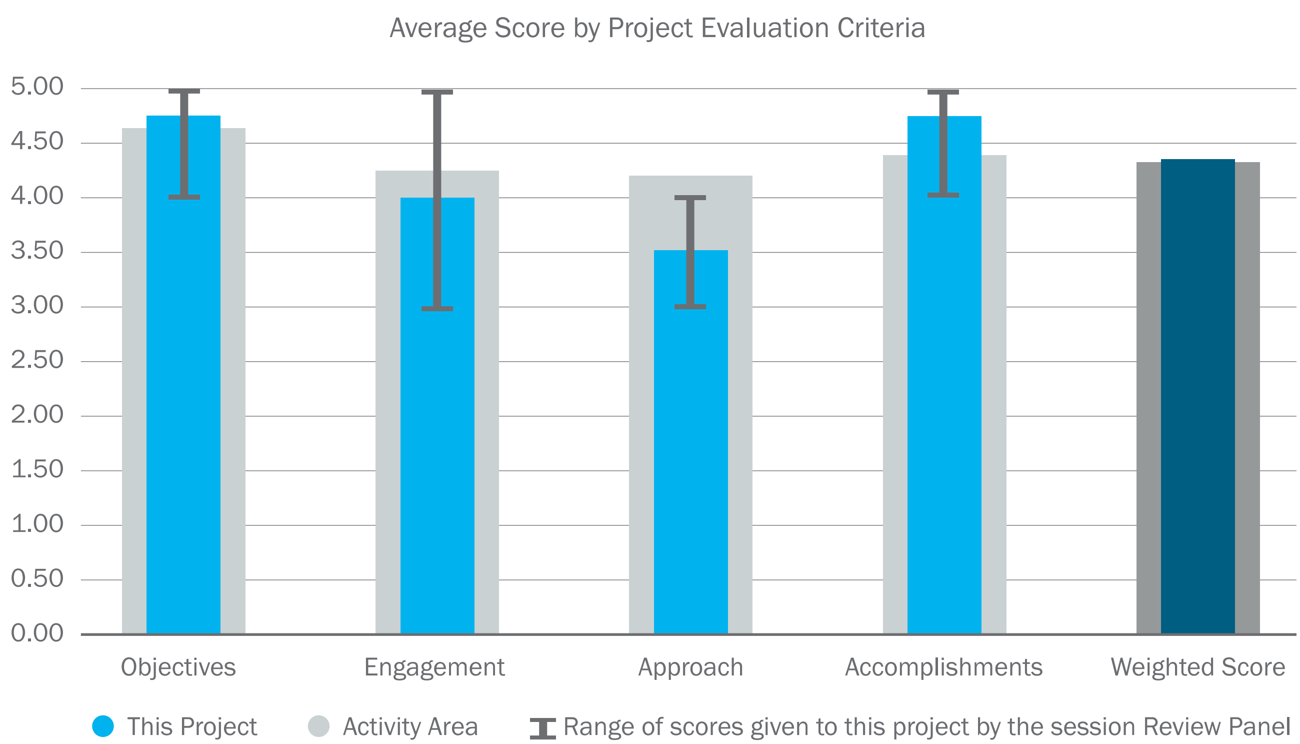
Recipient:	PNNL
Principal Investigator:	Daniel Deng
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$150K
Total Costed:	$150K

Project Description

The objectives of this project were to (1) commercialize the Sensor Fish Technology to support hydropower development and evaluations; and (2) develop a prototype of a smaller version (Sensor Fish Mini) to characterize the growing need for sustainable small hydropower and testing scale-turbine models. It will provide information, data, and tools for dam operators and turbine designers to use to improve turbines and structures, as well as to understand and mitigate the environmental effects of hydropower operations on fish. It will also reduce regulatory review times and costs by reducing the need to conduct studies with live fish.

Weighted Project Score: 4.4

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The commercialization process was a success, and the product was highly useful for improvement of fish conditions in turbines. Reviewers were positive about this PNNL support for commercialization and about the business model that was set up that brings license royalties back to the inventors and lab, and they encourage this support for other innovations. The need for ongoing user support for the product has not been addressed but needs to be. One concern was with the selection of partners for commercialization—the rationale and decision process were not provided. The project could not be evaluated as thoroughly as reviewers would have liked because of a lack of budget information. The reviewers would have also liked to see a schedule for commercialization of the Sensor Fish Mini.

Project Objectives, Impacts, and Alignment with the Program Strategy

Reviewers agree that this project is well aligned with the Hydropower Program objectives under the environmental R&D and hydrological systems pillar, as well as the technology R&D for low-impact hydropower growth pillar. They are enthusiastic about the value and success of the sensor and point out "the substantial interest in the hydropower industry to use this device. The effort to commercialize it does make sense and has been welcomed by the users. The development of a mini version of the device broadens its range of applications to small hydropower and possibly model test facilities."

End User Engagement and Dissemination Strategy

Half the reviewers were favorably impressed with the engagement with Natel, Advanced Telemetry Systems, and the farmers and irrigation organizations, as well as with the dissemination strategy that included licensing of IP, presentations and workshops, peer-reviewed journal articles, and media reports. However, reviewers also felt that the process for selecting the participants was not explained and could have been broader or more aligned with larger markets. Some reviewers expressed some dissatisfaction with the timeline of commercialization and limitations to PNNL during that process, as well as with "marginal industry participants," noting that the project should have mentioned wider industry applications.

Management and Technical Approach

The commercialization process, once started, happened efficiently and successfully. The reviewers expressed several concerns, including (1) selection of the commercialization partners was not described nor criteria provided; although ATS appears to be "the right way to successful dissemination of the sensor," (2) working with major turbine suppliers and users would be more appropriate; and (3) it took too long—well over a decade—for this commercialization, during which time data were collected for decisions, whereas other acoustic tags were being pushed out to commercial market more quickly. The project did not present a schedule, milestones, or success criteria for the testing.

Technical Accomplishments and Progress

Reviewers noted that the project is a success in that commercialization has been achieved and the product already contributed to the knowledge of turbine environment, testing new designs, and improving conditions for fish by operations. However, it is noted that this project is not the development of the product, but rather the commercialization. The three main tasks were accomplished: (1) the prototype design and lab field investigations of the mini; (2) development of a manufacturing process for commercialization; and (3) the patent was obtained, IP established and licensed, and papers published.

EVALUATION OF THE WHOOSHH FISH TRANSPORT SYSTEM

(WBS #: 3.1.0.604)

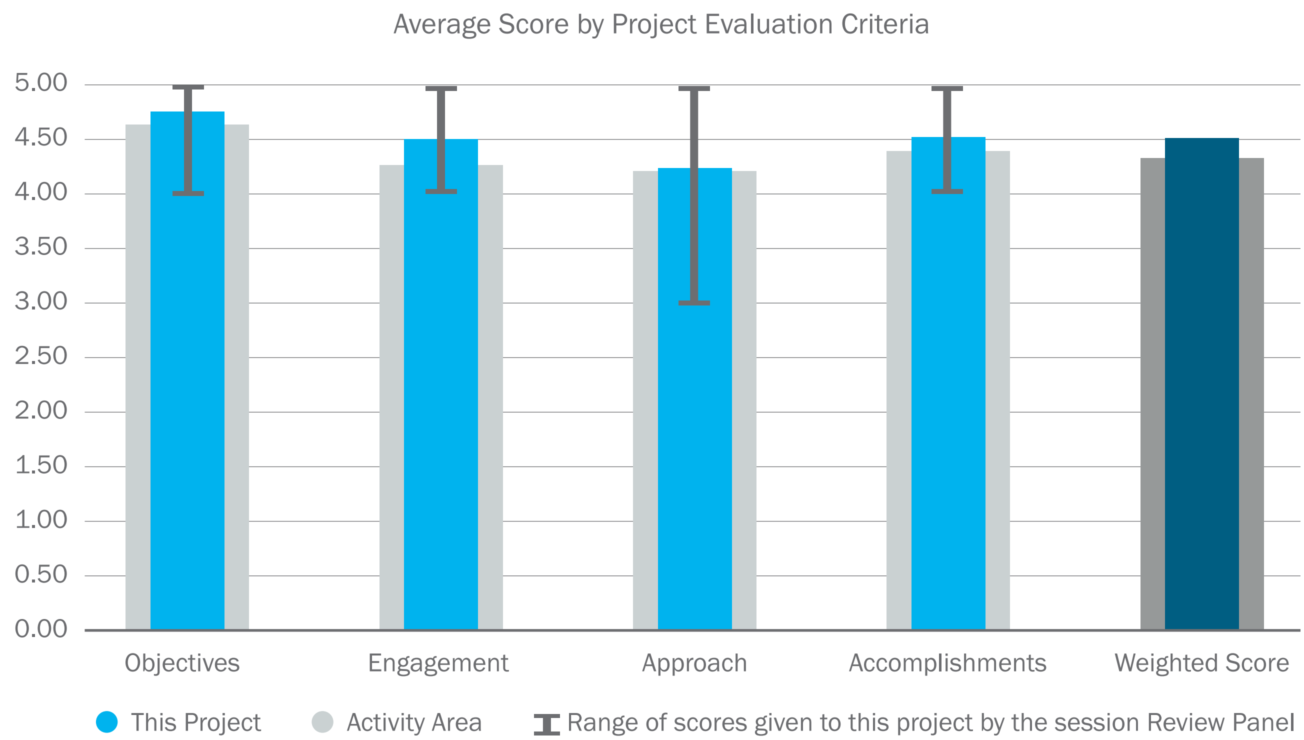
Recipient:	PNNL
Principal Investigator:	Alison Colotelo
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$375K
Total Costed:	$300K

Project Description

The evaluation of the Whooshh Fish Transport System project provided laboratory technical services to Whooshh Innovations, Inc. (Whooshh) in response to their SBV award. Under this program, PNNL supported Whooshh by (1) developing a flow chart roadmap that defined the limits and criteria for new fish passage technologies and (2) designing and executing an independent evaluation of the capabilities of the Whooshh Fish Transport System to sort fish by size. This project provided Whooshh with access to intellectual and technical resources found within PNNL, specifically experts in fish passage. PNNL conducted a third-party evaluation of the Whooshh Fish Transport System and published results in peer reviewed literature. This increased access of information about this technology to regulatory agencies and spurred regular meetings to share information about developments. These results aided Whooshh in their mission to fully commercialize the technology, specifically for river systems with species of regulatory concern.

Weighted Project Score: 4.5

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

Even though all of the objectives were not met, the reviewers provided high marks for this project. This system is an innovative fish passage option. Whooshh has struggled to get acceptance by agencies because it is new and untested. This test, along with a few others conducted or soon to be conducted, should help with the demonstration and acceptance of this option for fish passage. It promises significantly lower costs than conventional fishways because, in part, it requires much less, if any, civil works. Multiple reviewers appreciated the assistance provided to private firms.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that the explanation of project objectives was clear and aligned with DOE program objectives. The project had two primary objectives: (1) to develop a decision tree for evaluating new technologies and (2) to test the Whooshh Fish Transport System in the field under controlled conditions. One reviewer did not think that development of the decision tree was worthwhile because of differences in agencies' approaches and review processes. The field evaluation was supported by all.

End User Engagement and Dissemination Strategy

Reviewers agreed that the engagement and dissemination strategy of this project team appears to be sound. This project benefits Whooshh directly. Hopefully there will be indirect benefit to hydropower project owners.

Management and Technical Approach

Reviewers were divided on the management and technical approach. One criticized the lack of details on challenges and performance criteria (for the project itself). Another reviewer did not think the decision tree task was worthwhile. Other reviewers liked the Whooshh/PNNL partnership aspect and how it was conducted.

Technical Accomplishments and Progress

The project scored well for technical accomplishments and progress, with a minor hit for the fact that the decision tree was not accepted by regulators. The publishing of results is a strong point. One reviewer suggested publication in Hydro Review.

MODULAR AND SCALABLE DOWNSTREAM PASSAGE SYSTEMS FOR SILVER AMERICAN EELS

(WBS #: EE0008338)

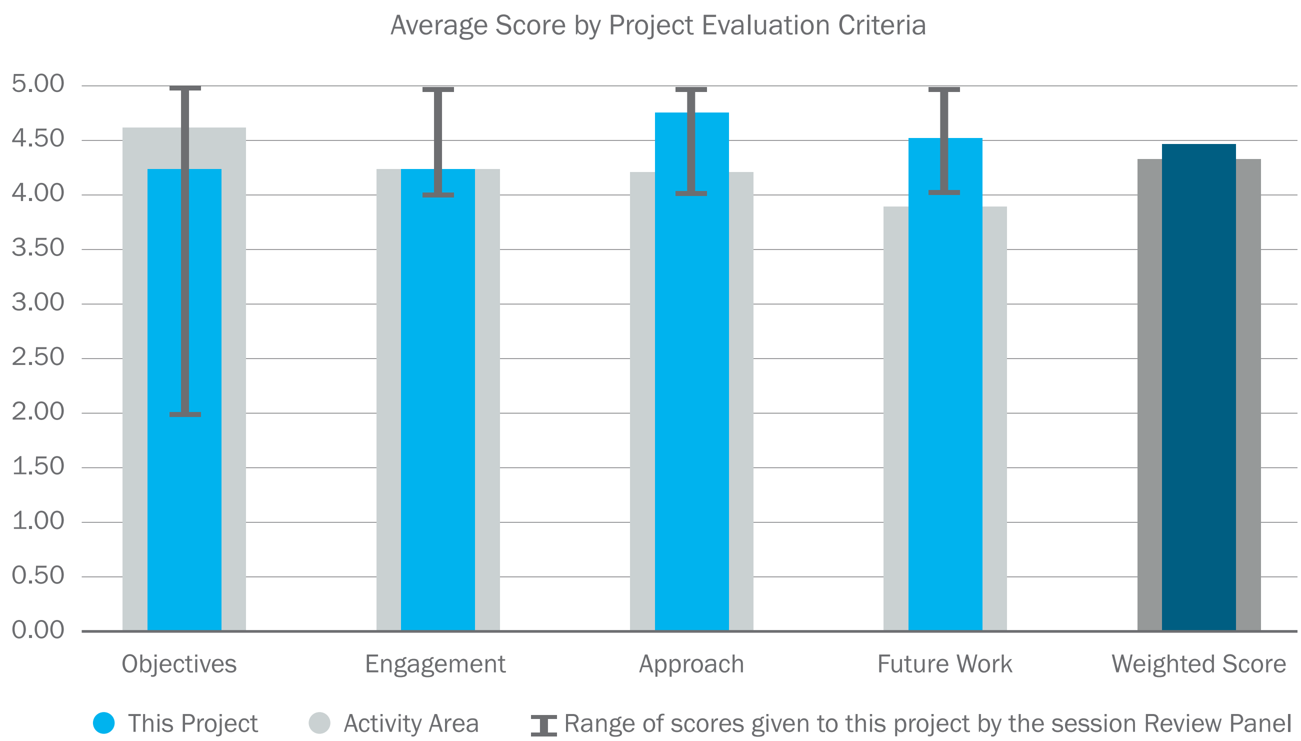
Recipient:	Alden Research Laboratory, Inc.
Principal Investigator:	Steve Amaral
Project Type:	FOA 1662: Innovative Solutions for Fish Passage at Hydropower Dams
Project Category:	New Projects
Total Authorized:	$1,020K
Total Costed:	$284K

Project Description

The goal of this project is to address the need for biologically and cost-effective downstream passage for silver American eels at hydropower dams. To achieve this goal, the project team is evaluating and optimizing the design and operation of two new bypass systems developed specifically for silver eels. The study includes lab, field, and hydraulic modeling evaluations of each system to determine biological performance. A desktop assessment of potential application at U.S. East Coast hydropower projects is also being conducted. The combination of evaluation methods will produce a robust set of biological and operational performance data to guide future applications of each technology.

Weighted Project Score: 4.5

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

This project applied several tools to reach its stated goals. In addition to laboratory and field testing, CFD modeling allowed the team to inform on design parameters in a way that physical testing alone would not be able to do. The reviewers noted that this promising technology should be made available as soon as possible to implement in the hydropower industry.

Project Objectives, Impacts, and Alignment with the Program Strategy

Reviewers generally agreed that the project was well-aligned with the program's strategic approaches and addresses a key problem of eel passage at hydropower facilities. Numerous facilities will benefit from this program, and successful completion of the project will lead to establishment of two downstream eel bypass designs that are modular, scalable, and cost-effective.

End User Engagement and Dissemination Strategy

Reviewers agreed that the end-user engagement and dissemination strategy was strong. Reviewers agreed that positive project aspects include strong outreach and generation of industry interest before the final results are known. The reviewers wished for more engagement of NGOs and entities that do not attend NHA conferences.

Management and Technical Approach

The reviewers positively scored the management and technical approach for this project, emphasizing that the project had a very strong group of project executors, including leading organizations in their respective fields. The combination of computational simulation followed by laboratory and field testing will lead to the conclusion of the program. One noted concern is the missing go/no-go point.

Technical Accomplishments and Progress

The achievements to date are strong, despite some understandable delays. The accomplishments to date have met or exceeded expectations and all technical targets have been achieved.

Future Work

Reviewers scored the planned future work positively. They felt that the project summary document lacked details, but they believed that work completed so far was well presented. More information was delivered during the presentation.

FISHWAY ENTRANCE PALISADE

(WBS #: EE0008340)

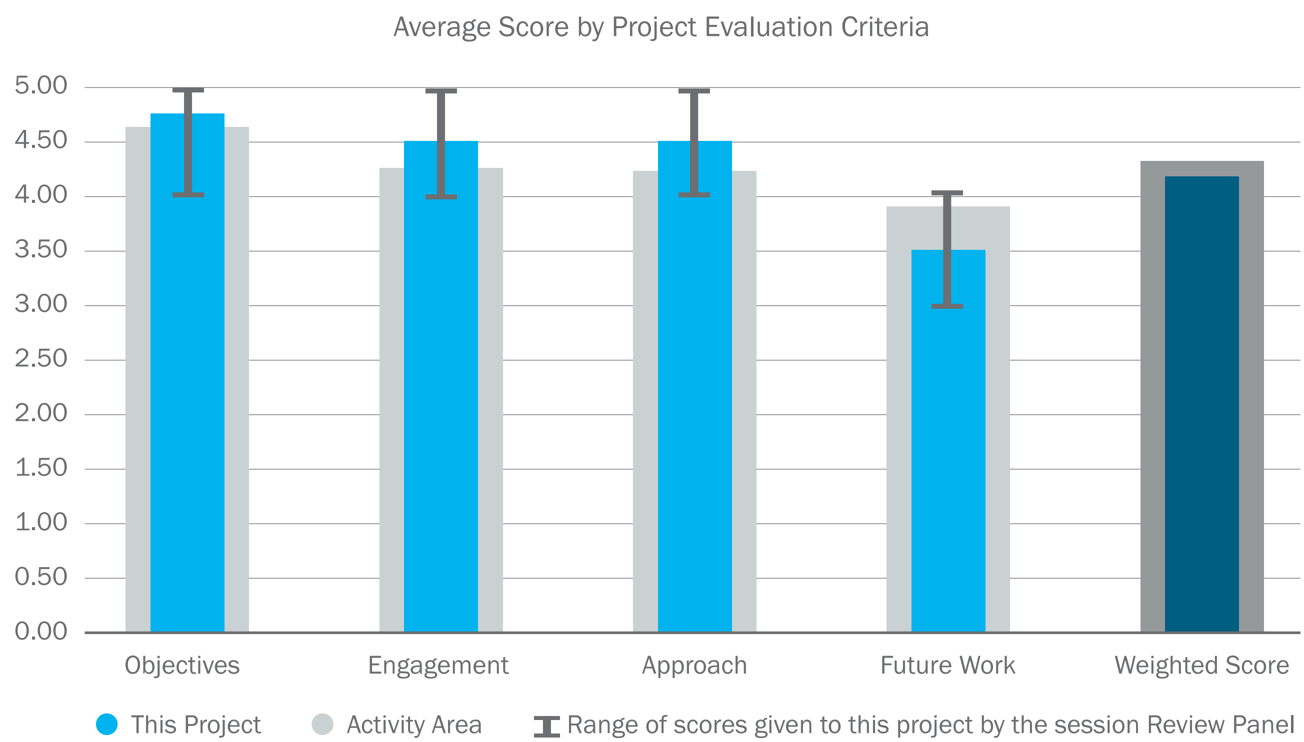
Recipient:	University of Massachusetts Amherst
Principal Investigator:	Richard Palmer
Project Type:	FOA 1662: Innovative Solutions for Fish Passage at Hydropower Dams
Project Category:	New Projects
Total Authorized:	$388K
Total Costed:	$46K

Project Description

The Entrance Palisade represents a fundamental shift in how to deliver auxiliary water to a fishway entrance. Unlike a conventional auxiliary water system, the Entrance Palisade discharges attraction water through an angled palisade (i.e., louvered exclusion diffuser) adjacent to the actual entrance. This eliminates the adverse, confusing hydraulics created by in-channel diffusers that have been linked to fish falling back out of a fishway. An Entrance Palisade can reduce construction and maintenance costs by using smaller diffusers.

Weighted Project Score: 4.2

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

The presented design offers the possibility of an economically attractive way to deliver water to the fishway entrance. The attraction method is based on fish behavior and eliminates disadvantages of traditional in-channel diffusers. The concept is simple and appears easy to implement. It also may offer a possibility of reduction of the rate of the flow of water, increasing its cost of operation.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed on the high value of the project, its impact, and its alignment with program strategy. The only objection noted was a desire for more information on how the project aligns with the program. A noted value is in the applicability of this concept to many target species.

End User Engagement and Dissemination Strategy

The reviewers agreed that the end user engagement and dissemination strategy was sound but noted that the project could benefit from more engagement and targeted outreach with resource agencies. One reviewer pointed out insufficient clarity on who will promote this design to the users.

Management and Technical Approach

The reviewers agreed that the project appears to be well managed and coordinated, with a diverse team from several agencies and research programs. No specific items lowering the score were identified.

Technical Accomplishments and Progress

Reviewers agreed that the preliminary results are promising, and a lot has been achieved so far. Notes from the reviewers pointed out that lab results may not be sufficient to satisfy needs by the regulators. It is also uncertain if conversion of the existing fishway to the proposed design will be feasible.

Future Work

Future work, as described, was scored at four by two reviewers and three by the others. The primary reason for the lowest score was the brevity of information provided. It would be desirable to provide a description of purpose or methodology of future work, as well as what is needed to make this innovative design used.

DEEP LEARNING FOR AUTOMATED IDENTIFICATION OF EELS IN SONAR DATA

(WBS #: EE0008341)

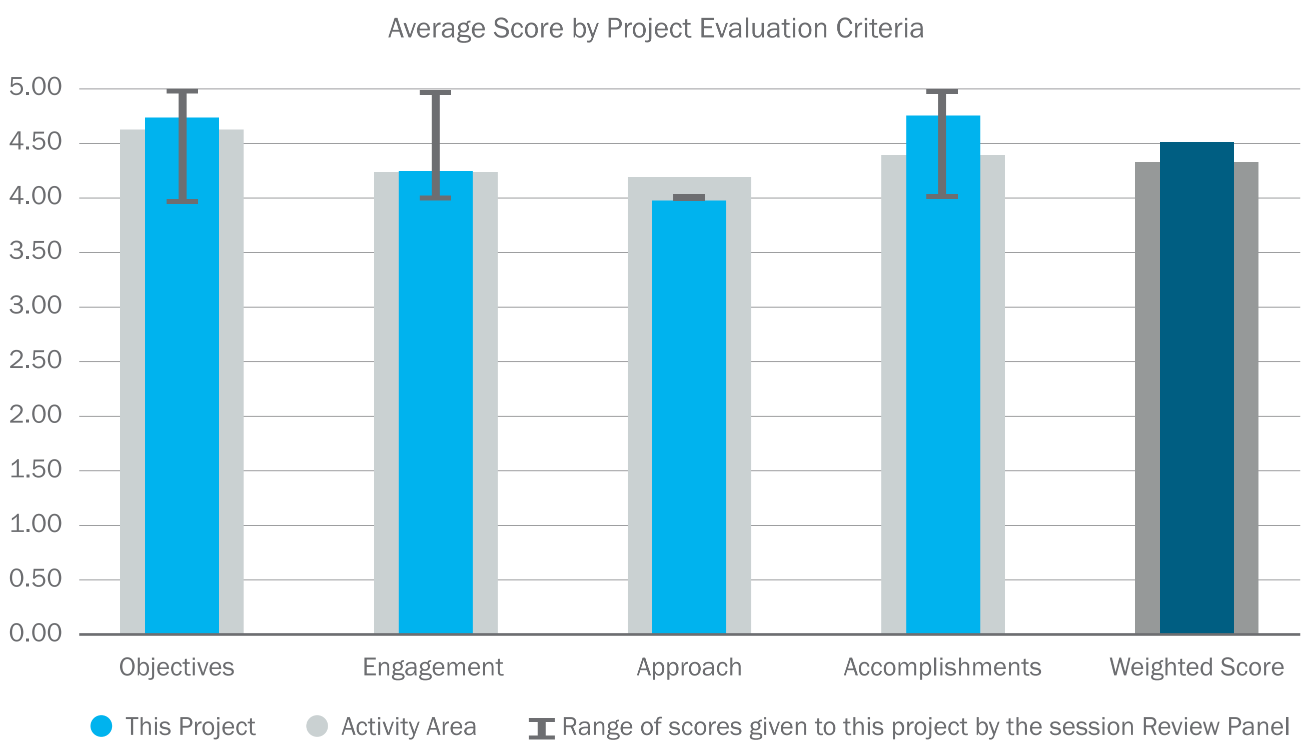
Recipient:	Electric Power Research Institute
Principal Investigator:	Paul T. Jacobson
Project Type:	FOA 1662: Innovative Solutions for Fish Passage at Hydropower Dams
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$500K
Total Costed:	$37K

Project Description

This project has the objectives of (1) developing machine-based detection of American eel from ARIS sonar data; (2) demonstrating automated classification accuracy commensurate with human-supervised classification accuracy; (3) encapsulating the analysis tools in open-source, computer language packages; and (4) disseminating the results to the relevant technical community. The project uses wavelet filtering to enhance the video images and applies convolutional neural networks for deep learning and object classification. The results will facilitate R&D and monitoring of eel passage facilities at hydropower projects, thereby reducing costs and enhancing environmental performance.

Weighted Project Score: 4.5

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The project addresses an important issue of identification of American eels passing through hydropower plants. The traditional process of reviewing collected data by a human is cumbersome and time consuming. An automated identification will substantially reduce cost and time, as well as provide better accuracy of detection. As a result, eel losses in hydropower plants can be reduced. The reviewer recommendations included marketing the software that results from this project.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were mostly in agreement on Project Objectives, Impacts, and Alignment with the Program Strategy. Outlined values of the program include the use of innovative technologies to advance the state of the art of eel monitoring. There were no comments substantiating score reduction.

End User Engagement and Dissemination Strategy

Most of the reviewers' comments were very positive, outlining that the work products will be available to outside users. Issues that reduced the score included lack of specific information and an insufficient explanation on how end user groups have been and will be engaged, including market assessment planning, dissemination, and adoption of the technology. Also, specific end users were not identified.

Management and Technical Approach

The reviewers scored the management and technical approach positively. Acknowledged positive elements are a strong team, composed of qualified individuals, as well as the fact that the project ends on budget. The identified weaknesses of the presentation include insufficient explanation of critical success factors and risks.

Technical Accomplishments and Progress

The reviewers agreed that the project has met its objective of developing machine learning algorithms for eel detection that are as good as the accuracy achieved by human analysts. Though there was some discrepancy between level of detail in the project summary and the presentation, reviewers agreed that the results are encouraging, with relatively high accuracy of detection.

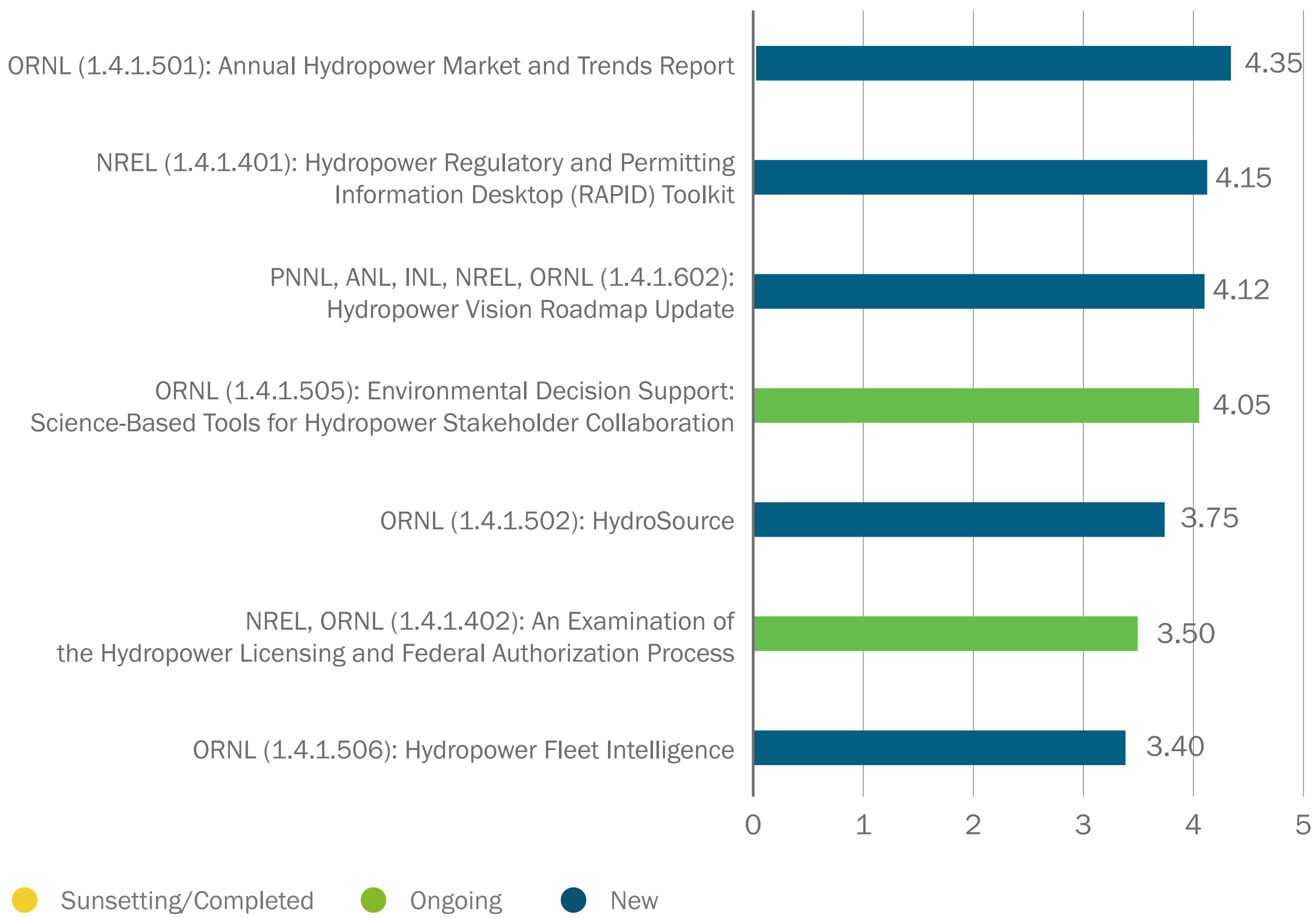
Big-Data Access and Management

This section provides an overview of the scoring for all projects within the Big-Data Access and Management activity area (see Figure 16); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Big-Data Access and Management	3.95

Figure 16. Big-Data Access and Management activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

In general, reviewers supported the projects in this activity area, but with some concerns and skepticism. All these projects are monumental undertakings. If done well, they should provide useful tools, but will likely need to be never ending because of a need to update information continuously. Some of the skepticism was based on whether seemingly small sample sizes would be representative (there were not explanations for how sample sizes were determined, nor how samples were selected). If these projects can be completed as proposed, the tools should be useful, although the value (utility/cost) may be lower than expected.

Summary of All Reviewers' Comments

Overall Impressions

Reviewers generally supported the projects' objectives. There were several comments on sample sizes and how samples were selected, the perceived lack of go/no-go decision frameworks, and the value of existing information to support a larger compiled database. Reviewers thought that some projects seemed to be more academic than applied. However, acknowledging the constraints of the peer review period in which projects were reviewed, the review panel evaluated projects using the snapshot of information provided in a brief timespan and with limited resources. Reviewers understood that there may have been additional background information that was not seen or reviewed. Under those constraints, the review panel was intent on offering thoughtful, constructive comments for WPTO to consider.

Program Strategy and Objectives

Given the power of computing, analytical, and compilation tools at hand today, the focus of the projects in the portfolio is understandable. Compiling, categorizing, and analyzing data are overarching traits of scientists and engineers. That said, reviewers were not convinced that all approaches and future direction will achieve the objectives. While there were no calls to stop any of the projects, an objective look at multiple reasonable points along the timelines of these projects would be worthwhile for DOE to take to ensure the wise use of taxpayer dollars.

In a sense, it appears that the program is compiling information because the information is there to compile. It is not clear whether that is the first step in a broader scheme or whether these projects are what were most appealing at the time of proposals regardless of a broader scheme. Certainly, the regulatory aspects of the industry continue to be a major concern. It is not clear that any of the big data projects presented will go a long way toward solving those problems. In fact, the one project with the objective to examine licensing and federal authorization explicitly states that no regulatory recommendations will be made as an outcome of the project. There may be DOE rules or policies preventing such recommendations, but they are needed to resolve the licensing problems. Reviewers thought that engaging with experienced licensing professionals in a short workshop could help to determine multiple well-reasoned potential solutions to licensing issues. With those potential solutions identified, big data support may be more useful, whether on the hydro growth or hydro curtailment side of the spectrum.

With respect to more technical issues, one reviewer was impressed with the huge amount of information gathered but could not see how it would contribute to improving grid reliability, resilience, or integration, or how it would promote further growth of hydro. The nexus between the more regulatory focused projects in this program and an acceleration of the development of innovative technologies is unclear. The nexus for the HydroSource and Hydropower Fleet Intelligence projects is more apparent. The reviews submitted for consideration in development of this summary recognized the potential for important outcomes, if the projects are done well. It was not clear to that reviewers how the desired outcomes would be achieved.

No reviewers explicitly stated that taxpayer funds have not been invested wisely. There were comments on the lack of attention (even though prompted by the review topics) to go/no-go decision points or frameworks. Given that the projects under peer review are in various stages along their timeline, it can be difficult to judge whether wise investments have been made. More attention to the go/no-go frameworks and presentation of what decisions were made (and why) during a project's timeline would be helpful.

Program Portfolio

If the projects are completed cost effectively and deemed useful by the end users, this program will contribute to meeting the strategy and objectives. For most in this program, it is simply too early to draw conclusions on this bullet item. If the regulatory-focused projects can be completed cost effectively, they may be useful tools for some. It is not clear at this time that they will address key challenges and reduce barriers in the regulatory arena. For the more technical-focused projects, they may also be useful tools, and, if completed cost effectively, they could help to address key challenges and advance technologies; it just was not clear to the reviewers of these projects how the teams intend to accomplish those goals.

There was mixed input from reviewers on whether presentations effectively conveyed the rationale and organization of the projects. One aspect that would be helpful to reviewers is for them to receive all materials (including presentations) well in advance of the peer review. Complete budget information was not presented in many cases, and few effectively described those milestones in the timeline where go/no-go decisions were made and why. In all cases, reviewers saw some or great merit in the projects, assuming they are completed in a cost-effective manner. Without complete budget information, reviewers had difficulties in assessing whether priorities and resources were allocated appropriately. One suggestion was to have a specific team of reviewers stay with a project (and perhaps program) from proposal to completion. There may be some difficulties in implementing such an approach, reviewers would like WPTO to consider it. Finally, the reviewers agreed that the projects within this program portfolio are appropriate for WPTO's role as a public R&D organization.

Program Management Approach

In most cases, reviewers agreed that the program team effectively manages and directs the activities needed to meet its objectives, which is exemplified by the high score for this evaluation criterion. There were some questions about how they might accomplish various aspects (e.g., how to deal with historical data that may not be of high quality or reliability, and how to incorporate intangible variables such as personalities and biases into a database intended to assist with study development).

While no reviewers suggested the termination of a project, there was mixed input on the value of some projects. Some reviewers thought a project had great promise, while others questioned whether the tools developed would have the impact desired. Regarding communicating the allocation of resources, reviewers indicated that presentation of budget and future work aspects would have been more useful if complete project budgets were included.

In all cases, the reviewers thought that the teams were well qualified. However, some of the PIs have not led the work that they are building a big dataset for. The inclusion of focus groups or advisors is a good approach for these types of projects. The reviewers agreed that the Hydropower Program team is robust and works well together, but it difficult to assess that with any rigor or detail within the limited amount of time to observe the team in action.

Stakeholder Engagement, Outreach, and Dissemination

Regarding transparently communicating how WPTO funds are being utilized, reviewers agreed that more information on the budgets and their use would have been appreciated. Some project presenters only presented budget used for the past two years and not the full project, so it was virtually impossible to assess whether funds were used efficiently over the course of the project.

In gathering feedback from stakeholders to inform and improve WPTO's projects and strategy, reviewers recommended continuing to consult with its current strong ties to NHA, NWHA, and The Hydropower Foundation. The Hydropower Foundation is anxious to find the next program with WPTO to make a difference in the hydro industry. With Linda Ciocci as the new Executive Director, the organization is well positioned to tackle new initiatives. Reviewers recommended engaging in a series of regional meetings with high-level representatives of individual hydro, regulatory, consulting, and special interest groups. It is unclear whether such meetings would be more productive if groups were to segregate or integrate based on their position along the hydro value spectrum, perhaps attempts at both would be informative. WPTO should pose questions and situations that test the representatives of each sector to justify their positions and broker meaningful conversations between articulate advocates for important issues/positions and policymakers.

Overall, reviewers thought that the dissemination of WPTO-supported research results was extensive. The panel lead questioned the importance of focusing on primary literature publications in journals that are relatively obscure to the industry. Reviewers recommended that PIs focus information dissemination to the end users.

Reviewers generally agreed that the program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision makers. Reviewers agreed that the program has the potential to accomplish this goal, as several projects are in 'midstream.'

HYDROPOWER REGULATORY AND PERMITTING INFORMATION DESKTOP (RAPID) TOOLKIT

(WBS #: 1.4.1.401)

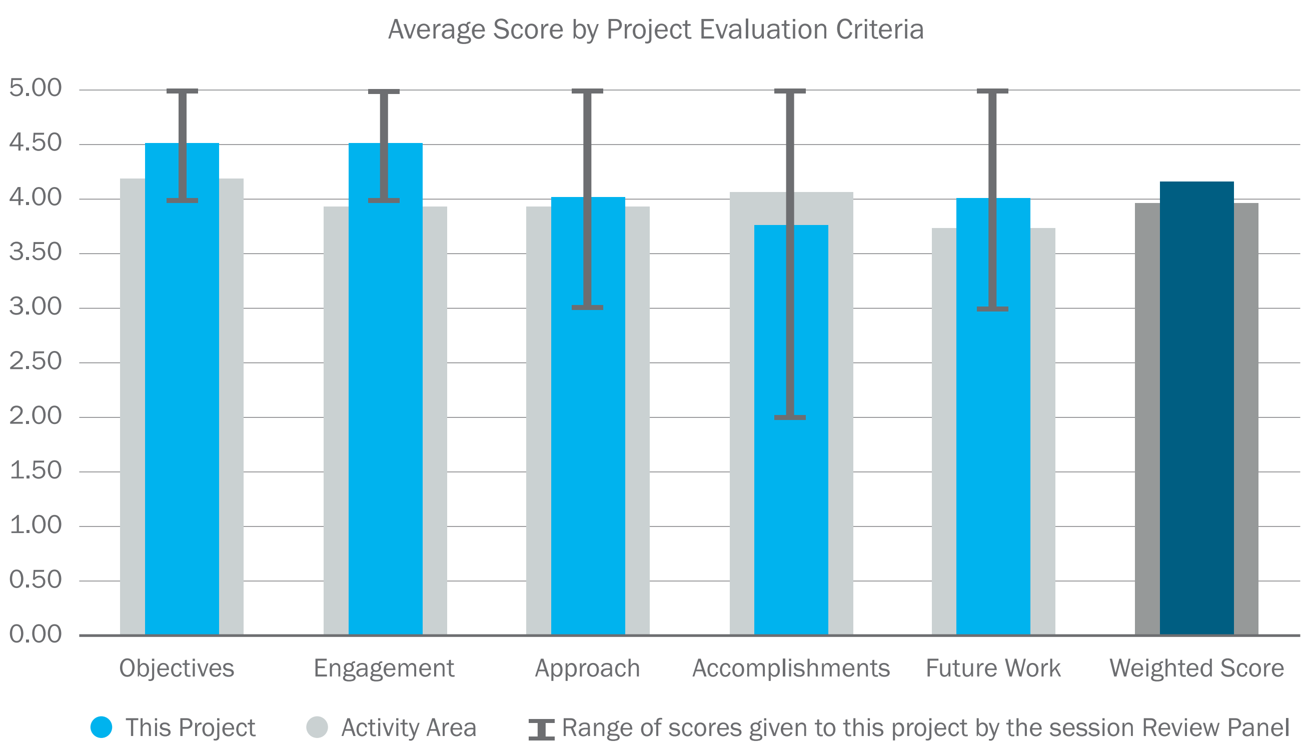
Recipient:	NREL
Principal Investigator:	Aaron Levine
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,211K
Total Costed:	$1,087K

Project Description

The Hydropower RAPID Toolkit project aims to increase the transparency and efficiency of the regulatory process for hydropower projects in the United States. Key aspects of the RAPID Toolkit project include performing significant stakeholder outreach and engagement to frame and guide the project for significant impact; reviewing federal and state permits and regulatory processes/approvals required for developing hydropower projects in the United States; developing/curating a regulatory and permitting database; cataloguing reference material; and documenting hydropower regulatory best practices and lessons learned. Federal and state agencies, as well as industry stakeholders, have reviewed and provided feedback on permitting processes for conventional hydro, non-powered dam development, and PSH projects.

Weighted Project Score: 4.2

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The RAPID toolkit successfully serves to increase transparency and efficiency in the hydropower licensing and permitting process, and it should be useful for stakeholders in the licensing process. All reviewers recommended that the toolkit be maintained past the stated project closure date, as otherwise, it will quickly become obsolete.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project clearly contributes to the program's strategy and approaches. The greatest contribution of the project is in helping hydropower developers understand and navigate the complex regulatory process. It also has the potential to help inform policymakers and improve coordination among resource agencies, although the success of this last is unclear. One reviewer said the discussion would benefit from a description of how the licensing process works in the absence of the tool and how it is improved by using the tool. The website is well-designed, and the potential use of the toolkit is strong.

End User Engagement and Dissemination Strategy

The beneficiaries and end users of the toolkit have been clearly identified, conducting early outreach to multiple key groups (industry and federal agencies) that helped inform the organization and functionality of the toolkit. This helped align the toolkit with industry expectations and needs. One reviewer pointed out that less outreach has been done with stakeholders from the non-government organization community, which can be improved. The various beneficiaries have different uses for the tool, which are not explicitly differentiated. Overall, the engagement and dissemination are strong.

Management and Technical Approach

The management approach is sound, with a highly qualified project team. The technical approach is thorough and appears to cover all the important elements of the processes covered by the toolkit. The use of search engine optimization and web-based tools to increase the reach of the toolkit are very good. Two reviewers pointed out the lack of critical success factors identified for the project, despite a description of metrics used to monitor progress. These reviewers disagreed on whether or not the project showed clear milestones.

Technical Accomplishments and Progress

The reviewers had the greatest differences in this section; all agree that the accomplishments have been clearly listed, but while one reviewer says these accomplishments are "impressive," another says it is impossible to judge their success without performance metrics. The lack of targets provided makes it difficult to judge how the milestones relate to overall project success. A wealth of information is contained within the toolkit website. The web analytics show increased access to the tool, but not how the tool has been used.

Future Work

The end date of the project is not clear, but the review team believes it's winding down. One reviewer questioned if all the data is already in the tool and suggests a plan for testing and feedback on data evolution and update needs. Another reviewer suggests that if sufficient time remains, it would be useful to develop additional best practices and other knowledge products, which do not appear in current plans for future work. A third reviewer suggested including a section in the toolkit on licensing delays (characterizations of why, how long, what the resolutions have been, and what strategies have been effective in reducing delays, with specific examples provided), as well as a characterization of mandatory conditions and trial type hearings. The reviewers recommend that a plan be made to keep the tool up to date, including the addition of new content, over the coming years to prevent early obsolescence.

AN EXAMINATION OF THE HYDROPOWER LICENSING AND FEDERAL AUTHORIZATION PROCESS

(WBS #: 1.4.1.402)

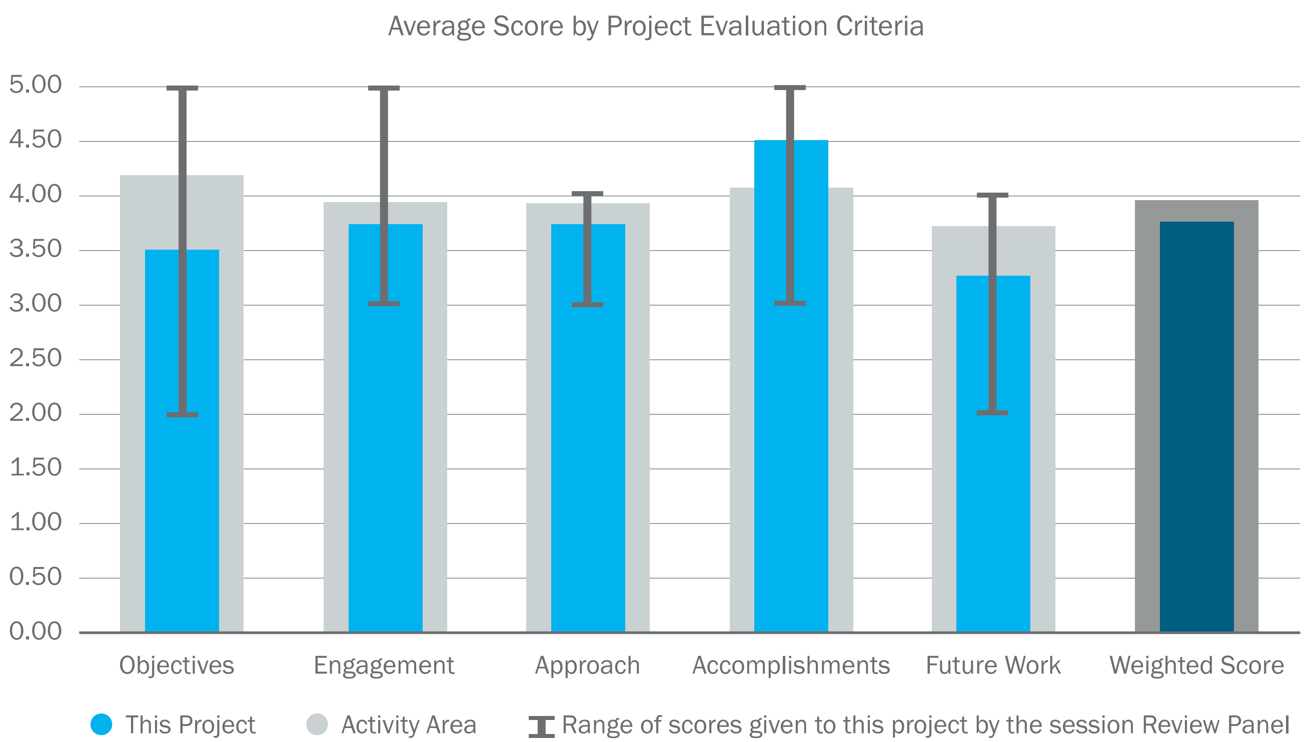
Recipient:	NREL and ORNL
Principal Investigator:	Aaron Levine
Project Type:	AOP
Project Category:	New Projects
Total Authorized:	$1,538K
Total Costed:	$342K

Project Description

The process to acquire a hydropower license and associated approvals for an individual development project is uncertain, impacting the length and cost of project development. As a result of this uncertainty, policymakers have relied solely on anecdotal information when proposing regulatory reform. This project will use scientifically based quantitative and qualitative analyses and a “multiple-lines-of-evidence” approach to examine hydropower licensing timelines; causal factors; and the implications of timelines on risk, cost, and deployment.

Weighted Project Score: 3.5

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers all agreed that the broad objectives of the project are worthwhile—to shed light on the licensing process with the ultimate goal of reducing time and cost. However, although the management team seems qualified, there is general skepticism about the technical approach, especially the potential success of the quantitative analysis due to sample size limitation, the possibility of finding a meaningful set of drivers of variability, and the likelihood that key factors such as personality of participants will not be considered. One reviewer suggested a feasibility level analysis to determine if the technical approach is sound; this could serve as the missing go/no-go decision point. Most reviewers felt that the project's outcomes will not be useful unless policy change recommendations are made, but this is not planned. Reviewers were not satisfied with the range of participants engaged in the project, with different reviewers wanting to see various additional entities included.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers all agreed that the broad objectives of the project are worthwhile; however, all reviewers pointed out conceptual flaws. These included the failure to focus on or make recommendations to decision makers who could alter policies, the challenge of being able to identify common obstacles because each case is so different, and the lack of identification of a specific use case for the results.

End User Engagement and Dissemination Strategy

References to almost all participants in the licensing process, as well as policymakers, are listed as end users or beneficiaries; these also include the various permitting agencies themselves who could identify redundancies in requirements. The reviewers were divided on how effective the engagement strategy is, reflecting satisfaction with the effort to get input on the methodology and scope, but noting concern that it has not been broad enough, has not targeted the most key entities, and that not enough information was provided about the engagement.

Management and Technical Approach

The project is managed by a strong, well-qualified team and has well-implemented processes, but began without a clear research approach. The reviewers had concerns that the current technical approach may not yield useful results, especially that the sample size of cases may be inadequate, that it may not be possible to extract a useful set of drivers in the statistical analysis, and that these would likely omit key considerations like personalities and geographic regions. The "multiple lines of evidence" approach was not explained, leaving uncertainty about the prospect of getting meaningful outcomes, and critical success factors listed are simply general tasks; meaningful success factors were not identified.

Technical Accomplishments and Progress

The main accomplishment for this project thus far is the identification of the collection of cases that will be used for the analysis, reports to stakeholders, and webinar. The project has been proceeding according to the timeline and has made great progress while being well under budget.

Future Work

The reviewers had varying opinions about the adequacy and quality of future project plans, with some satisfied that the description of future work is enough to give confidence in successful completion, and others noted that schedules and milestones for all the tasks were not provided in the project summary or presentation, nor were the go/no-go points identified.

ANNUAL HYDROPOWER MARKET AND TRENDS REPORT

(WBS #: 1.4.1.501)

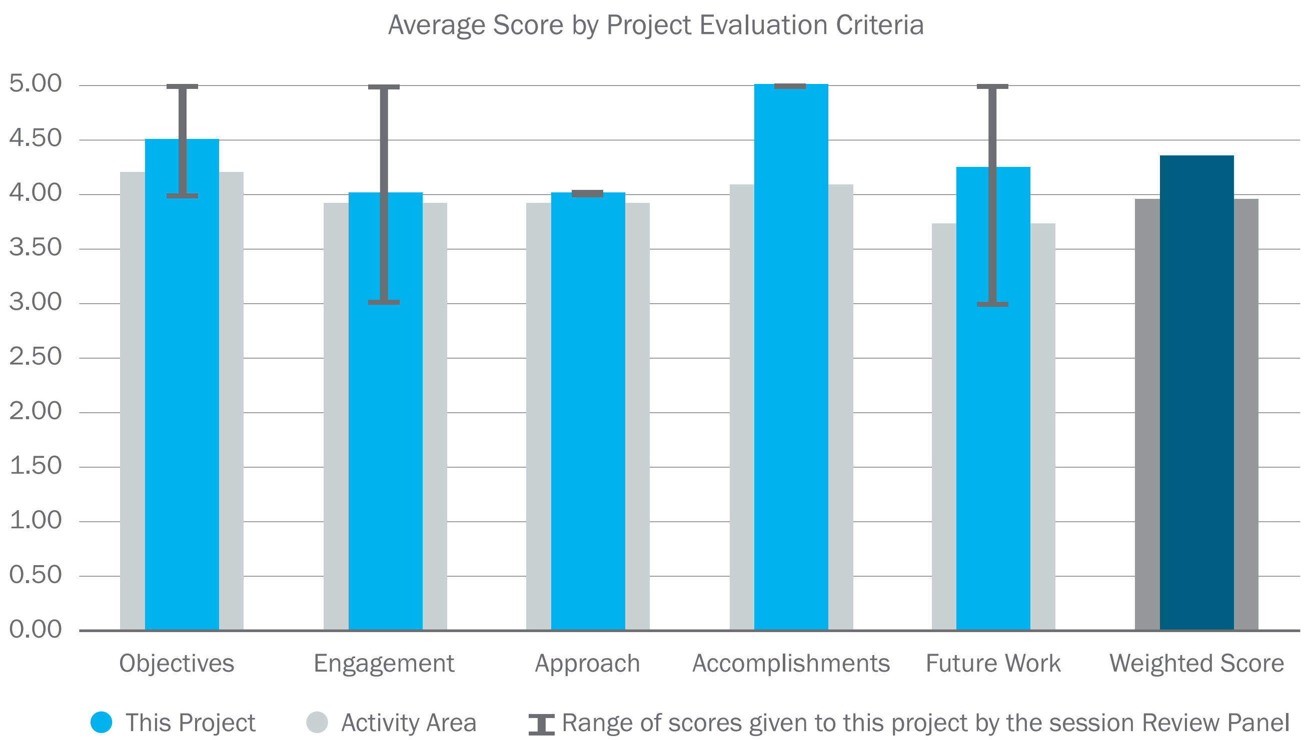
Recipient:	ORNL
Principal Investigator:	Rocio Uria-Martinez
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,033K
Total Costed:	$873K

Project Description

The Hydropower Market Report project is a data-driven summary of key trends in the U.S. hydropower industry. It provides up-to-date, comprehensive, objective data to industry, policymakers, and other interested stakeholders on U.S. hydropower development, operations, cost, and supply chain. The Hydropower Market Report aims to assemble datasets that are representative of the entire fleet and can be segmented by region or key plant attributes to provide more meaningful summary statistics.

Weighted Project Score: 4.4

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The Hydropower Market Report is a valuable resource for the entire hydropower industry, providing important information that would not otherwise be available. The datasets analyzed and the results provided cover a sound depth and breadth of issues relevant to the hydropower industry. However, reviewers noted that project performers could improve report dissemination and should develop quantitative performance metrics. Reviewers also recommended that the project team creates project plans that include how the database will be developed and maintained in the future.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were unanimous in their approval of the project objectives and contributions to the program strategy, as well as the overall value of the report. The project team did a good job considering and describing the applications of the report, which is a useful tool to all hydropower stakeholders.

End User Engagement and Dissemination Strategy

The dissemination efforts have been a good start, including the review of each version of the report by various experts, site/report views, and other efforts. Three of the reviewers thought the dissemination strategy could be improved. Recommendations included asking NHA, NWHA, and the Hydropower Foundation to post a link to the report on their sites; expanding outreach to resource agencies and NGOs; sending annual email blasts to all FERC licensees and preliminary permit holders; and adding a "subscribe" option to the report itself. Reviewers believed that end user engagement could also improve by collecting feedback data from users beyond what is done through surveys and increasing performance metrics, including tracking downloads and questions or requests received.

Management and Technical Approach

The reviewers agree that the project team is well qualified, with unique skillsets and a strong overall management approach. The technical approach is thoughtful and well-defined, containing the steps necessary for project success. One reviewer thought the project value was somewhat reduced in cases where specific information at the plant level is required, although noted that it is understandable that it would be difficult to obtain this level of data. Another reviewer recommended including the changes to the grid over time in each version of the report to support and provide more detail on the "rapidly evolving grid." No risks were reported for the project, and no critical success factors were described to the reviewers.

Technical Accomplishments and Progress

The reviewers agree that the major accomplishment of the project is the publication of the 2017 report, with additional milestones achieved each quarter of the project. The achievements are clearly described, and the project appears to be on track. Technical barriers for the project were not described.

Future Work

The plan for future work is well defined. One reviewer is concerned that no mention was made of how the team will continue to develop and maintain the database in the future, which is important for maintaining its usefulness. Another reviewer suggested that the number of users for each report could be factored into future dissemination strategies or into adjusting the frequency of future reports and updates. The project team did not provide project decision points, but it appeared that because the project has been active for a number of years, most of the challenges have already been addressed.

HYDROSOURCE

(WBS #: 1.4.1.502)

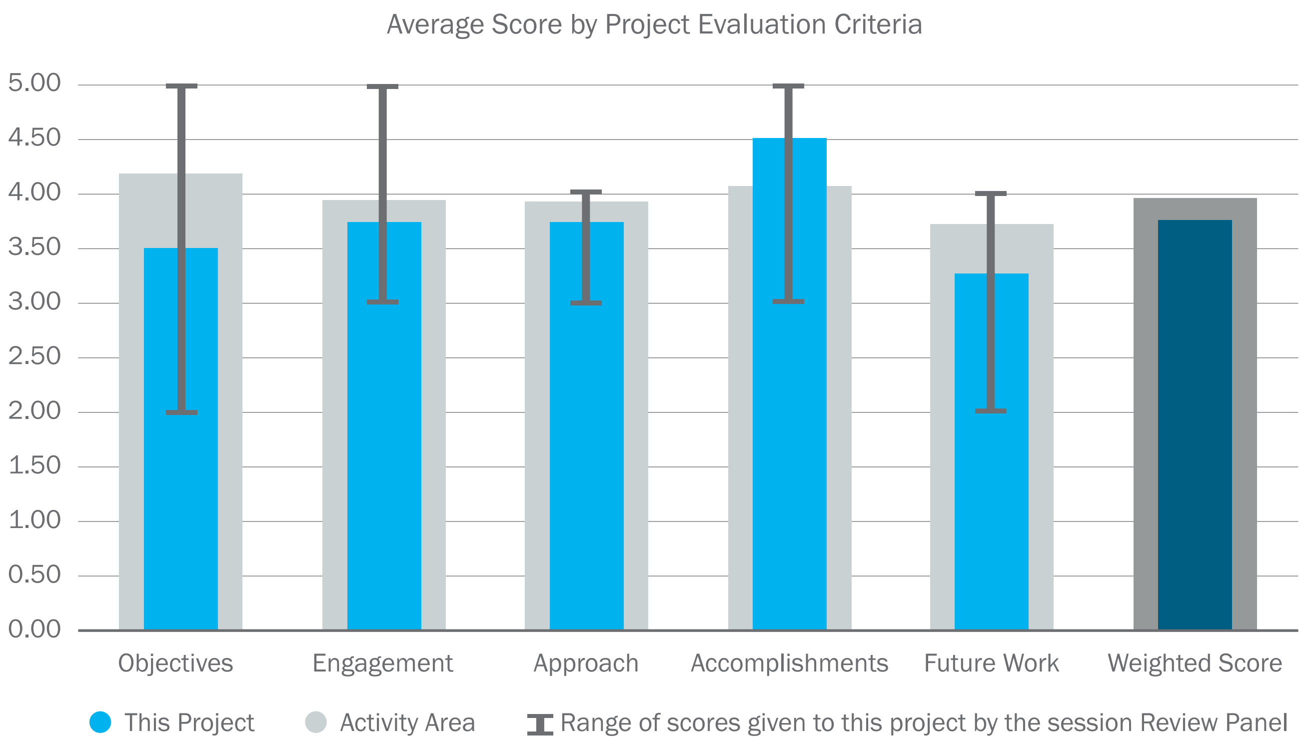
Recipient:	ORNL
Principal Investigator:	Brennan Smith
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,913K
Total Costed:	$1,731K

Project Description

Knowing the characteristics of the hydropower fleet and potential hydropower resources for the United States is critical to WPTO stakeholders and the research community. The U.S. hydropower fleet includes assets owned and operated by federal, state, municipal, and private interests, engendering a diversity of regulatory, market, management, and physical contexts. HydroSource accomplishes data stewardship (acquiring, aligning, refreshing) and data dissemination (website and provision of limited subject matter expertise) for U.S. hydropower stakeholders. The pre-cursor to HydroSource began in 2010 with the National Hydropower Asset Assessment Project. The transition to the new HydroSource web portal in FY 2017–FY 2018 brought together data sets and tools from 10 years of WPTO-funded hydropower analyses of the existing fleet, hydropower marketing, resource potential, environmental context, and baseline energy-water data.

Weighted Project Score: 3.8

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

HydroSource is a significant undertaking, with a focus on data collection and associated analytics. The purpose and usability of this data is less understood and not appreciated among the hydropower community as the goals and deliverables, in the form of user access tools, are not described. This project has a good head of steam, and the team should expand the project and develop user-friendly tools, such as online search functionality and a mechanism for updates to the data file. It is important to recognize that DOE has been in a unique position to be able to accomplish this work and has moved this data collection far beyond where it would have been otherwise.

Project Objectives, Impacts, and Alignment with the Program Strategy

The goal of HydroSource was succinct and straightforward and aligned with Program Strategy, describing the continuing desire for a comprehensive database of information on hydropower facilities and river systems that could aid hydropower research and stimulate hydropower development by providing site-specific geospatial data on a variety of biotic and abiotic variables. Researchers have garnered a huge amount of information that could inform stakeholders and users across the country, but it is hard to see how the data sets created contribute to improving grid reliability, resilience, or integration or how they promote growth in the hydropower sector. The use of the expected product has not been described, and its value to users is limited in its current form. There needs to be a means of searching or even sorting the data with web-based tools or even simple macros.

End User Engagement and Dissemination Strategy

The project summary clearly describes the multiple parties (utilities, agencies, etc.) who are and would be the end users of HydroSource. Project performers described presentations and demonstrations of HydroSource in various settings and locations, as well as a process of providing background data from user-specific information requests. Additionally, the project team described how they created a number of “data layers” that focus on the interests of hydropower assets, or perhaps environmental factors, in discrete states, regions, and basins. In this sense, HydroSource has already demonstrated a working and ongoing relationship with end users.

However, the program does not provide tools that are readily usable to allow online search and source documentation. Naturally, the program is only as good as how recently the data was updated, but no provision has been made for corrections and updates. HydroSource is posted publicly, and the project team stated that it is regularly accessed. The reviewers wanted to know if there is a success story where HydroSource provided critical information beyond the U.S. Energy Information Administration or other publicly available datasets that was integral in furthering the WPTO mission.

Outreach efforts appear to be increasing for the HydroSource website, but the project could benefit from additional exposure (e.g., conferences, webinars, e-magazines, etc.). Adding “where to find” links to other websites, such as hydrowise.energy.gov, or the ability to redirect from the search function to those other DOE websites/resources could be extremely helpful. One way to do that may be to include a mechanism where users can add comments on how to improve HydroSource in real time as they are using the programs. Encouraging online users to comment on their experiences and provide suggestions for improvement is a vital aspect of any dynamic database system. Without providing much in the way of detail, the project presenters stated that the ORNL staff will continue to integrate new environmental data into HydroSource. All these enhancements are sound.

Management and Technical Approach

The actual management plan for the execution of this project is left to the reader's imagination, as this section of the summary report focuses entirely on the technical disciplines of the ORNL staff. Reviewers noted that there is clearly an organizational structure within ORNL that manages the activities of the staff and directs their work on the creation of the HydroSource input data.

The site improvement system to track usage and downloads is an excellent approach and can help determine what areas need future work. Also, the Kearns and West surveys of how HydroSource is actually being used externally are an excellent way to foster continual improvement.

Technical Accomplishments and Progress

The project presenters focused less on the technical accomplishments and progress made to date, more on the historical trajectory of developing and maintaining a database on hydro-relevant information across the United States. Since its earlier versions focusing on hydropower assets, HydroSource has expanded to include environmental aspects of hydroelectric facilities. This includes importing information from SMH Explorer and creating a number of environmental attributes such as species, conservation lands, impaired streams, and licensing proceedings.

The National Hydropower Asset Assessment Project was a significant step forward and is incorporated into this database. HydroSource is a valuable addition to stakeholders looking for previous research information. The environmental module of the HydroSource will/does include an environmental mitigation predictor that is based on the above data, including prior issues associated with existing projects. Reviewers believed that the mitigation predictor may be a stretch, noting that while it's informative to licensees and potential new developers, the information on mitigation measures is determined by a number of factors, including resource agency staff involved in the relicensing process. Predictors of environmental issues of importance may be of limited use, as there is so much site specificity associated with environmental factors at hydropower facilities.

Future Work

HydroSource should continue to improve on its promise to provide relevant and useful information to the hydropower industry and other entities. This includes the continued need to take data from hydropower facilities throughout the country and convert their sometimes-disparate information/data into the model structure. Based on a review of the HydroSource tool and database, it seems that the project team should focus future effort into making the tool more useful to users. In using the stream classification web tool, layers that included plants and U.S. Geological Survey gage sites were available, but the markers do not display relevant information (plant names, U.S. Geological Survey gage numbers, river names). The plant database is similarly not much different from, and in some cases less than, information that can easily be tracked down via the U.S. Energy Information Administration, USACE's public data tool, and other public data sources. The team should focus on addressing these issues. A clear vision of the future state of HydroSource is lacking.

ENVIRONMENTAL DECISION SUPPORT: SCIENCE-BASED TOOLS FOR HYDROPOWER STAKEHOLDER COLLABORATION

(WBS #: 1.4.1.505)

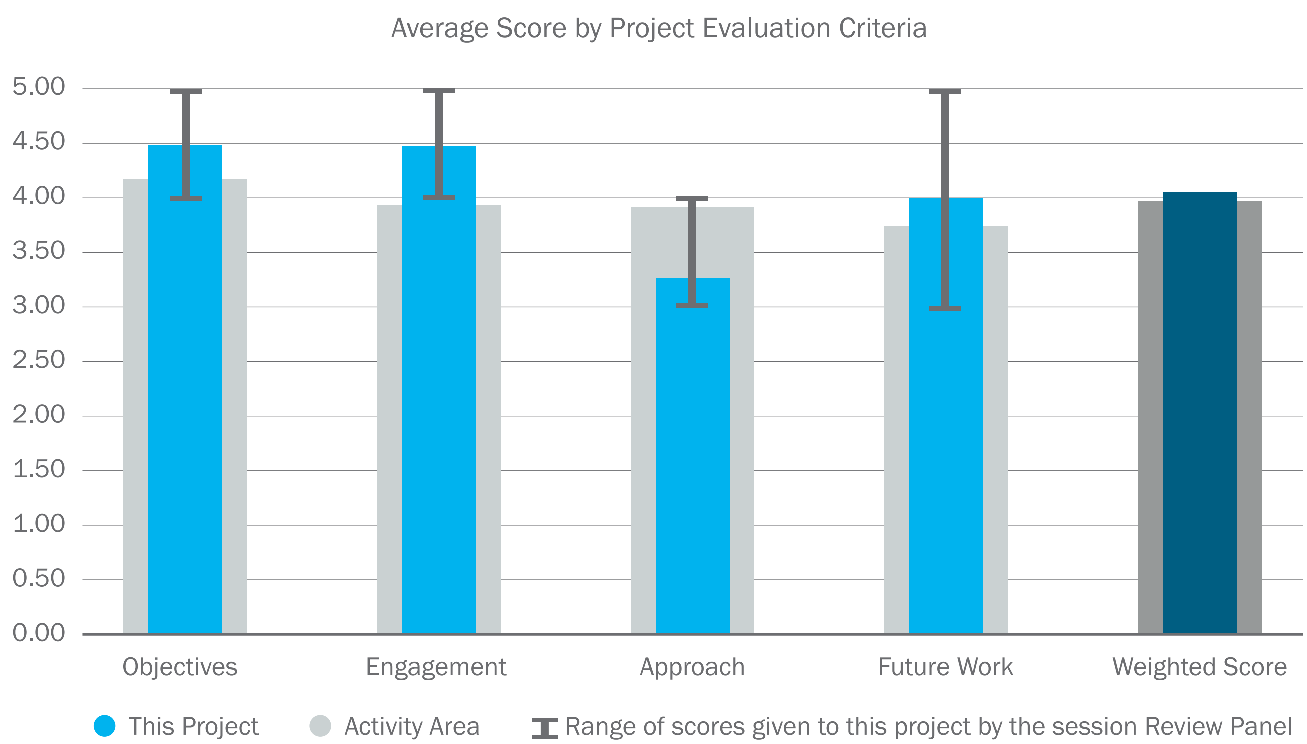
Recipient:	ORNL
Principal Investigator:	Brenda Pracheil
Project Type:	AOP
Project Category:	New Projects
Total Authorized:	$263K
Total Costed:	$236K

Project Description

The Environmental Decision Support project is the second phase of a strategic, long-term effort to characterize and summarize the best-available science for use by the diverse body of hydropower stakeholders looking to determine environmental and ecological impacts of hydropower development and operation. This project provides hydropower developers, owner/utilities, regulators, consultants, NGOs, agencies, and other stakeholders involved in the hydropower licensing process a transparent and consistent methodology based on the best available science for determining what studies to conduct during hydropower licensing. Since the environmental impact studies conducted may vary from project to project and may be subject to different negotiations and practices, the project's toolkit aims to provide a template for understanding which environmental impacts have project nexus. This may enable greater consistency in studies requested and help stakeholders communicate and determine the "right" environmental impact studies for a project, thus promoting transparency among stakeholders. Products created in this project are augmented by stakeholder advisory boards that provide input and feedback on methods content.

Weighted Project Score: 4.1

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

Reviewers generally supported for this project, but they believed that its waivers in certain aspects. Reviewers thought it would have been helpful to have more information on the go/no-go decision-making process and that the team should have identified points along the way where such decisions were/will be made. There are some concerns about how this tool will be used, whether it will streamline the scoping process (or in some cases increase the scoping time), and ultimately whether it will be embraced in licensing processes.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that the explanation of project objectives was clear and aligned with DOE program objectives. This project aims to develop a questionnaire-based tool for determining the relevant environmental impact studies as part of the FERC licensing process. One of the four reviewers is not convinced that this tool is needed.

End User Engagement and Dissemination Strategy

Reviewers agreed that the engagement and dissemination strategy appear to be sound. The project team included a group of advisors that provided feedback along the way to date; it sounds like that was a very good move because it facilitated some 'midstream' adjustments to key facets of the planned tool.

Management and Technical Approach

The tool that this project team intends to develop is a monumental task because of the variability in the environments, biota, and issues across the United States; policy and practice differences across agencies, licensees, and special interest groups; and specific representatives and their personalities, knowledge, backgrounds, and biases. While it is hoped that this tool will help to streamline the process, it's not clear at this time that this objective will be realized. That said, no reviewers thought the project should be stopped. The inclusion of an advisory group as part of the team was a wise decision and should significantly improve the likelihood of a useful tool.

Technical Accomplishments and Progress

There were mixed reviews on accomplishments and progress. It was not clear whether the budget presented was just for the 2-year period or for the entire project to date. One reviewer thought that the two publications cited should be included in a different project and not this one. One reviewer thought that too much focus was placed on international projects and not enough on U.S. projects. One reviewer would have liked an explanation of how the approximately 10% of FERC licensed projects were selected for inclusion and why that was determined to be representative.

Future Work

Multiple reviewers thought that more details on future work and go/no-go decision points would have been helpful. There were also questions about the planned beta testing (e.g., how will it be done; how will projects be selected; and what if results show something significantly different than what actually happened at a completed project?)

HYDROPOWER FLEET INTELLIGENCE

(WBS #: 1.4.1.506)

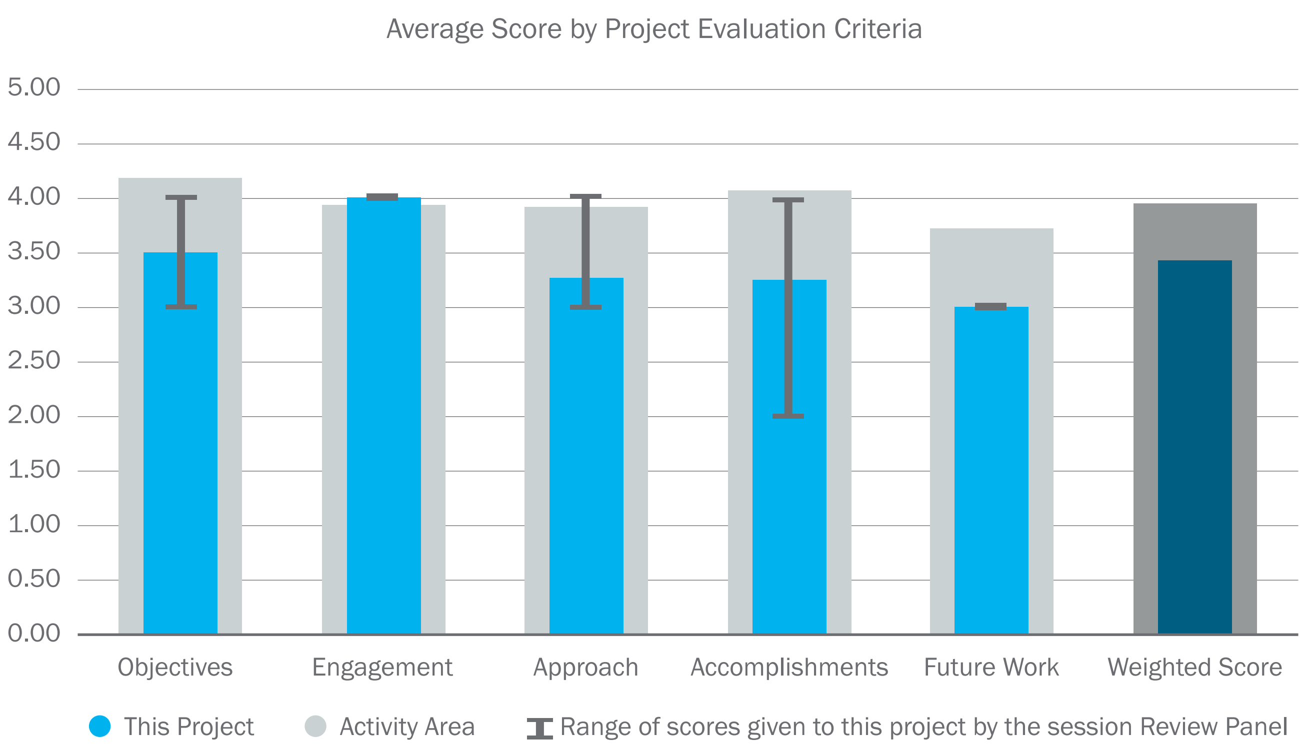
Recipient:	ORNL
Principal Investigator:	Stephen Signore
Project Type:	AOP
Project Category:	New Projects
Total Authorized:	$895K
Total Costed:	$769K

Project Description

The HFI project addresses the challenge of developing, sharing, and implementing data-driven decision-making best practices for fleets of hydropower facilities that are hydraulically and electrically linked within river and power systems, respectively. The hydropower facilities provide a unique link between the electrical grid and the river system and, as such, must be effectively managed to ensure sustainability and to maximize stakeholder value in both systems. In the near-term, HFI work is focused on developing and implementing a methodology to understand the O&M effects of intensifying hydropower dispatch variability (also referred to as Use-Case 1). Use-Case 1 work focuses on the synthesis and analyses of disparate cost, condition, and reliability data to reveal correlations, causes, and effects of dispatch patterns on O&M strategies and outcomes. Previous attempts at correlation analyses have only correlated unit starts to cost while neglecting other variables of possible significance, including ramping and synchronous condensing. By excluding other variables of possible significance to asset degradation, it is possible to overestimate the impact of starts and stops on the assets. Engagement with industry consortia of EUCG and hydroAMP provides a data synthesis beyond what was previously achieved.

Weighted Project Score: 3.4

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

This is a very complex undertaking, melding disparate databases to provide hydropower operators with new tools. While the relevance of this program is real, there is limited explanation or quantification of how much it could impact O&M costs or result in changes in operational regimens. The databases utilized are insufficient and inaccurate, and drawing them together accomplishes little at this stage.

Project Objectives, Impacts, and Alignment with the Program Strategy

The objectives of the project are summarized as collecting data of a sufficient level of granularity on hydropower facilities that are hydraulically or electrically linked to inform decision making regarding when and how to dispatch conventional and PSH units.

However, the project team did not effectively make the case that hydropower operators feel the need for this information and that they don't already implement internal decision-making strategies that integrate utility-specific goals and rules governing the operation of their fleet of hydropower facilities. The fact that the researchers are working within a CEATI sub-committee and have a willing test-test case utility in Pacific Gas and Electric, suggests there is potential value to this exercise.

It is known that HydroAMP and GADS are humanly inputted and thus are extremely subjective to human judgement and personal convenience. EUCG data is at least a step up by providing detailed cost line items. It is not a given that data of this nature is of use except as a benchmarking tool for hydropower operators. The ability to link this data to an operational regimen is a real stretch. Specific datasets such as bearing temperature profiles pre-failure would be useful to any operator in predicting outages versus how much time is spent on repair at another facility.

End User Engagement and Dissemination Strategy

The project presenters describe their work with the hydroAMP steering committee within CEATI as a means of advising and informing the development and progress of the project. They also describe a combination of publications and conference presentations that will get the word out as to the ongoing findings and results of the statistical analyses that are at the heart of their work. They have done a reasonably good job of reaching out and working within industry to move their work along.

Management and Technical Approach

The management structure, defined by the various staff within ORNL and members of academia, is adequately described, including how they will integrate the various tasks that need to be accomplished. The schedule presented only goes through September 2019.

The technical approach is fairly well described, but dense, promoting a general need to ensure that quality data is derived from different hydropower plants (condition, cost, and maintenance data) to develop correlations to help individual plant operators understand where their practices fit into the mix of operators across the country and improve their decision making.

The challenges of poor data quality are recognized, and the project team is taking steps to improve future data quality issues moving forward. Unfortunately, the existing historical data is often not of sufficient quality and completeness to be able to confidently draw meaningful conclusions. Many relevant historical equipment characterizations and conditions since commissioning (initial design margins, installation quality, historical operational dispatch, and quality of prior maintenance) cannot ever be determined, so cause and effect relationships can be extremely difficult to establish for future reliability or cost projections on aging assets.

Reviewers felt that the project was well-organized but felt that a clearer explanation of the key milestones in the schedule was necessary. Reviewers also felt that the project presentation lacked the details necessary to understand the technical approach.

Technical Accomplishments and Progress

The technical accomplishments to-date on this new project are aligned with the schedule presented in the project management section of the project summary:

- The development of a foundational concepts report to crystalize and organize the project
- The formation of a data quality improvement plan within the HydroAMP, including regular data quality checkpoints
- An examination of data coherency and a ranking system based on numerical scores ascribed to different plants.

The team has made progress in collecting data, but it is not clear what technical accomplishments they have achieved. While these are good first steps, the final determination of success of the effort will come as the project matures.

Future Work

The project presenters merely listed the tasks from their schedule that will be performed in the future for the project, with expected milestones or completion dates. They did not identify any technical challenges associated with the execution of the steps/accomplishments to-date and how these might alter the manner in which they address future tasks. There was little discussion of upcoming decision points and potential issues, which is where the researchers should be more specific about what they hope to achieve.

The project will face other challenges, as well, including the impact of the potential sale of hydropower assets by Pacific Gas and Electric, as well as defining ownership of the data, who has access to the datasets in HFI, and who will do the analysis.

HYDROPOWER VISION ROADMAP UPDATE

(WBS #: 1.4.1.602)

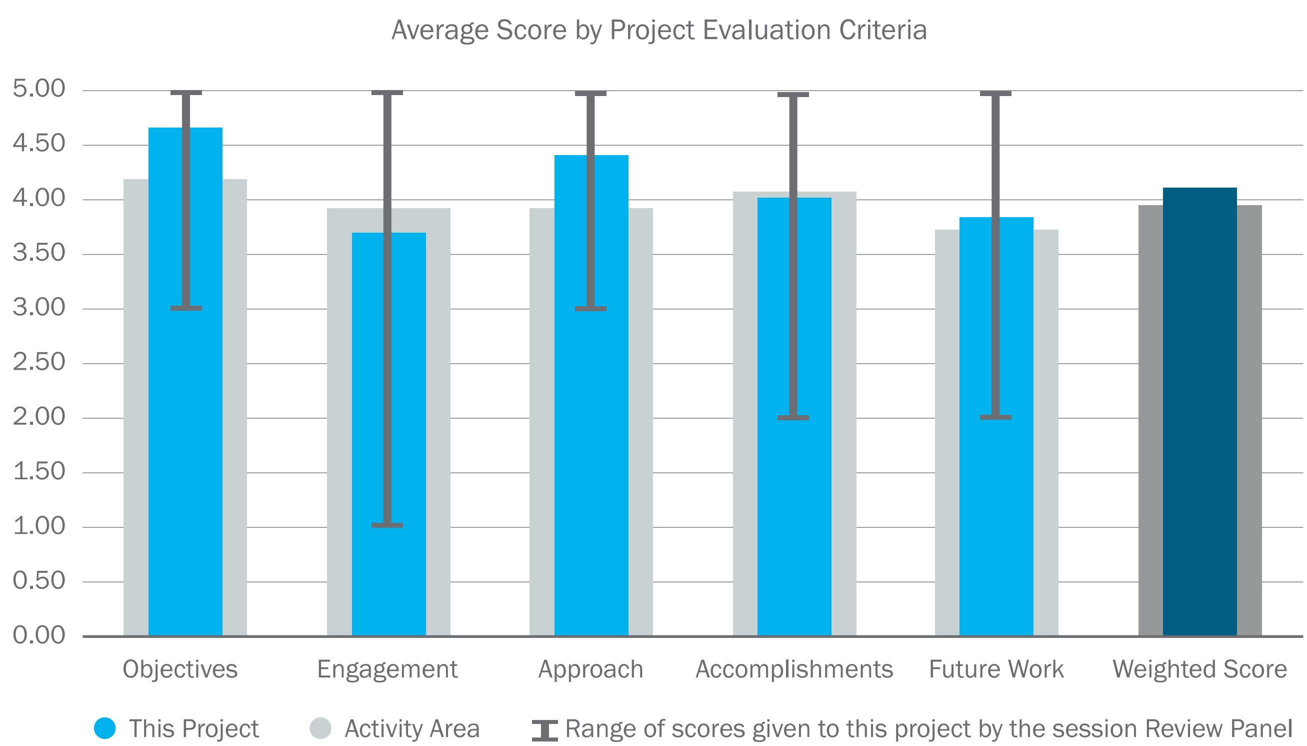
Recipient:	PNNL, ANL, INL, NREL, and ORNL
Principal Investigator:	T.J. Heibel
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,326K
Total Costed:	$776K

Project Description

DOE made a commitment to the hydropower community when it released the national Hydropower Vision Report in 2016 that it would be a living document. DOE acted as a convener in compiling and publishing the original report and will continue in this facilitating role to update the Hydropower Vision Roadmap (Roadmap) for publication in 2021, 5 years after the original report. The Roadmap is a series of detailed actions recommended to advance sustainable hydropower in the United States, allowing it to grow nearly 50 GW (13 GW of new hydropower and 36 GW of new PSH) by 2050. This project focuses on furthering the Roadmap as an evolving plan against which DOE can track progress of its own research, as well as activities throughout the broader hydropower community, toward realizing the Hydropower Vision. The project will continue to engage the hydropower community in gathering feedback and new information to update the Roadmap.

Weighted Project Score: **4.1**

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

This project represents an ambitious effort by WTPO to develop a comprehensive roadmap over a 5-year period to increase hydropower penetration in the United States by 50 GW. The development of that significant amount of hydropower will contribute to the strategic efforts within the United States to reduce its overall carbon footprint while contributing to grid reliability. The Roadmap is transparent and will address the following key areas: grid reliability, hydropower growth, R&D environmental impacts, and dealing with the significant amount of "big" data that will need to be collected and analyzed to assist in meeting these goals. The review team recognizes that this is a significant and important goal with nationwide implications.

Project Objectives, Impacts, and Alignment with the Program Strategy

The review team felt the Roadmap represented an extremely relevant proposal, while outlining a set of concrete steps toward achieving all the objectives WPTO set forth. It is also well aligned with other initiatives throughout the hydropower community, both internal to the United States and internationally. The original draft of the Roadmap was created in 2016. The reviewers felt there would be value in having the original drafters of the document come back and review the document to ascertain progress and alignment with the original vision as part of conducting a valid review.

End User Engagement and Dissemination Strategy

This project represents a significant effort between DOE, the hydropower community, DOE's national labs, and various hydropower subject matter expert groups. The reviewers felt WPTO has made significant inroads in communicating the roadmap and milestones within the hydropower community. However, the review team also felt the dissemination of valuable information was contained almost solely within the hydropower community silo. The reviewers felt that to advance the goal of higher hydropower penetration, it is critical to seek involvement and input from other key industry stakeholders, including regulators (FERC/NARUC/etc.), ISO/RTO (planners/operators/markets), USACE, environmental groups, etc.

Management and Technical Approach

With PNNL serving as a project lead, the other five national laboratories were all organized to work on the project. Each national lab was assigned a specific task within the framework of the Roadmap. The labs used their own tools and expertise to work on their slice of the project autonomously and then report back to the larger group. In the summary document, results for only two lab efforts were discussed, leading the review team to wonder what the other labs contributed. While the reviewers liked the task list, it was not intuitively clear where on the Roadmap the tasks and milestones were. A detailed list of milestones by task with a current status update would have been very beneficial.

Technical Accomplishments and Progress

The 2018 deliverables as presented in the summary do support progress toward both reaching the Roadmap goals and staying aligned with the plan. Efforts toward the 2019 goals were presented and summarized. The significant 2019 goal is to finalize database work and to develop a multi-year project plan laying out the necessary tasks to complete the Roadmap by 2021 and to attain the envisioned 50 GW hydropower penetration goal. While results were presented, the reviewers would have preferred to see detailed milestones to check on specific progress, which would have made the review of accomplishments easier. The results are funneled through the hydropower visionary group. The review team felt the membership may be too small and not broad enough to ensure efforts remain on track.

Future Work

The reviewers felt that timelier progress reporting is justifiable due to the strategic nature of this effort. As part of that, reviewers recognized that the industry is evolving at a rapid pace, and more frequent checks of the plan versus current state of the industry is warranted. Because of this, the Roadmap should be a dynamic document. The future Roadmap should have key milestones and decision points spelled out. There was also a feeling that the process needs to be expedited; 5 years in the industry is a very long time in this day and age. For hydropower to make inroads and meet its goals, work needs to continue in an expedited manner. As mentioned previously, broader industry engagement is strongly encouraged, as well as getting grassroots industry subject matter expert support.

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SECTION 2

Marine and Hydrokinetics Program

Foundational and Crosscutting R&D

Technology-Specific Design and Validation

Reducing Barriers to Testing

Data Sharing and Analysis

Powering the Blue Economy

MARINE AND HYDROKINETICS PROGRAM OVERVIEW

Marine and hydrokinetic (MHK) technologies are at an early stage of development due to the fundamental challenges of generating power from dynamic, low-velocity, and high-density resource while surviving in corrosive marine environments. These challenges are intensified by high costs and lengthy permitting processes associated with in-water testing. To achieve the mission and help to realize the vision, the program must support research and development (R&D) efforts that lead to significant reductions in the cost of MHK energy that enable industry to be competitive in U.S. electricity markets.

Vision

A U.S. marine and hydrokinetic industry that expands and diversifies the nation's energy portfolio by responsibly delivering power from ocean and river resources.

Mission

Conduct transformative early-stage research that advances the development of reliable and cost-competitive MHK technologies and reduces barriers to technology deployment.

The program has four core R&D activity areas, which represent its strategic approaches to addressing challenges faced by U.S. MHK stakeholders:

1. Foundational and Crosscutting R&D
2. Technology-Specific System Design and Validation
3. Reducing Barriers to Testing
4. Data Sharing and Analysis.

The MHK Program launched a public Request for Information to solicit feedback from stakeholders on its draft programmatic strategy in fiscal year (FY) 2017. Through the revised MHK Program strategy, the Water Power Technology Office (WPTO) aims to clearly communicate the rationale for and organization of possible U.S. Department of Energy (DOE)-supported hydropower marine energy R&D from now to 2030. The tables below summarize the foundation of the revised strategy: WPTO's description of U.S. MHK's challenges and the MHK Program's approaches to address such challenges.

Challenges for MHK Technology Development in the U.S.

Difficult Engineering	Installing and Operating Reliable Systems	Prolonged Design and Testing Cycles	Technology/Market Information and Supply Chains
• MHK resources have large ranges in intensity and present other fundamental difficulties for designing systems to efficiently capture usable energy, due to the unique physics of the systems. • There are open scientific and engineering questions about how devices interact with these complicated resources or with other devices, and efforts to develop validated methods to measure, model, and predict these interactions are ongoing. • Commonly accepted performance metrics are not well established to evaluate the wide range of existing technologies and drive early-stage designs toward performance improvements and cost competitiveness.	• Developing effective and efficient methods for installation, testing, O&M, and environmental monitoring are difficult due to the nature of high-energy and corrosive marine/ riverine systems, and there have been limited opportunities to improve through experimental learning. • Ships and other infrastructure necessary to deploy MHK devices and support other operations in high-energy and sometimes deep-water environments where devices will be deployed are limited and/or have not been optimized for MHK applications.	• Access to test infrastructure required for rapid iterative design improvements is limited and facilities do not exist at all necessary scales. • Permitting process are expensive and time consuming due to: ▫ Extensive requirements for environmental monitoring driven by high perceptions of risk, ▫ Limited transferability and utilization of accurate information about siting and deployment of MHK technologies, and ▫ The need for sometimes complicated coordination with numerous other existing users of ocean spaces and waterways.	• Many high value opportunities for utilizing MHK technologies are unclear due to the limited availability of information and analysis on the potential of MHK technologies in the electric sector and other maritime markets. • There is a lack of validated, pubicly-available data on the performance, costs and reliability of new MHK systems and the unique benefits which can be realized in developing these resources. • Manufacturing and supply chains for MHK applications are not well-developed and may results in long lead times and high costs for materials and components.

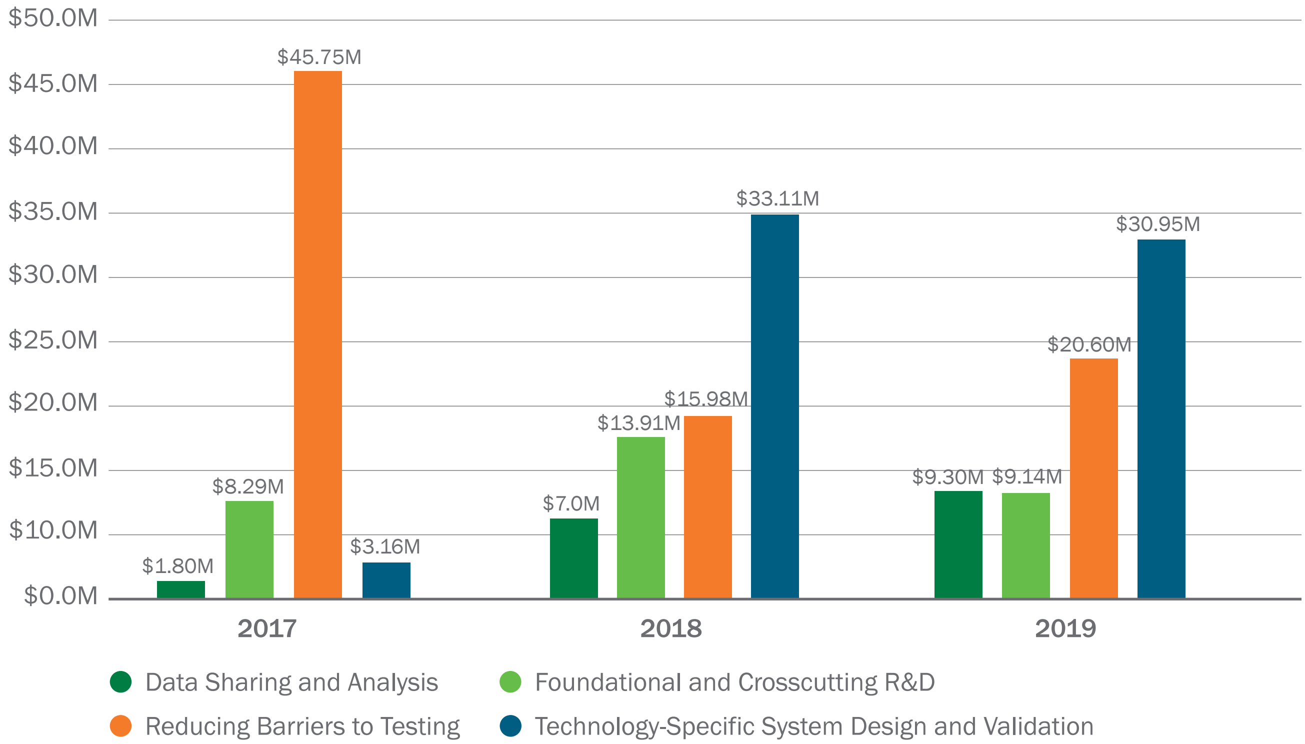
WPTO's Approaches to Address Challenges

Foundational and Crosscutting R&D	Technology-specific System Design and Validation	Reducing Barriers to Testing	Data Sharing and Analysis
• Drive innovation in components, controls, manufacturing, materials and systems with early-stage R&D specific to MHK applications. • Develop, improve, and validate numerical and experimental tools and methodologies needed to improve understanding of important fluid-structure interactions. • Improve MHK resource assessments and characterizations needed to optimize devices & arrays, and understand extreme conditions. • Collaboratively develop and apply quantitative metrics to identify and advance technologies with high ultimate techno-economic potential for their market applications.	• Validate performance and reliability of systems by conducting in-water tests of industry-designed prototypes at multiple relevant scales. • Improve methods for safe and cost-efficient installation, grid integration, operations, monitoring, maintenance, and decommissioning of MHK technologies. • Support the development and adoption of international standards for device performance and insurance certification. • Evaluate current and potential future needs for MHK-specific IO&M infrastructure (vessels, port facilities, etc.) and possible approaches to bridge gaps.	• Enable access to world-class testing facilities that help accelerate the pace of technology development. • Work with agencies and other groups to ensure that existing data is well-utilized and identify potential improvements to regulatory processes and requirements. • Support additional scientific research as needed, focused on retiring or mitigating environmental risks and reducing costs and complexity of environmental monitoring. • Engage in relevant coastal planning processes to ensure that MHK development interests are equitably considered.	• Provide original research to assess and communicate potential MHK market opportunities, including those relevant for other maritime markets (e.g., desalination, powering subsea sensors, charging for underwater vehicles). • Aggregate and analyze data on MHK performance and technology advances, and maintain information sharing platforms to enable dissemination. • Support the early incorporation of manufacturing considerations/ information into design processes. • Leverage expertise, technology, data methods, and lessons from the international MHK community and other offshore scientific & industrial sectors (e.g., offshore wind, oil and gas).

Overview of the MHK Program during this Peer Review Period

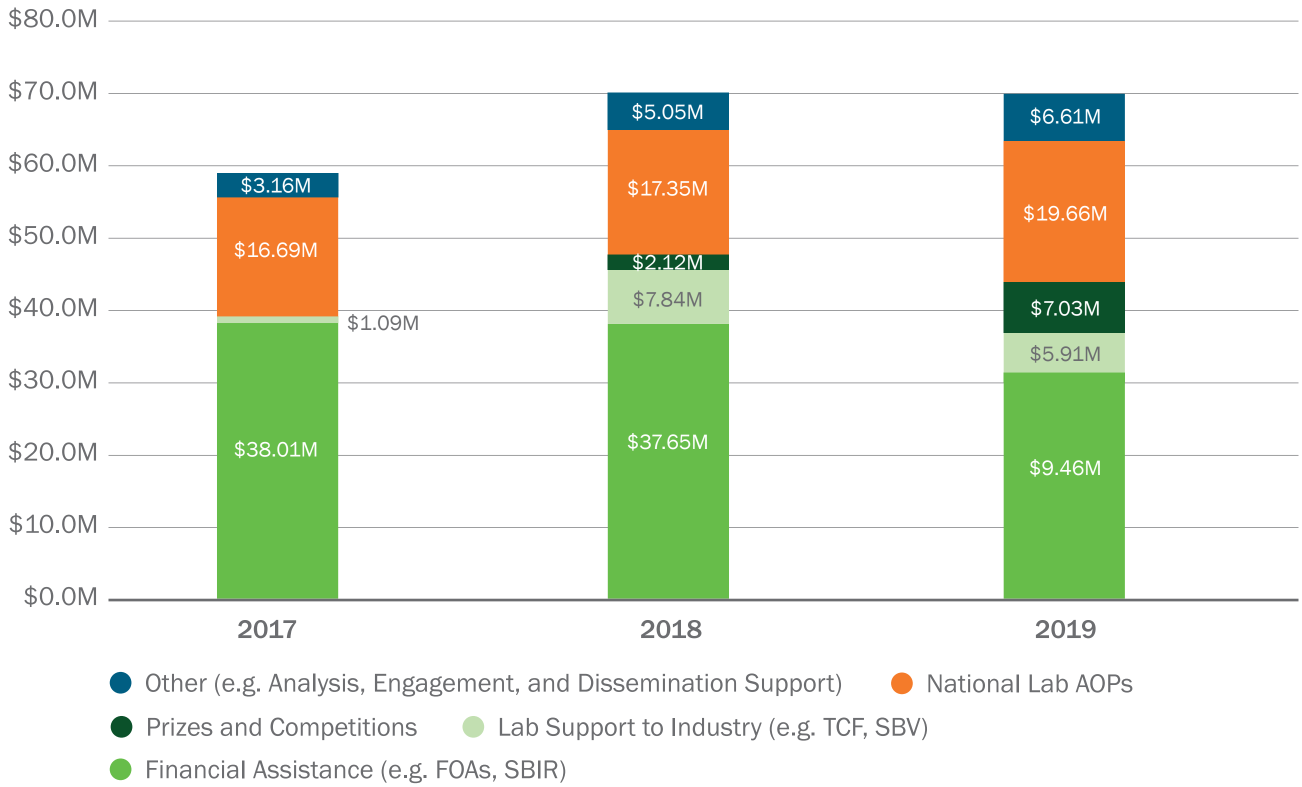
Figure 17 shows the MHK Program's spending by activity area over recent years (Fiscal Years 2017, 2018, and 2019). It should be noted that some of the projects reviewed during the 2019 WPTO Peer Review period were funded with prior year dollars (such as from FY 2016 or before). However, this chart, when viewed as a whole, best represents current and recent program funding. Due to the multi-year nature of DOE R&D program planning, some aspects of the portfolio were more heavily emphasized in a particular year. For example, WPTO awarded funding in FY 2017 to Oregon State University (OSU) for the development of a grid-connected MHK test site as the result of a funding opportunity announcement (FOA) that WPTO issued based on Congressional direction to develop a dedicated MHK test site. This explains the large spike in funding for Reducing Barriers to Testing in FY 2017.

Figure 17. MHK Program FY17-FY19 portfolio—total budget by activity area



The MHK Program leverages a variety of funding mechanisms, and the distribution by funding mechanism for FY 2017–2019 can be seen in the chart below. For descriptions of each funding mechanism, please see the Funding Mechanisms section of the Introduction.

Figure 18. MHK Program FY17–FY19 portfolio—total by budget by funding mechanism



The 2019 Peer Review looked at the first three years of WPTO as an independent office, and there were several program developments during this time period:

- **More devices in the water than ever before**: Year-on-year budget growth for the MHK Program has enabled WPTO to support more tests of marine energy technologies than previously possible. Several WPTO-funded in-water tests took place over the last few years. Most recently, the Ocean Energy 35 buoy with the Siemens Government Technologies Hydro Air Turbine arrived in Hawaii on December 1, 2019, at the Navy's Wave Energy Test Site (WETS). Also, in July 2019, the Ocean Renewable Power Company, in partnership with the Igiugig Village Council, deployed its RivGen system in the Kvichak River in Igiugig, Alaska. Multiple WPTO-funded projects are currently working toward open water tests—of which, a few are expected to begin in FY 2020 or FY 2021; for example, Verdant Power will return to the East River in 2020 to advance the development of the tidal power system and TriFrame mount.
- **The development of robust programs and facilities to support marine energy testing**: While WPTO continues to fund design development and testing efforts through FOAs, it is in the process of standing up a new program to support testing and research for marine energy technologies—the U.S. Testing Expertise and Access for Marine Energy Research (TEAMER) program. In September 2019, WPTO announced the competitive selection of the new network director, the Pacific Ocean Energy Trust. Through TEAMER, the Pacific Ocean Energy Trust will support WPTO in bringing together capabilities from universities and the national laboratory system to provide marine energy developers ready access to unique, world-class testing facilities and expertise. WPTO hopes this new program, along with the anticipated opening of the grid-connected PacWave facility, will pave the way for more marine energy testing and faster design iteration than ever before.

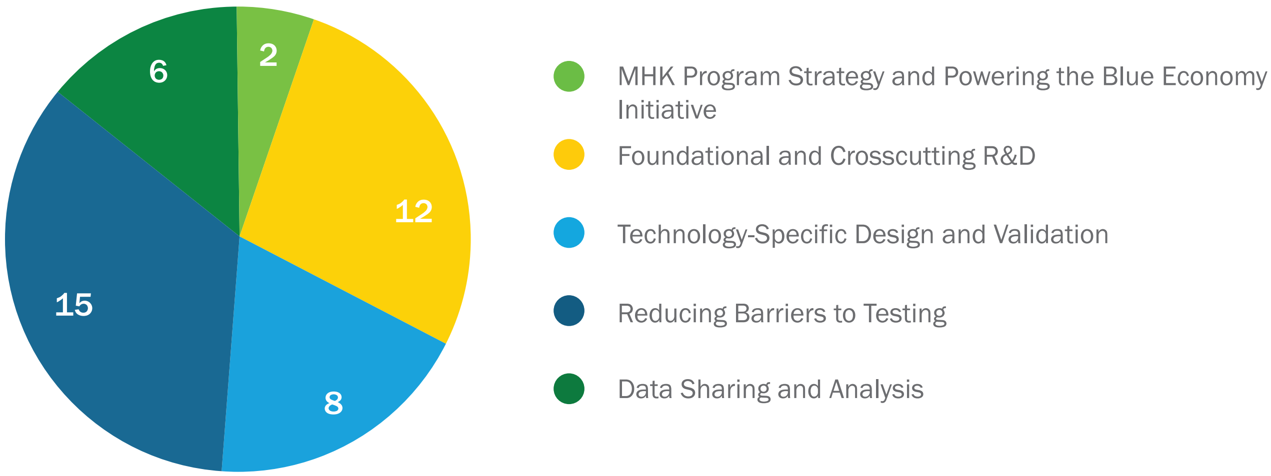
- **Advancing marine energy's potential to serve the Blue Economy**: Traditionally, international marine energy R&D has been focused on long-term cost reductions and performance improvements for grid-scale application. WPTO, while continuing to support R&D for technologies with grid applications, has also recently undertaken new efforts to explore nearer-term opportunities to reduce power constraints for other ocean-based industries and missions. In FY 2019, WPTO launched its Powering the Blue Economy Initiative (PBE), which aims to unlock opportunities for ocean science, security, and other maritime industries by exploring new applications for marine energy. Successfully leveraging marine energy technologies to address existing power challenges for other ocean sectors offers the potential to meaningfully accelerate cost reductions for marine energy systems.
    - Since releasing a foundational *Powering the Blue Economy* report, WPTO has announced two system design and build prizes and one business-case-based collegiate competition and has awarded several Small Business Innovation Research (SBIR) and FOA projects for R&D with Blue Economy applications. One of these prizes, the Ocean Observing Prize, was jointly announced with NOAA in FY 2019, with the goal of challenging innovators to integrate marine renewable energy with ocean observation systems. The other prize, the Waves to Water Prize, hopes to advance small, modular, cost-competitive desalination systems that use the power of ocean waves to provide clean drinking water for disaster recovery and for remote and coastal communities. This prize was also the first funding opportunity launched under the Water Security Grand Challenge, a White House-initiated, DOE-led framework to advance transformational technology and innovation to meet the global need for safe, secure, and affordable water.
- **Increased efforts to leverage a variety of funding mechanisms**: As aforementioned, the MHK Program launched its second and third prize competitions focused on developing marine energy systems in FY 2019. These build off the success of the office's first-ever prize in 2016, the Wave Energy Prize, and are well suited to achieve technology innovation goals because they can attract new ideas and incentivize collaborations. The Ocean Observing Prize was the first time the MHK Program worked this collaboratively with another federal agency to both scope and co-launch a funding opportunity.

These developments not only provide context for some of the newer approaches WPTO took during the years under review, but also preview what to expect from WPTO in future years and in the next peer review.

Organization of Tracks and Review Panels

Both the MHK Program strategy and individual projects were reviewed and scored during the 2019 WPTO Peer Review. Additionally, the reviewers scored and provided specific feedback on the future direction of PBE—a new effort that seeks to understand the power requirement of emerging coastal and maritime markets and advance technologies that could integrate marine renewable energy to relieve these power constraints and promote economic growth. Two panels of reviewers reviewed these program elements, as well as individual projects across all the MHK Program's technology areas. Figure 19 depicts the total number of MHK presentations reviewed by program and activity area.

Figure 19. MHK Program Portfolio—number of presentations by activity area



The following external experts served as reviewers for the MHK Program during the 2019 Peer Review.

Table 6. MHK Reviewers

Name	Organization	Review Panel
Elaine Buck*	European Marine Energy Centre	Foundational R&D, Technology Design, and Validation
Alex Fleming	iMetalx Group LLC	Foundational R&D, Technology Design, and Validation
Andy Hamilton	Monterey Bay Aquarium Research Institute	Foundational R&D, Technology Design, and Validation
Henry Jeffrey	The University of Edin-burgh	Foundational R&D, Technology Design, and Validation
Jim Bretl	Korvis Automation	Foundational R&D, Technology Design, and Validation
Mike Muglia	University of North Caroli-na	Foundational R&D, Technology Design, and Validation
Chris Bassett**	University of Washington	Reducing Barriers to Testing and Data Sharing
Anu Kumar	U.S. Navy, Living Marine Resources Program	Reducing Barriers to Testing and Data Sharing
Gayle Zydlewski	University of Maine	Reducing Barriers to Testing and Data Sharing
Jason Wood	SMRU Consulting	Reducing Barriers to Testing and Data Sharing
Martin Wosnik	University of New Hamp-shire	Reducing Barriers to Testing and Data Sharing
Whitney Hauer	Bureau of Ocean Energy Management - Pacific OCS Office	Reducing Barriers to Testing and Data Sharing

* MHK Program Review Chair and Panel Lead
** Review Panel Lead

Organization of the Results

The quantitative and qualitative results are summarized at the program, activity area, and project-level. Information in this section has been compiled based on the following sources and is organized as follows:

1. *MHK Program Evaluation Summary*: A summary of all hydropower reviewers' comments that provides insight into the program's strengths and weaknesses or potential issues and specific recommendations. The program review chair was responsible for drafting the program summary report in consultation with each review panel lead and all hydropower reviewers.
2. *MHK Programmatic Response*: The program's official response to the recommendations provided in the review chair's program evaluation summary.
3. *MHK Program Score Results*: The results are organized by the activity areas into which individual projects were grouped for the 2019 Peer Review. Each subsection includes each activity area's score results, an evaluation summary prepared by the review panel lead, and individual project evaluations.

MHK PROGRAM EVALUATION SUMMARY

Prepared by Elaine Buck, MHK Program Review Chair

Key Takeaways

Participating and contributing in WPTO's 2019 Peer Review provided reviewers and the general audience an in-depth understanding of the challenges that the MHK sector continues to face. The reviewers provided industry insight on project results and suggestions on potential next steps to address engineering challenges of the sector.

The U.S. MHK sector is poised to deliver significant results. The year-on-year congressional budget increases demonstrate support for MHK technologies R&D advancing toward commercialization. The outstanding professional and technical management of the MHK Program is accelerating U.S.-led MHK technology developments. DOE's national labs have contributed enormously to the development of vital tools that enable further technical breakthroughs (e.g., WaveSPARC, FlexWEC, wave energy converter (WEC) optimization, and co-design tools).

The MHK review panels fully expect advances in the performance and reliability of next-generation MHK developers. The time is now for improved integration, alignment, and focus within the existing program, while expanding access and support within PBE. Interagency collaborations with NOAA will provide a step-change in system integration and technological breakthroughs for the Blue Economy markets.

The 2019 MHK peer review chair, as an American whose international career focuses on overseeing MHK technology developments in the UK and Europe, considered it a great honor to be invited to lead this review. While the United States was not the first country to make investments in marine energy research, it is quickly becoming a leader in this field, and thus, all eyes are directed to U.S. activities and mechanisms supporting continued innovations and in-sea performance validation.

Feedback from the Review Chair to WPTO

Industry data sharing is a vital activity for each of the four MHK programmatic activity areas. The investments made to support data and information dissemination are recognized as essential and one of the strengths of the program. The *State of the Science* report is a valuable product, and the forthcoming 2020 edition will provide new and up-to-date information, while meeting WPTO's dissemination goals.

The review panel leads agreed on the necessary requirements to improve WPTO's data sharing knowledge hubs, including aligning and consolidating the databases that underpin the knowledge hubs. The main recommendation from the reviewers was to restructure the programs (Tethys, MHK Atlas, the Portal and Repository for Information on Marine Renewable Energy) that improve access to research findings, quality of information listed, and sustainability of the knowledge hubs' data management. WPTO should improve the definition of the needs case for the resource assessment portfolio. Improvement in regulatory stakeholder engagement is viewed as vital to align the needs case, while ensuring that the best available information is accessible to those stakeholders.

For the other three areas, the reviewers have the following summary recommendations.

Foundational & Crosscutting R&D/Technology Specific Design & Validation:

- Complete techno-economic assessments (WaveSPARC) on existing devices.
- Integrate lab-developed tools (such as the WEC Design Optimization tool) into existing devices where appropriate.
- Evaluate the appropriate prioritization of tidal R&D.
- Incorporate testing to standards and feedback to the International Electrotechnical Commission's System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications as a requirement for testing, such as at WETS, PacWave, and all tank testing.
- Integrate PBE objectives into existing device development projects, while not losing lessons learned from WPTO-funded developer projects focused on grid-scale application.
- More closely benchmark and ensure collaboration between funded projects with similar objectives, such as the controls projects.
- Set specific dissemination targets for all projects (e.g., the number of peer-reviewed journal papers, pipeline (CRM) of end users, and number of workshops).
- Expand and utilize additional platforms for the dissemination of tools produced through WPTO funding.

Reducing Barrier to Testing:

- Improve regulatory stakeholder engagement to align environmental, technological investments with regulatory concerns.
- Evaluate levels of investment across this activity area and opportunities to scale back support based on advances made in the field.
- Increase targeted deployments with environmental monitoring technologies developed through the program.
- Set specific dissemination targets for all projects.
- More closely benchmark and ensure collaboration between funded projects with similar objectives, such as activities supported by the Triton Initiative.

Summary of all Reviewers' Comments

Overall Impressions

Overall, the reviewers agreed that the MHK Program has a clear understanding of the near- and long-term challenges facing the industry and has developed a well-balanced program strategy to-date with objectives that were conveyed during the peer review. Long-term strategy concerns from reviewers included the integration of PBE in a manner that ensures WPTO continues to support both the longer established developers with higher technology readiness levels ("GEN1 developers" – as the reviewers called them) and newer developers with lower technology readiness levels or who may have an easier experience pivoting to Blue Economy markets (those the reviewers referred to as "GEN2 developers"). Also, the reviewers have concerns that the outstanding developments coming from the labs and environmental instrumentation portfolio have outpaced the device developers' results. There is opportunity for WPTO to refocus the program that balances the requirements of the PBE markets, including improved integration, alignment of the enabling tools, and initiatives with the MHK technology developers.

Program Strategy and Objectives

Most reviewers agreed that most program objectives supported the sector needs, though several goals of each activity area were not necessarily realized through the GEN1 developer projects. Specifically, validating performance and reliability of systems, as well as improvement in cost-effective methods for integrated operations and maintenance (O&M). In the Reducing Barriers to Testing activity area, the goals of enabling access to test facilities, coupled with R&D aimed at reducing permitting and environmental monitoring costs, have not yet proven to improve regulatory efficiencies. Below is a selection of reviewer comments related to each aspect of the program strategy and objectives criterion used for this review.

- The program's long-term strategy, strategic approaches, and future direction were effectively conveyed during the peer review.
    - The multi-year MHK strategy document is still in draft form and needs to be finalized and published in accordance with WPTO's outreach and engagement goals of transparency, feedback, dissemination, and accurate information.
    - Concern on the future direction of the current MHK GEN1 large-scale grid program is disparate from the new PBE program.
    - As the MHK Program budgets have steadily increased over recent years, international developers will seek opportunities to work in the U.S. market. WTPO should evaluate using business models that implement business support mechanisms, as well as SBIR.
- The program's strategy reflects an understanding of the near and long-term challenges facing the industry and other stakeholders.
    - A midterm challenge is the pipeline of developers ready to test/deploy in the United States. It is expected that more international device developers will seek to enter the U.S. market, and this will require a transparent business model that international developers can adopt and set up.
    - The program strategy appears solid in advancing MHK, and reviewers would recommend emphasizing improved integration of the excellent work done by the labs into developer efforts. Projects such as WaveSPARC and the System Advisor Model (SAM) can provide needed structure to technology developments as current GEN1 developers do not have a convincing trajectory toward commercial LCOE.
    - Further investigations into novel marine energy storage approaches, flexible materials, and distributed power take-off (PTO) approaches should be included in the program.
    - The disparity between regulatory permitting and environmental assessment issues are still a challenge, and further investments in stakeholder engagement and environmental tools is necessary. Program efficiency could be improved by reducing the spending on data sharing by consolidating existing projects.
- The program invests in early-stage research to accelerate the development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed.
    - The levels of investment for development of marine energy systems versus environmental monitoring technologies seem out of proportion given the relative stages of these technologies. WPTO has developed advanced supporting tools, and the office should look at where there are

opportunities to scale back in this area to refocus more resources on marine renewable energy (MRE) technology development.
    - WPTO has funded research to investigate and better understand environmental risk; however, there is not yet enough evidence that this has significantly impacted regulators' understanding of how environmental concerns are being addressed, nor has it resulted in improved regulatory efficiencies.
- The program supports efforts to validate performance and grid reliability for new technologies, develop and increase accessibility to necessary testing infrastructure, and evaluate systems-level opportunities and risks.
    - WPTO's announcement that there will be more detailed design reviews incorporating validation/verification processes will enhance program efforts to validate performance.
    - Program support to validate performance and reliability through NREL work is critical for the decision making of GEN1 further developments.
    - Funding for PacWave and TEAMER demonstrates clear focus for access to necessary testing infrastructure.
    - There is a need for a more regional approach for testing infrastructure
- The program invests taxpayer funds wisely to drive the most significant impact.
    - Taxpayer funds are distributed to a wide range of project types that reflect existing needs, but program efficiency could be improved by reducing spending on data sharing by consolidating similar data-sharing projects.
    - Concern that existing GEN1 devices that have been funded will deliver the most significant impact. Independent reviews are critical to be conducted on GEN1 developers to determine credible trajectory toward commercial LCOE.
    - Investments in material characterization, WECSim, WEC Design Response Toolbox, SAM, DTOcean, WaveSPARC, and Advanced Controls all are critical to accelerate and enable the MHK sector.

Program Portfolio

The breadth and depth of projects within the program's portfolio reflect the engineering, testing, and environmental challenges for the MHK sector. This is a strength of the program portfolio. A weakness to the portfolio is some redundancy of projects, for example, the investment in data sharing activities and overlap on environmental monitoring projects. These projects need further integration and streamlining.

The portfolio strengths stem from the projects led by the labs. One example is WPTO leveraging the Ocean Energy deployment at WETS, with the labs providing multiple instrumentation testing; this is an excellent example of value for taxpayer funds.

There is a need for more in-sea deployments and more emphasis on installation and O&M demonstrations, logistics, and supply chain needs. While facilitating developers' access to testing, the program must be ready to address potential operational challenges and advance the technologies. That means ensuring a skilled supply chain and support from the national labs.

There is a need to refocus GEN1 activities towards continued integration, focus GEN2 activities to expand disruptive technologies, and evaluate if tidal still/should be a priority for a U.S. program given progress in tidal internationally. The balance of the research priorities and allocation of resources is necessary within each of these portfolios.

PacWave does not appear to have a pipeline of technologies ready to test, and it is not clear how the site can be used for PBE-focused technologies. A programmatic emphasis on the wave resource in the Northwest has created a lack of balance across the other regional areas. The portfolio does not adequately balance research priorities or appropriately fund testing across the United States.

A weakness noted by reviewers is that WPTO did not always clearly convey the rationale for the funded projects. This is important for WPTO's role as a public R&D organization. A WPTO introduction of the FOA recipients explaining why WPTO agreed the projects aligned with the program strategy and objectives would save time during the peer review and be more useful for panel reviewers to hear. Professional and dedicated staff manage WPTO.

Program Management Approach

The significant strength of the MHK Program is the WPTO management approach and management team. Professional and dedicated staff manage WPTO. There is high confidence among reviewers that the success of the sector will be realized with the current team.

Some concerns raised on the approach are with the alignment of program objectives, implementation, and results where targets are implied (reduction of LCOE) in project portfolios and are not well quantified. One reviewer recommended the program ensure a stronger connection between strategic objectives and activities implemented to address the stated challenges of the industry. For example, if it is a programmatic objective to focus investments that will have the most significant impact to advance industry, a metric beyond LCOE reduction should be quantified. After LCOE, what is next?

The panel agreed that the WPTO team effectively communicated the priority research areas; however, it was less clear to the panel how the areas were resourced in terms of budgets identified or people resourced to support the specific research areas.

The WPTO team appears to be continuously skilling up to ensure excellent service delivery to the program, and specifically with the project awardees.

Stakeholder Engagement, Outreach, and Dissemination

The program is outstanding and effective in communications and coordination. Overall outreach is a potential weakness; however, some projects within the program have international awareness, such as DTOcean and international standards development. The program should seek further platforms available for outreach and dissemination of activities. The impact of the program results should engage wider with the international MHK community. The program's recent announcements of new programs to facilitate access to test sites and funding opportunities will attract the global market. With the inclusion of PBE, it is expected that outreach to the Blue Economy markets will bring further innovation, R&D focus, and resultant impact. The data sharing repositories/knowledge hubs are fundamental to dissemination. However, the accessibility and quality of information need improvement. Stakeholder engagement with regulators to understand requirements is vital moving forward.

The MHK Program Outreach and Engagement Strategy was communicated at peer review. WPTO should continue to optimize each goal in specific areas:

- Transparency: Project/portfolio impacts need to be precise; i.e., 'X was done, Y was achieved, and Z is what is learned.' Project performers (developers) need guidance on how to present this effectively, so immediate quantification of impacts is realized. The national labs have made significant traction in this area.

- Feedback: Engage regulators to understand their needs and environmental concerns. Incorporate this feedback into the environmental monitoring portfolio.
- Dissemination: Maximize impact by increasing international use and dissemination of tools, as well as program opportunities for international engagement, and expanding use of outreach platforms (such as university networks and social media).
- Objective and accurate information: Improve access to and quality of knowledge hubs.

All the above recommendations will maximize the MHK Outreach and Engagement Strategy.

MHK PROGRAMMATIC RESPONSE

Prepared by Tim Ramsey, MHK Program Manager

Overview

The MHK Program would like to thank the reviewers for the significant time and effort they contributed to this review. The program was honored to work with each of the reviewers and grateful that they shared their expertise. WPTO gained invaluable insights and has already started to incorporate some of the recommendations into our program strategy. The U.S. marine energy community will benefit for years to come thanks to the hard work and dedication of the reviewers. The MHK Program thanks the reviewers for their many positive comments on the quality of the WPTO staff. We are very proud of the team and acknowledge that the success of the program reflects their hard work and professionalism. Overall, reviewers outlined several areas for improvement in (1) clearly communicating metrics and goals, (2) incorporating detailed design reviews, techno-economic assessments, and standards, (3) incentivizing more lab-industry partnerships, and (4) effectively disseminating information and lessons learned. The following sections outline the program's response to the reviewers' key recommendations to the program and the most prevalent comments received for PBE and each individual activity area.

Recommendation 1: Clearly communicate metrics and goals

The MHK Program agrees with the reviewers' feedback that the program must better define metrics and goals across our portfolio, and the team is focused on adding specificity to the program's long-term goals and ensuring these are reflected in project-level goals. The program is working to re-baseline the current LCOE for marine energy technologies and to update our long-term LCOE reduction targets in accordance with the Government Performance and Results Act. We will continue to work closely with partners both within the United States and internationally on LCOE goals, as well as on new metrics and the appropriate use of such metrics. For example, the program is engaged in a metrics coordination project with the International Energy Agency (IEA)-Ocean Energy Systems (OES). This task, OES Task 12, addresses the ongoing need to define consistent evaluation criteria to assess progress in several critical target areas of ocean energy technology development. The overall objective of Task 12 is to establish a common international technology evaluation framework for technology developers, investors, and other funders to use. WPTO plans to incorporate Task 12 results into our own program and project planning.

In addition to improving metrics and goals across the portfolio, the office will also work over the next year to better evaluate impacts of WPTO-funded projects, better communicate progress made against stated goals, and disseminate these impacts and progress more broadly to industry. To help the project teams do the same, the program is developing a standard framework for a logic model designed to help PIs clearly define and articulate project activities, outputs, outcomes, and impacts, as well as how these align with the program's strategy and approach. WPTO envisions this logic model to serve as both a project management and communication tool that can inform project plans and help better identify meaningful and appropriate data and metrics to monitor and measure. We will pilot the logic model with several project teams in FY 2021 and further encourage PIs to integrate impact-focused thinking into the project lifecycle.

Recommendation 2: Detailed design reviews, techno-economic assessments, and standards

The program recognizes the need for more detailed design reviews and overall techno-economic assessments, and we intend to better incorporate quantifiable metrics and international standards into future rigorous reviews. Through EERE Active Project Management best practices, the program requires one go/no-go review or critical design review per year on most projects, with an emphasis on projects that are large, complex, and/or include testing as part of their scope of work. We will work to add more rigor to our required milestones and these reviews to focus on results rather than simply project progression. We will ensure that the metrics developed for these decision points reflect the program's metrics and long-term LCOE reduction goals which, as mentioned above, we are working to update. Additionally, the program has funded NREL and SNL to support the development of technology performance levels (TPLs), which are used as a metric to quantify techno-economic performance potential of WEC technologies at an early stage of development. The program will encourage and support additional TPL assessments on WEC technology development projects to inform the program of the overall techno-economic potential of different designs. The program will also consider expanding the use of TPLs to current energy converters.

Based on reviewer comments during the previous WPTO peer review in 2017, the program has already emphasized the development and implementation (to include third-party certification) of international standards for the marine energy industry. We have increased our support through collaboration with the International Electrotechnical Commission (IEC) Technical Committee 114 (TC 114) to develop technical specifications that will lead to standards for marine energy devices. The program has and will continue to cite technical specifications and standards in FOAs and require funded project teams to design to and adhere to these requirements throughout the project period. Recipients are required to demonstrate this adherence during go/no-go decisions and critical design reviews. The program has also initiated formal design reviews, utilizing subject matters experts from the labs and industry, for wave energy device designs planned for operations at PacWave. Finally, the program is investigating the opportunity to consult an independent engineering firm to perform third-party cost audits during award selection and subsequent design reviews to better inform the techno-economic assessment of funded technologies. The program plans to use these tools to evaluate project potential during selection and project success throughout the period of performance, including go/no-go reviews, to inform program decisions to continue, redirect, or sunset work.

Recommendation 3: Incentivize more lab-industry partnerships

We appreciate the reviewers' comments that they were impressed with the quality of work from the national labs and, in particular, industry-lab partnerships. We heard the reviewers found the lab-developed tools in the Foundational and Crosscutting R&D activity area to be of great value to technology developers, and they witnessed great results when technology developers leveraged these resources. We agree with the reviewers' recommendation to continue supporting collaborative partnerships, as we recognize the national labs are a great resource for the marine energy industry—both to the program (by supporting technical design reviews and assessments) and to technology developers (by partnering on device design and performance assessments).

The program continues to leverage the labs' capabilities for greatest impact to the industry, and we will continue to encourage and facilitate partnerships between labs and industry. For example, when appropriate, WPTO will consider setting aside funding specifically for labs to support selected FOA awardees. Another avenue for lab-industry collaboration will be through the recently established TEAMER program. TEAMER will bring together capabilities from universities and the national labs to provide marine energy developers ready access to unique, world-class testing facilities, expertise, and tools. We also envision the TEAMER program to help increase awareness and lead to greater adoption of lab-developed tools.

Recommendation 4: Effective dissemination of information and lessons learned

We thank the reviewers for acknowledging that the program is already doing extensive outreach and engagement to help the marine energy industry (for example, building new partnerships with Blue Economy stakeholders); however, we also agree that more work is always needed to further facilitate transparency and sharing of information, data, and lessons learned. Outreach and engagement, including dissemination, is critical to WPTO's R&D mission.

We will continue to prioritize outreach and engagement efforts, including dissemination, across the entire portfolio. In particular, we are focused on maintaining active communication with the marine energy community so that they are aware of and can contribute to the direction of the many tools and resources WPTO has developed for their benefit. One way we facilitate this for U.S. marine energy developers is through monthly presentations to the Marine Energy Council. WPTO organizes these monthly briefings during Marine Energy Council member meetings so that industry partners are better informed of capabilities and work ongoing at the labs and with other partners. We have heard from industry members that this series has improved their understanding of specific projects and tools and even facilitated new partnerships. Additionally, the recently established TEAMER program will provide another avenue to facilitate more industry and national lab collaboration, creating lessons learned and new data that will be made publicly available as soon as possible.

While maintaining consistent engagement with the U.S. marine energy community, the program is also exploring new information sharing strategies that can help us target new audiences. In 2019, WPTO stood up a public webinar series to highlight new program announcements, such as open funding opportunities, newly funded projects and their intended impacts, and project milestones. We always provide a question and answer (Q&A) session at the end of each webinar for listeners to directly engage with WPTO staff. We see this as a good vehicle for stakeholders—whether new to the program or not—to learn about the portfolio and its current direction and priorities, and we have seen many organizations that we have not already worked with participate in these webinars. To respond to the reviewers' recommendation to focus more on sharing lessons learned, WPTO can start by leveraging this webinar series, while also considering other avenues. We are also developing a 2019 Accomplishments Report to highlight project milestones and lessons learned over the last year. We intend to publish this document in the coming months and update the publication annually. Lastly, we began ramping up our support to increase video and media coverage of projects, especially projects involving in-water tests, and we will disseminate these products so the public can visually follow the deployment.

Powering the Blue Economy

The program thanks the reviewers for their supportive comments on the PBE effort. The reviewers stated the launch of PBE could ultimately help the marine energy industry test more devices, gain more in-water experience, and reduce costs, which are major objectives and motivations behind the initiative. WPTO would like to address two elements of our PBE strategy that reviewers specifically called out that will determine PBE's impact: (1) our outreach to Blue Economy partners and (2) how PBE activities complement R&D for grid-scale systems.

We appreciate the reviewers' recognition of how much stakeholder outreach we and our partners have already done to stand up the PBE effort. We will continue to engage Blue Economy stakeholders, both to inform research pathways and to better connect developers and researchers with the ultimate end users of the technologies they seek to develop. The national laboratories are directly surveying potential end users in Blue Economy markets to understand the energy requirements of their existing technologies (for example, ocean observing systems). These insights will directly inform PBE R&D pathways. At the same time, customer discovery tasks are being incorporated into all competitive solicitations; for example, we emphasized co-development (meaning the marine energy power take off (PTO) unit being designed/developed holistically with the overall end use system) through a recent SBIR/STTR solicitation, and we require all current prize and competition participants to engage end users and identify their needs. Also, as part of the prize portfolio, the program will continue to engage end users, investors, and other commercial partners in the review of prize submissions. We will also invite these organizations to convening events—like the finals of prize competitions—to help amplify the technologies developed in the PBE portfolio.

Additionally, the program is engaging other federal partners in PBE to leverage their expertise and tap into their broader networks, with NOAA as a key partner from the beginning of the effort and more recently, the U.S. Department of Commerce's Economic Development Administration.

While reviewers were overwhelmingly supportive of PBE, we also recognize some concerns over how PBE might impact developers interested in grid-scale devices; specifically, reviewers questioned whether PBE would ultimately be a benefit or a distraction to these developers. The PBE portfolio is meant to complement grid-scale efforts, not replace or redirect them. As an example, since the launch of PBE, the program launched a FOA (FY 2019 FOA DE-FOA-0002080) through which we funded four projects to develop full system designs that will be ready for fabrication, deployment, and prototype testing at the DOE-funded PacWave-South test site.

Foundational and Crosscutting R&D

WPTO appreciated the reviewers' comments that projects funded in our program's Foundational and Crosscutting R&D activity area have achieved innovation in controls, components, and systems with impressive results from the lab projects overall. These types of projects are selected and funded based on their potential to reduce costs and address difficult engineering challenges faced broadly by the industry. As an example, a major programmatic focus is on controls research, where studies have shown that advances can provide significant increases in energy capture (on the order of 200%–300%). To maximize the impact of these projects, the program will continue to encourage and actively facilitate dissemination of results and adoption by industry stakeholders as appropriate.

Technology-Specific Design and Validation

The program notes the concerns by reviewers that several technology development projects had notable challenges, which many believe are largely due to the few U.S. deployments to date. The program agrees with this assessment and the suggestion to create more opportunities for developers to share lessons learned during installation, operation, and maintenance (IO&M) activities. We fully agree that in-water testing is critical to gather the experience needed to drive down costs in system performance and IO&M. Some studies have shown that IO&M can account for greater than 45% of the lifetime costs of a commercial marine energy project. The program previously supported a FOA focused on durability and survivability (DE-FOA-0001310), which had a topic area focused on reducing uncertainty regarding the cost of IO&M. Three projects were selected under that topic area, one of which (the Igiugig Village Council) has already entered the operations phase of the project. Through this project, we are starting to capture IO&M lessons learned, and we will ensure dissemination of the results to the greatest extent possible. Also, the program's

FY 2019 FOA (DE-FOA-2080) included a topic area focused on IO&M cost reductions for current energy converters operating in riverine environments. Lastly, we will ensure that analysis, data, and lessons learned from TEAMER-supported activities, including IO&M information, will be disseminated broadly, and we will strongly consider prioritizing IO&M cost reduction measures within future work.

Reducing Barriers to Testing

WPTO appreciates the reviewers' strong support for the Triton Initiative, including positive comments on testing planned at WETS in Hawaii and an overarching statement that PNNL's provision of facility and technical support for industry-led projects is an effective use of funding and critical for the industry. The program thanks the reviewers and will continue to support the Triton project and additional testing at WETS.

The reviewers advocated for WPTO to focus on translating our marine energy environmental R&D into regulatory outcomes. They also encouraged the program to consider how regulators interpret the findings from our environmental research portfolio and whether monitoring tools would ultimately be accepted for monitoring needs. While DOE does not make regulations, we recognize these impacts can only be realized if the findings and tools are widely disseminated and used. To address this, a new project focused on developing an MHK environmental permitting toolkit was initiated in 2019. The toolkit will include a spatial, regulatory, and document database of the latest science and informational resources to help users rigorously and efficiently identify potential impacts of a proposed project. As regulators will be the primary end user for this toolkit, they are providing direct engagement and guidance to the project team during development.

The reviewers provided several recommendations on how to maximize the impact of our Reducing Barriers to Testing portfolio through coordination with offshore wind. WPTO has a strong historical relationship with DOE's Wind Energy Technologies Office (WETO), and we will continue to seek opportunities to partner on common technical and environmental research, such as the development of standards for environmental monitoring technologies.

An overarching recommendation from the reviewers that stuck out to WPTO was the suggestion to consider opportunities to better streamline regulatory R&D based on (1) recommendations from the permitting analysis projects led by PNNL and SNL and (2) the advanced state or environmental monitoring technologies relative to marine energy systems. All future work will be prioritized based on the cost/timeline reduction potential and the needs of the industry, as well as the insights gained from ongoing projects led by PNNL, SNL, and Kearns and West.

PacWave

As the first full-scale, grid-connected test facility in the U.S., PacWave is a large and important project for WPTO and the MHK industry. Reviewers overwhelmingly agreed that they recognized the importance of PacWave to the MHK Program's goals and to the industry. We heard from reviewers that WPTO should work with the PacWave team to produce a white paper that documents best practices and captures lessons learned from their permitting process. We agreed that this would be valuable and have since contracted PNNL to lead this effort for the program. The key questions we received from reviewers were about 1) how PacWave related to our PBE work, 2) whether there will be enough of a pipeline of devices to test at the facility, and 3) the potential for additional cost overruns and schedule delays. Although Blue Economy applications will not be the primary focus of the facility, certain elements will support PBE. Regarding the future pipeline question, the program recognizes the importance of a robust pipeline of devices across all stages of development, both for the needs of PacWave and the health of the marine energy industry. The program has supported early stage development of marine energy devices for several years and will continue to prioritize effective utilization of the nation's first permanent, grid-scale test facility. Lastly, the reviewers acknowledged potential for additional cost overruns and schedule delays. Since the peer review, the PacWave team has finalized the cost estimate and Congress provided an additional $26 million for the PacWave test facility. Based on this increased commitment from Congress, the PacWave team has finalized the site design and moved toward facility construction.

Data Sharing and Analysis

The reviewers provided important feedback on our program's Data Sharing and Analysis work; we agree that we need to assess some of our investments and approaches in this area, and we commit to reexamining our data strategy overall. Of the comments received, the recommendations that stuck out most to us were that the program should consider (1) more efficient and effective means to collect, organize, and analyze high-quality data and the storage needs/implications for such data; (2) whether PRIMRE, in its current form, has helped address marine energy data challenges; and (3) developing metrics to quantify the impact of this work that are more meaningful than the number of downloads of datasets or visits to a site.

Data collection and impactful dissemination is critical to WPTO's R&D mission. The program recognizes the need to better collect, organize, and analyze high-quality data for device testing and performance, environmental data streams, and lessons learned (especially from in-water testing experiences). We fully recognize that the impact of the data created, and lessons learned from WPTO-funded R&D will only be impactful if they are easily accessible, broadly disseminated, and used. We will continue to assess areas for improvement, including methods to more systematically document lessons learned, across the portfolio. When we start new programs, we do so with these critical goals driving our actions. For example, we are expecting TEAMER to create new data that could be informative for other marine energy developers and researchers. Therefore, we stood up a TEAMER Technical Board who are currently developing a test plan template to ensure data is collected in a consistent, repeatable manner and adheres to relevant technical specifications and standards. We envision that best practices to collect, organize, and analyze data will be developed by the Technical Board. In addition, through the Kearns & West MHK toolkit award, the project team is engaging regulatory agencies in discussions around the use cases for datasets WPTO collects and makes available, including environmental data. These activities will inform programmatic decisions moving forward with respect to better collecting, organizing, and analyzing data.

The reviewers expressed some concerns about the PRIMRE project, a multi-lab effort to improve the discoverability and use of data produced from MHK Program-funded R&D. Currently, these data are collected and stored in many ways. The PRIMRE project is still relatively new and, at the time of the peer review, some functions had not yet been realized. As the project is still under development, construct and function can still be modified as appropriate. Nevertheless, we understand the reviewers' concerns around PRIMRE, and we are reassessing our data strategy overall while working to beef up our team's data science expertise.

Lastly, we heard from reviewers that the program staff and project teams supporting marine energy data sharing need better metrics to quantify the impact of this work. We fully agree with this sentiment, as the impact of knowledge sharing is not adequately reflected by metrics such as number of visits to a site. Developing meaningful metrics for websites, databases, and communications work is a challenge for anyone working in these fields. The standard logic model WPTO is developing will help projects, including data sharing projects, to better define and articulate project activities, outputs, outcomes, and impacts. The function of the logic model will also inform project management plans and help better identify meaningful and appropriate data and metrics to monitor and measure.

MHK PROGRAM SCORE RESULTS

This section provides an overview of the scoring for the MHK Program strategy, all projects within the MHK Program, and PBE. Reviewers evaluated the MHK Program strategy and PBE on the following, equally weighted criteria: (1) program strategy and objectives; (2) program portfolio; (3) program management approach; and (4) stakeholder engagement, outreach, and dissemination. Reviewers provided scores on a scale of 1 (“unsatisfactory”) to 5 (“superior”) for each criterion and were also asked to answer unscored, supplemental questions for each program or strategic initiative, which are outlined in Appendix B. A summary of the reviewers’ responses to the unscored, supplemental questions were incorporated into the MHK Program Evaluation Summary. Figure 20 summarizes the weighted score of the MHK Program strategy and average reviewer score according to each program evaluation criteria.

In addition, reviewers were asked to evaluate a set of WPTO’s projects, both numerically and with specific, concise comments to support each evaluation. Reviewers evaluated each project on the following specific criteria: (1) project objectives, impacts, and alignment with the program strategy; (2) end user engagement and dissemination strategy; (3) management and technical approach; (4) technical accomplishments and progress; and (5) future work. Project scoring involved weighting the evaluation criteria based on each project’s category—sunsetting/completed, ongoing, or new—which was based upon a project’s start and/or end date. Reviewers were asked to comment on the strengths and weaknesses behind their scoring and to provide recommendations that they felt that the office should consider. Figure 21 summarizes the average score of all projects within each activity area, the average score of all MHK projects, the average PBE strategy score, and the average program strategy score.

Figure 20. Average reviewer score of the MHK Program Strategy by program evaluation criteria

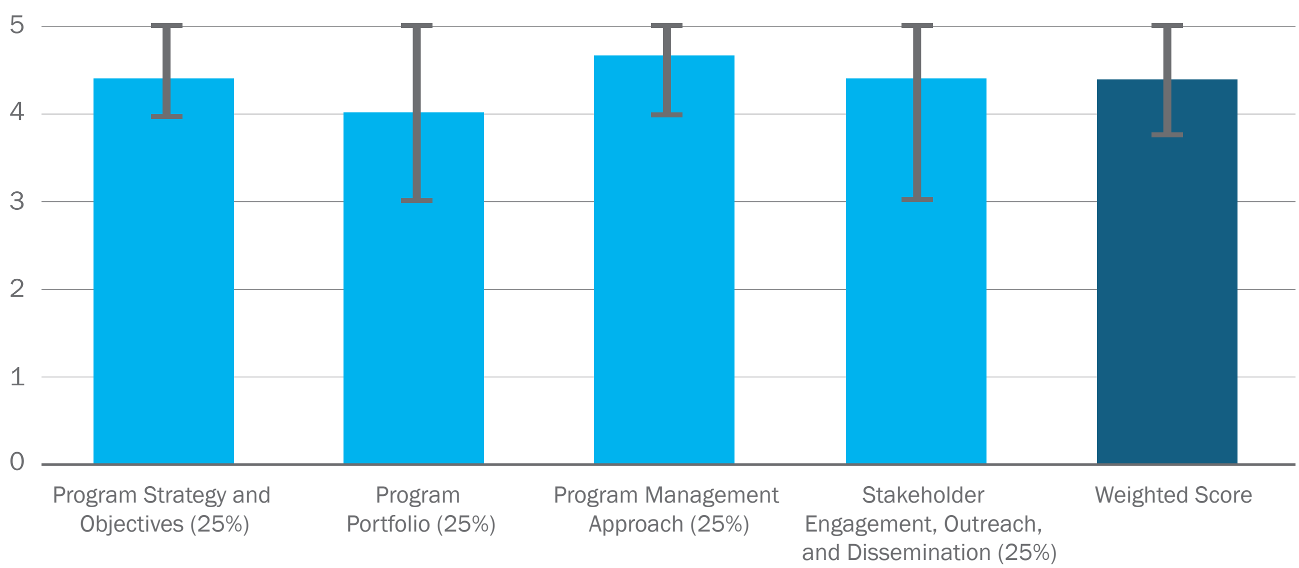
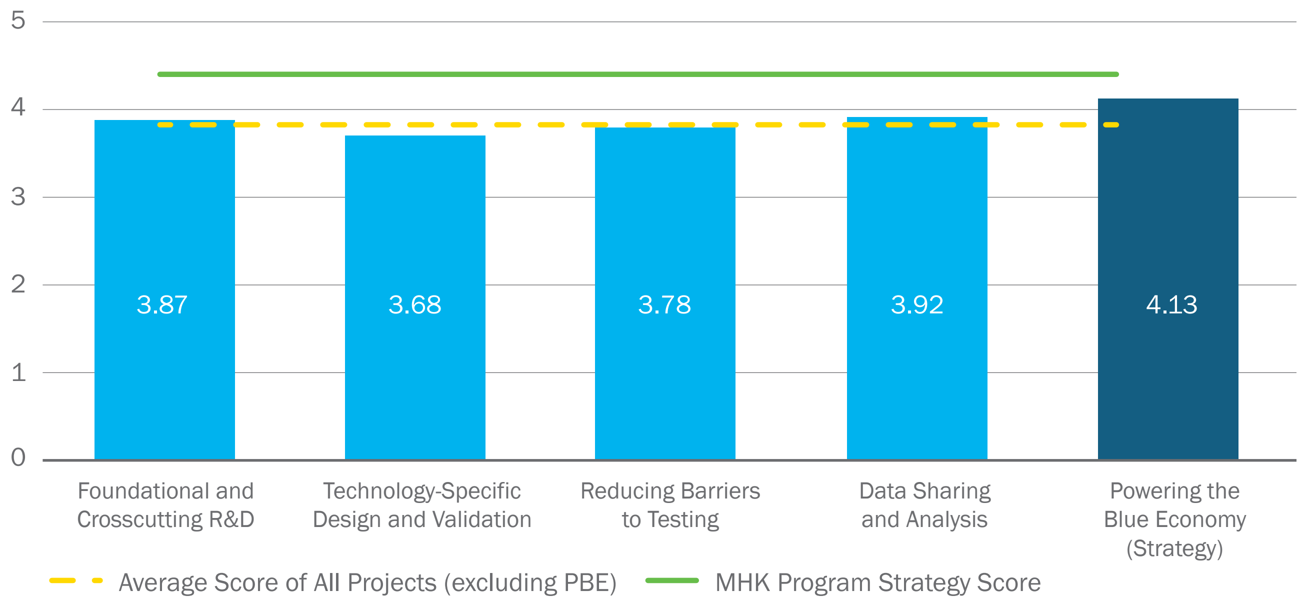


Figure 21. Average weighted score by MHK Program activity area



Note: Of the 41 projects reviewed in the MHK portfolio, the number of projects reviewed per activity area include: Foundational R&D—12 (29%); Design and Validation—8 (19%); Testing—15 (37%); Data—6 (15%).

Organization of Activity Area and Project Results

The results are organized by the activity areas into which individual projects were grouped for the 2019 Peer Review. Each subsection (i.e., activity area) includes the following components:

1. *Activity Area Score Results*: This chart depicts the average weighted score for each project in each activity area.
2. *Activity Area Summary Report*: This consists of a summary of the review panel's comments that provides insight into the activity area's strengths and weaknesses or potential issues and specific recommendations. Review Panel Leads were responsible for drafting activity area evaluation summaries in consultation with the full review panel and Program Review Chair. Consensus among the reviewers was not required, and reviewers were asked to include differences of opinion and dissenting views within the report.
3. *Project Evaluations*: These are individual project reports, which constitute 2–3-page reports summarizing the results of each project evaluated during the review process. Each report includes the following elements:
    a. *Project Name and Work Breakdown Structure (WBS) Number or Award Agreement*: The full project name is listed as the heading, with the identifying code underneath in parentheses. Project evaluations for each activity area are ordered by WBS number, followed by award agreement number, from lowest to highest.
    b. *Weighted Project Score*: Each project's average weighted score is stated numerically. A bar chart depicts the average scores for each evaluation criterion, as well as the range of scores given to the project by the individuals within the Review Panel. The chart also indicates the average value for each evaluation criterion across all projects within the activity area.

c. *Summary Table*: Each report provides reference information about the project, including the recipient organization, PI name, project dates, project type, and funding values.

   i. *Recipient*: The recipient indicates the organization tasked with leading the project (this may include multiple organizations in situations where the project has more than one recipient).

   ii. *Principle Investigator*: The PI is the individual affiliated with the recipient organization who is assigned to lead the project.

   iii. *Project Category*: Each project is categorized as sun-setting, ongoing, or new, based on its start/end date.

   iv. *Project Type*: There are many types of projects within the WPTO portfolio, but this review focused primarily on two types of projects: (1) AOPs, which are core R&D projects performed by DOE's national laboratories, and (2) projects awarded through a funding opportunity announcement, which are indicated in this table by listing the FOA's name or number.

   v. *Funding*: Each project includes total costed and total authorized. Total costed is the budget executed during the full peer review period (from FY17 through Q2 of FY19). Total authorized for AOPs is the sum of prior year (FY16) carryover and budget authorized during the full peer review period (from FY17 through Q2 of FY19). Total authorized for FOAs is the total DOE negotiated award amount, including amounts allocated to sub-recipients.

   vi. *Project Descriptions*: Project descriptions are compiled from the project summaries that the PIs submitted for each project.

   vii. *Summary of All Reviewers' Comments*: Reviewers were responsible for consolidating and summarizing all reviewer comments on their assigned projects, in consultation with the Review Panel Leads and Program Chairs. These project evaluation summaries were edited only for grammar and clarity. In a limited number of cases, reviewer remarks deemed inappropriate or irrelevant were excluded from the final report.

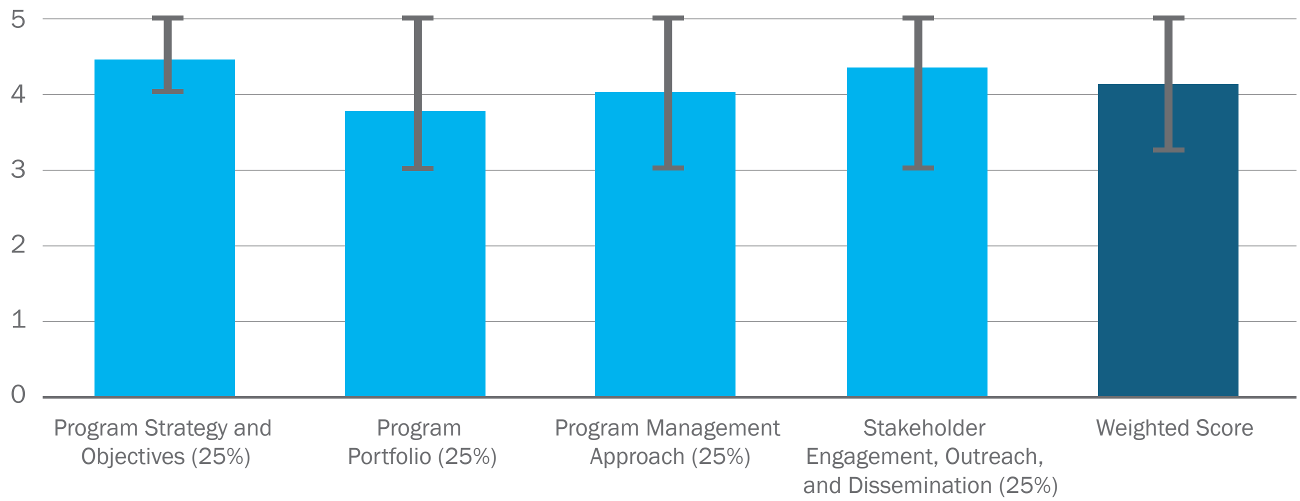
Powering the Blue Economy

This section provides full evaluation results for PBE and its strategy, as well as the lead reviewer's summary of reviewer comments in response to the program evaluation criteria.

PBE Score Results

Figure 22 summarizes the weighted score of the PBE strategy and average reviewer score according to each program evaluation criteria. The program evaluation criteria and the unscored, supplemental information are outlined in Appendix B. A summary of the reviewers' responses to the unscored, supplemental questions were incorporated into the below PBE Summary Report.

Figure 22. Average reviewer score of the PBE strategy by program evaluation criteria



PBE Summary Report

Prepared by the PBE Lead Reviewer

Feedback from the Review Panel to WPTO

The reviewers agreed that the long-term goals and objectives of PBE were clearly communicated. WPTO presentations, panel discussions, and reports conveyed the direction of the WPTO to address the near-term opportunities for MHK. The consensus is that PBE is a good track for WPTO to pursue.

The connection between PBE and a path to grid-scale power was not clear to the reviewers. Additionally, the role in existing testing centers and grid-scale investments for PBE was also questioned. This primarily included whether PacWave was still going to be essential for PBE support and success. Reviewers agreed that the increasing focus on PBE should not result in a lack of support for past efforts toward grid-scale development, which includes modeling, test centers, and devices. However, reviewers did note that TEAMER was seen as a well-poised facilitator of PBE.

The reviewers provided feedback on market-specific opportunities, as well. The consensus of the reviewers was that WPTO place more emphasis on aquaculture. There were several counter views on whether autonomous underwater vehicle docking, specifically on improvements to docking, should be a goal of PBE or funded by DOE. Some thought this should be an early focus, while others recommended that investment in this technology fell outside of the WPTO mandate. Counter examples include "the areas of Ocean

Observation and Underwater Vehicle Charging go hand in hand and should be pursued concurrently," and "these costs, like advancing AUV [autonomous underwater vehicle] docking technology, cannot and should not be supported by WPTO," with the latter being in the minority. In its objectives, WPTO doesn't appear to prioritize novel storage solutions for power at sea. There should be more emphasis on finding novel clean storage solutions at sea, as storage is just as essential as energy production.

Most reviewers were concerned that there is still not enough of an understanding of the size and scale of market opportunities across the Blue Economy for marine energy developments and found that this should be investigated further as soon as possible.

Lab support and integration will be essential for success, and reviewers recommended that this collaboration build on past successful efforts at integrating the labs. Additionally, reviewers recommended synchronizing with efforts of other funding agencies, like the work with IOOS, and they cited multiple agencies, like NSF, NOAA, and USAID, and private big private industry partners like Teledyne.

Summary of all Reviewers' Comments

Overall Impressions

The PBE direction was viewed positively by the reviewers. Specific concerns that were addressed by all reviewers included available markets; metrics for markets; and the balance between previous investment in grid power and test facilities. There were differences of opinion about whether autonomous underwater vehicle development docking/recharging should be a focus, and a consensus on increasing the priority of activities that support aquaculture development.

Program Strategy and Objectives

There was strong consensus among reviewers that the program's PBE long-term strategy, strategic approaches, and future direction was effectively conveyed during the peer review. The program has demonstrated funding opportunities that align with near-term PBE opportunities. Examples of these funding activities were SBIR awards, the Waves to Water prize, and the Marine Energy Collegiate Competition. This new track for DOE fits well within other governmental program mandates that are already being conducted in close collaboration with DOE. This includes specifically NOAA IOOS, NSF, and the U.S. Coastal Research Program (which includes USACE and the U.S. Geological Survey) for resilient coasts. These agencies present many new opportunities for the program to fill data gaps by powering instruments with micro to small scale power needs.

The link from PBE to utility scale MHK generation is less clear and should be detailed more, considering a portfolio that supports past and current investments in grid-scale technology, while still facilitating this new PBE direction and fully utilizing the labs for making connections between the two tracks where they exist. The program invests taxpayer funds wisely to drive the greatest impact, but impact needs to be defined and evaluated for this initiative early.

Program Portfolio

There was nearly unanimous consensus among the reviewers that PBE being so young makes it more difficult to assess, from a portfolio perspective, as there are few PBE funded projects currently. The Waves to Water prize was viewed favorably as a first step, as was the upcoming Ocean Observing prize. But in general, the reviewers viewed PBE as a positive perspective portfolio direction, but with few examples to fully evaluate the program portfolio.

The minority dissention and critical comments from individual reviewers of the PBE approach noted that the allocation of resources could not be evaluated, as the associated budget for PBE development or plans for PBE activities were not shared. It was also unclear the relationship between presumably niche lower-power MHK devices and grid-scale devices. However, it was noted that there are certainly lessons to be learned from smaller-scale devices that apply to grid-scale development. Some investigation of the relationship between these two programmatic themes is warranted early. And, it appeared from the peer review during open discussions that developers are still not fully aware of WPTO support mechanisms and view collaboration with labs (IP) as a barrier.

Program Management Approach

There was strong consensus, with only minority dissent, in support for the program team among reviewers. This is a unique team of capable people to manage and execute this new PBE initiative, which has been constructed over the last 5 years. Reviewers were impressed with the program leadership, initiative, and team camaraderie. A specific example that reviewers commended was the collaboration and cross-pollination of funding opportunities between DOE and NOAA IOOS. Attendance by several WPTO leadership staff at the decadal Ocean Observing meeting in Hawaii tangibly demonstrated a motivated attempt to understand the needs and opportunities in the observing community early. One exception to consensus was given in a minority opinion, "[t]he vision of the powering the blue economy was clear, but the management approach to implement the vision was vague." While one reviewer noted that the portfolio was, "somewhat unfocused," another noted that, "overall the team is very focused, motivated and with budget behind them empowered to make a success of PBE."

Several reviewers noted the team is focused on priority research areas that could create the greatest impact on new technology and industry advancement, and the team is effectively communicating what these areas are and how the program is allocating resources. Reviewers noted that the program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects, but that while operations and oversight procedures are in place to ensure efficient direction of office activities—both internally and with project awardees—it could be strengthened.

Stakeholder Engagement, Outreach, and Dissemination

Reviewers shared opinions that at this early stage, program efforts at stakeholder engagement, outreach, and dissemination for PBE were positive. But at this early stage of PBE, it is difficult to evaluate the stewardship of tax dollars; however, reviewers have confidence in the WPTO team to do so effectively based on past performance. The program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision makers, which will be important for PBE. Like the feedback in other areas, reviewers suggested other agencies (e.g., USAID, NSF, and NOAA) that could be engaged to further understand the PBE markets. And reviewers did include additional recommended partners and engagement strategies.

Reviewers recommended that WPTO investigate ways to disseminate information more broadly. This included reaching beyond its current website; conducting workshops with additional stakeholders; utilizing other platforms like Udemy, Coursera, and TEDx for disseminating to a global community; and working with leaders on PBE—for example, with Silvia Earl on how her ocean exploration campaign should align with the PBE objectives for ocean observation or with Professor Lienhard for desalination. One reviewer suggested leveraging events, such as the Institute of Electrical and Electronics Engineers' Oceanic Engineering Society

Marine Technology Society Offshore Technology Conference, to amplify PBE and connect with new stakeholders.

Another reviewer suggested that WPTO send delegates to IOOS regional associations like SECOORA/MACOORA to learn about their needs and facilitate and collaborate on relevant funding opportunities. Most of the regional associations have annual meetings where WPTO staff would have an opportunity to engage with researchers to learn about specific needs within those regions.

It was also suggested that the program have early engagement with companies like Teledyne, specifically their Webb, RDI, and Benthos branches. Additional companies that reviewers suggested for potential collaboration included Seabird, Edgetech, and RBR. These companies produce many of the ocean observing instruments in use. Determining their power needs, and the potential for MHK to grow their capabilities may help to craft even more relevant funding opportunities. Additionally, another reviewer suggested reaching out to Siemens on their BlueVault Energy Storage and Subsea Power Grid.

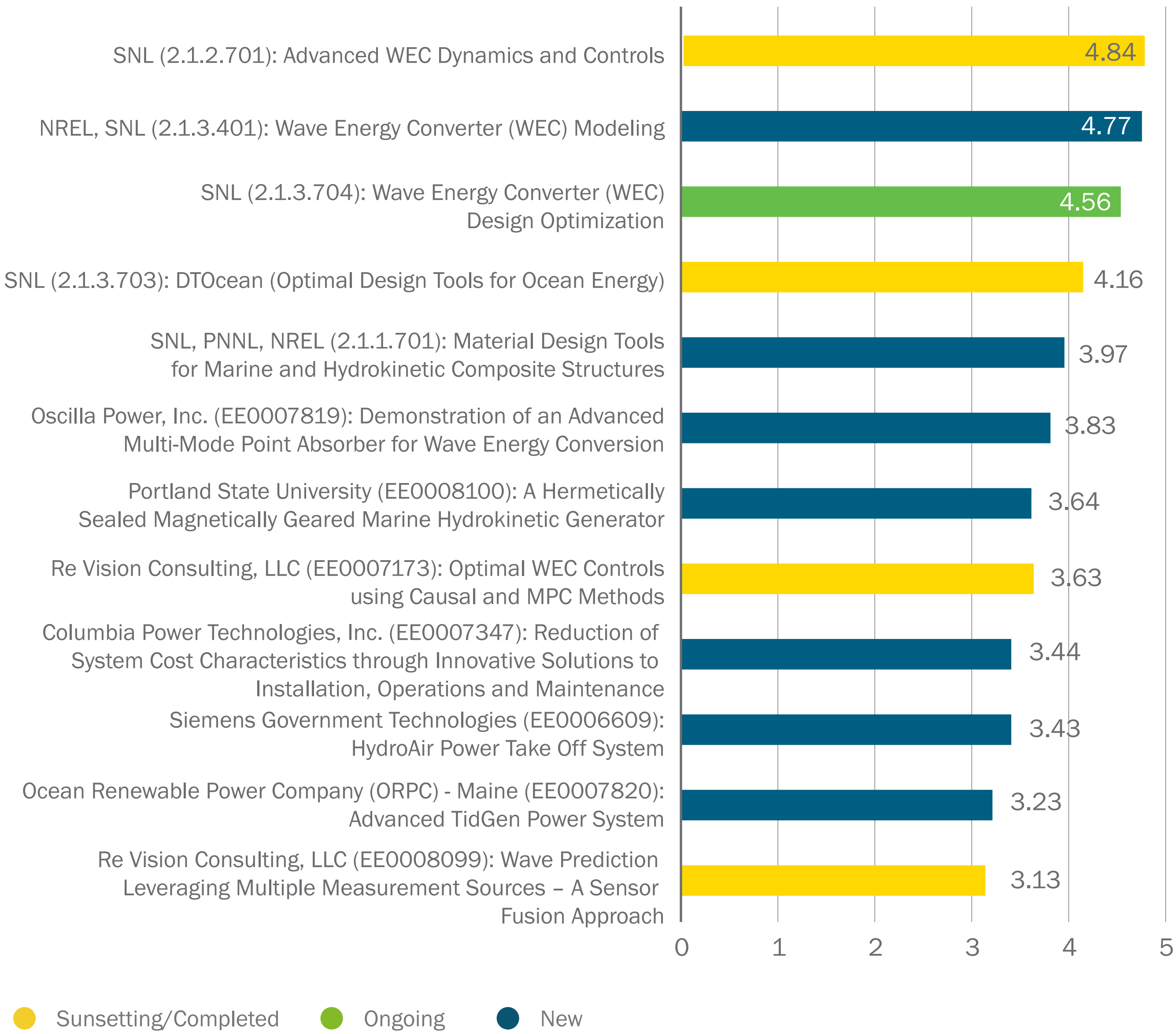
Foundational and Crosscutting R&D

This section provides an overview of the scoring for all projects within the Foundational and Crosscutting R&D activity area (see Figure 23); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Foundational and Crosscutting R&D	**3.87**

Figure 23. Foundational and crosscutting R&D activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

The Foundational and Crosscutting R&D activity area encompassed projects presented and focused on the development of controls, device subsystems (i.e., generators), PTOs, components, materials, the preparation for WEC/TEC tank/in-sea performance testing, O&M methodologies, modeling, and design tools all targeting the reduction of LCOE. The foundational knowledge and data disseminated from the portfolio of projects are vital to future technology breakthroughs, improvements in device performance, and LCOE reduction. Several excellent examples of projects led by the labs were presented and scored highly. The panel agreed that the new market requirements, as addressed in PBE, should be well defined and integrated under the Foundational and Crosscutting R&D program activity area. The panel agreed that the portfolio's impact and technical progress to the sector, including end user engagement and dissemination, are areas WPTO should improve upon, with recommendations described below.

Program Impact and Technical Progress

One reviewer recommended that, where there is a discrepancy in panel comments and scores, WPTO evaluate the comments on the specific project impact and progress. Reviewers agreed overall that the developer (GEN1) projects had conflicting evidence demonstrating impact to the sector; for example, a common comment on individual projects was that "it is not fully clear the impact that this particular device adds to improving significant cost reduction and performance improvement that is required in the ocean energy sector overall."

With the introduction of the PBE initiative and incorporation into the MHK program, it appears that GEN1 developers have opportunities to deliver lower-cost, smaller-scale devices that can power markets within the Blue Economy, such as ocean observation or remote communities. Most of the GEN1 developers did mention how they could impact these markets. The concern is how they pivot into a new technology development program that does not integrate the lessons learned during full-scale development. The reviewers recommended that, if possible, WPTO incorporate PBE objectives into GEN1 developer projects and in a manner that ensures the lessons learned are not lost, even if it is to deliver a proposal for lower-cost design options at kW scale utilizing remaining budgets. It is crucial for the GEN1 developers to demonstrate their capability to deliver into Blue Economy markets.

The panel consistently agreed that WPTO should implement more detailed design reviews and overall have labs lead technology assessments with GEN1 developers that determine whether each design has a credible path to a competitive LCOE or not. The outputs of key lab projects should be integrated much earlier into GEN1/GEN2 design projects. For example, the outputs of the materials project should inform potential component design and the WEC optimization tool presented by SNL. A reviewer commented, 'Sandia's involvement and not doing it in an intellectual vacuum by bringing in developers is the right kind of symbiosis the MHK industry desperately needs to be successful.'

Another recommendation is to ensure lessons learned are in a standard format within WPTO project peer review presentations. Identifying common events/effects/causes is vital to the sector not repeating mistakes.

WPTO should ensure that work is accessible to the whole sector to avoid duplication of efforts. For example, the optimal WEC controls/MPC methodology is vital to work, but the comment by the project performer that ‘recovery on the cost-share before they are willing to make the model predictive controls (MPC) work open source’ fundamentally limits impact and progress at the program level.

Another recommendation is that projects winding down, such as the WEC-Sim and DTOcean projects, should have a long-term sustainability plan with ownership and support continued at the lab level. WPTO should ensure that the WEC design optimization tool is embedded/utilized with all GEN2 funded WEC developers.

Program Dissemination/End User Engagement

Regarding dissemination strategies and end user engagement presented throughout the projects, a reviewer recommended that dissemination targets are set by WPTO and communicated. For example, the number of expected peer-reviewed journal papers on foundational R&D projects. Reviewers also recommended that WPTO support end user engagement workshops so that business to business opportunities are realized.

Reviewers recommended that further engagement with international community for development, engagement, and implementation of the SNL WEC design optimization tool is critical for further uptake in the MHK sector.

Dissemination of the lab tools into university courses or on other online learning platforms will increase tool utilization and learnings. One reviewer expressed interest in seeing facilities added to easily direct the tool to evaluate performance based on real sea spectra. This utility will be significant for the PBE effort because two-parameter spectra commonly lose details that are relevant at a smaller scale.

Lab modeling and controls work should be disseminated and opportunistically integrated with other GEN1/GEN2 developers/PBE developers. The panel recommend that WPTO assess the controls projects to determine the state of the art or use the SNL advanced WEC dynamic and control tool as the standard for which other WEC tools are benchmarked.

Summary of All Reviewers’ Comments

Overall Impressions

The projects presented under the Foundational and Crosscutting R&D activity area demonstrated key outputs toward innovation in controls, components, and systems, with impressive results from the lab projects overall. For example, all reviewers agreed that the work on controls and modeling done by SNL and NREL was driving innovations ahead of developers’ abilities, and thus it was critical to realign the work done to accelerate Oscilla, Columbia Power Technologies, Ocean Renewable Power Company (ORPC), and Siemens/OE (which the reviewers referred to as the GEN1 developers).

The reviewers agreed in varying degrees on the developer/industry projects in how well the projects conveyed their progress, how those projects impacted the challenges facing the industry, and, most importantly, how those projects supported the program to validate performance and grid reliability for new technologies. For example, regarding PTO developments with potential innovation for other WEC technologies, a reviewer stated, “It is not fully clear the impact that (a) particular device adds to improving significant cost reductions and performance improvements that is required in the sector overall.” Another example was on a developer’s design approach with late-stage changes to designs that limit the potential of the technology. “It is not clear what the overall benefit is of the particular technology compared to more conventional (devices).” Reviewers did have concerns on specific devices’ PTO applicability with other WECs or the scalability for different applications.

All reviewers agreed that all developers presented under this activity area did require an investigation or assessment by WPTO to determine if each of the device designs has a credible path to a competitive LCOE. A defined LCOE is fundamental to achieving the program strategy that identifies and advances technologies with the highest potential.

The significant disagreement from reviewers was on consultancy projects' progress and impact on innovation. For example, the consultancy project on optimal controls methodology using predictive control and feedback versus the lab project on prediction-less control methodologies. Both deliver on the objectives for foundational R&D. However, the impact is unclear for the sector. Which one will drive WEC performance to competitive LCOE?

Program Strategy and Objectives

All reviewers agreed that the Foundational and Crosscutting R&D are demonstrates a strategic approach for MHK sector development focused on overcoming difficult engineering. The program efficiently demonstrated a portfolio of projects that align with driving innovation in components, controls, manufacturing, materials, and systems; developing tools and methodologies; and aggregating analyses of the MHK device performance and technology advances. Less evident at the program portfolio level was the number of collaborative development and application of quantitative metrics projects.

At the program level, reviewers agreed that the projects addressing modeling and design optimization tools worked toward the goal of early-stage research that accelerates the development of innovative technologies. Examples of this include the Advanced WEC dynamics and controls and WEC design optimization tool.

The program has significant international reach with uptake in the researcher community on the tools developed, such as WEC-SIM and DTOcean tools.

The panel agreed that the program does fund the efforts to validate the performance and grid reliability for new technologies. However, a more integrated lab approach with GEN1 developers is necessary to support the efforts to validate performance and, most importantly, assess the successful technology trajectory toward a competitive LCOE. The reviewers expressed concerns that the taxpayer investment made compared to GEN1 developer results will continue to depress investor confidence.

Program Portfolio

The reviewers all agreed that the lab modeling and design tools developed aligned well with the program strategy and objectives needed to improve understanding between WEC structure and fluid dynamics.

Most challenging to the program strategy and objectives was the delivery of the device-specific projects and their progress. Most reviewers agreed that the GEN1 developer results emphasize the challenges facing the sector and do not demonstrate effectively how to overcome those challenges. For example, the integration challenges with a PTO and WEC structure individually designed as subsystems. Each of the GEN1 developer projects included objectives to drive down LCOE. However, reviewers are skeptical of the ultimate results toward those targets.

One project was presented that fit the objective to improve resource assessment and characterization. Reviewers had varying comments on the significance of this project and how the wave prediction tool utilizing marine radar will ultimately impact resource characterization necessary at small and array scale. Overall, there were positive comments about the consultancy projects regarding their novel approaches. For example, "no one has been able to implement MPC on a WEC device at sea…important milestone and impact for the MHK community...this is essential work at does have the opportunity to benefit all scales of wave energy converters."

All reviewers agreed that the organization of the project and program approaches were effectively conveyed. Most reviewers questioned how the foundational and crosscutting R&D program will be impacted by PBE strategy as presented. Will the innovation in components, for example, as developed by GEN1 developers, be scalable for a smaller size, lower power requirement device? It is a challenge to the program portfolio to balance the research priorities effectively without loss to the lessons learned and innovations developed through the projects.

Program Management Approach
All reviewers agreed that the WPTO program team is highly competent and energetic in the delivery of the program. The team is focused on creating the most significant impact to advance the sector, and it is evident when the project manager effectively engages and influences the developer projects that bring them closer to successful outcomes. Examples include the insertion of lab support into developer projects, such as the NREL instrumentation of the OE buoy to obtain and validate vital performance data. The program team has demonstrated strong professional and technical capabilities, including active portfolio management.

Stakeholder Engagement, Outreach, and Dissemination
The reviewers agreed that the program does provide access for project performers to disseminate data and report results. However, the reviewers have concerns about how effectively the project performers are utilizing the repositories. There is a concern that the data repositories have high-level information only. There are some useful sites where the number of hits and downloads on the open-source tools are effectively utilized, but qualifying how the access is helping to accelerate the industry and inform decision makers is less evident.

The WPTO peer review process is an excellent example of maximizing R&D impact, while demonstrating sound stewardship of taxpayer funds. The active promotion of the Foundational and Crosscutting R&D portfolio, while encouraging transparent feedback from stakeholders attending the peer review week is vital to the success of the MHK program.

It is essential for WPTO to reach a wider international audience and present on program developments. The peer review week should not encourage the same attendees with the same 'faces' repeatedly, which could lead to 'group think.'

The keynote presentations from Conservation X Labs and Greentown Labs were excellent examples of outreach to stakeholders. These stakeholders have excellent platforms for disseminating results of the WPTO program, including access for the MHK sector to capitalize on Greentown Lab programs. Involving other similar stakeholders is a 'new' networking service WPTO can offer to the MHK product development sector.

Project Evaluations

MATERIAL DESIGN TOOLS FOR MARINE AND HYDROKINETIC COMPOSITE STRUCTURES

(WBS #: 2.1.1.701)

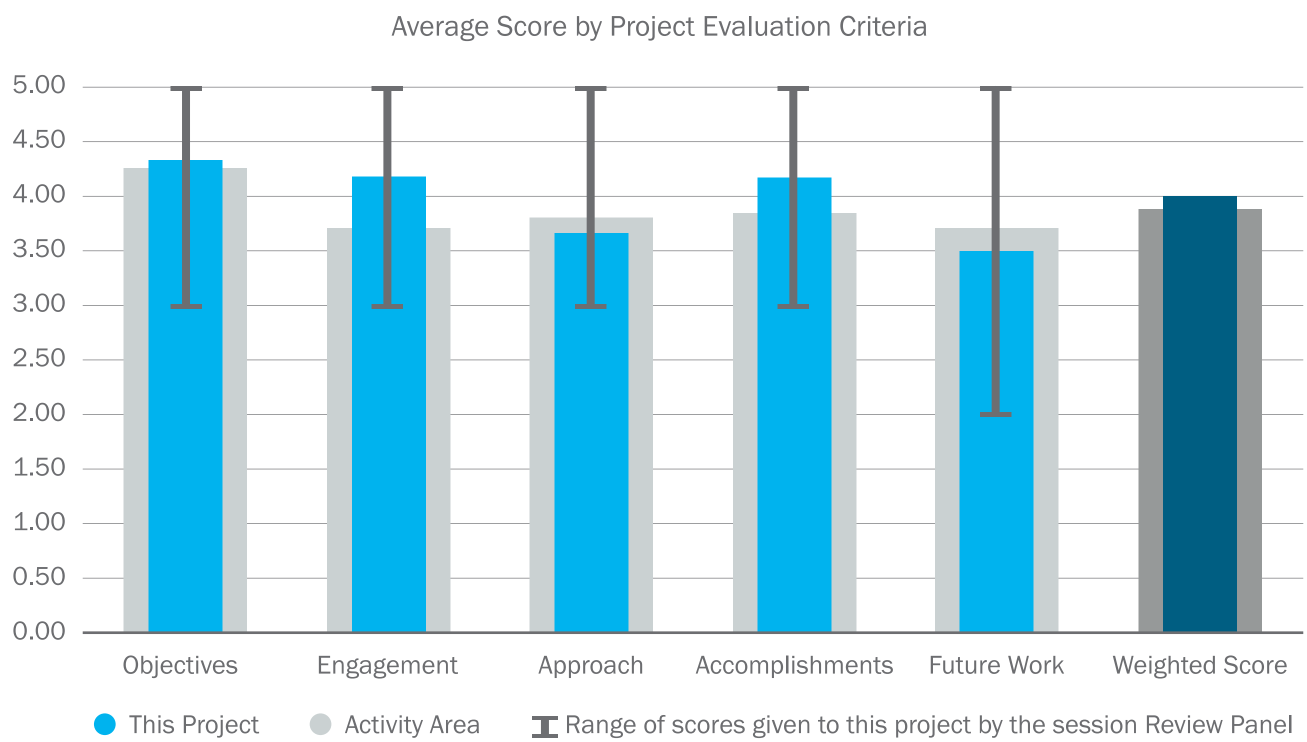
Recipient:	SNL, PNNL, and NREL
Principal Investigator:	Bernadette Hernandez-Sanchez
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,866K
Total Costed:	$1,194K

Project Description

MHK technologies manufactured with composites are promising to increase efficiency and improve levelized cost of energy (LCOE) metrics; however, composites in marine energy applications are largely untested. During a composites workshop that the project team conducted in 2015, the community voiced a need to better understand composite materials and structure performance properties related to MHK conditions. Therefore, the project goal is to reduce risk/uncertainty in using composite designs by demonstrating their potential advantages. Through this project, the team plans to: (1) assess industry supplied coupons for biofouling, loads, and corrosion; (2) identify relevant substructures for fabrication/testing; and (3) provide descriptive resources of materials properties (database/best practices handbook) and solutions addressing industry's priority needs.

Weighted Project Score: 4.0

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

Reviewers generally ranked this project in the average-to-good range, and they thought it served a useful purpose within the program. It was specifically noted that building a database for MHK materials is a significant contribution to the MHK community.

Reviewers made several suggestions on ways to improve the project. One reviewer suggested that the project team should have collaborated with specific partners that had several years of experience with materials in the marine environment. The reviewer stated "I would have liked to see more involvement from Penn State Applied Research Laboratory as I have worked with them in the past on these issues, and they have a significant repository of composite designs that may or may not be shared from the U.S. Department of Defense (DOD) customer. Additionally, Navy Carderock should have been involved to leverage their materials group and long history in characterizing these materials to fully realize the impact of government R&D dollars."

In the project summary/bio, the technical approach mentions that in comparison to international efforts —e.g., the European Marine Energy Centre (EMEC), the French Research Institute for Exploitation of the Sea (IFRMER), and Wave Energy Scotland (WES)—this program is focused on performance testing of glass and carbon fiber reinforced composites (coupons to subcomponents), coatings, and carbon-metal interconnects. It would be important to either align with or discuss differences between the international efforts at EMEC, IFRMER and WES. Reviewers recommended that this is further detailed in follow-on work in 2020 and shared via webinar with EMEC, IFREMER, and WES.

This project comes about as close as any to a material science effort in the WPTO portfolio. While it is useful work, it is not the type of effort that is liable to provide a breakthrough advance that will have a transformational change on the technology. Nevertheless, for its goals, the effort is well run and provides a central place for work involving the long-term and fatigue testing of components and materials. This is useful and could lead to incremental improvements in the devices being developed. Fatigue, corrosion, and biofouling are common problems with ocean-deployed equipment, and it's not entirely clear to one reviewer that WPTO needs this project in the program.

What are the range of environmental parameters investigated? In Particular, some details about various salinities and temperatures for testing scenarios would be valuable and quite relevant.

Project Objectives, Impacts, and Alignment with the Program Strategy

Reviewers felt that this project had a significant impact on MHK development and generally agreed that it aligned with program strategies. The performers have engaged with several industry and lab partners to evaluate community needs. Insofar as the number of relatively advanced industry partners listed, the performers have established communications that help the project provide meaningful and immediate impacts to developers.

Building a database for MHK materials is a significant contribution to the MHK community. Many small developers do not understand the impact of seawater on fatigue lives of steel components, which may be reduced by half from in-air material characterizations. Solid load case generation and a material database are the foundation of successful MHK designs for factors of safety to arrive at cost-competitive LCOE.

This project looks to replace incumbent steel with composite and hybrid structures. Most MHK devices have remained as steel structures due to more mature fabrication methods, the relative low materials and manufacturing costs, wide availability of resources, and greater characterization of steel alloys' performance in marine environments.

There was, however, one less favorable view of the impact of this project: "The project performers have worked to identify areas to study but, in the end, [this project] doesn't appear to be filling a critical hole in the WPTO project portfolio. A lot of what's being studied applies to a lot of ocean deployed equipment and the specific testing and study details device developers face may or may not be covered by this study."

End User Engagement and Dissemination Strategy

Reviewers rated the end user engagement strategy from average to good, noting that the project performers have clearly described the rationale for the stakeholder/end user engagement strategy, as well as dissemination plans for project results and information. However, it appears that the results disseminated are to a smaller audience within the MHK sector.

Final results will be published in public databases (OpenEI, SNL, and Tethys), and incremental results have been shared through telecons, webinars (EPRI, Marine Energy Council), presentations (Institute for Advance Composites Manufacturing Innovation and Marine Energy Technology Symposium), and workshops (Water Power Week) to inform beneficiaries of progress.

They have also reached beyond their immediate partners to request input through DOE facilitated webinars, workshops at conferences, and a planned publication. Several specific dissemination examples were provided, but the reviewers would have appreciated a list.

The only potential challenge with the dissemination effort could be due to user error. Following the link that provides the Materials and Structures Database for download, one reviewer filled out the user form (noting that it didn't provide an academic user community option) and attempted to download the database. Nothing happened, and the reviewer was redirected to fill out the form again.

Management and Technical Approach

A recurring theme among the reviewers was to see longer term testing provided. There were a myriad of suggestions given by reviewers for improvement in this area

Reviewers were concerned that there was no discussion of potential risks to projects. One reviewer made the insightful comment that longer-term tests on materials would make a very valuable contribution to developers who could not afford the time and investment to do this on their own.

It would be important to either align with or discuss differences between the international efforts at EMEC, IFRMER and WES. Reviewers recommended that the project team provide more details in follow-on work in 2020 and share dissemination with webinar with EMEC/IFREMER, WES would be appropriate.

One reviewer suggested that a more rigorous characterization of the testing environments should have been presented, stating that testing for biofouling and corrosion presents challenges that were not immediately addressed in the technical approach. For example, what were the salinity ranges for the corrosion tests? Various water bodies in ocean environments vary widely in salinity from ~33 practical salinity units to above 36 practical salinity units. Also, temperature and different biological communities that are present/absent in different water masses can have profound effects on the amount of biofouling. Clearly, all water bodies can't be tested, but were these affects considered in some of the tests? It would be helpful to define the water mass/community/temperature/salinity of some of these tests.

The reviewers also felt that international MHK developers should have been solicited for input. The project performers have identified a project management plan that includes well-defined milestones and adequate methods for addressing potential risks, though again, the risks were not well described.

Technical Accomplishments and Progress

Reviewers ranked the technical accomplishments and progress of this project from average to good. They noted that based on the project management plan, the project performers have made progress in reaching their objectives. The project performers described their most important accomplishments in achieving milestones, reaching technical targets, and overcoming technical barriers. Additionally, the project performers have clearly described the progress since the last review period, and they did a good job of describing outcomes and progress on the tests.

Reviewers suggested that this knowledge should be evaluated with GEN2 developers who are incorporating composites into their designs. The project results described that moisture diffusion within the laminate affects the longitudinal and transverse mechanical behavior. Project performers observed similar degradations in strength and an increase in failure strain across almost all the 33 industry supplied material systems tested.

Reviewers generally agreed that milestones appear to have been met, but the project team is not monitoring program health as to what the critical success factors are in what is required for MHK developers to be commercially viable. Reviewers noted that characterizing the test coupons is not enough and that this program would benefit from U.S. Navy support. The project performers have described their most important accomplishments in achieving milestones, reaching technical targets, and overcoming technical barriers.

Future Work

One common theme among about half the reviewers was that risks and mitigation strategies were not presented, and a vision for integration into future projects was not well established. Future work is only focused on the first half FY 2020. It would be good to see engagement/collaboration with a range of European Union-funded materials projects. About half of the reviewers ranked future work favorably, considering that the perception was that this project is wrapping up.

One reviewer questioned if a component reliability database can be reverse engineered, prioritizing components that could be made from composite materials without limited/lower failure risk. Another reviewer suggested that the team establish a cost versus performance database.

ADVANCED WEC DYNAMICS AND CONTROLS

(WBS #: 2.1.2.701)

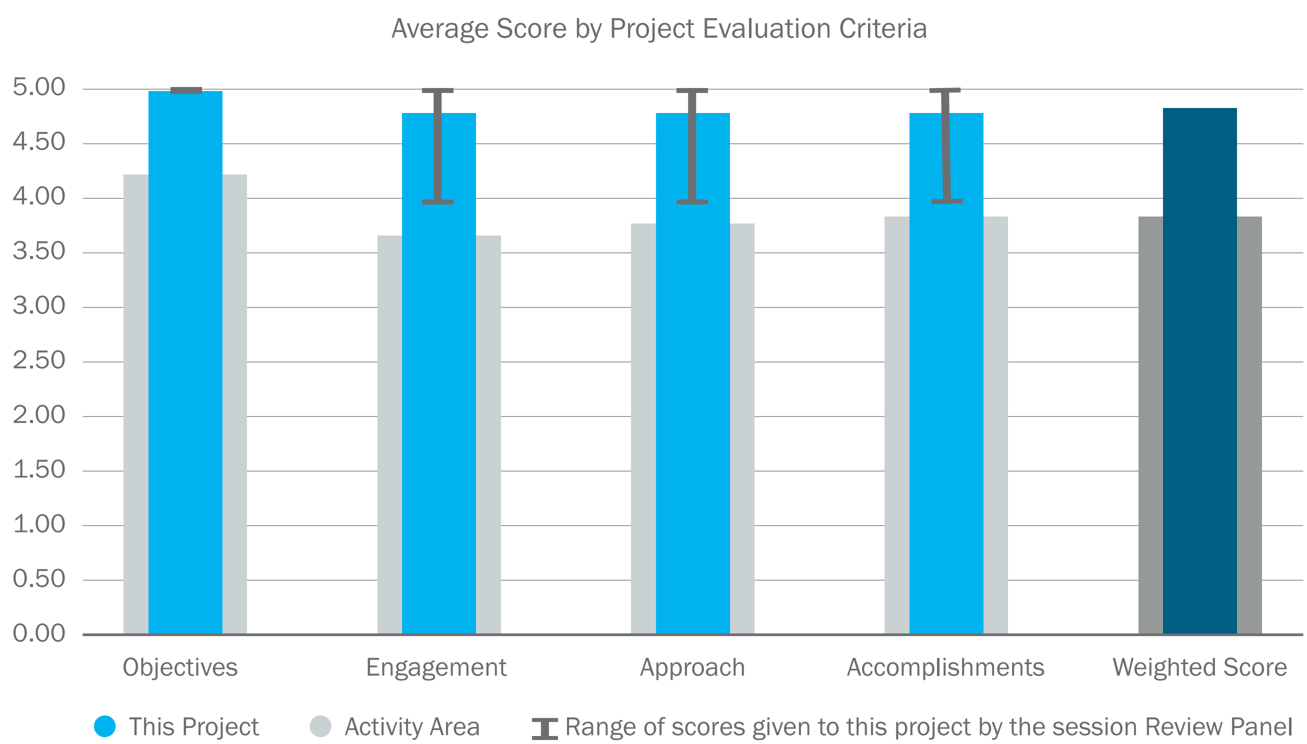
Recipient:	SNL
Principal Investigator:	Ryan Coe
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$3,528K
Total Costed:	$2,983K

Project Description

Numerous studies have shown that advanced control of a wave energy converter (WEC) PTO can provide significant increases (on the order of 200%–300%) in WEC energy absorption. These increases can lead to reductions in the LCOE, both by increasing energy generation and decreasing loading. SNL's Advanced WEC Dynamics and Controls project is focused on transitioning control design approaches from simplified paper studies to application in full-scale devices. By leveraging a wide range of dynamics and controls, robotics, modeling, and testing expertise, this project has delivered on its goal, producing broad dissemination products (webinars, workshops, journal and conference papers, and open-source data sets) and providing a direct benefit to individual WEC developers through industry collaboration projects.

Weighted Project Score: 4.8

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers were unanimous on this project's value to the program and its alignment with objectives. The performers presented clear, dense descriptions of the main objectives of the project along with their use. One reviewer thought that this project provided the best benefit per dollar of all spends in the MHK program. The presentation provided powerful content, lending a clear view to the importance of applying this tool as early as possible in the design cycle.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were unanimous with regards to the project's clear alignment with program strategy and objectives. The performers presented clear, dense descriptions of the main objectives of the project along with their use. Fundamental lessons learned also described 'prediction less controllers' and 'the most central example of this principle is this project's pursuit of feedback-based controllers. This approach is suboptimal only by perhaps 10% to an approach based on prediction, but unlike a prediction-based controller, is fully realizable today without expensive sensors or cutting-edge research on wave prediction.'

The outputs of this effort provide developers strong tools to support the co-design of PTO control and the physical WEC topology. This ability provides an extremely valuable asset for reducing costs and providing design guidance earlier in the design cycle.

End User Engagement and Dissemination Strategy

The reviewers unanimously agreed the project team had a solid end-user engagement and dissemination strategy, addressing all the objectives for this criterion. Performers believe that their work has no value if it isn't disseminated well, and their approach demonstrates the emphasis they put on dissemination. The summary shows clear evidence of strong end user engagement through industry collaborations. Practices and plans include clear pathways/events defined for dissemination and user feedback, including open-source, online databases and results, journal publications, workshops, webinars, and online support. One reviewer wrote, "Sandia's involvement and not doing it in an intellectual vacuum by bringing in developers is the right kind of symbiosis the MHK industry desperately needs to be successful."

Management and Technical Approach

The management approach of multi-lab partners' endeavors to leverage strengths across different organizations and the output of the project shows that they have succeeded. A Well-organized team that has leveraged the best of America from Navy Carderock maneuvering and seakeeping basin facilities, OSU, and Michigan Tech. Again, one reviewer wanted to see this tool pointed at a thorough failure mode and effects analysis. Reviewers recognized that the presenters focused on LCOE as a strength for the project outputs, helping the industry focus on practical technology advancement. The focus on device-agnostic evaluation was also recognized as a clear strength for this project, providing the MHK industry with some much needed ability to focus on practical comparisons.

Technical Accomplishments and Progress

The performers provided a brief description of accomplishments, along with evidence of outputs sprinkled through the earlier sections of the summary. Further details were clearly given in an impactful presentation, including the following:

- Improved experimental testing and system identification methods
- Fully realizable "prediction less" control capable of rivaling performance of prediction-based controllers
- WEC array and multi-modal device modeling and control
- Open-source datasets (most popular on MHK DR).

WAVE ENERGY CONVERTER (WEC) MODELING

(WBS #: 2.1.3.401)

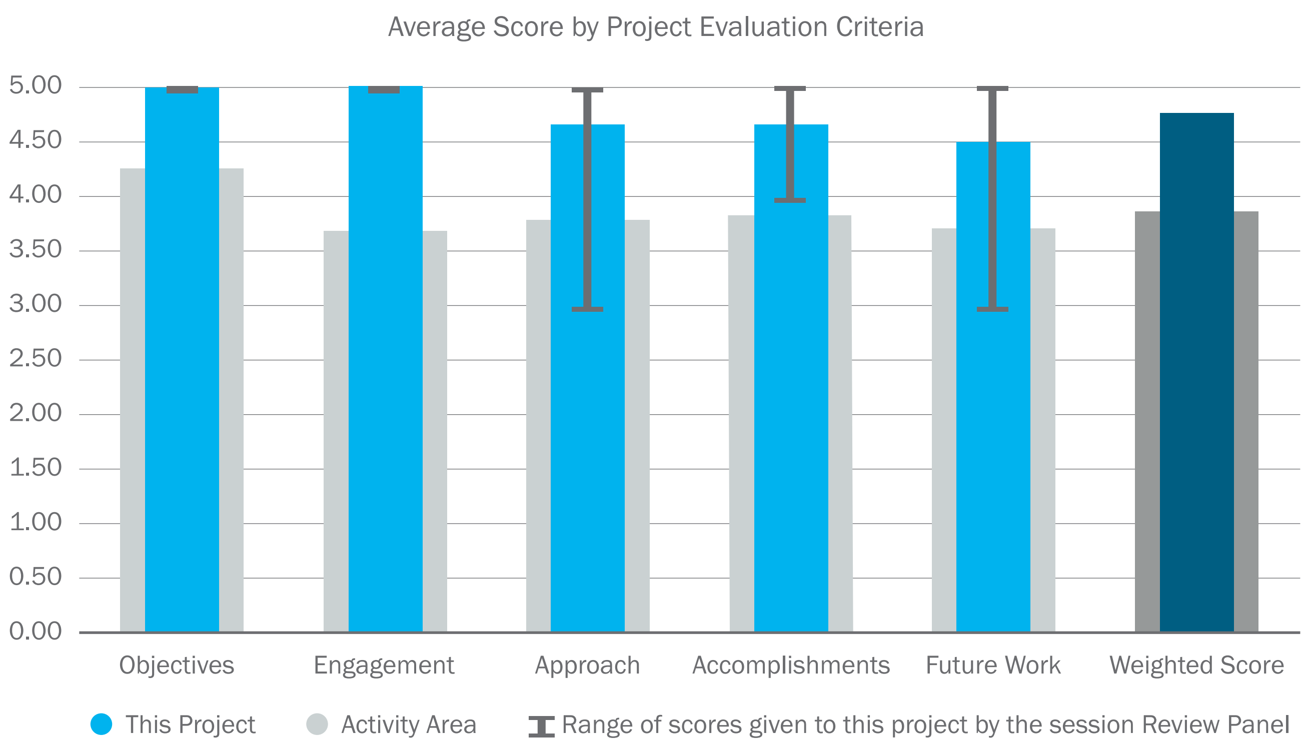
Recipient:	NREL and SNL
Principal Investigator:	Yi-Hsiang Yu
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$3,639K
Total Costed:	$3,295K

Project Description

This project supports the modeling capabilities to improve device performance and reduce costs for the wave energy industry. This includes the development, release, maintenance, and application of a suite of customizable open-source tools for WEC design and analysis and extreme condition modeling, i.e., Wave Energy Converter SIMulator (WEC-Sim) and WEC Design Response Toolbox. The effort also includes the application of these tools, putting the developed tools into practice, through numerical modeling support for the Wave Energy Prize and an industry support task to evaluate the design load and survivability of three industry-developed WECs. The project also supports international collaborations, including the IEA-OES Task 10 code verification and validation, IEC TC 114 standard development, and the WEC control competition.

Weighted Project Score: 4.8

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers were unanimous on this project's value to the program and its alignment with WPTO's stated objectives. One reviewer wrote that the efforts of NREL and SNL and the extended team are critical to the certification and commercialization of WEC devices. This team has made good choices in the software infrastructure and approach, and dissemination and uptake are clear from the GitHub activity. The team appeared to be aware of the challenges faced when modeling these systems, and they are continuing to add features to make their tool more general. The reliance on MATLAB does add a bit of cost to the user, but access to MATLAB is far from an onerous requirement, and the benefits to building on that mature and well-supported environment outweigh these costs. A reviewer mentioned failure modes and effects analysis (FMEA) and trade studies that they hope to see explored within the tool. While all reviewers gave high marks for dissemination, it was mentioned that the team might evaluate putting WEC-Sim on a wider educational platform, like Coursera or Udemy.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were unanimous with regards to the project's clear alignment with program strategy and objectives. Both the summary and presentation gave clear and concise details on the use and application of WEC-Sim, and they laid out the path for users to engage with and utilize the tool. One reviewer wrote that NREL and SNL have done a great job collaborating and lifting the WEC community with their efforts in developing these open-source tools, opening up the possibility for other nascent wave energy technology. Another reviewer noted that tools application to various scales gives it depth of utility for the Powering the Blue Economy (PBE) effort.

End User Engagement and Dissemination Strategy

Again, there was unanimous agreement on the efforts for all three points under this criterion. The project summary clearly addresses all three of the above points. They show clear examples of their success with engaging end users, supporting their training, and providing ongoing support and reacting evolving needs. The project team is working hard to engage their users and the open-source dissemination of their work appears effective, as evidenced by the healthy GitHub activity and the other download metrics presented. They provide clear details regarding the users of WEC-Sim and demonstrate clear goals to continue engaging and growing the user base. The project objectives and impacts section of the summary clearly describes the rationale for the stakeholder/end user engagement strategy and how project results and information have been/are planned to be disseminated.

Management and Technical Approach

The management approach of multi-lab partners' endeavors to leverage strengths across different organizations, along with project outputs, show that they have succeeded. Collaboration with industry partners ensures that relevant outputs reach both the end user and the industry as a whole. One reviewer felt that there could be more detail provided on the expected performance of the tool compared to other industry tools and model scale versus full scale.

The technical approach of developing on a widely used platform such as MATLAB is a clear benefit to many. The inherent lack of propriety and the open-source strategy of code dissemination gives this software a significant advantage over a commercially available solution. Providing validated wave tank models and databases is a gift to the industry and has demonstrated that it has provided benefits.

Technical Accomplishments and Progress

The technical accomplishments and progress are clearly demonstrated in the key milestone descriptions provided. This team has done a good job of balancing capability and complexity, resulting in a usable tool that seems expandable into more challenging areas, such as the inclusion of mooring cable dynamics. The reliance on MATLAB programming language is a slight barrier to acceptance but also comes with the benefits of that mature and well-supported computational environment. As the team mentioned, Python would be the second choice and would be less expensive to operate, but the use of MATLAB shouldn't be too big of a hurdle for most users.

Future Work

Efforts in the development of the tool are winding down, while the efforts to use the tool are ramping up. These efforts are defined under different projects in the review. The future work set out in this summary does show focus in planning for the future use, maintenance, and improvement of the tool. It would be concerning if this focus was not maintained. One reviewer expressed interest in seeing facilities added to easily direct the tool to evaluate performance based on real sea spectra. This utility will be significant for the PBE effort because 2-parameter spectra commonly lose details that are relevant at smaller scale.

DTOCEAN (OPTIMAL DESIGN TOOLS FOR OCEAN ENERGY)

(WBS #: 2.1.3.703)

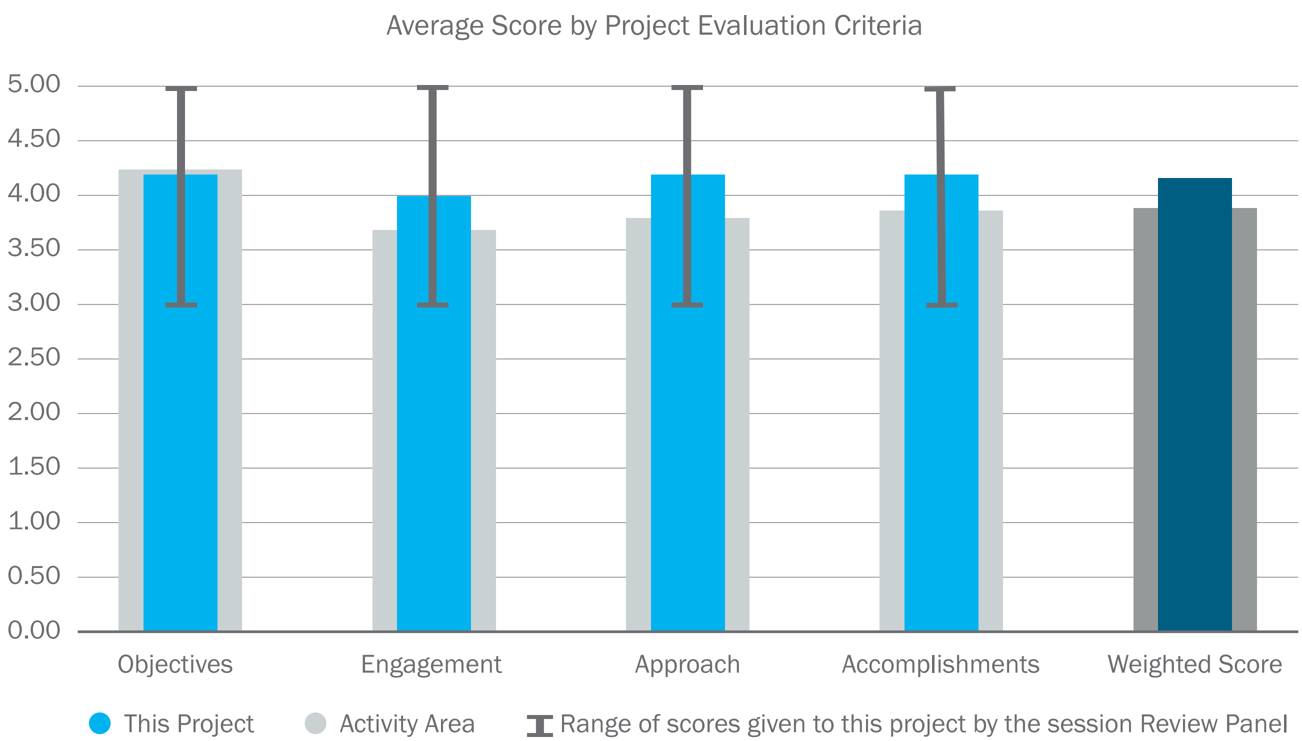
Recipient:	SNL
Principal Investigator:	Jesse Roberts
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$148K
Total Costed:	$122K

Project Description

The DTOcean project pioneered a new, open-source collaborative development model for wave and tidal array design tools that considers the entire ocean energy farm throughout its lifecycle. The software helps to find optimal array designs that minimize the LCOE and identify cost drivers, allowing the industry to progress toward economic viability. DTOcean was an international collaboration between 18 European institutions and SNL. DTOcean was funded under the Seventh Framework Programme (FP7), which bundles all research-related European Union (EU) initiatives together under a common umbrella.

Weighted Project Score: 4.2

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

This project was reviewed favorably by the reviewers. The general consensus was that this project is contributing to and leveraging an international effort, so it is valuable for the resources being committed. Two concerns were voiced: (1) that as a tool for array planning, it is out in front of the development of wave-energy devices; (2) that activity (downloads and contributions) on the GitHub site is relatively low, indicating a lack of engagement. With the project ending and without active maintenance, it seems that use of this tool is unlikely to expand.

Project Objectives, Impacts, and Alignment with the Program Strategy

In this category, the project received high scores from the reviewers, which were supported by comments indicating the reviewers felt this type of whole-plant modeling software has values and could benefit both developers and researchers who would like to study tradeoffs in plant design. For instance, one reviewer stated: "This project is widely applicable to MHK array design for wave and tidal array design in several different environments worldwide and is highly relevant for advancing commercial applications." One lower scoring reviewer commented that this was predicated on concern that this tool is too ambitious in modeling all aspects of a wave-energy system and would have a hard time being useful.

End User Engagement and Dissemination Strategy

Reviewers generally scored this high, commenting that the online presence of the tool was well established, with particular attention being paid to the YouTube tutorials. In general, the reviewers' comments answered the question of whether or not the performers had identified their dissemination strategy, but they stayed away from judging the effectiveness of that strategy, possibly indicating the effectiveness was not that clear. Typical comments were non-committal; for example, "The project performers have identified who will benefit from this project and how the success of the project will advance the industry or meet the needs of specific stakeholder/ end user groups."

Management and Technical Approach

Reviewers noted repeatedly that this is a large international collaboration, which is somewhat dictating the management approach. Most comments were positive, with some dissatisfaction expressed regarding the lack of risk identification and management.

Technical Accomplishments and Progress

More than half of the reviewers made a point to note that the project objectives were met and that the project has made a significant contribution to the code base. The clear list of technical accomplishments in both the written and presented materials was noted. Also evident in the comments was a concern about both the impact of this code, as well as the prospects for maintaining it as the project ends. For instance, "Not clear how DTOCEAN tool will be maintained once DTOCEAN+ suite of tools is delivered? Where will the maintenance and site be held?"

WAVE ENERGY CONVERTER (WEC) DESIGN OPTIMIZATION

(WBS #: 2.1.3.704)

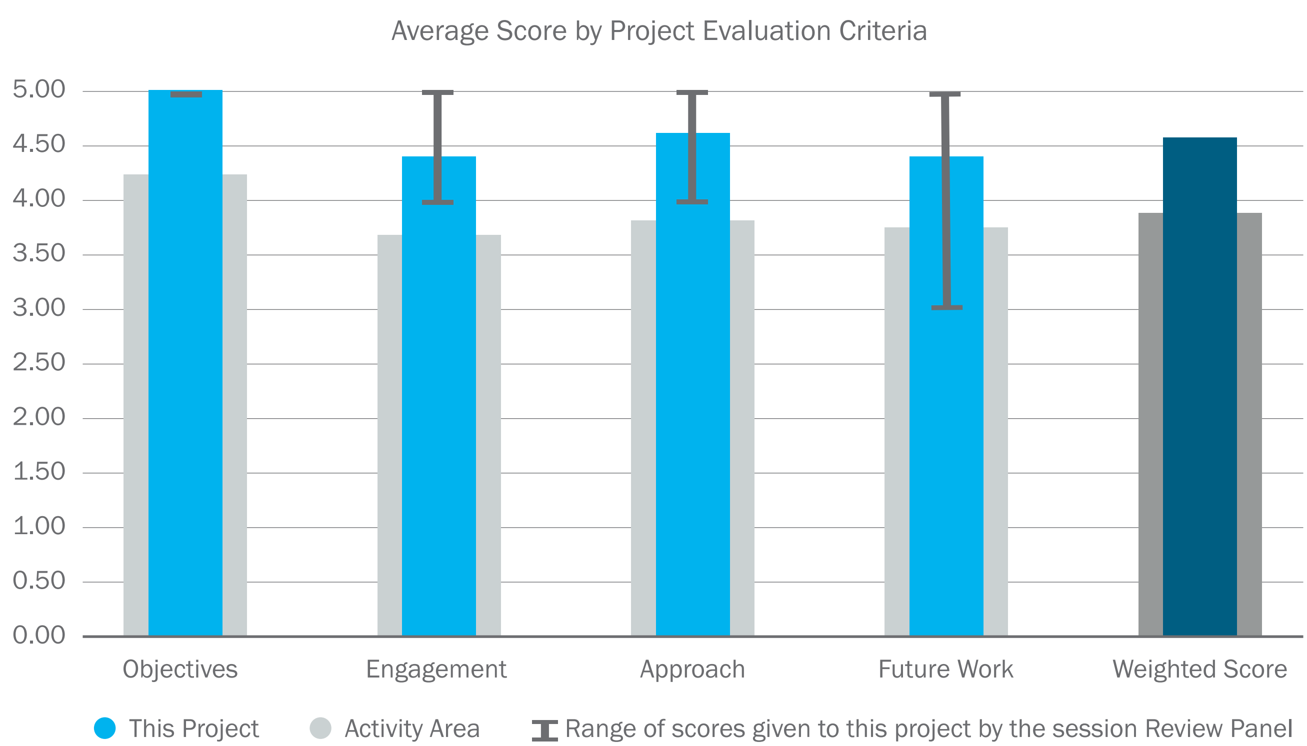
Recipient:	SNL
Principal Investigator:	Ryan Coe
Project Type:	AOP
Project Category:	New Projects
Total Authorized:	$280K
Total Costed:	$64K

Project Description

The DTOcean project pioneered a new, open-source collaborative development model for wave and tidal array design tools that considers the entire ocean energy farm throughout its lifecycle. The software helps to find optimal array designs that minimize the LCOE and identify cost drivers, allowing the industry to progress toward economic viability. DTOcean was an international collaboration between 18 European institutions and SNL. DTOcean was funded under the Seventh Framework Programme (FP7), which bundles all research-related European Union (EU) initiatives together under a common umbrella.

Weighted Project Score: 4.6

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers were unanimous on this project's value to the program and its alignment with objectives. The performers presented clear, dense descriptions of the main objectives of the project, along with their use. The presentation showed the importance of considering the complete system when optimizing design and, in particular, the effect that advanced active control has on the LCOE design space for a WEC. One powerful slide showed two surfaces, one showing power absorbed and the other representing LCOE or an analogous metric. The PI went on to state the profound insight that the future needed to embrace exploring the space between such surfaces.

One reviewer expressed concern that developers might be technically challenged to exploit the tool. This suggests that continued support from labs in using the tools should be maintained. Another suggested expanding the budget to include potential other partners who can help support development. The reviewers recommended that the project team engage with the international community for development/engagement/implementation of the optimization tool.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were unanimous with regards to the project's very strong alignment with strategy and objectives. The project performers demonstrated clear and deep consideration of the use and application of the project's output. They provided a high-level roadmap of how successful implementation of the outputs can impact LCOE. The presenters were able to update the presentation with a late breaking slide showing two surfaces, one showing power absorbed and the other representing LCOE or an analogous metric. The striking feature of the graphic was that the peak in power production did not align with the LCOE peak. A tool that allows for the relatively quick exploration of such spaces is very impactful.

End User Engagement and Dissemination Strategy

The point of the project is to disseminate as widely as possible. Reviewers rated this effort pretty highly, but there is some concern that developers may be challenged technically to take full advantage of the toolset. Performers believe that their work has no value if it isn't disseminated well, and their approach demonstrates the emphasis they put on dissemination. The summary shows clear evidence of strong end user engagement through industry collaborations. Practices and plans include clear pathways/events defined for dissemination and user feedback, including open source, online databases and results, journal publications, workshops, webinars, and online support. A few reviewers recommended the project team solidify engagement with more developers to establish the tool's base for industry use, and the project summary the SNL team provided did show that the next phase of the project has that effort as a major focus.

Management and Technical Approach

The collaborative management approach focusing the efforts of OSU and SNL is appropriate for this project. Reviewers recognized that the project team's focus on LCOE was a strength for the project outputs, helping the industry focus on practical technology advancement.

The project leverages the co-design framework to help support the industry as it wrestles with the extremely complex task in optimizing for the marine environment. One reviewer noted the impact of the following statement, 'Users will be able to iterate WEC geometry and controls systems computationally, using efficient pseudo-spectral modeling, to improve design concepts as they are still being ideated.' A clear timeline shows project milestones.

Technical Accomplishments and Progress

The progress discussed shows the team to be on time with expectations at this point.

Details of the present state of development are clear. The performers provided a brief description of accomplishment, along with evidence of outputs sprinkled through the earlier sections of the summary.

Future Work

The future work section is a little thin, but discussion in the earlier sections clearly describes the intention behind the highlights shown. Some added details on conference presentations, webinars, and the industry partner collaboration would have been helpful.

HYDROAIR POWER TAKE OFF SYSTEM

(WBS #: EE0006609)

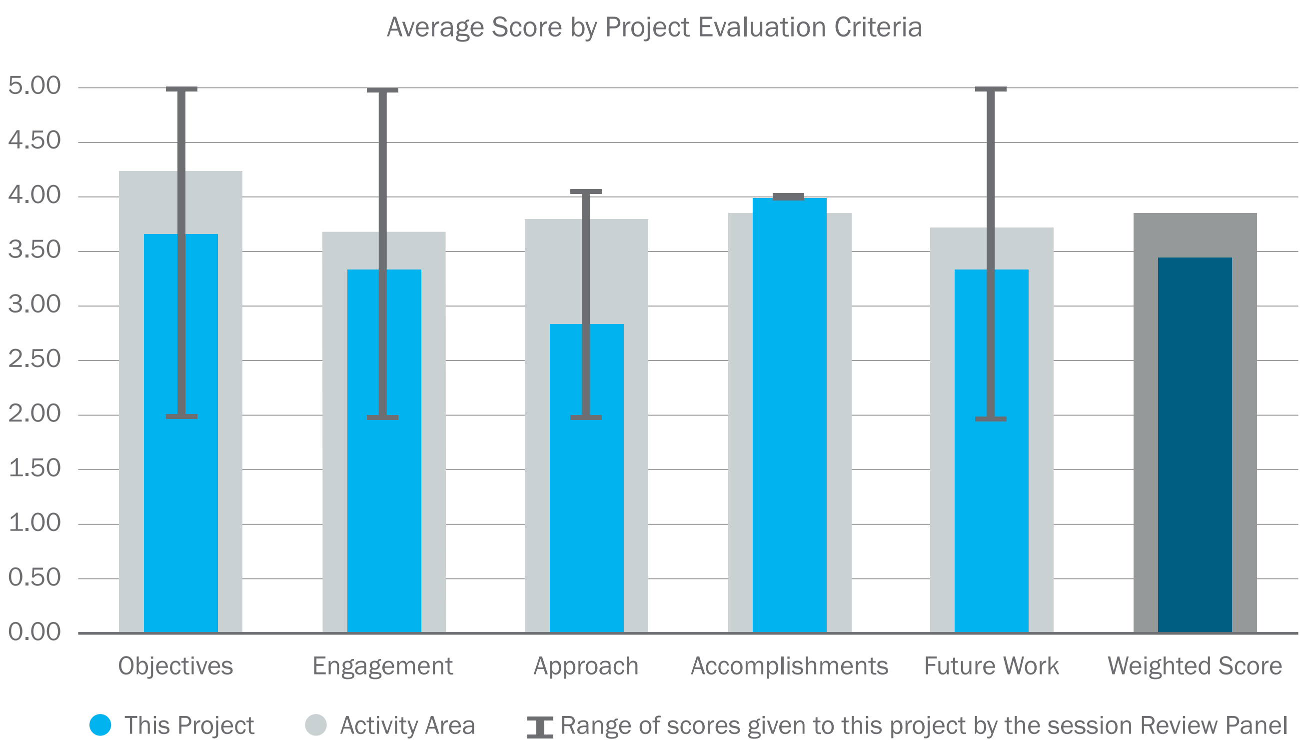
Recipient:	Siemens Government Technologies
Principal Investigator:	Rod Blunk
Project Type:	FOA 848: Marine and Hydrokinetic System Performance Advancement
Project Category:	Ongoing Projects
Total Authorized:	$6,807K
Total Costed:	$5,521K

Project Description

The project's objective is to design, construct, and test a full-scale, 500-kW HydroAir turbine and Power Take Off (PTO). Optimally, the project team planned to design the HydroAir turbine PTO to utilize the volumetric airflow and pressure transmitted from an Oscillating Water Column on the Ocean Energy (OE) buoy with planned deployment at the Navy's grid-connected WETS in late FY 2019. The project hopes to provide industry understanding on innovation in the turbine design to improve reliability, availability, and efficiency by using composite materials for maritime application. Additionally, the project team planned to leverage commercially available components such as off the shelf generators and variable frequency drives and other components where possible to enable transition from prototype to production capability for commercial applications.

Weighted Project Score: 3.4

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

This project produced an impressive piece of hardware that is just now entering operational use, so the results should be available soon and enable a fuller review. It is not entirely clear whether the design of this turbine and the design of the buoy, which will be installed together, were carefully coordinated. The presentation indicated that there are some design and control unknowns that will be adjusted or at least studied during the upcoming deployment. The summary and presentation did not address the workings of this device or why it is expected to be superior to devices fielded in the past.

Project Objectives, Impacts, and Alignment with the Program Strategy

This project aligns with programmatic goals. However, it is not clear how applicable this PTO is to various WECs or what the scalability of this PTO is for different applications. This is foundational R&D, but it is not crosscutting. The plan for design and validation is sound and aligns well with the program's strategic initiatives.

End User Engagement and Dissemination Strategy

The project performer did not do a sufficient job describing beneficiaries of this technology by providing specific examples. The ocean power industry they quoted is very general and does not show end user engagement. Additionally, it was not clear as to how a number of different technologies currently being developed will benefit from this PTO. Potential clients are identified, but no specific examples of collaborations with such clients were provided.

Management and Technical Approach

The performers sufficiently described their subcontractor relationships and have a technically sound approach to get this PTO tested at WETS. The project schedule was presented, and most milestones have been met. However, potential challenges during deployment and testing have not been clearly communicated.

Technical Accomplishments and Progress

All reviewers agreed that this team did succeed in designing and building the device. That major accomplishment should not be underestimated. However, it was not fully clear how this design improves existing turbines in this space.

Future Work

The project plans only describe steps for testing at WETS, but they did not cover length of time or decommissioning discussions after testing. Therefore, it is not fully clear how the post-test lessons learned will be handled/processed.

OPTIMAL WEC CONTROLS USING CAUSAL AND MPC METHODS

(WBS #: EE0007173)

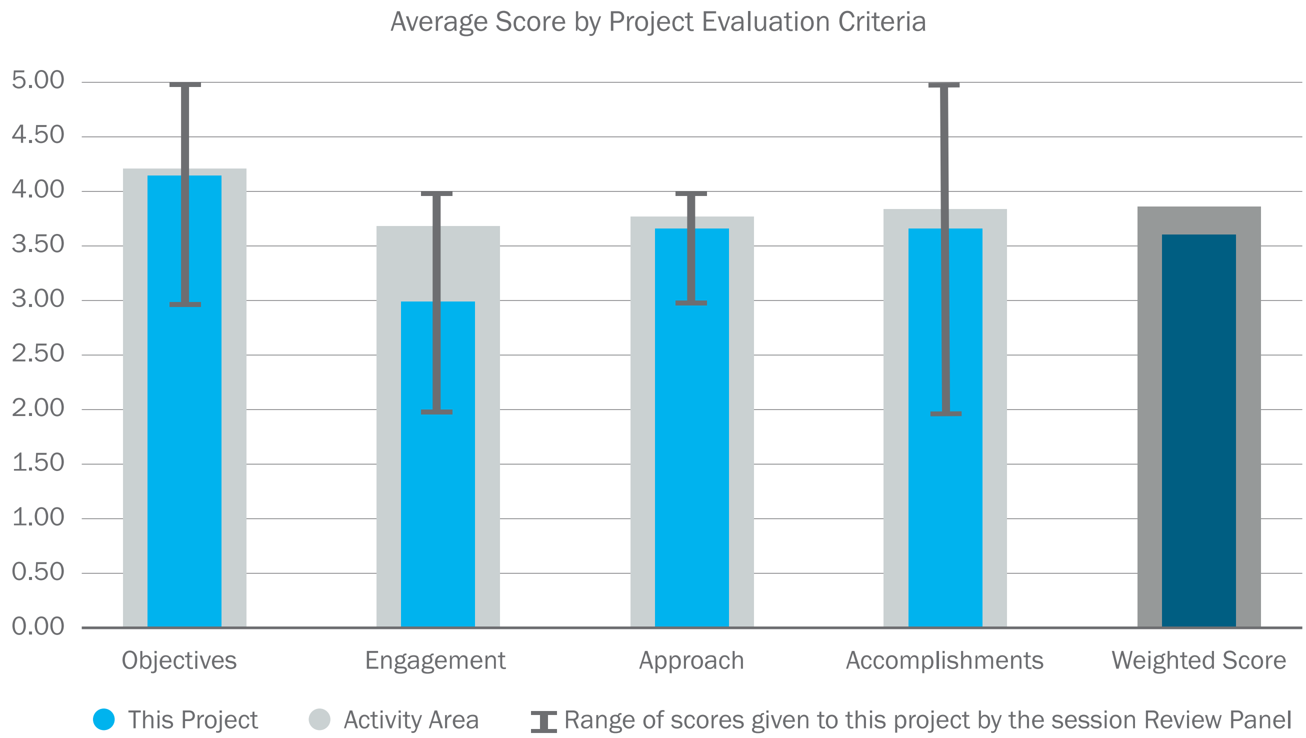
Recipient:	Re Vision Consulting
Principal Investigator:	Mirko Previsic
Project Type:	FOA 1182: Marine and Hy-drokinetic Systems Perfor-mance Advancement II (SPA II): Component Metric Validation
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$3,124K
Total Costed:	$2,927K

Project Description

The overarching project objective is to fully develop and validate an optimal controls framework that can subsequently be applied widely to different WEC devices and concepts. Optimal controls of WEC devices represent a fundamental building block for WEC designers that must be considered as an integral part of every stage of device development. Using a building-blocks approach to optimal controls development, this effort will result in the full development of a feed-forward and feed-back control approach and a wave prediction system. Phase I focused on numerical offline optimization and validation using wave tank testing of three industry partners' WEC devices, including CalWave, Ocean Energy, and Resolute Marine Energy. These industry partnerships allowed the project team to identify optimal control strategies for these different WEC topologies at different maturity levels. Phase II focuses on demonstrating an integrated control system on an at-sea prototype that is to be custom-built and maturing the hardware and software required to successfully run our advanced controls code frameworks on at-sea systems. A secondary focus during phase II is to adapt our systems identification, controls, and wave-prediction frameworks to become more robust and comprehensive in respect to RT capability, robustness, and reliability.

Weighted Project Score: 3.6

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

A project in an important/enabling topic for WECs. It is not fully clear how transferable this project's approach will be to the wider sector and other WECs. Reviewers suggested that the DOE ensures the work is accessible to the whole sector to avoid any duplication of effort.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project performers have presented the relevance of this project and how the successful completion of the project will advance the state of technology and the viability of any commercial WEC applications. Optimal controls leveraging MPC and causal (feedback) control strategies have the potential to significantly improve the economic viability in most WEC devices under development. This is a clear fit with the program to ensure the optimal performance of WECs.

End User Engagement and Dissemination Strategy

Three WEC topologies were identified, but there were no testimonials on how well the MPC control framework worked to enhance WEC performance. There was also no further mention of the project team engaging with other WEC developers. Key comments do indicate that 'significant challenges and advances need to be made before commercial uptake.' It appears that engagement is rather limited; the other key message is that Re Vision would seek cost recovery on the cost share before they are willing to make the MPC controls work open source. The performers do a good job engaging with several different WEC developers early, but do not present future dissemination strategies for engaging a wider WEC community that might benefit from the use of this tool.

Management and Technical Approach

A project management plan and schedule were described with milestones. Cost over runs were identified. The team also provided a clear discussion on the challenges and next steps to achieve success.

Technical Accomplishments and Progress

The project performers have made significant progress toward getting their MPC implemented in at-sea testing with device developers. The 8-kW device at-sea testing has been completed successfully. The progress is clearly presented in the table of schedules and milestones. Tank testing has been completed.

REDUCTION OF SYSTEM COST CHARACTERISTICS THROUGH INNOVATIVE SOLUTIONS TO INSTALLATION, OPERATIONS AND MAINTENANCE

(WBS #: EE0007347)

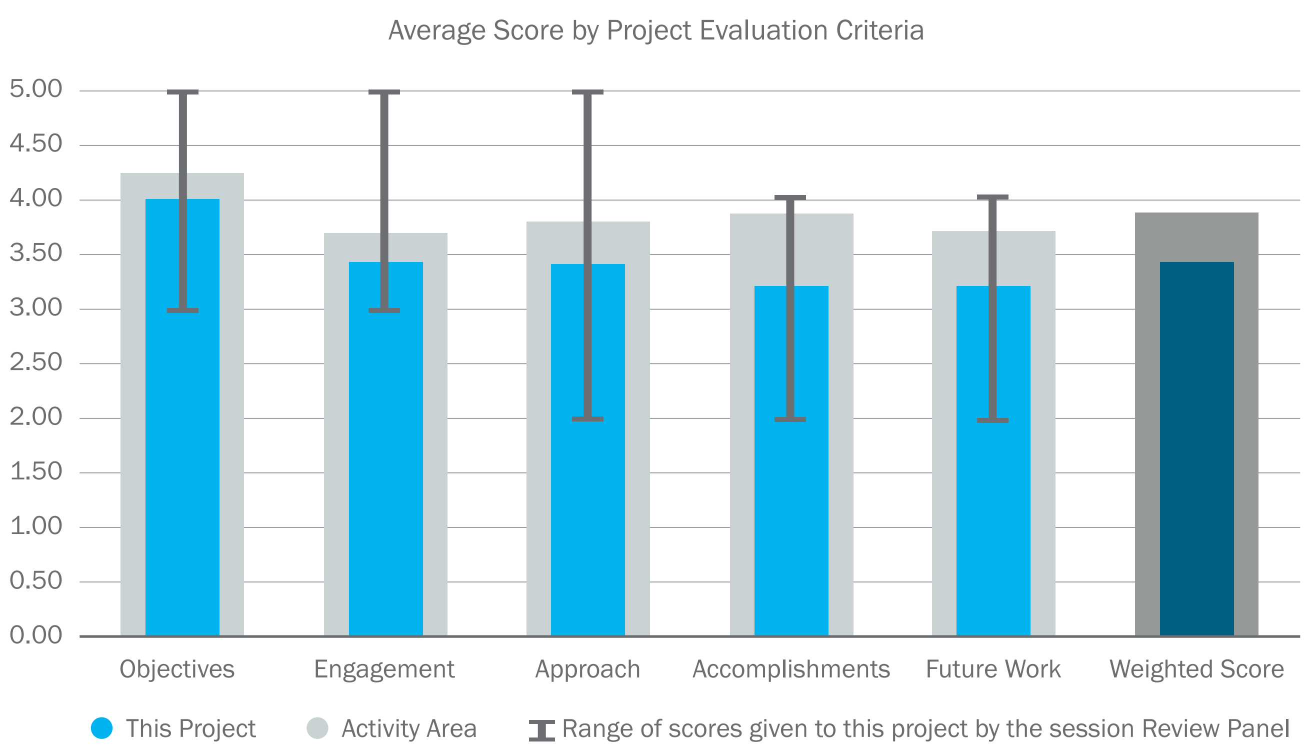
Recipient:	Columbia Power Technologies, Inc.
Principal Investigator:	Michael Ondusko
Project Type:	FOA 1310: Next-Generation Marine Energy Systems—Durability and Survivability
Project Category:	Ongoing Projects
Total Authorized:	$13,488K
Total Costed:	$1,658K

Project Description

C·Power is developing a WEC—StingRAY H2—that converts ocean waves into megawatt-scale electric power. The project goal is to demonstrate the techno-economic viability of the StingRAY H2 WEC by: (1) establishing IO&M costs based on operational and research data; (2) implementing and testing innovative IO&M-centric design improvements; (3) demonstrating the StingRAY H2 WEC in 12-month grid-connected, open-ocean test; and (4) identifying specific cost reduction pathways for future implementation.

Weighted Project Score: 3.4

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The general impression of this project is that they are progressing toward fielding their system but that the efforts really are about fielding the equipment rather than the stated goal in the project title of "Reduction of System

Cost Characteristics through Innovative Solutions to Installation, Operations, and Maintenance." This impression is not that surprising as the planned deployment is not a repeat of previously deployed equipment with changes to address cost, as other development projects in this area have done.

Project Objectives, Impacts, and Alignment with the Program Strategy

This criterion received the highest scores for this project. The reviewers generally agreed that this project is well aligned with WPTO's R&D toward utility-scale development. Despite the high scores, multiple reviewers hinted at concerns about this project. For example, one reviewer thought some of the improvements, such as the ballasting system and umbilical location, were not really innovative but more like corrections to recognized flaws. Another review noted that the PI described risk mitigation strategies that were not honestly or sufficiently addressed, and potential corrosion to components was identified as the only insufficiently mitigated high risk. One reviewer recommended that, while this project fits well with the WPTO program strategy, it should undergo a full review to show there is confidence from DOE that there is a clear trajectory to an attractive LCOE for both utility and niche markets.

End User Engagement and Dissemination Strategy

Reviewers voiced concerns that the project team rationalized the lack of end user engagement by the fact that this project is focused on a specific device development and therefore concentrated on making the device work correctly. Some reviewers noted the project strategy follows industry norms for market exploration and engagement and that it was not fully clear that the project team engaged effectively with potential end users in both utility and niche markets.

However, some reviewers did note that the objectives and impacts of this project as scoped with WPTO would support the office's technology-specific validation objectives. The items the PI list as foundational are valid and useful, though still quite specific to this design. Many of the "nine innovative technical and design opportunities" appear to be reasonable refinements of the H1 design. These refinements are the type of improvements that ultimately make any new engineering design successful and are an important part of this sort of development.

Management and Technical Approach

This section received an average score of 3.4 with a broad range of scores from 2 to 5. The comments and conclusions in this section were hard to summarize due to their breadth. Concerns and strengths of both the management and technical approaches were expressed by the reviewers.

Technical Accomplishments and Progress

Reviewers had diverse opinions regarding the project's technical accomplishments and progress. On the positive side, reviewers recognized that this project is headed for deployment in Hawaii in the near future. A widely expressed concern is that while the PI presented a detailed table of cost reductions, the basis for these encouraging numbers is unclear, as they were compared against a device that was never built or tested. Specifically, one reviewer noted that although there is a very detailed table of the cost reductions and performance improvements, it was not clear how they have been achieved, what the benchmarks were, and whether the cost reductions and performance improvements have been validated.

Future Work

Reviewers offered a range of scares and opinions on the scope of future work. They recognized that the upcoming testing at WETS is the future task that has significant importance. One reviewer indicated concern for this project and the prospects of the upcoming deployment based on performance in earlier phases of the project. Reviewers were generally unsure whether the upcoming deployment will advance the state of the art.

DEMONSTRATION OF AN ADVANCED MULTI-MODE POINT ABSORBER FOR WAVE ENERGY CONVERSION

(WBS #: EE0007819)

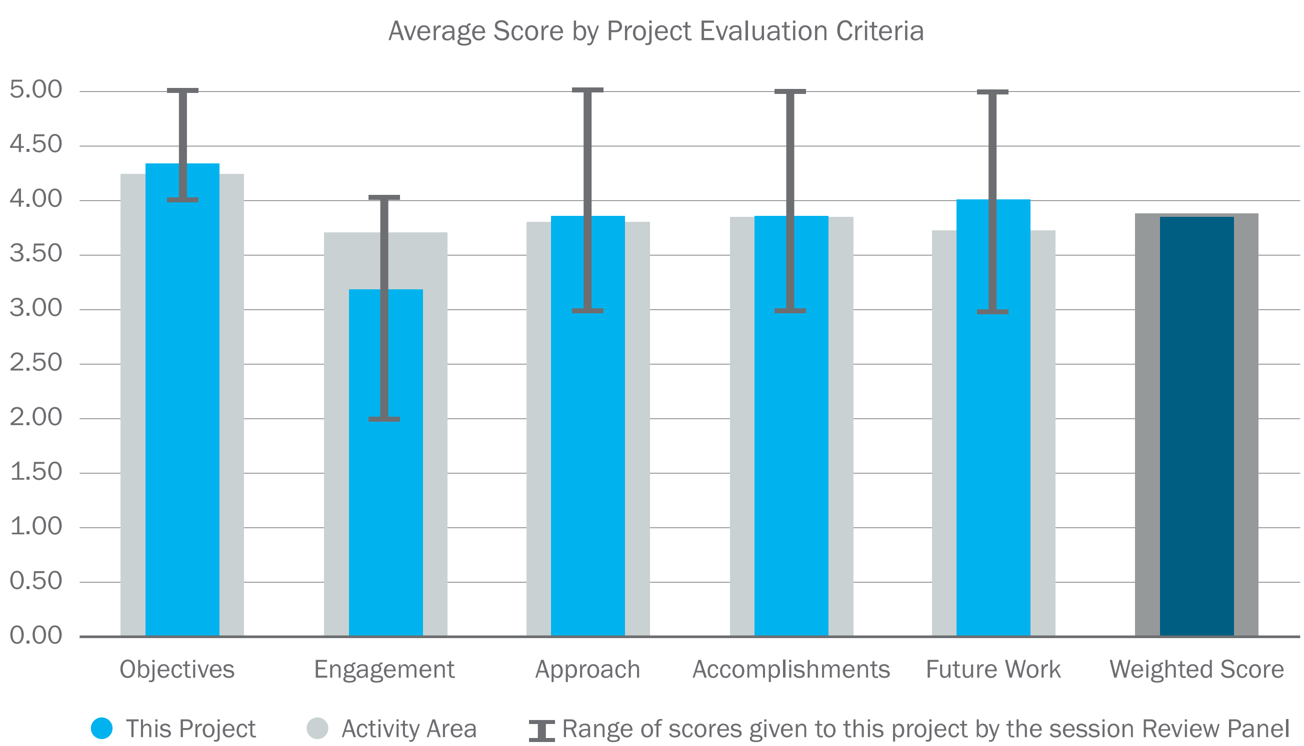
Recipient:	Oscilla Power
Principal Investigator:	Tim Mundon
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Ad-vancement
Project Category:	Ongoing Projects
Total Authorized:	$9,990K
Total Costed:	$2,382K

Project Description

The purpose of this project is to design, construct, deploy, and prove performance of the Triton C community-scale wave energy system. The Triton C is a 100-kW rated power system based on Oscilla Power Inc.'s (OPI's)Triton two-body, multi-mode architecture. At its basic level, the Triton architecture comprises a ring-shaped reaction structure that hangs below a surface float via three tendons. Wave action on the float generates relative motion between these two bodies, which can then be converted to electrical power by the drivetrains. The Triton C is intended to provide power to remote and isolated communities that currently have exceptionally high energy costs and uncertain energy security. The intent is that the Triton C will be able to provide these communities with resilient, independent, and self-sufficient energy. The Triton C has been developed specifically for this application through a long travel rotary drivetrain, allowing a smaller system to operate in fully energetic waves, as well as an improved self-deploying installation approach that allows the system to be deployed quickly and simply with low-cost vessels.

Weighted Project Score: 3.8

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

Scaling down the OPI WEC from a utility scale to supply power to niche markets, and be deployable from smaller, low-cost vessels should be a key consideration of this project because it will increase its utility to the greater community. It would be valuable to provide more detail about scaling down considerations already given to the Triton C. Reviewers wondered if there is an estimate for a timeline required to do so, or funding level required to successfully provide a small scale version, also questioning what scales are tenable. During the review, the reviewer received more information from OPI pertinent to the downscaling opportunities for this device. OPI has clearly considered applying this knowledge to several different markets at different scales. There was good detail provided in presentation on manufacturing and design layout to help reviewers understand the project.

Concerns:

- Reviewers are interested in what the LCOE is for the device for remote communities; for example, is it low enough to displace incumbent technology (diesel/electric)?
- Has a drive sub-system test been carried out to characterize the drivetrain efficiency over the wave spectra in the chosen site?
- Reviewers felt they needed more details on the drivetrain topology. Most developers to date are caught in a trade space of PTOs relative to techno economics, survivability, and efficiency, as well as O&M. This critical stage gate impacts schedule and future funding unless the developer can show a path to high technology readiness level (TRL), as well as high TPL.
- There was a design review by DNV-GL. Is the deliverable a certification of the prototype or conformity statement?
- The budget is in its third year, and having spent $2,382K of $9,990K implies the project is under spent but behind schedule. What needs to be done, and what are the risks?
- The performers mention that they have found their numerical models to be relatively accurate for predicting performance. They join a number of other developers in gaining this important insight. How do they plan to use this ability?
- I would think that the performers evaluated the option of doing the tendon replacement test in harbor for safety sake. Can they share the result of that evaluation?
- The performer does not mention any effort to use historical sea state conditions from the target site to perform simulations prior to deployment.

Recommendations:

- Recommendation to include discussion on cost-share achievements that won't risk the project deployment/installation at WETS.
- Recommendation to complete a detailed techno-economic assessment completed on the project to determine if OPI has a credible pathway to competitive LCOE.
- Recommendation to perform a full-scale experimental tow test that does not focus only on tension loading during the tow but incorporates the actual hydrodynamics of the towed body. Making progress at 3 knots in the ocean may mean not making progress at all. Towing 3 knots through an inlet may have the same results. Some testing is recommended in speeds in excess of 5 knots.

Project Objectives, Impacts, and Alignment with the Program Strategy

This project has contributed to the development of an innovative long travel rotary drivetrain that allows Triton C, and potentially other smaller WEC technologies, to be suitable in fully energetic ocean environments, and it aligns with PBE goals. The Triton C is intended to provide power to remote and isolated communities that currently have exceptionally high energy costs and uncertain energy security. This program has a specific target of powering isolated communities. The intent is that the Triton C will be able to provide these communities with resilient, independent, and self-sufficient energy. The mission statement clearly identified providing power to isolated coastal communities. Discussions around the techno economics of incumbent technology such as diesel generators and cost-benefit of trident system are not discussed/disclosed. Reviewers would have liked to see a cost waterfall with non-recurring engineering vs. Component cost reduction to see where investment in components and sub systems could drive the bill of material cost down or O&M. Reviewers also wanted to know what the baseline COE is and how it compares to diesel. Additionally, reviewers wanted to know what other ancillary markets the Trident could serve in the blue economy. Reviewers noted that project alignment to PBE strategy needs more treatment, as does the impact this topology has in moving the state of the art forward.

The project demonstrated further alignment with data sharing and analysis and provided clear discussion of the project objectives and impacts that address an increase in annual electricity production (AEP) and decreases in OPEX/CAPEX. This project makes contributions in both the "Foundational R&D" area and the "Technology-specific" areas. Fundamentally, DOE funding is allowing this company to field and test their specific design, but that design includes the interested long-travel tendon arrangement that could find application in smaller WEC devices as noted. This technology is almost certainly challenging to perfect. At a high level, there is a clear fit with the program. Although the installation approach appears cost effective, this device's impact toward the significant cost reduction and performance improvement that is required in the ocean energy sector overall is not clear.

Design and validation through in-water testing are well aligned with program strategies. The performers mention that they have found their numerical models to be relatively accurate for predicting performance. They join a growing group of developers in this class. The reviewers find that OPI references vague improvements to efficiency, without details on baseline and objectives. OPI mentions the broad application of aspects of the R&D effort, which clearly aligns with program objectives.

The intent of this WEC to provide power to remote and isolated communities is clearly stated. Technology innovation is explained by the contribution of the long travel rotary drivetrain. Cost-enhancing deployment advances are described through mating the hull and reaction ring for transport and deployment of the drivetrains to deploy the ring at operation depth on sight. The validation of linear numerical models to sufficiently predict power, motion, and loads even when nonlinearities begin to manifest themselves in larger wave environments makes a meaningful impact to the rest of the community. The PI provided evidence that technology progress had been made with the long travel rotary drivetrain, and he identified the research and characterization of the tendons as a potential point of failure/risk. Eventual deployment of the Triton C at WETS and data collection will inform and validate performance and reliability.

End User Engagement and Dissemination Strategy

The OPI WEC is intended to provide power to remote and isolated communities where the cost of energy is exceptionally high. OPI has considered and described the use/applications of their expected products and outputs. The longer-term objective is that the Triton C will be able to (ultimately, in subsequent commercial versions) produce power at competitive rates. When installed in these communities, the Triton C will provide resilient, independent, and self-sufficient energy. The Triton could be a valuable tool as an engineering test bed. Reviewers would like to know what the process of identifying promising cost improvements and testing them on this platform in situ to improve efficiency is for AEP as well as O&M. They also asked about ancillary markets (such as desalination).

Further, OPI's partners, some with little experience in the WEC area, are gaining important experience and exposure to wave energy, which will benefit the industry as a whole. At a specific innovation level, technology elements being developed as part of the Triton C may have application in other WEC components. These include elements such as the drivetrain, tendons, installation strategy, etc.

Reviewers would like to know what kind of market research and customer uptake have been done to date. Where would the first deployment likely be, and how does the cost-benefit compare to incumbent technology (diesel generator). This section was less expanded upon in terms of end user engagement. It is therefore recommended that a strategy is put in place for how they will engage with potential remote small-scale communities and where. Some reviewers felt OPI does have clear impact in terms of dissemination strategies, including discussion of their intellectual property.

As a commercial technology development and test project, the end users aren't immediately identifiable, and there isn't a big motivation for technology dissemination beyond high-level descriptions. There appears to be an adequate dissemination and engagement process in place. The summary clearly lays out the target for this project as reduced-scale remote customers. The strategy follows industry norms for market exploration and engagement.

Dissemination is in line with the usual efforts to disseminate information.

OPI mentioned a presentation at the ICOE conference and possible journal publication. Much more could be done to engage potential stakeholders. The mention of a down-scaled version of the device could be significant to niche market users like national security, ocean observing, and aquaculture farmers. A rather vague statement was made about how the industry as a whole will benefit from these substantial innovations without providing sufficient examples for how this will be done. Reviewers suggested that OPI develop an engagement plan with specific examples and targets.

Management and Technical Approach

The project performers have implemented technically sound R&D approaches and have demonstrated/validated the results needed to meet their targets. It is known that advances in (active) controls can significantly improve the power output of WECs; however, there is limited to no data about how these strategies perform in a real-world environment. The Triton C drivetrain has been designed to allow different advanced control algorithms to be tested to advance the state of the art and maximize the performance of the system. Having the ability to test the impact of different control strategies and tune the device is valuable. Reviewers would like to know how much has been done with SNL and Re Vision to test the efficacy of those control strategies.

The project performers have identified a project management plan that includes well-defined milestones and adequate methods for addressing potential risks. Another area of investigation is the reliability of the tendons. While OPI has put considerable effort into designing maximum longevity into the tendon, the type of loading and bending that the tendon experiences is unlike any other application, and data does not exist that will allow accurate predictions of lifetime. OPI has used conservative best practices and laboratory testing to develop estimates, but these will be validated through operational data.

Reviewers would like to know what kind of lab testing has been completed to date. How does one test corner points and characterize the duty cycle for low cycle fatigue and high cycle fatigue of the tendons?

The project performers clearly described critical success factors, which will define technical viability, and they explained and understand the challenges they must overcome to achieve success.

Reviewers felt the management approach has solid project team partners that have vast experience in renewable energy. Reviewers would caution that this is predominately wind turbine and not marine based, with the exception of Glosten. Reviewers would have liked to see more treatment with an FMEA and key metric milestones relative to baseline metrics. One reviewer asked what the commercial goal posts for this device were.

Reviewers felt that more detail on the management approach is warranted. OPI discussed how they control their plan, and it is clear in the technical approach how they systematically address each objective and resulting milestone. Additionally, in the future work, they outline the remaining tasks and milestones.

One reviewer remarked that OPI has an excellent technical approach narrative and that it gives confidence in the projected impact of the project. The management approach of this team appears to be appropriate to a project of this size/scale, and they have incorporated appropriate outside expertise.

The primary risk in this design appears to be the tendon design; OPI indicated that they have done extensive testing of this component, and this is a critical detail to get correct. The report includes high-level logistical steps associated with getting the Triton C deployed and recovered from WETS. OPI demonstrated experience with instrumentation and communication of monitoring and control. Objectives of testing included active control; however, there should be a carefully planned campaign that moves from theory to simulation and tank testing to make ocean testing safe and effective.

The project management and technical approach was well presented by the project developers, with specifics of numerical modeling for ocean conditions presented. Reviewers felt that there was a lack of testing in actual ocean conditions—even for the small-scale Triton C prototypes presented. Reviewers stressed that nothing is as good as actual deployment experience and testing in an ocean environment. Reviewers expressed interest in whether there were best practices or lessons learned from previous testing experience to inform transport, deployment, maintenance, and removal strategies. Post deployment strategies for component fatigue and structural assessment have been well considered.

Technical Accomplishments and Progress

The project performers have made progress in reaching their objectives based on their project management plan. However, utilizing $2,382K of $9,990K implies the project is under spent but behind schedule. Reviewers are concerned whether a drivetrain sub-system test had been carried out to characterize the drivetrain efficiency over the wave spectra in the chosen site. Most developers that the reviewers have seen are caught in a trade space of PTOs relative to techno economics, survivability, efficiency, and O&M. This critical stage gate impacts schedule and future funding unless the developer can show a path to high TRL, as well as TPL. Reviewers felt that the project team provided good details on the drivetrain and system top-level topology lacking from other developers. One reviewer questioned their consideration of a gearbox/generator versus a fixed displacement pump where one can dissipate energy via a keel cooler versus a brake. Another asked about the design trades that led to this topology and its relative advantage from an O&M and controls standpoint.

OPI has described its most important accomplishments in achieving milestones, reaching technical targets, and overcoming technical barriers. Using Triton C test data obtained from physical model testing, this project has demonstrated that time-domain models based on linearized potential flow hydrodynamics can produce fairly accurate predictions of power, motions, and loads (to within approximately 10%), even in large wave conditions where nonlinearities begin to occur. This provides important validation to the numerical modeling approach used and provides increased confidence in the loads used to design the Triton C system.

Through this project, a full-scale prototype (100 kW, 10m x 7m) Triton C WEC has been designed and is currently under construction, with deployment expected in 2020.

Reviewers have found that in some areas, the suggested safety factors are conservative (this implies increased cost of electricity), while they are perhaps marginal in others. Reviewers would be interested in what subsystem sequential de-risking can be done prior to integration and deployment.

Composite hull construction would be less than 50% of the cost of a steel unit and around 70% of the mass. Buoyancy is always a challenge in a fixed displacement system. Composite should be considered in case the system comes in overweight

Reviewers found there to be a strong narrative on the progress of the project milestones achieved and impact of the results, with a clear description of the progress since the last review period. Reviewers noted that the developer provided detailed design completion results. The consideration of composite construction to reduce cost was well considered, but the project team could have provided more details on the specific composites they're considering. Corrosion and biofouling considerations were notably absent from the technical discussion. Tendon testing for fatigue provided valuable information. One reviewer estimated that with a 10-s wave, the tendons would see approximately 3+million cycles over a year. The 4 million cycles tested seemed sufficient, especially with sporadic monitoring during the deployment period.

Future Work

The project performers have outlined adequate plans for future work, including key milestones and go/no-go decision points. The project team should demonstrate that the first commercial units of the Triton C can achieve a system CAPEX of <$1M/Unit with an AEP of >127MWh/yr. Whitehill performed extensive testing to evaluate the fatigue lifetime of the tendons, demonstrating >4M cycles duty cycle. Reviewers have concerns that a bend restrictor or J tube has not been discussed for the power export; they also expressed fatigue concerns around this.

Reviewers wondered how the remainder of cost-share will be met outside of the $1 million matching grant from the State of Washington Department of Commerce through the Clean Energy Fund, further questioning if this would throttle WETS deployment or construction.

Reviewers felt there was a clear outline/summary of the plans for future work and milestones, but they were not able to locate go/no-go decision points in their schedule. Reviewers also expressed concern on the amount of funding OPI has to get the WEC in the water, noting that a cost share of $4.6 million is not insignificant.

The future work is the deployment and test of the device. This appears to be dependent on a BP2/BP3 go/no-go decision. There is not sufficient detail in this summary to advise that decision, and go/no-go decision points are not clearly identified. Some field exercises that consider transport to WETS, deployment, maintenance, and removal should be incorporated into future work. Planned system wear tests after the device returns to Seattle will provide valuable assessment tools.

ADVANCED TIDGEN POWER SYSTEM

(WBS #: EE0007820)

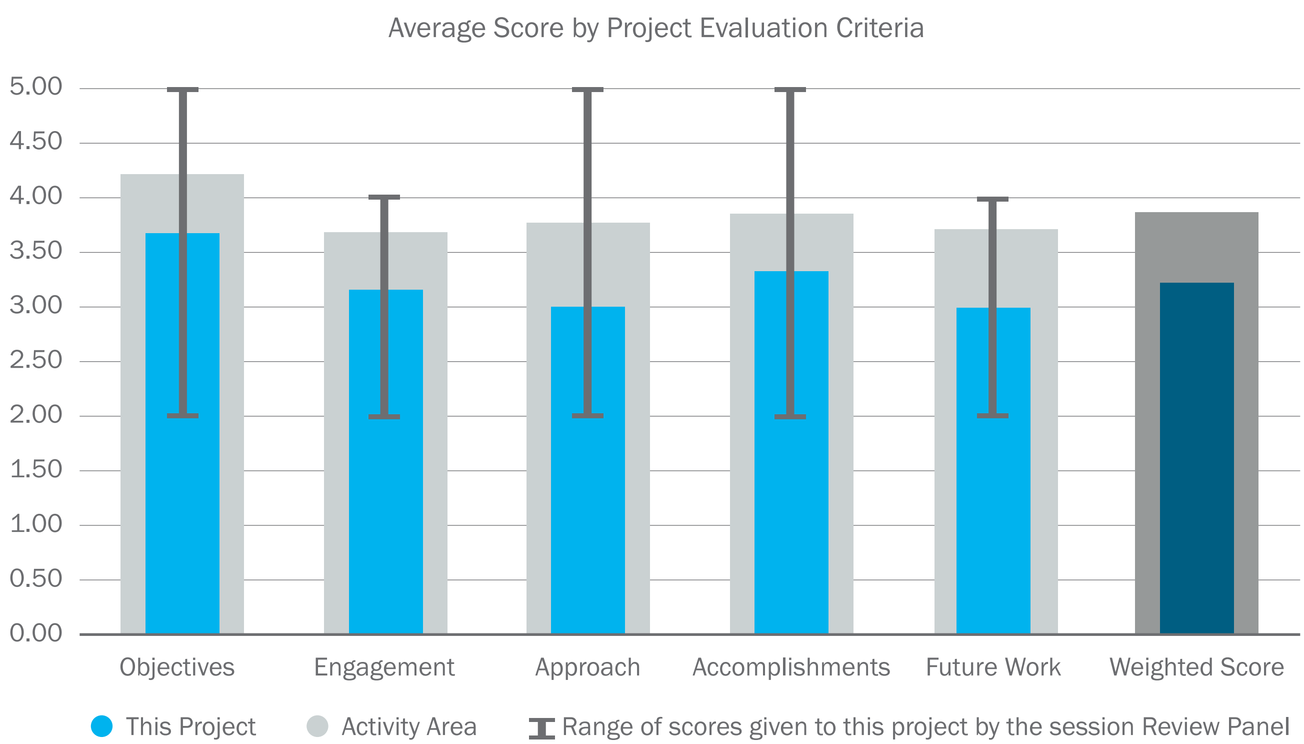
Recipient:	ORPC Maine
Principal Investigator:	Jarlath McEntee
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conver-sion and Environmental Monitoring Technology Advancement
Project Category:	Ongoing Projects
Total Authorized:	$11,602K
Total Costed:	$2,248K

Project Description

ORPC Maine, a wholly owned subsidiary of Ocean Renewable Power Company, Inc. (ORPC), will design and demonstrate a commercially viable tidal power system, integrating technologies through a program focused on cost of energy, risk reduction, and component life. ORPC will design; construct, test, and verify subsystems; perform system integration; verify system performance; and validate system reliability and availability by a continuous 12-month deployment in Western Passage, Maine. The integrated design will demonstrate significantly decreased LCOE by improving turbine performance and reliability and by decreasing IO&M costs.

Weighted Project Score: 3.2

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The proposers learned during execution that there are issues with the gravity base anchors' size, cost, and handling. They also identified an issue with deployment detachability. From a certain perspective, this does align with program goals if the industry learns from it. Reviewers would like the project team to share clear and concise details regarding these issues.

The reviewers found it hard to see this project overcoming the anchoring problem, which raises the question of how this approach that involves so much vertical lift in the anchoring came about. The project presentation acknowledges this problem and the project team is advertising a delay of 2 years to address this. Reviewers noted that with the project entering a go/no-go decision at the end of Budget Period 2, WPTO needs to carefully consider the prospects for this project. Reviewers thought the design approach pursued appeared poorly developed (as the reliance on unrealistically large anchors indicates). Additionally, it seems there are tidal energy plans being deployed in Europe that are at a significantly advanced state of maturity. This raises the question of why WPTO would spend a lot of money to invent a competing technology before that technology is proven or disproven as effective.

Concerns:

- What are the range of efficiencies expected for this device in low and high current environments? Expected increases in efficiency of 30% are described, but what are the expected ranges for the device?
- More specific details on composites being utilized through the partnership with USACE's Construction Engineering Research Laboratory might benefit other developers through describing lessons learned.
- Are there site-specific anchoring considerations that could be made? For example, if there are boulders at the deployment locations, could existing boulders be ensnared by some sort of netting, and then lines tensioned from the net to the device to secure the device in place? That seems like a cheaper, less comprehensive strategy when compared to screw anchors, and the heavy equipment needed for drilling into stone.
- What is the plan of attack for the anchor selection and deployment window? Is there enough budget to cover this?
- Demonstration of risk (FMECA) analysis should be incorporated and reviewed with WPTO not annually but quarterly if not after design studies have been completed.

Reviewers recommended ORPC undertake a detailed techno-economic assessment to determine if they can achieve a credible pathway to LCOE. DOE should review grid-scale market for TECs in the United States; will it be large enough, and will the current designs be credible with a competitive LCOE?

Project Objectives, Impacts, and Alignment with the Program Strategy

ORPC, will design and demonstrate a commercially viable tidal power system, integrating technologies through a program focused on cost of energy, risk reduction, and component life. ORPC will design; construct, test, and verify subsystems; perform system integration; verify system performance; and validate system reliability and availability by a continuous 12-month deployment in Western Passage, Maine. ORPC plans to significantly decrease LCOE by improving turbine performance and reliability, as well as by decreasing IO&M costs.

Reviewers noted that the project team had clear objectives but needed to mention threshold requirements for reliability, maintainability, and availability, O&M, AEP, and COE. The project team needs to quantify what the expected decrease will be and what the expected baseline performance is for theoretical versus experimental. Reviewers would like to see a comparison of key performance indicators versus milestones to show progress toward achieving 15 cents/kwh.

Strengths

- Strong narrative on alignment with MHK program. Key outcomes and social acceptance from past projects in Igiugig Village are still relevant.
- This is a high-impact project for the program, as it intends to bring a tidal generator close to being a viable, tested, commercially available device to use in different settings.
- This will validate device performance in low and high velocity current environments, thus determining an LCOE that includes deployment, short-term maintenance, and recovery of the system.
- A 12-month test will both prove the viability of this technology and demonstrate areas for improvement. The practical path for achieving 15 cents/kWh is impressive. Several advances in the PTO, control, and mooring are described.

Weaknesses

- Community engagement is discussed, but not specific regarding use cases synergy with adjacent industries (aqua culture) or displacement of incumbent technology (diesel electric).
- Advancements on the state of the art are mentioned relative to advanced controls and generator. Meaningful impacts are not provided in terms of LCOE or % improvement.
- Commercial applications outside of prime power grid applications are not mentioned.
- More treatment on impact and glidepath to LCOE and latest lessons on cost-efficient anchoring systems (i.e., SEPLA?) need to be considered. What is the trade space on this?
- This project obviously addresses the desire for free-standing tidal generation, but it's hard to see that this development is going to compete with the existing technology in Europe that is at a much more advanced state of maturity.
- On a high level, this project clearly fits with the program strategy. What is not clear and is a question for DOE is how important the tidal sector is to their overall MHK strategy.

End User Engagement and Dissemination Strategy

Reviewers felt they needed more information on community benefit. The 15 cents/kwh roadmap is instructive, but the reviewers would like to see a cost waterfall that gives separate cost buckets for discrete improvements in LCOE relative to NRE, BOM cost, and O&M benefits that do not rely on economies of scale. An FMEA should also be included in these reviews. Stakeholder requirements are not mentioned nor are requirements for commercial uptake. Reviewers questioned what traction ORPC has had on a power purchase agreement. There are multiple references to Eastport Community, West passage site, and stakeholders, but reviewers would like more emphasis on peer reviewed papers for journal publication. This is critical to demonstrate the successful innovations discussed that will be implemented in the next device. The project seems to have engaged users through the permitting process, but it's hard to see how this project will be cost effective before the anchoring problem (and perhaps other issues) is addressed. Although it was clear what ORPC's engagement with regulators has been, it was not displayed how they have engaged with their stakeholders to assess the need for this technology with end users/customers. The performers have demonstrated successful stakeholder engagement with the public and with regulators at the test sites, which has resulted in permission to test. This is a substantial accomplishment. Engagement with city managers, fisherman, and aquaculture facilities is mentioned. DOE engagement through reporting of results is also planned. Participation in industry conferences is mentioned, and specific examples would be useful.

Management and Technical Approach

The results of this project to date have demonstrated a successful management and technical approach to commercialization. Several specific examples of ongoing collaborations that serve the project were presented, and detailed milestones were given.

The challenges with anchoring systems were described, and solutions being considered were addressed. One reviewer thought earlier discussions with the supply chain back in 2017/2018 would have revealed the costly challenges. It appears this design change could also impact the structural loads on the turbines as they are placed in more appropriate flow conditions. Demonstration of a robust risk management system should be described on mitigating the moorings/gravity base anchors and or rock anchors. Rock anchors will require further geotechnical surveys, which are expensive.

Installation of the system is expected to be delayed by at least one year while ORPC resolves the anchoring issue. Over a year delay has been incurred by construction costs, and reviewers suggested engaging with outside consults steeped in mooring design and at sea deployment (e.g., PCCI, InterMoor, etc.). This poses significant risk to the working capital position of the company with engineering rework for deployment that perhaps came too late in the design spiral. O&M and deployment will drive a lot of the design decisions depending on the scale of the array as they are major cost drivers in the COE model. One reviewer asked about the current plan of attack for the anchors to not stall the program.

The fact that the design progressed so far without a viable anchoring strategy is a worrisome reflection upon the management approach. Technically, the presentation and summary don't explain what the benefits of this approach are and why it's worth it to design a system with such major installation costs.

Some additional reviewer comments included the following:

- It is not clear what the overall benefit of the particular technology is compared to more conventional tidal turbines.
- It's not clear how the risk involved with the gravity base anchors was missed.
- This is not a new technology.

Technical Accomplishments and Progress

ORPC has a structured program along the lines of a DOD design practice. As a critical design review has already been concluded, one can surmise the deployment and anchoring is still an outstanding issue and is pacing the program, causing a year or more delay.

Turbine Design

While there was good detail in how the program is structured with milestones and details on the design, the reviewers would like to see more in the way of subsystem testing and FMEA tracking. They did not get a sense that there is a solid basis for load case development. Tidal turbines historically have high turbulence intensity, with ~25% variable load, impacting endurance of the turbine. This impact should be captured on a Goodman diagram using saturated test coupons. The reviewers recognize ORPC went through the effort of saturating the coupons as fatigue lives tend to drop 50% in sea water relative to air. A Campbell diagram should be considered to determine if there are any resonant frequencies getting excited by generator, blade passing frequency, or upstream flow perturbance to make sure there is no high cycle fatigue excitation through the added mass to drop frequencies, which is usually critically damped.

The turbine manufacturer performed a joint test. The test specimen was completed, and the project team will perform testing and complete a test report that outlines the methodology and results. These results will be used to validate Finite Element Analysis to ensure the overall turbine design will meet design requirements. Reviewers are wondering how the load cases have been captured: Was there an active flow measurement plan to capture flow gradient and turbulence intensity? What designs are allowed, and how will the test coupons loop back into the life calculations of the turbine and impact the design? What is the cavitation margin relative to superposition of sea states, depth, and turbulence intensity?

Reviewers also believe that the project team should introduce flow measurements to capture gradient (ADCPs) and turbulence intensity (ADVs) to capture seasonal variability and load cases for design.

Anchoring and Deployment

Reviewers questioned what the project's major cost drivers that impacted cost efficacy of the design were, also wondering if the project team contemplated a solution path in the cost waterfall and FMEA. Additionally, the reviewers wanted to know what contractor designed the anchor, and they wanted details about their experience (is it mostly with Oil & Gas or naval installations?). Mooring is a critical design element that is crosscutting and impacts all developers in the MHK space. The project team should consider specialty ships of opportunity for MHK deployment, just as testing berths are required as this impacts design. The reviewers scored the outcomes as marginal due to the delay in mooring/foundation design. One reviewer thought the technical accomplishments were hard to score well when ORPC is facing a two-year delay to address the anchoring system. While the project team learned during execution that there are issues with the size, cost, and handling of the gravity base anchor, the reviewers agreed this work does align with program objectives.

Takeaways

While the reviewers recognize there are some good technical achievements, what is not clear is how credible the plan is to achieve the target LCOE of $0.15 will be achieved.

Clear and concise details regarding the issues encountered should be shared. This project has made significant progress and has identified the anchoring system as the main challenge to attaining the LCOE project goal. The project is clearly described in detail, with specific milestones provided.

Future Work

This anchor trade study is still a high-risk factor both from a working capital and technical risk perspective, as it flows back into the design spiral, which impacts the TRL and TPL significantly. This portion of the program needs to be carefully monitored, with ORPC engaging with consultants steeped in deployment, as it is the most cost-intensive part of the program, and other developers have lost their business through a failed deployment or an infant mortality failure (or rather, an early failure resulting in poor performance). The project's highest priorities should be closing out the mooring anchor risk, as well as load cases for turbine design based on measurements that need treatment.

Future work has been described, but the plans are not fully detailed from a risk management perspective. Reviewers recommended that the project performers complete a techno-economic assessment on current design, including the new GBAs to determine if there is a credible path to competitive LCOE. While the future work is obviously aimed at addressing the anchoring issues, at the level of detail presented, it's hard to see why this design has advantages over simpler-to-install devices, some of which appear to be in significantly advanced stages of development in Europe.

The summary identifies the challenge of anchoring the system as a key hurdle, but there is no discussion of what is at risk if a cost-effective solution is not found. Questions from reviewers include the following: How will this project deal with upcoming anchoring decisions? Are there go/no-go decisions to be made here, or does this challenge just change the LCOE?

WAVE PREDICTION LEVERAGING MULTIPLE MEASUREMENT SOURCES – A SENSOR FUSION APPROACH

(WBS #: EE0008099)

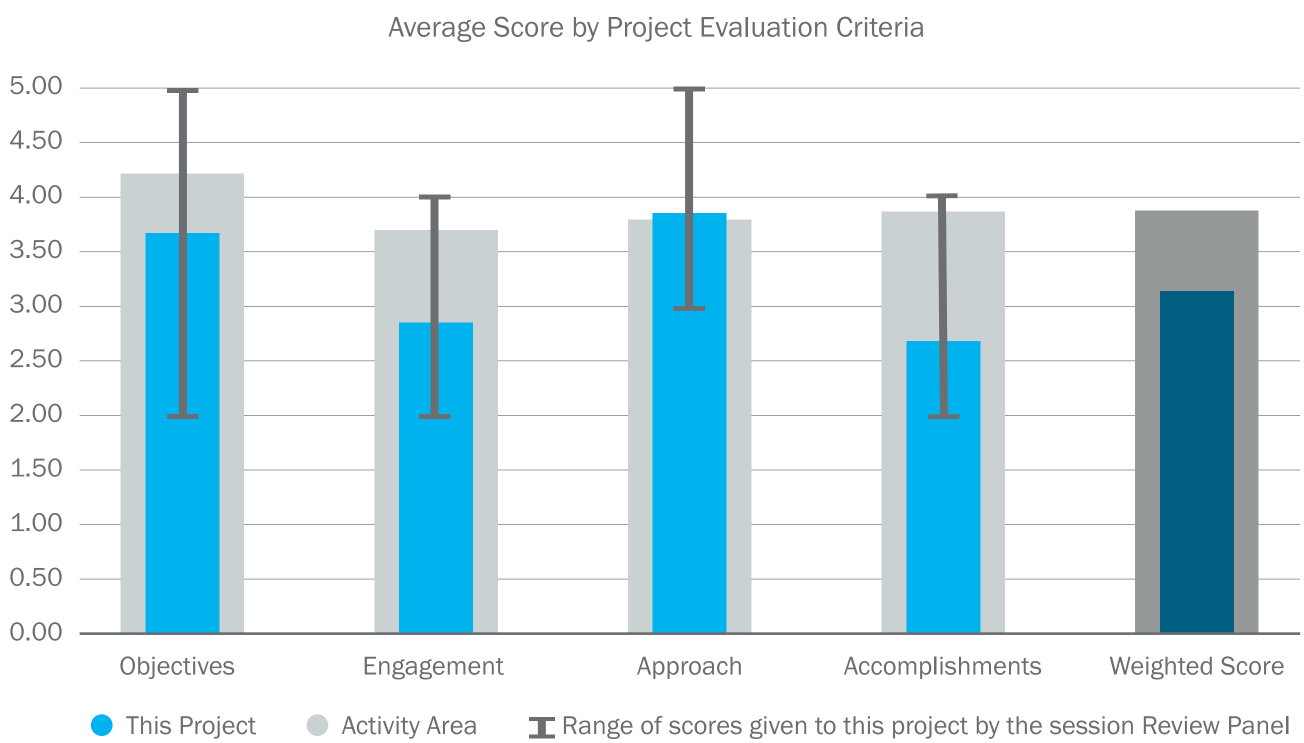
Recipient:	Re Vision Consulting
Principal Investigator:	Mirko Previsic
Project Type:	FOA 1663: Marine and Hydrokinetic Technology Development and Advance-ment
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,192K
Total Costed:	$625K

Project Description

The purpose of the present effort is to combine wave radar and buoy measurement sources to leverage their unique advantages. Wave radar provides a broad spatial representation of the free surface with limited accuracy, while measurement buoys provide highly accurate measurements at a single point in space. Using sensor-fusion algorithms, the advantages of both measurement sources can be maximized. The core objectives are to: (1) improve the prediction accuracy, and (2) move the TRL from 4 to 6, leading to a technology building block that can be readily employed by WEC system developers in pilot WEC deployments.

Weighted Project Score: 3.1

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

There was very little overall consensus on several areas of this project among reviewers. Some thought this was a terrific project and thought the at-sea effort was quite valuable. Others found that the technology was not novel, and they felt like several of the statements the project team made were either vague, not supported with examples/details, or a stretch.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers were not in consensus on this project, providing scores that ranged from 2 to 5.

Some of the positive comments from reviewers are as follows:

- "No one has been able to implement MPC on a WEC device at sea, due to the fact that phase-resolved wave-prediction is not a capability that has been sufficiently developed to date."
- "This is important work that has an opportunity to benefit all scales of wave energy converters. Excellent fit with the program to ensure performance improvement and the survival of wave energy devices."

There were two reviewers that did not agree that this project was impactful. One reviewer noted that some of the advances in commercial applications presented appear to be a bit of a stretch, including "reducing motion sickness at sea, extending operational windows in marine construction" with a 30-second forecast capability. The project has discussed the potential for the project to advance MPC and noted application with three WEC developers; however, none provided or demonstrated impact on their design, and on the contrary MPC was not applicable or viable for commercial success. The investment in X-band radar development does not seem novel, several developers have made wave measurements with X-band radar in the past. Why develop this technology when off-the-shelf technology like wave rider buoys can provide a more robust at-sea, 30-second forecast with a radio link?

End User Engagement and Dissemination Strategy

Reviewers found little consensus with rankings that ranged from 2–5.

Favorable comments about engagement strategies and collaborations included:

- Good engagement with the Navy to leverage expertise, accelerate scheduling, and reduce cost.
- The performer references strong end user engagement and efforts to maintain their relationships. Engagement with the Navy on the existing data sets is a plus.
- Engagement with WEC developers has provided lessons learned into the development of MPC. However, no demonstration of the use of the X-Band Radar approach was undertaken.
- Good listing of publications, but it is disappointing that the white paper for DOE has not been published yet.
- The dissemination of their work seems weak, and the summary and presentation do not present enough information to evaluate their progress.
- A solid peer-reviewed publication showing the techniques and results is important for this work to have a broad effect on the field.

Management and Technical Approach

The reviewers provided slightly more positive reviews for the management and technical approach of this project, yet there still wasn't full consensus.

For example, some positive review statements provided included the following:

- “An excellent, logical and well-planned technical approach”
- “Leveraging existing data sets is a sound R&D approach. Validating and improving numerical models on such data is of course the thing to do, but they are doing it.”

Additional reviewer comments included the following:

- For foundational R&D, one would think the university lab model provides the incentive to publish their work, which may be a better approach.
- Including marine x-band radar for wave prediction has many challenges, and previous projects undertaking marine radar also proved limited industry uptake. There are more demonstrated technical achievements utilizing wave buoys.
- While the report demonstrated that performers have successfully met development goals, there aren’t many specifics provided about the technical approach. For example, no details were provided about the buoy types, communication methods, or proximity to the experiment site. I’m guessing these are Waverider buoys that are part of the the Coastal Data Information Program network with Hydropower Foundation telemetry, but was not communicated.
- Several times, co-located measurement devices were mentioned without any detail provided.
- Mention is made of benchmarking the prediction accuracy, but none is quantified in the report. Specifically, what improvements were made in establishing X-band radar accuracy in providing 30-second predictive capabilities to wave phase?

Technical Accomplishments and Progress

There was more consensus in terms of technical accomplishments, with less favorable reviews provided for the developer in technical accomplishments and progress. Most of the critical comments were related to improvement claims made by the developers, without sufficient detail provided. There were few examples of metrics that quantitatively demonstrated improvement.

Specific comments include:

- “It is not possible to evaluate the technical accomplishments and progress from the information presented in the summary and presentation. The companies need to keep their methods proprietary is understandable but some performance graphs that clearly show the success of the method would seem to be possible without compromising the company.”
- There is no discussion of how much of a gain in net improvement is made. Based on the milestones table the project appears to have accomplished the goals stated in the project management plan. However, the project summary did not provide specific metrics for improvement on the X-band wave prediction method. I will seek them in the list of publications, but it would be nice to have summarized them in the report. The progress isn’t clearly stated, nor is it quantified. What are the improvements in predictive accuracy made by using the proximal buoys? In the illustration on the left, what is the curve? What are the units?”
- “The technical accomplishments and progress lack specific details and are not quantified. It appears there was testing done, but to what end? What improvements were made to the system?”

One reviewer provided a favorable review of this project’s technical accomplishments, saying the Re Vision team had made excellent technical progress, but that it was not clear how this will be made available to developers. This reviewer urged DOE to ensure this is open source.

A HERMETICALLY SEALED MAGNETICALLY GEARED MARINE HYDROKINETIC GENERATOR

(WBS #: EE0008100)

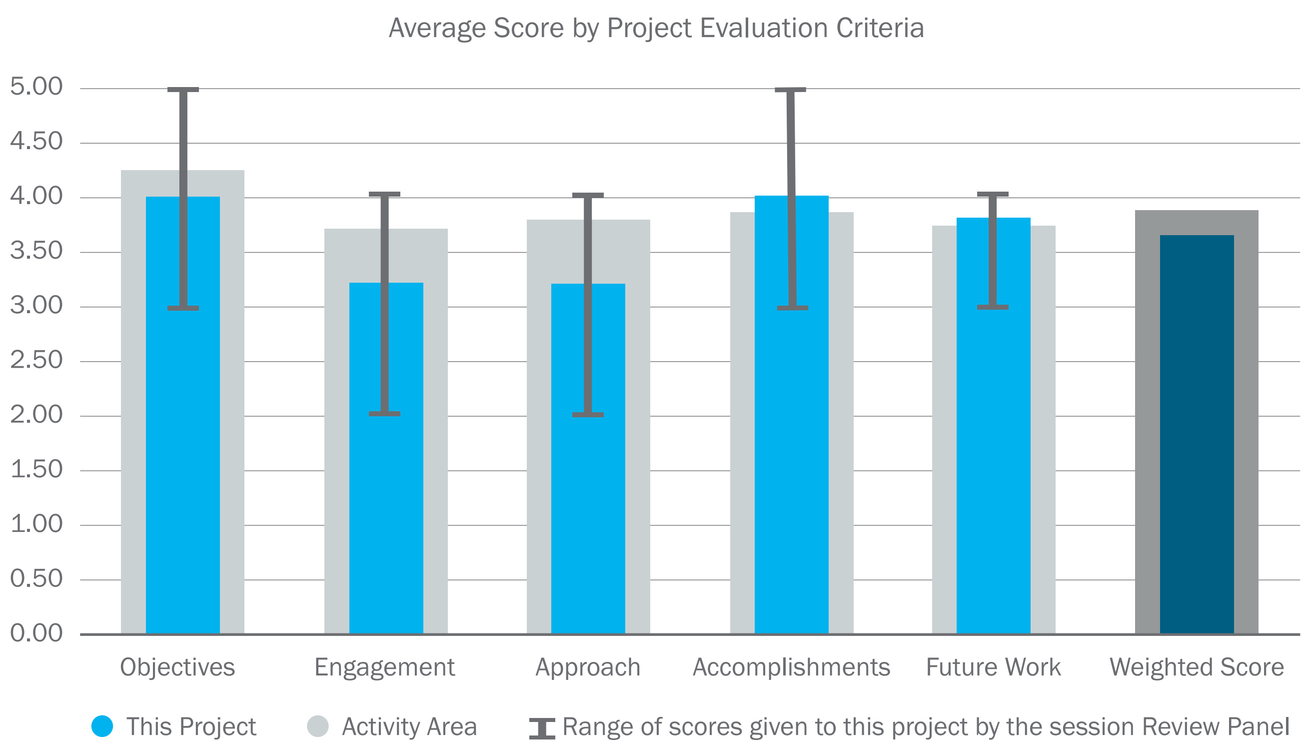
Recipient:	Portland State
University	Mirko Previsic
Principal Investigator:	Jonathan Bird
Project Type:	FOA 1663: Marine and Hydrokinetic Technology Development and Advancement
Project Category:	Ongoing Projects
Total Authorized:	$889K
Total Costed:	$490K

Project Description

The primary objective of this project is to design, fabricate, and test a hermetically sealed 50-kW multistage magnetically geared generator (MGG). To reduce risk, a sub-scale 5-kW multistage MGG was first built. At the end of this project, the team will have (1) experimentally demonstrated a 59:1 gear ratio multistage MGG with a torque density that has at least 3X higher torque density than prior-art baseline published designs, and (2) utilized water tank testing to demonstrate that the efficiency of the hermetically sealed multistage MGG is competitive with existing technology.

Weighted Project Score: 3.6

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

Most reviewers scored the project favorably, with the exception of one who assigned noticeably lower scores. There was general agreement that this is a foundational technology that has the potential to be applicable to high-torque/low-speed issue of wave-energy conversion. This point of view is supported by comments such as *"Important and impactful project that is crosscutting for MHK developers whether tidal or wave energy. Unique attributes can also provide needed opportunities to implement controls."* and *"This is an interesting project that if successful has the ability to address a critical challenge with wave-energy devices."* The project appeared to the reviewers to be well-managed and moving along according to schedule. The upcoming 50-kW device build and test was recognized as a key event. Negative commentary centered on the lack of a direct connection between this project and the impacts of OPEX and the lack of explanation of why a one-year, no-cost extension is required.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers generally agreed the project aligned well with the program strategy as a foundational research project that has the potential to provide a needed reliable and high-density gearing capability useful for MHK energy conversion. Several comments supported this point of view, and most reviewers commented specifically that this project is a good fit for the program. The use/application of this technology development is envisioned, but immature at this point, as the work is a proof-of-concept project. One reviewer found insufficient relevancy was presented as characterized by the following comment. *"Limited discussion on the use/application of their expected products and results."*

End User Engagement and Dissemination Strategy

The reviewers' scores were moderate in this category, with one reviewer scoring significantly lower, which was explained by a concern that the performers could have done a better job relating their work to expected reductions OPEX compared to existing technologies. Regarding end users, one reviewer commented that no key stakeholders were mentioned. On the other hand, several reviewers commented that the existence of a start-up company alongside this project provided a vehicle for commercialization should this technology development be successful. There was some concern in the reviewers' comments that it's not entirely clear how engaged these researchers are in the MHK sector, as there are other applications for this technology outside of the MHK application space that are perhaps being pursued in parallel. To this end, one reviewer recommended that a technology roadmap should be developed for a magnetic generator, so MHK developers can consider this topology in their product roadmap.

Management and Technical Approach

There was general agreement that the performers have implemented a technically sound R&D project. There was some dissatisfaction with the issues of milestones and risk mitigation, and one reviewer stated the team could have provided a more detailed execution plan, including a FMEA risk mitigation plan and sequential de-risking plan of attack. One reviewer scored lower than others due a concern over the reason for the requested one-year extension. In that comment the reviewer limited the criticism to the "management approach" but thought the technical approach was better.

Technical Accomplishments and Progress

This criterion was scored highest by the reviewers. There was broad agreement that the technical work and development of the 5-kW system was well done and has generated information that has been incorporated into the 50-kW design. Reviewers thought the team was making positive technical accomplishments and progress with a rigorous testing plan in place. The reviewers would have preferred the final device benchmarked against mechanical work, as this should be compared to mechanical alternatives.

Future Work

In general, the reviewers find the future work compelling and adequately described. There was broad agreement that the results of the 50-kW device will be instrumental in evaluating the potential of this work. These results naturally will feed into future go/no-go decision points. Concerns were expressed about remaining issues related to the packaging of magnets, hermetically sealing the device, and the impacts on heat dissipation.

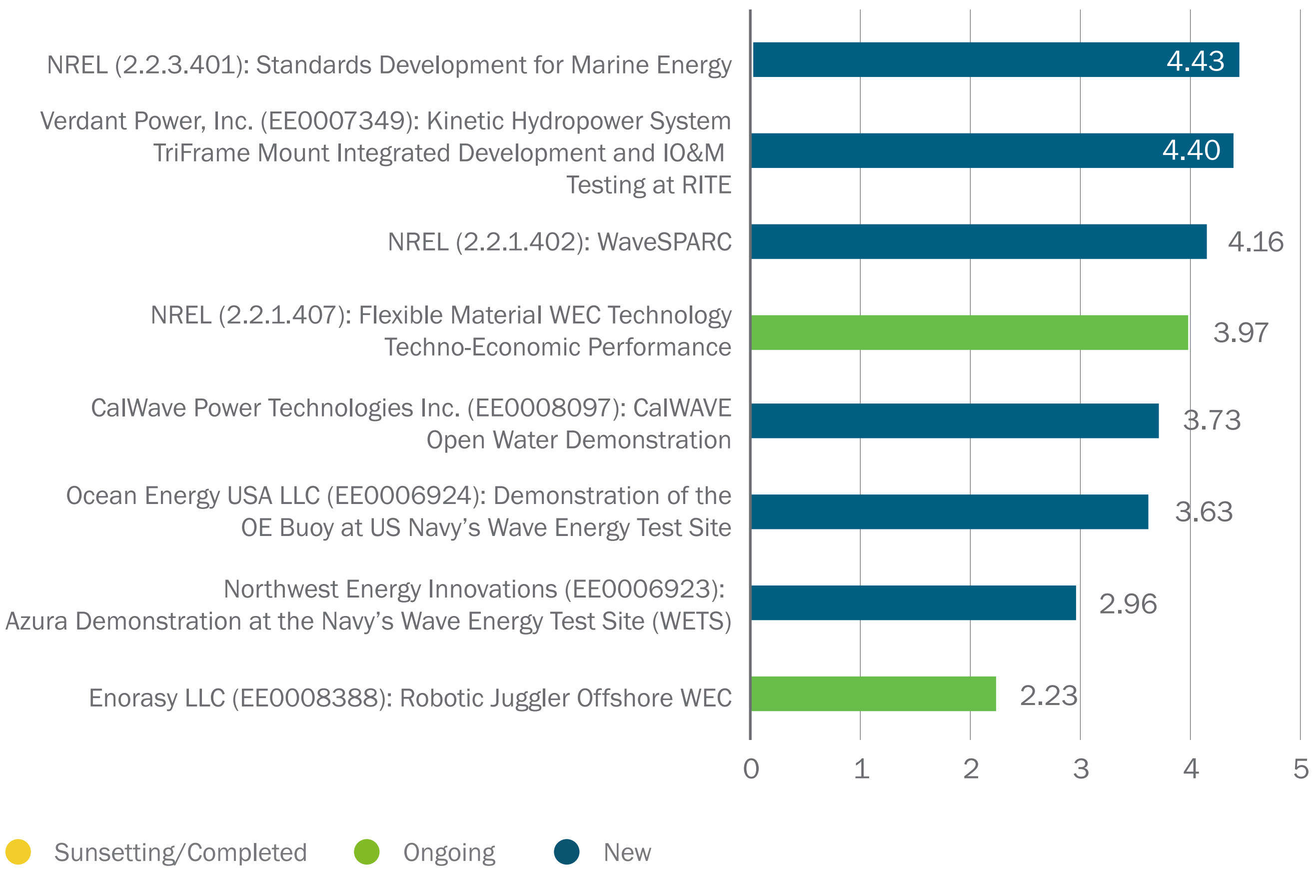
Technology-Specific Design and Validation

This section provides an overview of the scoring for all projects within the Technology-Specific Design and Validation activity area (see Figure 24); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Technology-Specific Design and Validation	3.68

Figure 24. Technology-Specific Design and Validation activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

The Technology Specific Design and Validation activity area incorporated device-specific and lab-specific developments, device testing (tank/in-sea), standards development, and techno-economic assessment tool development. Several projects in this activity area had challenges addressing two activity area objectives. Those objectives focused on improvements in methods for safe and cost-efficient installation, grid integration, operations, monitoring, maintenance, and decommissioning, including the evaluation of potential IO&M infrastructure needs and approaches to bridge gaps that significantly impact the MHK sector.

Device-specific design and validation projects should provide more information on the actual design geometry. The reviewers were unanimous in stating that they would like to see more details and examples demonstrated during the peer reviews. They recommended that WPTO require developers to provide at least a topographical representation or description of the device under investigation (point absorber, attenuator, or oscillating wave surge converter, for example).

WPTO should undertake techno-economic assessments (such as through WaveSPARC) and, at minimum, quarterly detailed design reviews as part of the technology-specific design and validation activities with the developers. Lab integration of tools at early stages with developers is vital for success to the MHK sector. These recommendations are also iterated in the Foundational and Crosscutting R&D activity area.

The panel recommends integration of testing to the standards for developers at technology readiness level (TRL) 7–8. Incorporation of testing to standards and feedback to WG360 will improve the performance and applicability of the standards. The future projects in the MHK program, such as PacWave and TEAMER, should support this effort with developers. It is a vital activity for the medium/long term (reduction of risks and improving investor confidence) for the Technology Specific Design and Validation activity area.

Summary of all Reviewers' Comments

Overall Impressions

The Technology Specific Design and Validation activity area covered two wave developers that the reviewers considered at concept to TRL 4, one wave developer at TRL 5–6, and one wave and tidal developer at TRL 7–8. The reviewers agreed that most projects aligned well with the program strategy and objectives, as stated in the presentations. The developers at concept to TRL 4 have yet to conduct in-water tests (in-sea tests), and thus project teams validate performance models during tank testing.

There was a significant difference between the wave developers at earlier TRL levels. One was well organized and appropriately demonstrated test planning, including a description of results with high confidence by reviewers that they are on a successful path toward a competitive LCOE, even without seeing the actual design geometry. The reviewers had less favorable comments on the second developer's technology development pathway, with a recommendation for WPTO to provide a techno-economic assessment of the concept.

The wave developer seeking to improve and validate the number of design iterations at TRL 5-6, had reviewer comments that questioned the design and recommended that WPTO undertake a techno-economic assessment of the device. "This project is one of four utility-scale wave-energy devices headed for at-sea tests. This project is not as far along… having recently completed a preliminary design go/no-go. The reviewers find it difficult to see a path to economic utility-scale power, and there is insufficient detail in the summary and presentation to make an accurate judgment."

The tidal and wave developer at TRL 7–8 had different reviews overall. There is significant agreement among the reviewers that the tidal device presented "is one of the more well-developed MHK projects in the DOE portfolio."

Whereas the wave device presented gave way to comments that are concerned about the size versus the power rating. “The MHK sector experience to date has displayed that you can develop/build/commission large construction projects only to have failures in poor generation results.” These results further erode investor confidence, and reviewers recommended that WPTO provide a detailed techno-economic assessment of the device.

The panel agrees that where the labs are well integrated and supporting the developers, the impact on project performance results is vital to the success of the program.

The other three projects described are focused on standards development, the development of a techno-economic assessment tool, and validation of an innovative material, which could be a paradigm shift in structural device designs. All are led by the labs and were recognized for their experience and innovation. Most reviewers responded favorably and supported these projects as part of the activity area and MHK program.

Program Strategy and Objectives

All reviewers agreed that there is a split between developers in the activity area that demonstrate good value and performance, as well as provide confidence toward a competitive LCOE. The reviewers agreed that the program supports efforts to validate device designs, but the most significant impact of this support is when the labs integrated within developer projects. A developer “demonstrated good synergy with Sandia. The impact is clearly described in terms of results: used to verify the system identification principles/approaches published by Sandia.”

The reviewers are not sure of how well the activity area supports the program objective of ensuring long-term sustainability of the MHK sector. The reviewers agree that less performing developers are not providing a clear demonstration of device design performance. The panel agrees that further assessment is required by WPTO to manage stakeholder expectations and confidently utilize taxpayer funds. It will ensure the long-term sustainability of the program, while continually testing and validating new innovations as introduced in the sector.

What is not clear to the reviewers is the link between the activity area approach (technology specific design and validation) and projects presented to the challenge of installing and operating reliable systems. There were device-specific presentations in the Foundational Crosscutting R&D portfolio that would have fit better in this activity area (e.g., the HAT integrated into the OE Buoy, or the Columbia Power Technologies device). Although each developer has aligned across the activity areas, can the two approaches now be incorporated? Opportunities for shared lessons learned during installing and operating activities, as well as innovations in components and materials should help accelerate the sector.

Program Portfolio

Reviewers did comment that there is a split between device designs and how they are addressing the critical challenge of installing and operating reliable systems. Only one device design presented convincingly on the installation and operating challenges. One reviewer commented that the developer should, after in-water tests, incorporate lessons learned quickly and effectively in design upgrades. The portfolio provided less evidence that installation and operating reliability challenges are addressed.

The reviewers consider all other aspects of the portfolio, including contribution to program strategy and objectives, the rationale for funding and approach taken, balance of research priorities, resource allocation, and WPTO's role, to be appropriate.

Program Management Approach

All reviewers agreed that the WPTO program team is highly competent and energetic in the delivery of the program. The team is focused on creating the most significant impact on advancing the sector. It is evident that the WPTO staff effectively engage and influence the developer projects to bring them closer to successful outcomes. The program team has demonstrated strong professional and technical capabilities, including active portfolio management.

Stakeholder Engagement, Outreach, and Dissemination

The reviewers agree that the outreach achieved in the standards projects and demonstrated by a couple of the developers and how they are incorporating, applying, and critically evaluating the standards is of great value to the sector.

The reviewers are unanimous that developers should provide more detail in their concept description or design representation. The MHK program strategy states, "the WPTO program is committed to sharing and disseminating the results of government-supported R&D while respecting the intellectual property rights of industry partners to ensure public investment in MHK technologies advance the state of the entire industry." During the peer review, this was a hot topic of discussion during the Q&A session. The panel and audience do not necessarily agree that there is consistent transparency. The panel expects WPTO to give clear guidance on how it is managed for future peer reviews.

As mentioned in the summary of the Foundational and Crosscutting R&D activity area, the peer review process in and of itself is an excellent example of communicating how WPTO funds are being utilized and providing evaluations (reviews) on the success and impacts of the projects as a whole.

Project Evaluations

WAVESPARC

(WBS #: 2.2.1.402)

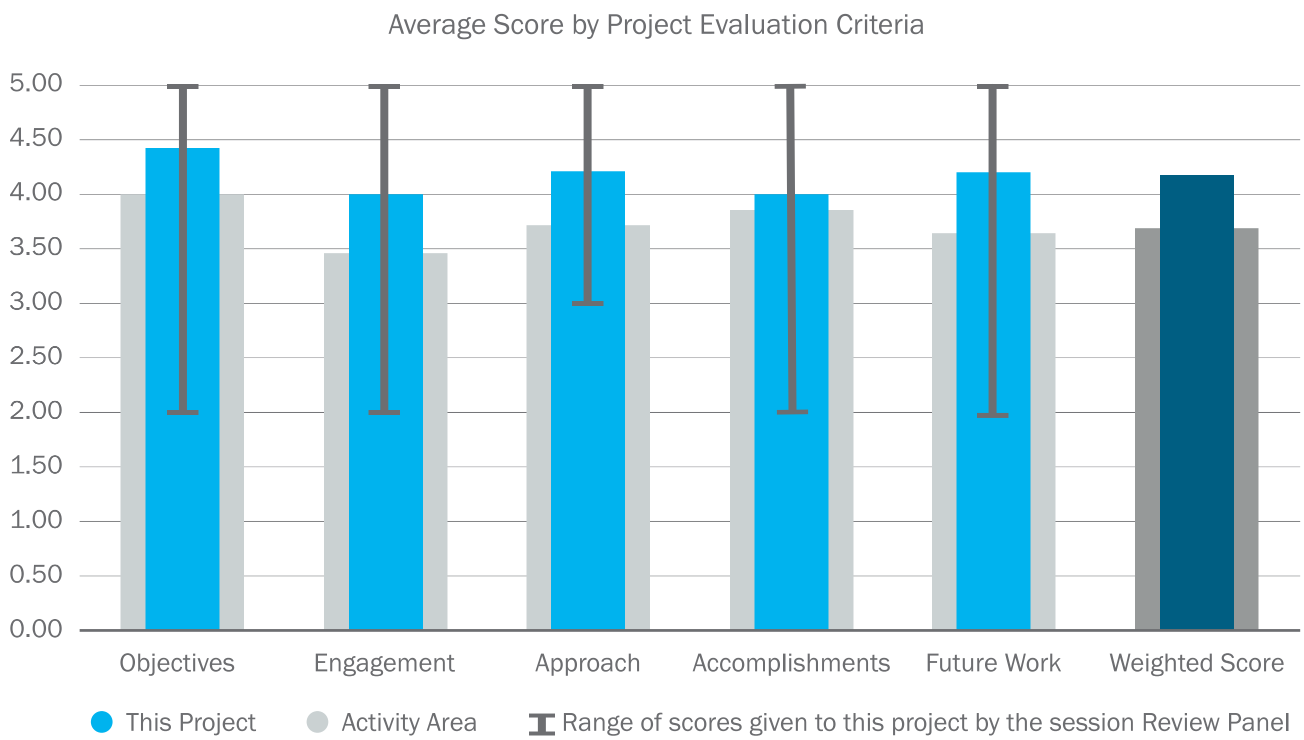
Recipient:	NREL
Principal Investigator:	Jochem Weber
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$4,866K
Total Costed:	$3,378K

Project Description

The core objective of Wave-SPARC is empowering the marine energy community with the tools necessary to achieve a significant improvement in techno-economic performance of wave-generated grid power. A detailed systems-engineering approach simultaneously balances around 100 cost and performance drivers (functional requirements and capabilities) for WEC devices. This holistic approach is crucial for unlocking the vast wave energy opportunity. This project has delivered publicly accessible technology innovation and assessment methods and tools (new to the wave energy sector), which are used to identify potential novel, high-promise WEC concepts for further exploration, development, and commercialization. Leveraging these tools, WEC techno-economic performance increases can be realized by implementing the technology development trajectories with the lowest possible cost, schedule, and risk mitigation at the earliest stages of development. Future efforts will expand Wave-SPARC capability to the various PBE maritime markets (e.g., ocean observation, autonomous underwater vehicle recharge, desalination).

Weighted Project Score: 4.2

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

Reviewers thought this was a great project and demonstrated perseverance in the midst of protests from developers. The tool is informative as to what projects are worth pursuing with a high TPL level, as well as "structure innovation" to new paradigms in MHK topology development, with a glidepath to commercial LCOE potentially.

Project Objectives, Impacts, and Alignment with the Program Strategy

Project performers have demonstrated alignment with program strategies by continuing to drive device design innovation, through component controls and early stage R&D. The project builds collaboration between users and provides a valuable tool for developers. This project, if successful, has the potential to set the program strategy in the future.

End User Engagement and Dissemination Strategy

The project performers have identified who will benefit from this project and how the success of the project will advance the industry or meet the needs of specific stakeholder/end user groups.

Many stakeholders have already benefitted, and will further benefit, from the successful outcomes of the project to date and in the future. It provides an important structure for nascent wave energy developers to cover all the ilities in a holistic design sense. The project performers have not fully explained whether specific industry members or end users were engaged/are planning to engage and at which points in the project.

Management and Technical Approach

Although the objective of the project was clear, the management and structured innovative process applied was not clear for the down-select approach used in this project.

Technical Accomplishments and Progress

The 500 use cases and 100 technologies appear very impressive. What would be useful to see is the impact the tool is having for its users.

Future Work

The future work to build the user-friendly interface in practice is a welcome plan for this tool. The future work is well organized, divided into project branches with individual details.

FLEXIBLE MATERIAL WEC TECHNOLOGY TECHNO-ECONOMIC PERFORMANCE

(WBS #: 2.2.1.407)

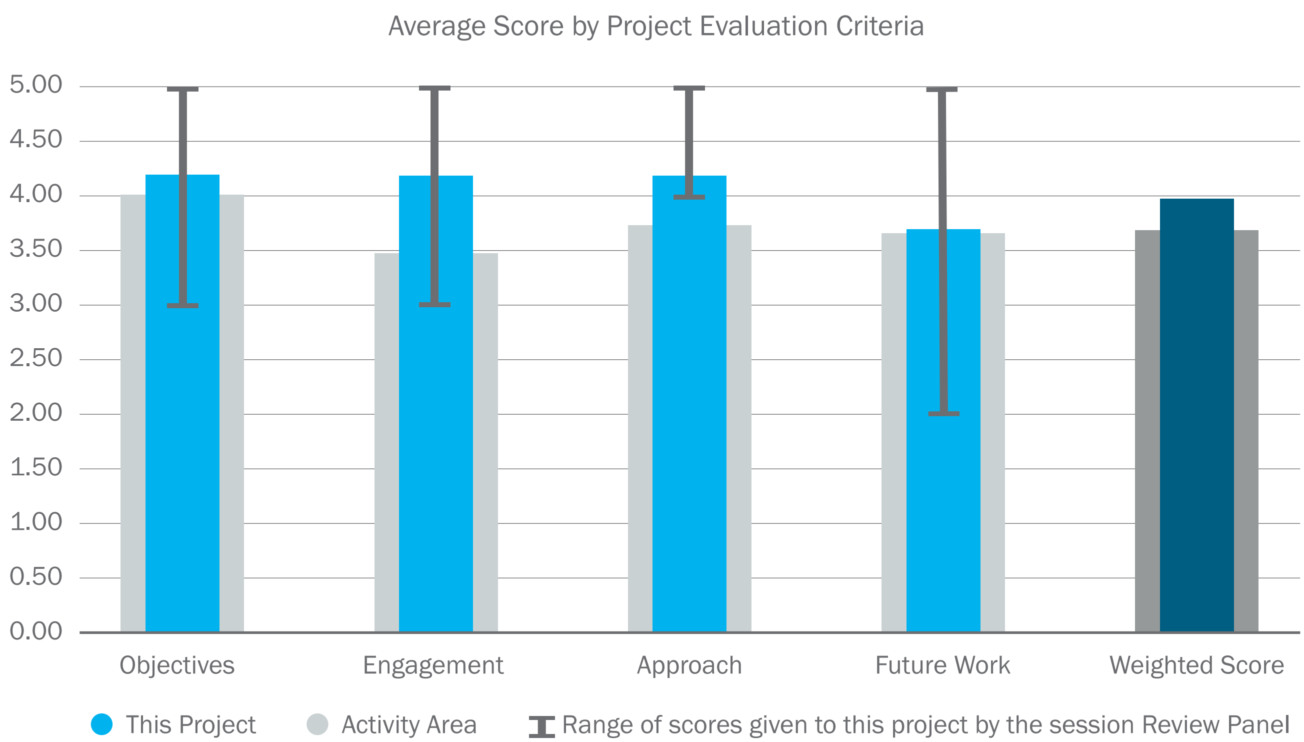
Recipient:	NREL
Principal Investigator:	Jochem Weber
Project Type:	AOP
Project Category:	New Projects
Total Authorized:	$426K
Total Costed:	$51K

Project Description

WECs using flexible materials with distributed PTO systems (FMDP-WECs) have attractive features: (1) broad-banded wave energy absorption; (2) redundant PTO systems; (3) low material costs; (4) ease of deployment and survival mechanisms; (5) reduced maintenance schedules; and (6) near-continuous structural control. Accordingly, this project's objective is to identify, understand, and evaluate foundational characteristics of FMDP-WECs for their general techno-economic assessment. Therefore, the project team will provide descriptions of archetype FMDP-WEC technology with corresponding appropriate assessment criteria, achieve numerical modeling techniques and outreach programs, and identify future innovation pathways.

Weighted Project Score: 4.0

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

Reviewers generally agreed that this is a successful project with the potential to provide disruptive new technology for PTO systems in WECs. One reviewer stated that this is an exciting project that could unlock the economic potential of MHK devices more than other presented concepts, as long as material can meet LCOE goals. This is an important effort. Given how difficult it has been to realize cost-effective WECs using existing and mature technology (hydraulics and generators), an innovation in material science will likely be necessary to make wave energy cost effective.

Project Objectives, Impacts, and Alignment with the Program Strategy

Reviewers found positive consensus that this is a valuable project with significant potential impacts, although a fairly new technology. One reviewer wasn't sure that this was in alignment with the program strategy, perhaps because it is so different from previous WEC tracts funded, but agreed that it was a good project if in alignment.

This project represents a paradigm shift in thinking in the MHK ecosystem, with distinct advantages over current rigid structure Gen-1 approaches in terms of load shedding and efficient use of structure. Reviewers thought this project was very innovative and had positive feedback on the following project activities:

- Research into the embedment of distributed PTO systems within relatively inexpensive and easily manufactured structurally flexible materials (e.g., synthetic plastics and/or natural rubbers)
- Use of inexpensive and easily manufactured materials for novel PTO systems that are effective and efficient (e.g., stretchable elastic capacitors, miniature electrolytic generator cells, static electricity nano-generators, and/or magnetostrictive fibers)
- Use of distributed PTO systems—hundreds or thousands of PTOs being embedded throughout a WEC structure
- Ability to respond to inherent PTO redundancy—if a few PTOs fail, the FMDP-WEC is, overall, unscathed
- Semi-infinite control of the FMDP-WEC structure—the distributed embedded PTO system is a means of control for an FMDP-WEC structure, thereby enabling greater structure-ocean-wave-resonance
- Use of advanced manufacturing and/or novel new material-manufacturing synergy techniques.

Numerical modeling of this technology is novel as well, and the development of numerical models for this technology will also provide valuable new tools to the community. Although this project is in the very early stages, reviewers suggested considering implications for at-sea deployment, maintenance, and recovery strategies as early as possible by considering a specific example of this technology; the report refers to the SBM Offshore S2 WEC.

End User Engagement and Dissemination Strategy

The reviewers' scores ranged from average to good in this category. Examples of very favorable reviews of the project strategy include:

- The project performers have clearly described the rationale for the stakeholder/end user engagement strategy and how project results and information have been/will be disseminated.
- The project interacts directly with a private developer and SBM Offshore, and it has plans to disseminate project outcomes through technical reports, journals, and presentations.

- They provide a good working foundation for addressing specific issues and promoting new discoveries.
- It would be valuable for the team to identify additional developers that could also benefit from this effort.
- There is at least one other project funded by DOD that could leverage this effort. Pliant Energy Systems (PES) should be engaged in this effort early as a collaborator as well, and other similar developers should be sought.

Less favorable comments include:

- It is not clear what the dissemination strategy is for this project.
- The summary and presentation don't really describe much beyond the standard "technical publications and conference presentations."

Management and Technical Approach

Reviewers agreed that this project demonstrated a sound management and technical approach. While reviews were generally favorable, noting that the project performers provided an overall excellent description of the critical success factors to investigate, which will define overall success of FMDP-WEC viability, they shared several suggestions for this early stage project:

- Involve PBE requirements (aquaculture), as this could be a step change for both sectors.
- Integrate power into product (FMDP material into aquaculture cages), which would be similar to integrating solar into roof tiles.
- Research, distill, describe, and model those archetypical characteristics defining FMDP-WECs.
- Identify those cost-performance drivers predominantly associated with FMDP-WECs technologies
- Assess the potential for FMDP-WECs to be game-changing, paradigm-shifting forms of WEC technology.

Performers describe the challenge to modeling their particular type of WEC and clearly understand some of the challenges. It would help the review to have an example description of the existing SBM Offshore S3 technology with diagrams/pictures for consideration. In addition, if it isn't too soon to consider LCOE, it shouldn't be too early to consider practical considerations for deployment, maintenance, and recovery strategies that will be essential to accurately estimate LCOE. "Offshore engineering and marine operations" are mentioned in the management approach without further detail.

Technical Accomplishments and Progress

It was apparent to the reviewers that this project is at too early a stage to have high expectations for technical accomplishments and progress. However, there were recommendations made for the project as it progresses, and some questions posed.

The tasks and work done to date have high potential impact for the industry, and the reviewers hope the knowledge (including the promising elements of design) makes the intended impact once transferred to and applied by WEC developers. One concern expressed was that the PI did not mention any validation attempts or baseline metrics that the team is considering for this technology.

Future Work

Reviewers lacked consensus in this category, with scores ranging from 2–5. One reviewer felt that information provided on the plan for future work was a bit vague and not entirely focused on the most important aspects of the project's scope. A project website and journal articles related to project approach are not going to have a big impact without the successful identification and evaluation of materials that could be useful, as well as a concept design showing how these materials would be used with a quantifiable benefit over existing technologies. Reviewers would have liked more details about next steps, and they noted that details about integration with other sectors (semiconductor, textiles, etc.) would have been appreciated. Finally, reviewers recommended the project team seek and engage developers of similar technologies early to share in this study.

STANDARDS DEVELOPMENT FOR MARINE ENERGY

(WBS #: 2.2.3.401)

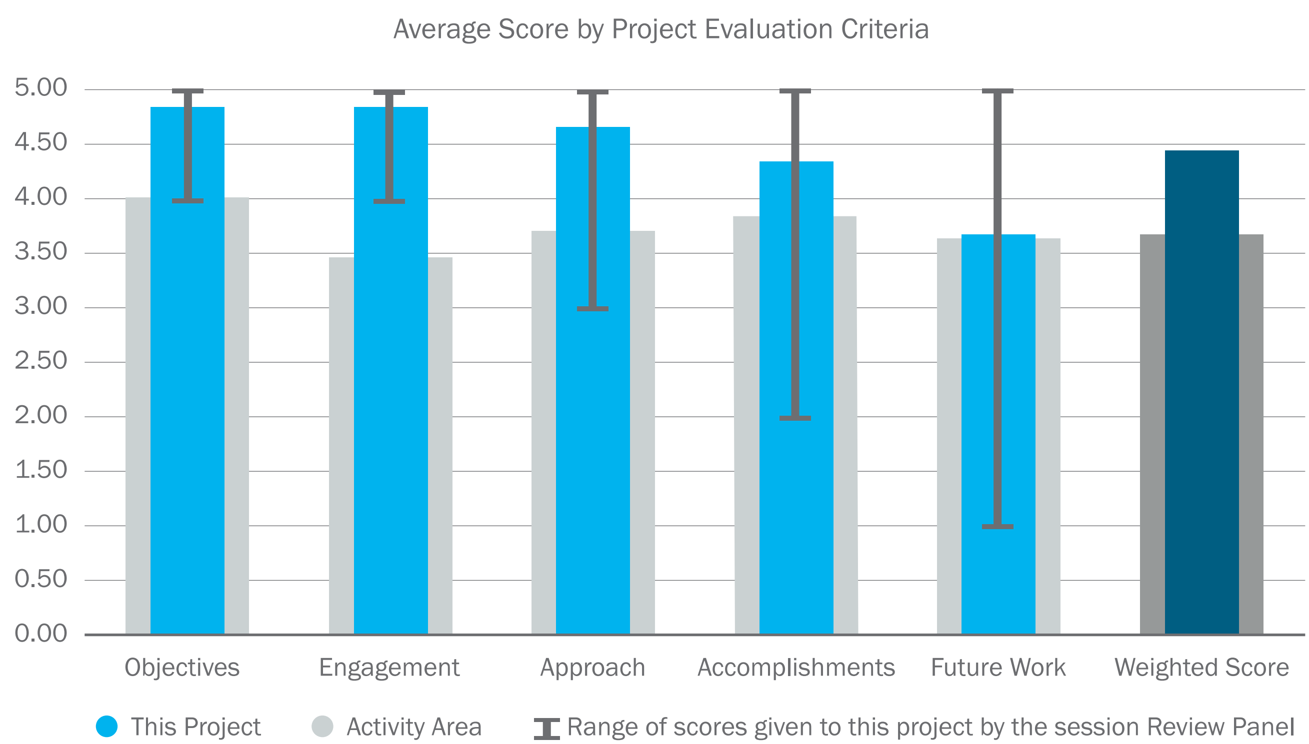
Recipient:	NREL
Principal Investigator:	Walt Musial
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,934K
Total Costed:	$1,536K

Project Description

The project comprises two primary activities: (1) standards development and conformity assessment by the IEC TC 114 Marine Energy and IEC System relating to renewable energy applications (IECRE), and (2) U.S. representation on the IEA-OES Executive Committee. Consensus-based, internationally recognized standards and conformity assessment are vital to the industry to ensure safety, reduce market barriers, and increase confidence in the technology. DOE's support of IEC and IEA-OES is the only formal international project connecting the Program with the global industry and is necessary to construct a well-informed, targeted Program. These activities will help accelerate the development of ocean energy devices in the United States by providing critical information on international ocean energy research activities, such as standards working groups, workshops, and technology benchmarking tasks.

Weighted Project Score: 4.4

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers recognize NREL's experience in wind and solar standards development as a strength for the overall leadership of this project and MHK standards. The contributions made by the coordinated activities of NREL to the U.S. Technical Advisory Group and internationally at IEA-OES and IECRE are exemplary. The reviewers caution, though, that the success of the project may have overtaken the U.S. MHK device development progress. The reviewers recommended a performing baseline assessment of standards through test site application and testing the applicability of standards, including the provision of improvement feedback to the IEC TC 114.

The reviewers want to commend NREL and WPTO on the vision and focus of this critical project, as well as the initiative of contributing to the international standards community. The reviewers want to ensure that standards development and conformity assessment are integral initiatives into future projects such as PacWave, TEAMER, and lab support to developer projects.

Project Objectives, Impacts, and Alignment with the Program Strategy

The NREL-led project demonstrates a key project aim in the U.S. coordinated activities supporting the IEC, IEA-OES, and IECRE development of marine energy standards and conformity assessment.

This project provides formal U.S. representation at the international level. Without DOE funding of these activities, the MHK sector would struggle to reduce technology risks and gain investor confidence, thereby limiting overall sector progression to commercialization.

The reviewers agreed that the project objectives aligned directly with the MHK program approach for technology-specific system design and validation that address the challenges of installing and operating reliable MHK systems.

The reviewers agreed the project demonstrates how the outcomes of its activities will eventually impact the following in the near, mid, and long term MHK technology development:

Near term:

- Increase access to critical data and provide growth opportunities with international collaboration.
- Enable DOE to construct a well-informed and targeted ocean energy research program.
- Provide feedback to the U.S. sector on international activities.

Midterm:

- Help regulators manage public safety by reducing failures.
- Reduce technical risks.

Long term:

- Gain investor community confidence for project financing.
- Accelerate the commercialization of marine energy technology.

Reviewers clearly understood the importance of the NREL project as this work is supporting vital standards development. The technical accomplishments include international collaboration activities benchmarking WEC simulation models and LCOE; representation at IEC TC 114, IEA-OES, and IECRE; and outputs from engagements such as the annual reports to DOE. The reviewers thought the project was clearly achieving near-term goals and recommend WPTO project managers focus on future activities that address the mid-term and long-term objectives, such as building conformity assessment into PacWave accreditation strategy, thereby achieving Renewable Energy Testing Laboratory status.

The project demonstrated significant outputs from its activities, including publications, U.S. representation, and subject matter experts recruited to U.S. Technical Advisory Group, IEC TC 114, and IEC ME-OMC groups. The nomination and support of young professionals in the standards program is vital to the sustainability of U.S. standards engagement, as are the newly launched U.S. Technical Advisory Group website and the successful ongoing international commitment through meetings and workshops.

End User Engagement and Dissemination Strategy

The project demonstrated who the end users are and how they will interact and benefit from the standards development activities. Most immediately notable end users are the developers, researchers, and WPTO. A few developers, through the peer review presentations, are addressing the implementation of specific standards. The annual report to DOE supports evidence that the project delivers critical information on international progress and activities back to WPTO.

The presentation did not describe how the project engaged with other end users. The regulators, certification bodies, and test centers do not seem to be taking up the requirements for standardized test reports and conformity statements as quickly as needed for the advancement of the industry. The challenge back to NREL is how can they influence and lead in best practices to improve international acceptance.

Dissemination activities described by the lead project performer are outstanding. DOE support of NREL to manage this activity, especially the management of 25 subject matter experts and participation in international meetings and workshops, is vital to the success of the MHK program.

Management and Technical Approach

The reviewers agreed that the strength of the project lies in NREL experience and management of standards development. There is a detailed management plan with milestones. However, a reviewer noted that without an end milestone that has a defined goal post for baseline standards documentation, the developer is at risk to be in an infinite loop trying to certify their program with an evolving certification process.

Reviewers identified another risk, stating that the development of standards has overtaken MHK device development progress. Stating that if the project team accelerates the technical approach (as demonstrated by the support activities to the IEC TC 114) without follow-on implementation back into the U.S. developer community could slow down the successful installation and operation of a reliable MHK device.

Reviewers recommended that NREL and the 25 subject matter experts develop a report on best practices in standards implementation to disseminate into the U.S. developer sector.

The reviewers also noted that the project technical approach lacks a description of critical success factors.

The reviewers questioned several potential critical success factors. What are the technical barriers? What are the gaps in the certification process that should be addressed? What tools are required to enable the implementation of standards and methods for safe, cost-efficient installations? What is the pathway to certification? The answers to these questions are critical success factors and should be emphasized and described in the technical approach.

Technical Accomplishments and Progress

As noted above, the technical accomplishments are the results of activities that are addressed for the near-term objectives:

- Increase access to critical data and provide growth opportunities with international collaboration.
- Enable DOE to construct a well informed and targeted ocean energy research program.
- Provide feedback to the U.S. sector on international activities.

The challenge will be for NREL to demonstrate at the next peer review how they have achieved progress toward the mid and long-term objectives:

- Help regulators manage public safety by reducing failures.
- Reduce technical risks.
- Gain investor community confidence for project financing.
- Accelerate the commercialization of marine energy technology.

The proof will be dependent on a viable industry that is developing at the same pace as the standards development.

Future Work

Reviewers thought the future work, as described, needed more vision and detail.

The reviewers recognized the importance of the continued participation and contributions at IEC, IEA-OES, and IECRE, as well as the international collaboration undertaken through the benchmarking activities. However, the focus on standards for cable laying and grid connection will outpace the development of fit-for-purpose cable and connector designs for MHK devices.

Reviewers recommended that the project team provide more detail in the next budget period phase of this project, especially addressing PBE and integration into standards development. Will PBE make the pace of MHK standards development more apparent and potentially irrelevant?

AZURA DEMONSTRATION AT THE NAVY'S WAVE ENERGY TEST SITE (WETS)

(WBS #: EE0006923)

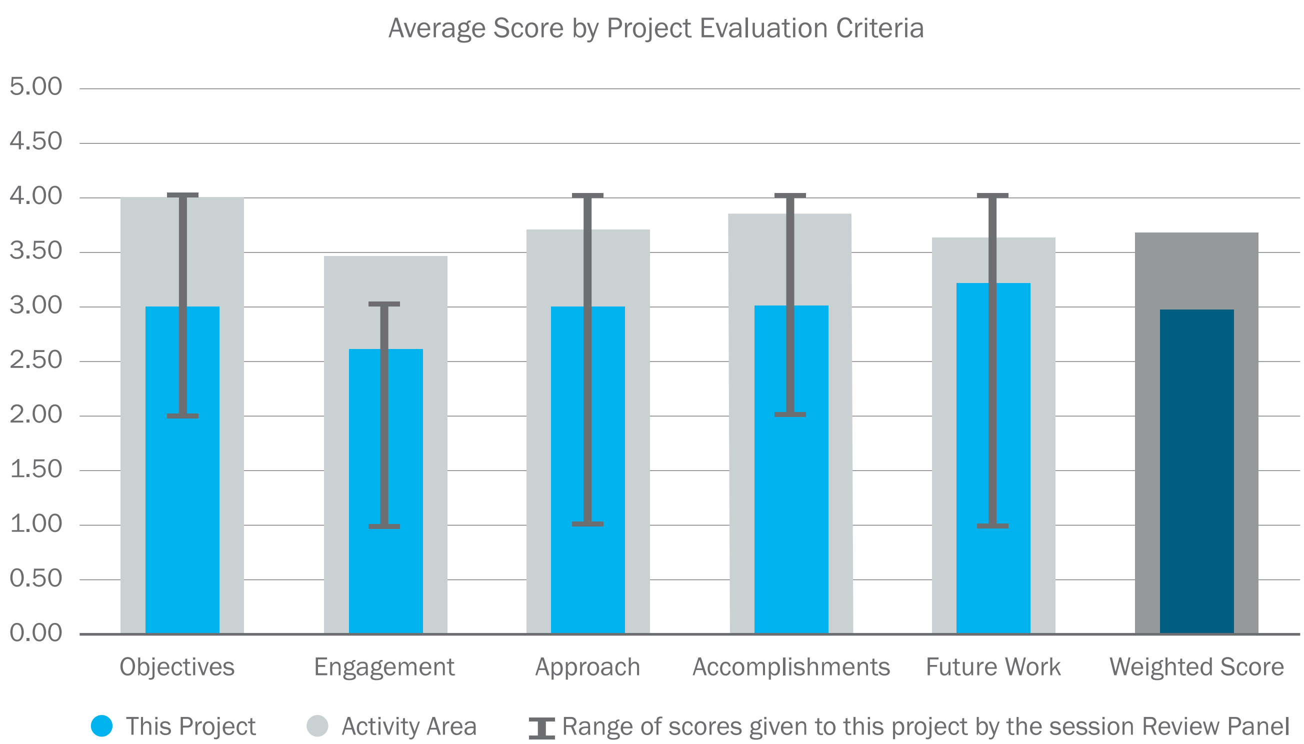
Recipient:	Northwest Energy Innovations
Principal Investigator:	Steven Kopf
Project Type:	FOA 1081: Marine and Hydrokinetic Demonstrations at the Navy's Wave Energy Test Site (WETS)
Project Category:	Ongoing Projects
Total Authorized:	$9,623K
Total Costed:	$1,476K

Project Description

The objective of the project is to design, fabricate, deploy, and test a full-scale 250-kW Azura wave energy device appropriately sized for the Hawaii wave climate with an LCOE reduction over previous WECs, demonstrating a pathway to commercialization. Northwest Energy Innovations (NWEI) plans to test the Azura device at the Navy's WETS located at the Marine Corps Base Hawaii for comparison of performance, reliability, and LCOE. The preliminary design of the 250-kW Azura device has been completed; predicted performance has been verified with 1/15th scale wave tank testing; and detailed design tasks are currently underway.

Weighted Project Score: 3.0

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

Reviewers recommended that the new methodology as described in the WEC design optimization program be evaluated for the Azura design and that it undergoes detailed techno-economic assessment to determine if there is a credible pathway to competitive LCOE. This project is one of four utility-scale wave-energy devices headed for at-sea tests. This project is not as far along as C-power and Ocean Energy, having recently completed a preliminary design go/no-go. The reviewers found it difficult to see a path for Azura to achieve economical utility-scale power, and there is insufficient detail in the summary and presentation to make an accurate judgement. Performance aside, the presentation did indicate a reasonably scoped project, and they highlighted that a key factor for success is the development of a cost-effective, robust, and reliable structure. As they are earlier in the process than the Ocean Energy and C-Power designs, the reviewers think that the performer or perhaps DOE should make a comparison of the techno-economic viability of this project compared to the others. The underlying issues of the two-year delay need to be understood. The reviewers felt that funding should be directed to MHK developers that are making progress toward deployment; therefore, it is important that progress is made and a viable pathway to cost-competitive LCOE is understood for NWEI.

Project Objectives, Impacts, and Alignment with the Program Strategy

The objective of the project is to design, fabricate, deploy, and test a full-scale 250-kW Azura wave energy device appropriately sized for the Hawaii wave climate, with an LCOE reduction over previous WECs, demonstrating a pathway to commercialization. The project performers presented the relevancy of this project and how successful completion of the project will advance the state-of-the-art technology, meaningful impacts, and/or the viability of any commercial applications through the following:

1. Advance understanding of innovative MHK technologies in the ocean environment
2. Demonstrate system durability in a highly energetic ocean environment
3. Validate numerical models to allow commercial-scale design validation.

Strengths

- Reviewers agree the Azura project does align well with WPTO's priorities to conduct in-water tests of industry-designed prototypes at multiple relevant scales.
- Based on the project's objectives, the reviewers thought this work also aligned well with the MHK Program's objective to advance System Integration R&D and Testing of Prototype Devices.

Weaknesses

- The target LCOE of the prototype is $500/MWh. At 50 cents/kwh, this is not going to be cost competitive with the exception of isolated coastal communities reliant on diesel generators. The reviewers suggest NWEI consider aligning better with the PBE strategy and consider potential Blue Economy markets.
- The project team's description of the performance of the device and its rated capacity were insufficient in detail.
- The validation of the performance was during tank testing and not in-sea tests. It is also noted that device power rating was reduced from 500 kW to 250 kW due to the electrical infrastructure at WETS. It is not apparent if the first prototype to go in was rated at 500 kW and then it was found that it could not be grid integrated due to the WETS electrical infrastructure.

- It is doubtful that a 12-month test will demonstrate useful data for device design life.
- The potential impacts described were generalized and would have been better if they were more specific to the NWEI device.

The goal of this project is clearly aimed at cost-effective, utility-scale power, which fits into the stated goals of the program. However, there is a big question as to whether or not this is possible, which the summary and presentation seemed to acknowledge.

End User Engagement and Dissemination Strategy

The statements of end user engagement are practical in that they recognize that the utilities are the end users, and successful dissemination will require a reliable and robust device. They also deserve credit for their plan to upload their test data to the Marine and Hydrokinetic Data Repository (MHKDR) after the 5-year moratorium expires. Although some conference presentations have been delivered, there is not a clear formal dissemination and engagement strategy in place. The reviewers felt like there were only nominal efforts at dissemination and end user engagement for a WEC developer. Data dissemination is discussed with data uploaded to the MHKDR and the 1/15th scale experimental data disseminated at conferences.

Reviewers felt the project lacks engagement from the broader MHK community. What results were shared on the wave tank tests with SNL or NREL? Reviewers did acknowledge efforts to disseminate data through numerous relevant conference venues.

Reviewers were confused by NWEI stating the aim was to achieve LCOE and provide confidence to utilities, while also stating that they have ongoing discussions with utilities but no “formal stakeholder engagement planned.” The primary objective of engaging utilities and energy investors is to validate that the project provides confidence to secure the ongoing private investment required to advance the technology. The reviewers recommended the presenter be clearer in this messaging in the future.

Management and Technical Approach

The reviewers found it difficult to discern whether the LCOE metric is achievable based on the data provided. It appeared that the team carried out some good wave tank testing at 1/15th scale, but the results were effusive with the exception variable versus baseline hydraulic control. The second budget period will consist of detailed design activities. This will include developing structural load estimates; developing a detailed structural design; finalizing the PTO design, grid interface designs, and a mooring design; and developing an O&M plan. NWEI will also develop a commercialization plan and update the LCOE and AEP analysis of the design. Once the detailed design is completed, the next major project milestone is the Critical Design review #2.

Concerns:

- How does the tank test translate to full-scale results?
- The project has been stalled out for two years, and there doesn’t appear to be any traction with full-scale design development.
- The reviewers do not see any progress toward the second budget period deliverables, seeing cogent milestones but no progress toward them. The project seems stalled out due to budget shortfalls, a critical flaw to the technological approach, or a combination of the two. Risks are not identified, nor mitigated.

- Although project partner roles are clearly documented, there does not appear to be a clear management structure in place for this project.
- There was no discussion of risk for the full-scale PTO design/build, and it seems there would be a significant number of risks there.

The project performers described the project management approach through a work breakdown structure. Interface with other projects funded by WPTO was also described. The PI also covered the high-level project schedule with go/no-go dates and assumed milestones, with the Installation Readiness Review in 2021. NWEI described a project strength as the utilization of expertise at NREL, whereby NWEI is working with NREL to determine structural loads (WEC-SIM) that will impact the design of the full-scale Azura.

Based on the review of the SNL WEC Design Optimization project led by Ryan Coe, it should be decided whether Azura should be engaged to utilize this tool prior to final design. Reviewers recommended that the new methodology as described in the WEC design optimization program be evaluated for the Azura design.

The program mentions effective use of scaled testing to reduce risk and aid design as scales increased. The summary gives details for significant studies that will be leveraged to de-risk and improve the prototype design.

Technical Accomplishments and Progress

A 1/15th scale model was constructed for testing at the University of Maine. A test campaign was performed to validate the numerical WEC-Sim model of the Azura used to estimate power production, verify the predicted performance of the Azura in irregular sea states, and perform preliminary survivability tests. The hydraulic PTO dynamics were included in the wave tank testing via a hardware-in-the-loop scheme. The performers shared some specific, clearly described metrics regarding their program during the presentation

Concerns:

- Outside of the 1/15th wave tank tests, this program has not shown consistent execution.
- The outputs and accomplishments were explained, but there are still some concerns on budget period one’s budget overrun and no decision for budget period two or three yet.
- The fact Azura is still in the design phase (preliminary) is concerning. This is a 7-year project (2015 to 2022), and so far, the preliminary design phase has taken 4 years.
- Downsizing from 500 kW to 250 kW is not a technical accomplishment.
- NWEI is making progress with the technical aspects of the program and have completed modeling and scale wave tank testing. They show some results, which indicate close agreement between modeling and testing. Unfortunately, there aren’t results presented that demonstrate a path to cost-effective power beyond the statement of expecting specific LCOE. The assumptions and modeling that go into that estimate are critically important.
- It is too early to assess the overall technical achievements. It is not clear whether there is a clear strategy to achieve an attractive LCOE. Reviewers suggest this is investigated prior to the go/no-go review.
- There is no mention of baseline metrics from their test campaign. They do offer an opinion that testing was good enough to provide confidence.

There is some good execution from the PI on the wave tank test that the reviewers would like to see translated to the rest of the program. Reviewers acknowledged good work modeling the hydraulic PTO response.

Future Work

The reviewers expressed the following about the project's future work:

- What is the progress toward the second budget period objectives?
- The future plans are made unclear by mentioned negotiations. The presentation elaborated on some future work, including pressure distribution for finite element analysis.
- The summary provides high-level details for schedule and milestones.
- The reviewers feel this program should be seriously scrutinized and reviewed.
- The next budget period's work involves detailed design. As NWEI plans to "refine" the LCOE, WPTO oversight should probably pay close attention to this refinement to ensure this project is headed toward a successful outcome if built.

DEMONSTRATION OF THE OE BUOY AT US NAVY'S WAVE ENERGY TEST SITE

(WBS #: EE0006924)

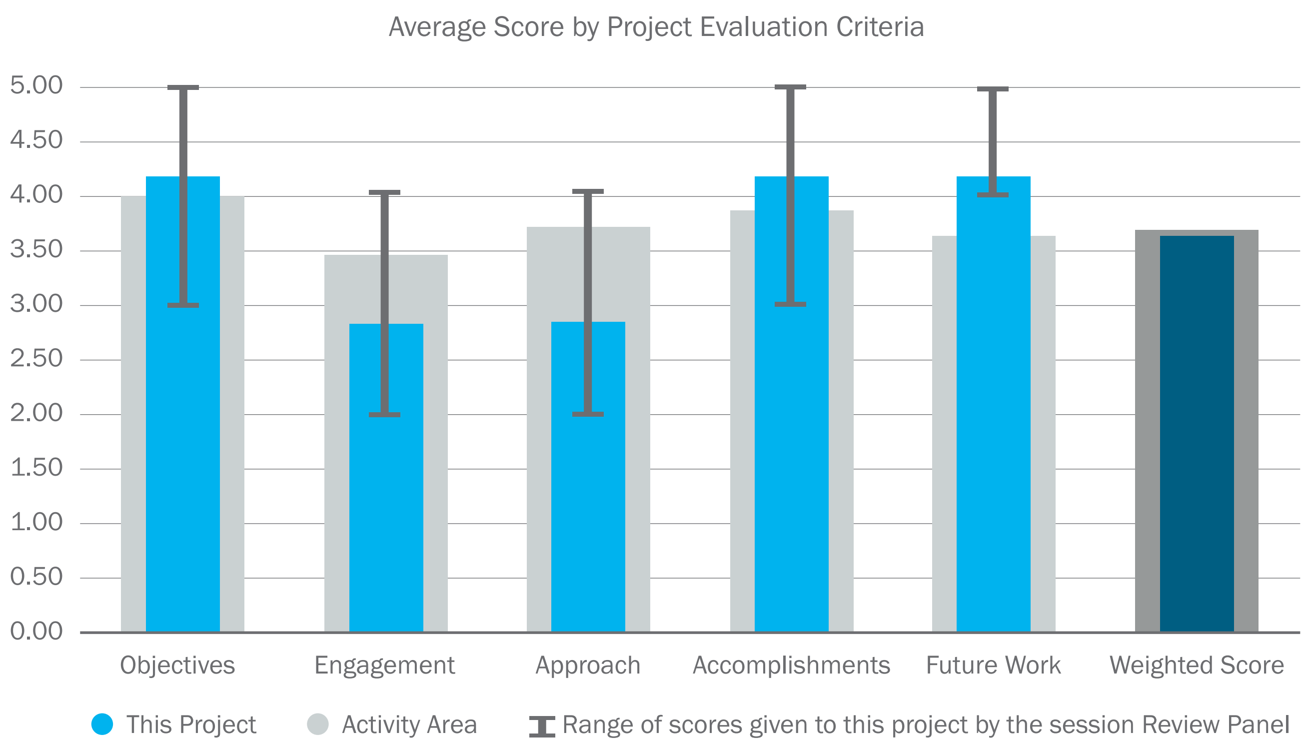
Recipient:	Ocean Energy USA LLC.
Principal Investigator:	Tony Lewis
Project Type:	FOA 1081: Marine and Hydrokinetic Demonstrations at the Navy's Wave Energy Test Site
Project Category:	Ongoing Projects
Total Authorized:	$11,650K
Total Costed:	$8,589K

Project Description

The OE Buoy is based on the floating oscillating water column concept, which uses variability in wave height to move air through an air turbine that rotates in a single direction. The device isolates the power conversion system from seawater and provides a high-speed air flow to the turbine to generate electricity. The OE Buoy has been tested at quarter scale in real sea conditions for over 3 years, resulting in a TRL level of 6. The OE Buoy will be demonstrated for 12 months at large scale, with a prototype machine rated at 500 kW at the U.S. Navy's WETS in Hawaii.

Weighted Project Score: 3.6

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The MHK sector experience to date has displayed that you can develop/build/commission large construction projects only to have failures in poor generation results. The funding that goes into demonstration projects with lower-than-expected results contributes to a watered-down success story for the entire MHK sector. It is strongly recommended that OE/HydroAir turbine integration undergo detailed techno-economic analysis to determine if there is a credible path to a competitive LCOE.

Project Objectives, Impacts, and Alignment with the Program Strategy

The main project objective is to make a full-scale demonstration of Oscillating Water Column energy production for an extended length deployment. This is a very ambitious undertaking requiring a sizable investment that would produce a meaningful result of the WPTO program. What is not clear is how the economics of this device are viable; it is a large structure for a modest amount of electricity. It would seem a system failure or an under-performance of the energy production during this test would be a significant failure and setback for wave energy.

End User Engagement and Dissemination Strategy

There have been conference presentations and DOE engagement, but it is not clear what the dissemination strategy is for this project. The reviewers would have appreciated more of a discussion on who will benefit from this project and how project performers planned to meet the needs of their key stakeholders or end user groups.

Management and Technical Approach

The reviewers did not feel like they received sufficient information to be certain the project teams implemented clear management and technical practices to manage the project partners effectively. The project principals did not perform the project presentations, so it was harder to get insight into how this is being executed from a management point of view. The associated turbine project did express concerns about the lack of a common integrator of the two components, and it sounds like WPTO brought in support from NREL to help the teams complete this project.

Technical Accomplishments and Progress

The teams involved have worked hard to overcome the usual problems that come up in any large effort. The result is that this system is completed and on its way to the test site, so the team should be commended for all of this. Overall, there appears to be good technical progress. It would be good to see the commercial progress of this device.

Future Work

Future work has a brief timeline but no inclusion of operational reviews. This would be important to include for showing lessons learned after each phase/step in the deployment/installation activities are critically assessed and verified.

KINETIC HYDROPOWER SYSTEM TRIFRAME MOUNT INTEGRATED DEVELOPMENT AND IO&M TESTING AT RITE

(WBS #: EE0007349)

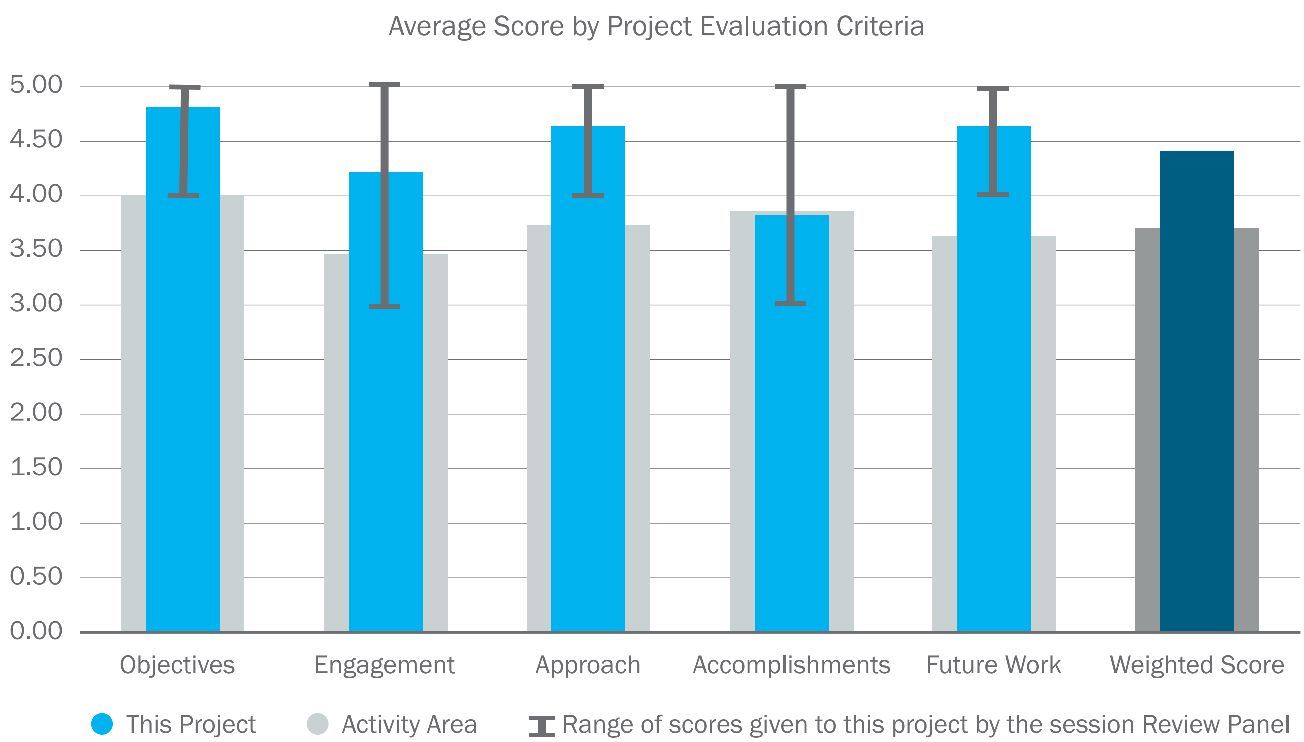
Recipient:	Verdant Power, Inc.
Principal Investigator:	Dean Corren
Project Type:	FOA 1310: Next-Generation Marine Energy Systems—Durability and Survivability
Project Category:	Ongoing Projects
Total Authorized:	$7,999K
Total Costed:	$2,310K

Project Description

This full-scale, open-water project will develop, build, operate, and maintain a TriFrame™ mount with three Verdant Power Gen5 Kinetic Hydropower System axial-flow turbines. Deployment is at Verdant's FERC-licensed RITE Project in New York. Goals include advancing the TriFrame from TRL 3 to 8 and optimizing the TriFrame for both CAPEX and OPEX. Metrics include the time and cost of on-water operations for installation and maintenance, while meeting all requirements and providing a path for scale-up. A key aspect to this project is the Integrated Design Process, closely and iteratively linking mechanical design with operational procedures to reduce the combined contributions of CAPEX and OPEX to LCOE.

Weighted Project Score: 4.4

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

This project was favorably reviewed and received high scores from the reviewers. Two reviewers noted that the upcoming deployment is a proof of concept for the cost-saving approach of relying on accurate site bathymetry and found that the results from this will be interesting and worth following. Reviewers also had some technical concerns about cavitation and turbulence intensity, and they were pleased to see the upcoming review by NREL. Finally, one reviewer was interested to learn more about other markets and locations outside of the test site. One comment suggested that this is one of the more well-developed MHK projects in the DOE portfolio.

Project Objectives, Impacts, and Alignment with the Program Strategy

This category was scored very highly by the reviewers. The comments reflect the high quality of the presentation and explanations of what the upcoming deployment aims to achieve.

Representative comments include:

- "The project performers have presented the relevance of this project and how successful completion of the project will advance the state of technology, meaningful impacts, and/or the viability of any commercial applications."
- "This new foundation structure for the Verdant turbines aligns with the program's strategy in both crosscutting R&D as a new design meant to minimize CAPEX and OPEX."

End User Engagement and Dissemination Strategy

The reviewers scored Verdant well on this criterion, though a few comments show some concern that a description of end users outside of the grid operators were neglected in the presentation. This is explained somewhat by the fact that Verdant is setting up to be both a technology developer and operator, so they are their own end user. Several reviewers commended the high degree of engagement Verdant has regarding standards development, and they recognize this is a significant dissemination of their efforts. For instance, "Verdant has done an industry leading job on standards development, pushed regulatory approval and adopted a failure mode and effects analysis in concert with National Lab oversight."

Management and Technical Approach

In this category, the reviewers scored very highly. Again, the high quality of the presentation was reflected in the comments, and all reviewers felt this group has performed well in both their management and technical approach. One reviewer noted that Verdant was the only developer in the peer review that provided detailed cost metrics and goal posts. The project performers have clearly described critical success factors, which will define technical viability and have explained and understand the challenges they must overcome to achieve success. The emphasis this company appears to have on the management and technical process was also noted by reviewers. The reviewers were intrigued by the technical approach of using detailed bathymetry to simplify the design of the device and allow three turbines to be deployed/recovered simultaneously.

Technical Accomplishments and Progress

The reviewers scored this section slightly lower than the rest. This was possibly due to the fact that the deployment phase and proof of concept of this project is still upcoming.

The lowest scores were supported with comments such as the following:

- "Light on details here. I would have liked to have seen more on I am still concerned about tip cavitation with superposition of loads since this is at a fixed depth. Tides, Wave orbitals and turbulence intensity can have a periodic cavitation issue one a once per a rev. Where is the cavitation bucket margin?"
- "Detail was missing on the achievement of the competitive LCOE, which will be essential for the commercialization of this technology."

Positive scores were supported with comments about the project's demonstrated ability to perform in-water tests and "incorporate lessons learned quickly and effectively in design upgrades."

Future Work

This section was scored favorably by the reviewers. The reviewers expressed an interest in the results of the upcoming test and the 120-day results. Other noteworthy reviewer comments include:

- "Good detail in the future work section. Interested in the activity with the Magnetic Gearbox group."
- "The project performers have communicated key planned milestones and addressed how they plan to deal with upcoming decision points and any remaining issues."
- "Future work focuses on testing of Gen5 plastic blades and assessing post-deployment performance of upgrades made, as it should. Consideration for the expiring FERC license in 2021 and whether the program will be continued or retired in the East River [should be] a focus."
- "Suggest significant consideration for broadening future markets, and testing/deploying at other sites should be paramount."

CALWAVE OPEN WATER DEMONSTRATION

(WBS #: EE0008097)

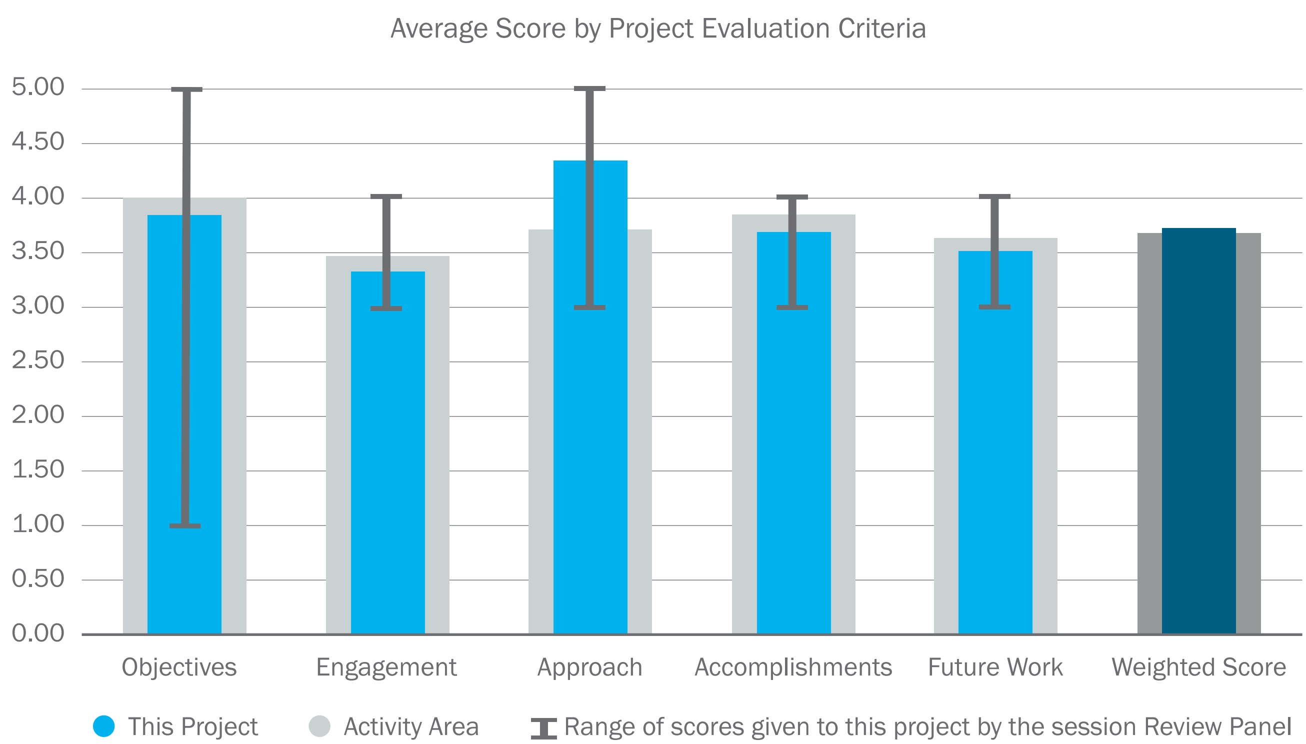
Recipient:	CalWave Power Technologies Inc.
Principal Investigator:	Thomas Boerner
Project Type:	FOA 1663: Marine and Hydrokinetic Technology Development and Advancement
Project Category:	Ongoing Projects
Total Authorized:	$5,517K
Total Costed:	$2,566K

Project Description

The main project objective is to advance the TRL of the WEC developed by CalWave Power Technologies Inc. (CalWave) through advanced numerical simulations, hardware/tank testing, and ultimately scaled open water demonstration, while continuing to exceed DOE's target ACE (Average Climate Capture Width / Characteristic Capital Expenditure) threshold of 3 meters/M$. Budget Period 1 concluded in June 2019, with detailed design of the scaled demonstration unit and bench testing of the critical hardware components. Key outcomes in Budget Period 2 will be installation and operation of the demonstration unit in open water in close proximity to the Scripps Institution of Oceanography. Performance and load measurements will be used to validate the high techno-economic performance of the concept.

Weighted Project Score: 3.7

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers’ Comments

Overall Impressions

The reviewers recognize CalWave as a well-organized team that has incorporated the industry best practices of utilizing state-of-the-art controls from SNL and tools to guide load shedding approaches. The reviewers consider CalWave a promising MHK wave energy topology, with a better chance of reaching commercial LCOE; however, the reviewers felt unable to give a full assessment due to the lack of top-level system drawings and metrics. The reviewers would like to see greater dissemination of the actual design geometry and review of deployment area in terms of operational device performance loads expected. The reviewers considered CalWave an interesting project in that this team is pursuing a different approach to wave energy compared to what developers have done previously. In particular, the choice to keep the entire device submerged could significantly benefit the survivability of the device, which is a large cost driver in most wave-energy systems. The reviewers felt CalWave did not give a sufficient overview of the device in the review materials, making it difficult to make a judgement on the device itself. Perhaps because there are so few details, it’s enticing to imagine that there is a novel design here that could change the economics and viability of wave energy compared to the surface piercing devices that have not fared very well. CalWave readily admitted that their reluctance to share details publicly is a company choice made for strategic reasons and not a lack of knowledge about their device. This team seems very competent and well organized. Even without providing details, they are able to answer questions about the device and their approach that inspires confidence. Presumably, the DOE team had access to considerably more detail about the device in the recent DOE go/no-go process and found a compelling story as the project is still funded. The next budget phase includes an at-sea demonstration, and CalWave appears well along in those preparations. The results from that test will be very interesting and should dictate the appropriateness of future funding.

The reviewers unanimously agreed that they would have liked to see more details and examples of this WEC technology. There are many significant claims made about the novel abilities and applicability of this WEC for several applications without providing examples of end users, diagrams, quantified outputs from the WEC modeling, etc. The reviewers believe that the close collaboration with the labs corroborates some of these claims, but would still like to see more evidence.

Project Objectives, Impacts, and Alignment with the Program Strategy

The CalWave project performers have described how the project contributes to the program’s strategy/approaches with Wave Prize ACE metric threshold of 3 meters/M$. Project objectives embraced the work developed by the labs to advance TRL/TPL. CalWave demonstrated good synergy with SNL. The reviewers would have liked to see where CalWave is relative to wave prize requirements analytically and demonstrated through wave tank test.

The project performers have considered and described the use/applications of their expected products and outputs.

- Budget Period 1 concluded in June 2019, with a detailed design of the scaled demonstration unit and bench testing of the critical hardware components.
- CalWave’s holistic control approach includes novel means to directly control the energy input into the WEC, such as loads exerted into the physical structure by using novel load management capabilities such as absorber geometry control. Similar to pitch- and yaw control in wind energy, this novel approach has not been implemented in any deployed WEC technologies so far, however, it allows a paradigm shift in designing and operating WEC devices.

The project performers have presented the relevance of this project and how successful completion of the project will advance the state of technology, meaningful impacts, and/or the viability of any commercial applications.

- The WEC's high performance numerical prediction and capability to survive extreme wave events was validated by CalWave during 7 weeks of wave tank testing at 1:25 scale (operational cases) and 1:30 scale (survival cases) at various wave tanks.
- Final objective of the project is to deploy and operate a 1:5 scale device at open water (Scripps, San Diego) for at least 6 months to assess the device performance in realistic environments and to validate the novel holistic control approach, including geometry and depth control.
- Experimental system identification tests for multiple degrees of freedom of the device were conducted that allow the derivation of precise hydrodynamic models for simulation and control. During multiple wave tank test campaigns, the project team conducted experimental system identification. SNL staff attended these campaigns. Results were used to verify the system identification principles that SNL staff released a year prior using a floating point-absorber. Lessons learned fed back into multi-degree-of-freedom system identification work conducted by SNL. Proof of principle of the method was validated again using the CalWave device as an inherently different device archetype.

Strengths

- Reviewers found CalWave's approach that makes the project impactful is that they use a different device topology archetype, which aligns with the creative design approach of NREL (e.g., Dr. Jochem Weber's use of flexible structures).
- Project PI described well how the project contributes to the program strategy and approaches. The impact is clearly described in terms of the results:
    - The project was used to verify the system identification principles/approaches published by SNL.
    - The 7 weeks of tank testing operational cases developed and at 1:30 scale with survival cases.
    - The team is currently critically evaluating the testing -103 standard for wave tank assessments.
- Of all the wave-energy development projects in the WPTO portfolio, this project is the most interesting in that the project team appears to be pursuing a novel approach to wave-energy extraction. The presentation materials align well the WPTO objectives, in this case fundamental R&D and also device specific technology development.
- The project objectives align with program strategies. This project is unique, as it is a WEC design that has been developed with the full assistance of the new modeling tools developed in the labs, and the performers have demonstrated several successful collaborations that utilize these evolving new tools.
- The progressive numerical model validation is well aligned with DOE strategies.

Weaknesses.

- Many reviewers felt it was difficult to judge the fit with the program, as very limited information has been discussed about the actual technology.
- The reviewers were universal in that there was not enough design information given. It was hard to discern the efficacy of the design. For instance, what was the result of these wave tests relative to threshold requirements?
- The load management aspect of this project does provide a straightforward exercise for pursuing such benefits.

End User Engagement and Dissemination Strategy

During their detailed design, CalWave has advanced the state of the art of existing numerical tools. In one example, fundamental improvements to the WEC-Sim framework have been developed in collaboration with NREL and Evergreen Innovations to properly simulate the multi-degree-of-freedom device. CalWave showed good use of national lab resources, leveraging their expertise as a force multiplier and garnering state of the art control work to drive PTO design.

The project performers have clearly described the rationale for the stakeholder/end user engagement strategy and how project results and information have been/are planned to be disseminated. SNL work on high-fidelity CFD modeling for extreme wave response yielded improvements to the WEC Device Response Toolbox Extreme Sea State Contour tools. Coupling CFD modeling tools with other software environments to simulate staged failure modes of the device in extreme seas led to a scientific paper being presented at the 2019 European Wave and Tidal Energy Conference potential first market-ready WEC product, addressing the maritime markets identified by DOE's *Powering the Blue Economy* report.

CalWave has engaged many potential customers, ranging from defense to ocean science and observation to marine aquaculture, who have expressed interest in a low-power, rapidly deployable WEC. Feedback from all customers has been collected and synthesized into guidance for a potential revision and market introduction of the WEC developed in this project. A lot of good work has been carried out by CalWave, but the topology remains a mystery to reviewers, which impacts the scoring assessment.

Strengths

- Excellent demonstration of dissemination back into tools WEC-SIM and MHK lessons learned (10 reports).
- They have listed who they have spoken to in state agencies, local agencies, and the oceanographic research community.
- Within the limitations of their relatively secretive approach to their technology, the project team describes appropriate interactions with stakeholders in the state government and broader community. For instance, they have done some public education work with both politicians and the Exploratorium in San Francisco. Additionally, they appear to have involved SNL in their design work.
- The project summary describes efforts and plans for WEC developers in the area of dissemination, as well as end user engagement.
- The performers identify engagement primarily through the development of a novel WEC device, and they suggest that the multiple degrees of freedom of the device have pushed model advances at the labs.
- They identify utility in the PBE initiative by "addressing the maritime markets identified by the DOE's Powering the Blue Economy report."

Weaknesses

- There is very limited information provided about end user/customer engagement and dissemination of this project.
- While promising, it is difficult for the reviewers to identify actual engagement without specific examples.
- End users are unclear. There is mention of maritime markets in PBE, but because we can't see the device, it is not clear who those customers could be.

- There is no clear plan explained on how the project team will continue engagement or on their rationale for stakeholder/end user engagement strategy.
- Little detail or examples of specific customers within this sector are identified.

Management and Technical Approach

CalWave's approach considers the entire chain of conversion steps as a single process with intrinsically connected requirements, revealing optimization potential for WEC performance improvement and cost-efficient device design via synergies at the subsystem interfaces. This involves Co-optimized WEC hulls, PTOs, and electrical export frameworks, which must be considered holistically. The reviewers see CalWave as a well-managed team, with independent validation via the Wave Energy Prize. Reviewers' main concern is the PTO down-select and characterization that many teams suffer from that prevents the design from moving forward and achieving a cost-competitive LCOE.

Strengths:

- The device topology is derived from a kinematic modal optimization, allowing for true extraction of multiple degrees of freedom (Surge, Sway, Heave, Pitch, and Roll) with inherent load management capabilities.
- The project takes a "holistic design" approach. CalWave has advanced a submerged pressure differential type WEC since first developed in 2014. The single body device is oscillating, submerged, positively buoyant, and taut moored to the sea floor. A completely submerged device avoids many of the pitfalls of a surface presence device subjected to extreme loads and 100-year storm events.
- Customers in the blue economy, especially DOD applications, would prefer an approach without a signature or surface presence.
- Capturing multiple degrees of freedom in energy extraction is unique relative to others
- A wave load control mechanism via adjustable absorber geometry was integrated from the beginning of the project. This is analogous to the pitch/yaw control of wind turbines.
- Interesting approach to shed load that the author should have disclosed to access efficacy or independent validation; the concern would be active versus passive load shedding.
- No need for active measurement devices to improve power output through feedback loop is a plus.
- The project allows for control of five degrees of freedom separately (heave and yaw resemble a coupled mode), further optimizing operations in different bandwidth limited wave states.
- Kinematic control of the device follows cable driven parallel robot approaches, which are well understood.
- This team seems very competent and well organized; even without device details, they present a compelling storyline of integrated development involving all aspects of the problem in the design (controls, structural, operational costs, etc.). The project is organized into milestones, and the team size is appropriate to the tasks.

Weaknesses

- Reviewers are skeptical of the approach using undersea winches, as they have a litany of issues and will pose an O&M issue if it is actively used or intermittent as a means of power optimization or load shedding.
- Is there a design requirements and best practices report? Or is there a conformity statement?

- Use of techno-economic metrics for performance monitoring of the project, including technical/commercial viability, to dictate the development targets is a best practice and should be incorporated into other project/technical approaches. WPTO should use this best practice.
- The technical approach is hard to evaluate from the materials presented, but it does appear that this group has been thoughtful about pursuing a design that addresses one of the prime challenges of wave energy (storm loading) by keeping with a submerged device.
- There was very limited information provided about the project's management and technical approach.

CalWave included the management of the project in LCOE considerations, which was unique for most of the presentations. The collaborations with the labs appear to be mutually beneficial. It is difficult to completely evaluate the management and technical approach without more details and examples. Why are there not more details, pictures, schematics, etc. available? All of the outcomes of this project sound appealing, but the lack of concrete examples concerned the reviewers.

Technical Accomplishments and Progress

CalWave has fully designed a 1:5th scale novel submerged pressure differential WEC.

Over 200 project and technical risks have been identified in collaboration with national lab and industry partners, and mitigation strategies were successfully derived. The reviewers would be interested in seeing this FMEA and how issues were mitigated through analysis, inspection, or test. System identification via experimental tank testing was used to derive hydrodynamic models for numerical simulation and controls development. Models were successfully implemented and used for performance optimization, load assessment, and hardware-in-the-loop PTO bench testing.

Concerns:

- Reviewers wonder how accurate the numerical simulation and hydrodynamic model prediction was relative to wave tank tests. Is it accurate enough to predict full-scale performance and used as a design tool? What are the limitations?
- Validation of the device's high energy absorption capability was carried out via extensive experimental wave tank testing. Results yielded a two-fold performance improvement, reaching up to 60%–70% capture width ratio in common wave states. This was a great result and a reason to do more experimental wave tank testing in a controlled environment versus open water tests to iterate quickly in a controlled and cost-efficient setting
- An efficient PTO drivetrain was developed, which is capable to support the submergence depth change of the device, while enabling execution of advanced PTO control strategies to maximize absorption efficiency. Absorption efficiency was increased by up to 40% compared to a passively controlled device. The reviewers would like to know what the baseline performance was relative to key COE metrics and ACE system requirements. While a 40% improvement is impressive, it has to be in the context of acceptable baseline performance.
- A PTO test stand and single PTO unit were developed. PTO characteristics were derived from experimental system identification. A hardware-in-the-loop approach using the validated numerical simulation was used to experimentally assess the PTO's behavior in all conceivable wave states. PTO performance characteristics were found to be well in the bounds of numerically derived values. Reviewers would like to know if a PTO topology been down selected or if the trade space still open.

- For the CWR Performance results in Case IWS5 significant: what sea state was this in? Was the load reduction also by factor of 2?
- The reviewers agreed that while all of the performer's claims were tantalizing, they were not provided quantifiable examples. What is the current expected LCOE of this device, and the path for lowering it? The reviewers don't have much more information to evaluate the technical prowess of this project than the successful collaborations with the labs and the claims of the performers.

The project provided an excellent review of the FMEA analysis in approach to risks associated with IO&M planning. The co-design approach is well demonstrated in this project. Additionally, the incorporation of the third-party reviews demonstrated to validate the performance of project were excellent. They have completed the design and tank test, but no specifics have been presented. They are moving to an at-sea deployment and appear to be on schedule and budget. There appears to be a good technical process. It would be good to see the commercial process.

Future Work

Future plans include further project development contributing to the holistic control design for the open water demonstration. The second is a FOA to co-design a PTO with controls. Improved understanding of device behavior gained from the open water demonstration project will feed into this PTO design project. CalWave was awarded tank testing from the MaRINET2 fund, which enabled tank testing to be conducted without accruing cost to the project

The upcoming Budget Period 2 of the project includes the manufacturing, build-out, deployment, operation for at least 6 months, and decommissioning of a 1:5th scale WEC. This demonstration device will include all novel features to manage loads directly in the wave-structure conversion step. Geometry control, as well as submergence depth control, of the device will be integrated into a holistic control framework with the PTO controls. Target deployment site is Scripps, San Diego, which has a well-suited wave climate to assess relevant operation of the WEC.

Concerns

- Reviewers would like to see a free-body diagram layout of the system to understand it better. Reviewers were concerned about buoyancy control versus an active ballast system or winch system to control depth. Reviewers needed to see more detail on the design, as others have provided to give a proper assessment.
- The future plans for testing and evaluating the WEC at Scripps are sound. Reviewers would like to know the scalability of this novel WEC system. Deployment is planned for Scripps because this wave climate is well suited for the WEC. Are other climates wells suited for getting power from this WEC? The developers claim there is interest in PBE applications, so does future work include scaling the WEC to provide power in lower-energy wave climates?
- The reviewers would like to know how CalWave envisions that survivability in large sea states will be demonstrated at SCRIPPS pier.

The 2020 deployment will be the big test for this project, and the project performers outlined appropriate planning and an understanding of what they hope to achieve from the testing.

ROBOTIC JUGGLER OFFSHORE WEC

(WBS #: EE0008388)

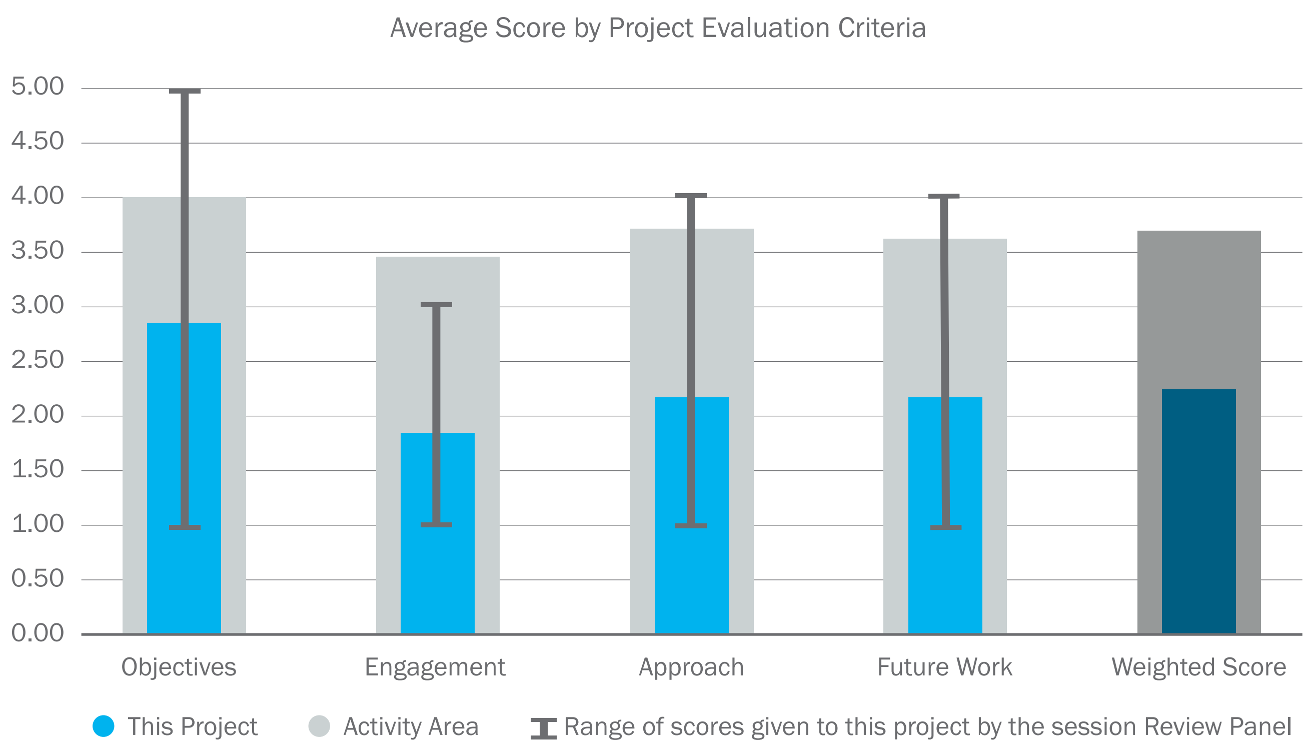
Recipient:	Enorasy LLC
Principal Investigator:	Vassilios Vamvas
Project Type:	FOA 1663: Marine and Hydrokinetic Technology Development and Advancement
Project Category:	New Projects
Total Authorized:	$942K
Total Costed:	$93K

Project Description

The Robotic Juggler device is an innovative, offshore floating WEC that utilizes a rotating eccentric mass. The eccentric mass rotates about a vertical shaft and provides rotation to a permanent magnet generator. The device's PTO is entirely enclosed within the WEC's hull. The project objectives are to numerically model the performance of the Robotic Juggler, validate the device's average climate capture width/characteristic capital expenditure metric, and then test a scaled prototype with an incorporated control algorithm.

Weighted Project Score: 2.2

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Future Work–40%.



Summary of all Reviewers' Comments

Overall Impressions

Many reviewers thought the very early stage aspect of this project explained some of its shortcomings. All reviewers expressed concern that the performer was perhaps not taking the project as seriously as he should. There was some agreement among reviewers that the project should undergo a techno-economic review as part of upcoming go/no-go decisions.

Project Objectives, Impacts, and Alignment with the Program Strategy

A number of the reviewers agreed that the project aligned well with the WPTO strategy for cross-cutting R&D. In particular, the sealed PTO provides an attractive area of focus for the industry. However, a lack of detail on performance measurements and the inability to model the system were a concern. There were a number of comments indicating the reviewers used the very early stage aspect of this project to explain some of its shortcomings.

End User Engagement and Dissemination Strategy

Reviewers agreed that the details on end user engagement were lacking or vague. Dissemination strategies were nominal for a developer.

Management and Technical Approach

A number of the reviewers noted the absence of a clear management plan. A few of the reviewers recognized the value of the scaled testing program that was discussed and presented. This is accepted as a good technical approach; however, the reviewers also expressed some concern on the technical strength of the team given the admitted struggles with modeling a fairly simple topology.

Technical Accomplishments and Progress

This was not scored due to the early stage of the project. Concern again was mentioned regarding technical ability due to the modeling struggles.

Future Work

The reviewers noted that a discussion of milestones was missing from the presentation but recognized the upcoming go/no-go decision point. There were a couple of reviewers that expressed a fair bit of skepticism regarding the viability of the project given the summary and presentation content.

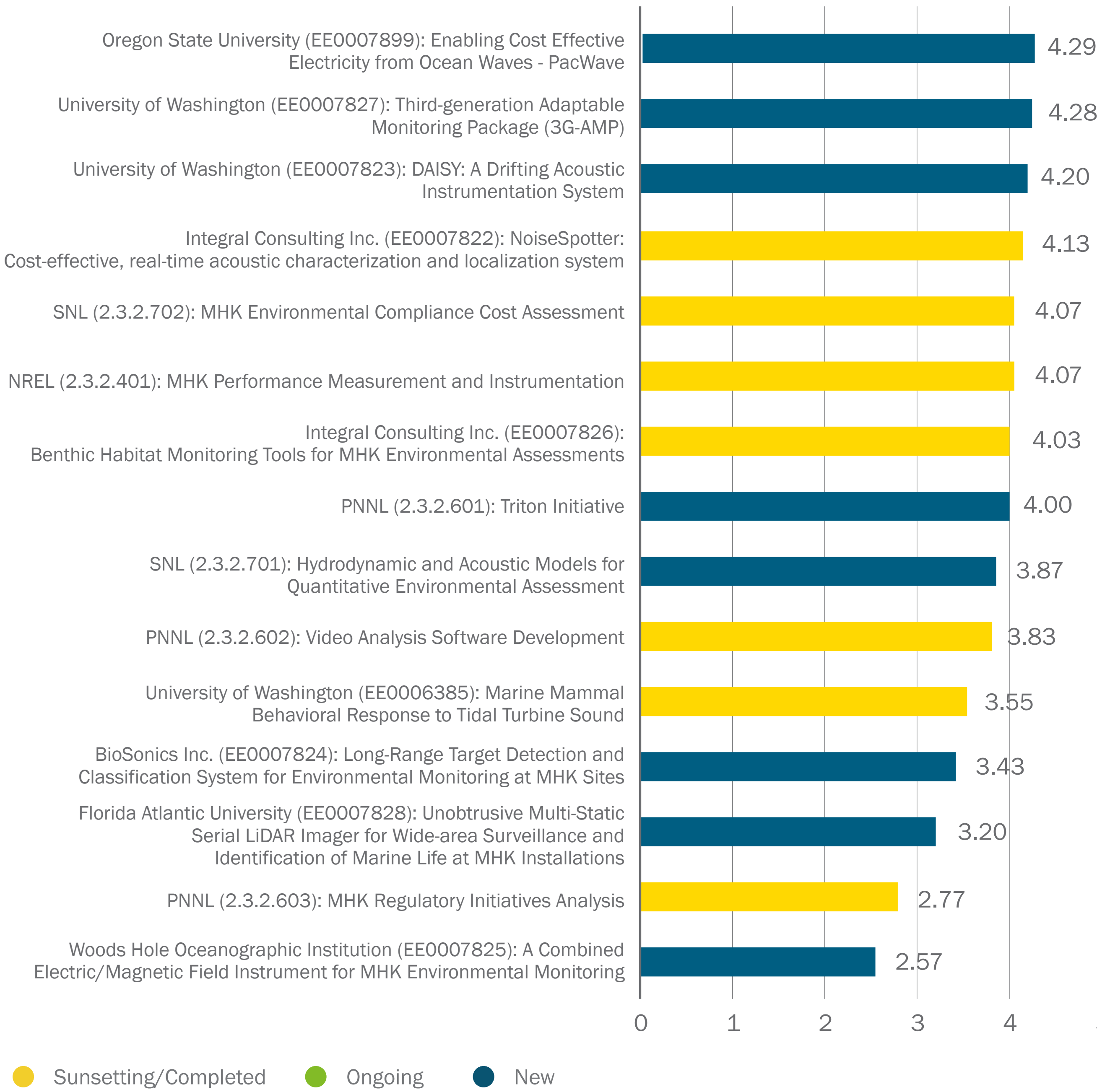
Reducing Barriers to Testing

This section provides an overview of the scoring for all projects within the Reducing Barriers to Testing activity area (see Figure 25); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Reducing Barriers to Testing	**3.78**

Figure 25. Reducing Barriers to Testing activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

The projects presented within the Reducing Barriers to Testing track deal broadly with issues of environmental monitoring and regulatory concerns. The investments in technological development appear to be driven by environmental concerns identified in previous MHK projects and reflect a programmatic vision to be well-prepared to address the same issues should they be raised in future projects. This forward-looking objective contrasts with the discussions related to regulatory concerns, which appear to be primarily driven by experience. New information, if any exists, that can guide projects and investments should be collected from relevant stakeholders and further refined and communicated to project participants supported by WPTO. The most efficient way to achieve these goals is not at the level of individual projects.

A regular discussion point among reviewers was end user engagement and how engagement strategies informed project objectives and broader program goals. For these projects, the end users are generally regulatory agencies and developers. When available, project performers should work to better convey how information obtained from these conversations was used as opposed to stating that the discussions took place.

Reviewers agreed that, at a program level, now is a good time for WPTO to engage in conversations with the regulatory community to better understand their needs and what technology gaps remain for addressing these issues (i.e., are most of the necessary tools now available to address key concerns?). When engaging in conversations with regulators, it is important to follow up and ensure that the conclusions drawn by the program or project participants adequately reflect the concerns and priorities of these agencies and individuals. An outcome of these conversations should be a conclusion as to whether WPTO should continue to invest at comparable levels in these areas or whether technological developments allow the program to scale back the levels of investment. It was not clear during the review process what up-to-date information is available on this subject and how that is informing program strategies. However, due to investments in this area, the program is likely well-positioned to leverage work funded in this track to address high priority issues.

The technology development for environmental monitoring in this track appears to be going well, with projects generally making progress toward field deployments at WETS. While WETS demonstrations will demonstrate key technological advances, it is not clear how these deployments will successfully achieve WPTO strategies of reducing risks. It would be highly beneficial to industry if similar targeted deployments of these technologies were accompanied by specific efforts to identify and/or reduce risks associated with device deployments.

Given the level of investment in environmental monitoring technologies, WPTO should identify pathways for providing funding for environmental monitoring using technologies developed through this program at future device deployments. Any technologies chosen for such deployments should have previously demonstrated the capacity to directly address a concern raised by a regulatory agency. This points to the benefit of upcoming deployments at WETS, even if the deployments are not successful in working toward the reduction of risk. One potential approach to ensuring investments in environmental monitoring technologies are leveraged in the future would be a structure like TEAMER, which would allow flexibility in timing that is more difficult to manage with a traditional FOA.

Some projects within the portfolio may ultimately be unable to play a future role in field efforts to reduce risks around MHK devices, and upcoming deployments will identify the effectiveness of applicability of the projects. Regardless, progress on these projects suggests that the technological developments will be useful in other contexts. For example, several projects are already scheduled to be used in non-MHK studies or have resulted in peer-reviewed publications.

Several reviewers commented that, when possible, WPTO should encourage project participants to publish results in peer-reviewed publications as opposed to technical reports. Some projects appear to be progressing toward peer-reviewed publications, but others seemed to be entirely focused on technical reports and documents addressing internal resources and goals. Although technical reports are still of value, particularly when they provide a level of detail that cannot otherwise be conveyed, peer-reviewed publications are likely to have a wider audience and a broader impact.

Large projects like Triton are difficult to evaluate in this context. Numerous reviewers recommended that each Triton task be subject to an independent review or that the project be broken up given that they are not necessarily related. Given the available time and information, a thorough review of Triton Tasks 2 (fish mesocosm) and Task 3 (Triton Field Trials) was not possible. As a significant project within the portfolio, this, and others with comparably large scopes, should be given additional time and space in written reports. Triton Task 1 seemed to be extremely successful, with the PIs of all projects interacting with Triton speaking highly of the interactions and the benefits to their projects. This collaborative work could also be emphasized when there is overlap between other existing projects (e.g., projects emphasizing compliance costs and regulatory initiatives).

Quantifying the return on investment (ROI) made by this program is difficult and made more challenging by the shortage of opportunities to test these technologies and address existing risks. Nonetheless, WPTO should identify ways to quantify the impacts of these projects and ask project performers to provide meaningful metrics, when possible, to the program.

Many reviewers commented on and had strong feelings about the widely used “risk retirement” narrative employed by many project participants. This framing inadequately captures the nuances of the regulatory processes and concerns of regulators, while failing to recognize that no two projects are subject to identical concerns or pressures. As such, a risk cannot be retired, but it can be reduced or minimized. Stating that risk has been “retired” undermines the value judgements of those tasked with making key regulatory decisions. Relative levels of risk should instead be presented with appropriate context. Reframing the “risk retirement” discussing acknowledges that identifying and appropriately managing regulatory concerns requires dialogue between diverse stakeholders and cannot be simply reduced to binary statements.

The most significant strengths present in the portfolio were the advances that should facilitate environmental risk studies in future deployments of MHK devices. Perhaps the most significant weakness was a general lack of understanding of how these projects align with regulatory concerns.

Summary of all Reviewers’ Comments

Overall Impressions

Projects within the Reducing Barrier to Testing track are diverse and represent different challenges facing the MRE industry. The projects that are focused on instrumentation or methods to address existing environmental concerns apply a broad range of technologies, some of which are likely to be applied in future projects. In some cases, there were concerns that the technologies themselves would be a source of concern. These projects are making progress, but the impact of these investments can't be measured without devices in the water analysis to quantify impacts of devices. Regulatory and compliance initiatives might benefit from synergies with offshore wind regulatory processes and analyses that directly compare compliance costs of MHK with that of other maritime industries. Multiple reviewers expressed concerns for multiple projects, stating that technological developments being pursued with WPTO funding were similar to developments that had other agencies had previously funded. Identifying pathways for ensuring these efforts better leverage other work would be beneficial.

Program Strategy and Objectives

The program's long-term strategic approaches and future direction were not clearly conveyed during the peer review. This is less of a concern if WPTO plans to maintain the status quo with respect to this research track. Many of the presented projects are completed or nearing completion. Additional information about how recent investments will be leveraged to reduce risk in the future would have been helpful. The program understands important barriers to testing and development based on previous experience, and these can logically be extended to the near and long term given that little has happened in recent years that would fundamentally change existing challenges. Although not included in this review, WPTO has invested more recently in better understanding the current challenges in this area.

The Reducing Barriers to Testing research portfolio invests in a variety of early-stage research projects that aim to support studies and ensure long-term sustainability and environmental impacts are understood. In addition to technologies to measure these impacts at the scale of individual devices, program funding supports modeling efforts to expand these results to larger scales to address larger-scale development scenarios.

Investment returns for projects in this track are difficult to measure given the state of the industry. However, should ongoing projects perform successfully in future deployments—thereby demonstrating their future role in environmental monitoring and risk mitigation—the investments will provide meaningful returns for the MRE industry, with many applications to other industries.

Program Portfolio

Projects within the Reducing Barrier to Testing track contribute to program strategies by supporting scientific research to mitigate environmental risks and reduce the costs of environmental monitoring. Funded projects within this track aligned well with program strategic approaches. These projects address a range of potential environmental impacts, including collisions with devices, avoidance, radiated noise, and physical effects on the environment. Additional program-level information regarding the selection of the different projects would have helped reviewers understand whether their existing redundancies in the portfolio were strategic. For example, there were two projects aimed at quantifying radiated noise, two projects whose technology would be focused on the detection and quantification of animals in the near-field of devices, and two regulation-oriented projects. This redundancy is not inherently problematic, and to an expert, the benefits may be clear, but such funding decisions could be better conveyed.

Apart from the significant initiatives with larger budgets, funds were well distributed between the projects aimed at technological development and those working to research the costs of compliance and the regulatory environment. The broad range of projects is appropriate for WPTO's role as a public R&D organization.

Program Management Approach

The program team appears to effectively manage and direct program activities to meet program objectives. For the benefit of reviewers, WPTO could provide brief summary of procedures for the development of project milestones, statements of project objectives, and steps taken to ensure project alignment and progress during quarterly reporting. Additional information could also be provided to help reviewers better understand internal processes at WPTO that are used to manage the existing portfolio.

Within the context of the Reducing Barrier to Testing activity area, research priorities were not explicitly identified; however, the program portfolio effectively communicates an interest in a range of environmental effects research and instrumentation needs to accomplish these goals. These projects represent areas of research that have been identified as high priority based in part on past experiences. Any additional motivating factors informing portfolio investments should be more clearly communicated to reviewers.

Program team members have many of the professional and technical capabilities to guide the portfolio. There were, however, a couple of cases in which program investments overlapped with niche technologies from other industries. With additional expertise from the technology, oceanographic, and defense sectors, different paths toward more efficient technological development could have been identified. WPTO could explore the possibility of open communication with experts from these other agencies to identify areas of overlap.

Stakeholder Engagement, Outreach, and Dissemination

WPTO effectively communicates how investments are distributed to address priority research areas. Identifying methods for evaluating project impacts would help to better communicate the results of program investments. For projects within this track, such metrics could include (but are not limited to) estimates in the reduction of costs associated with the use of technologies developed with program funds and metrics on relevant publications with an emphasis on peer-reviewed publications.

WPTO funding in this area should be directly driven by the issues that are of highest concern to stakeholders. While project performers can individually reach out to these stakeholders, multiple reviewers raised concerns about stakeholder fatigue. By addressing stakeholder issues at a program level, as opposed to having project performers guide this outreach, program managers could reduce the burden on individual stakeholders, while gaining a better understanding of how individual projects address their concerns. When the stakeholders are regulatory agencies, the program should seek to leverage activities in other industries (e.g., offshore wind) to identify overlapping issues and solutions relevant to both sectors.

WPTO-funded projects are active participants in industry conferences and document project achievements through technical reports and other documents to DOE. Not all potentially interested parties have the bandwidth to attend these conferences or will be aware of technical reports. When relevant, projects should seek to publish results in areas with broader readership and in places where reviewers may have deeper subject matter expertise (i.e., a renewable energy journal is not always the most appropriate place to present environmental monitoring results even if the application is MRE). Another option identified by a reviewer was to create a consolidated database populated with known environmental concerns, as well as with information about existing capabilities to address the issue, and to publish results demonstrating the types of observations that could be expected.

Through its other efforts, WPTO provides access to information and data with the goal of informing decision makers and accelerating industry development. As discussed, with respect to the Data Sharing and Analysis activity area, it may be possible to streamline these resources to ensure that the best available information is better emphasized.

Project Evaluations

MHK PERFORMANCE MEASUREMENT AND INSTRUMENTATION

(WBS #: 2.3.2.401)

Recipient:	NREL
Principal Investigator:	Rick Driscoll
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$195K
Total Costed:	$195K

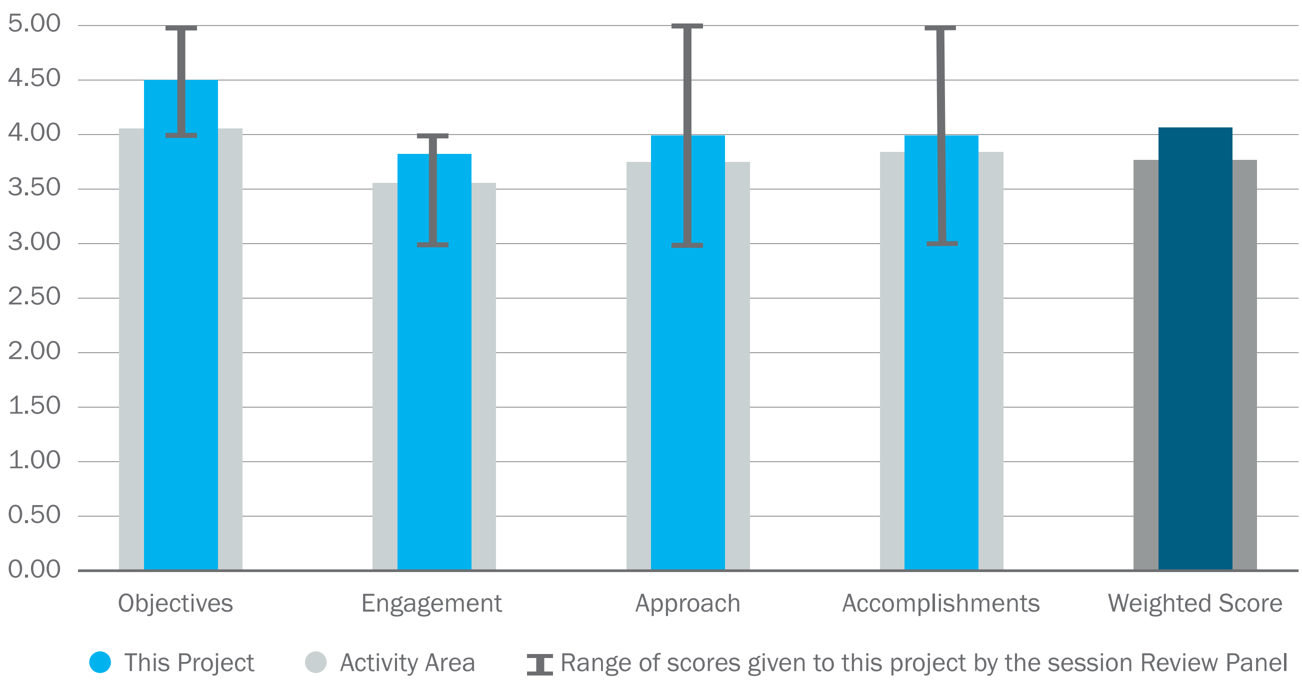
Project Description

The project identified gaps, characterized impacts, and prioritized solution pathways for measurement and data processing for the marine energy community. Along with years of engagement with and activity in the marine energy and other offshore industries informing this effort, a third MHK Instrumentation Workshop was held at Florida Atlantic University's Sea Tech Campus from February 28 to March 1, 2017. In addition, a comprehensive assessment and literature review was performed for gaps in MRE measurement and testing technology. The focus was marine-grade instrumentation systems used for site characterization, structural testing, certification testing, system verification, commissioning, operational monitoring, and controlled testing in a laboratory environment for wave and current systems. Findings were published as a technical report and disseminated through mechanisms such as conferences and on Tethys (tethys.pnnl.gov).

Weighted Project Score: 4.1

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.

Average Score by Project Evaluation Criteria



Summary of all Reviewers' Comments

Overall Impressions

The reviewers were positive about this project, and three of the reviewers explicitly stated that the workshop the project team organized should happen again at regular intervals, as there seemed to be good value generated. Two of the reviewers commented that they were not sure how the results of the workshop fed into WPTO priorities, and that it might be worth strengthening this connection when communicating about this project. One reviewer also commented that there was good representation by national labs and universities at the workshop but not from the MHK industry and that it would be good to increase industry participation.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that the project performers described how the project contributes to the program's strategy/approaches, the use/applications of their products/outputs, and the relevance of the project. One reviewer pointed out that the outcomes won't directly lead to impacts but that the implementation of the recommendations from the workshops will.

End User Engagement and Dissemination Strategy

The review team felt that there was appropriate end user engagement and dissemination. Particular strengths were good use of pre and post workshop surveys, as well as good theme generation and identification of limited knowledge transfers. One reviewer seemed to question if an invite-only approach was the right one to take, and another noted that they would have liked to have the workshop generate a more detailed technical report.

Management and Technical Approach

The review team agreed that the management and technical approach was good for this project. The breakout sessions, which identified gaps and ranked potential solutions, were a workshop strength.

Technical Accomplishments and Progress

All of the reviewers felt that the project performers had reached their objectives of conducting the workshop, identifying gaps, and reporting on this. The report and recommendations have since been used by DOE and have led to other national lab collaborations. These are all project strengths.

TRITON INITIATIVE

(WBS #: 2.3.2.601)

Recipient:	PNNL
Principal Investigator:	Genevra Harker-Kilmes
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$8,365K
Total Costed:	$4,746K

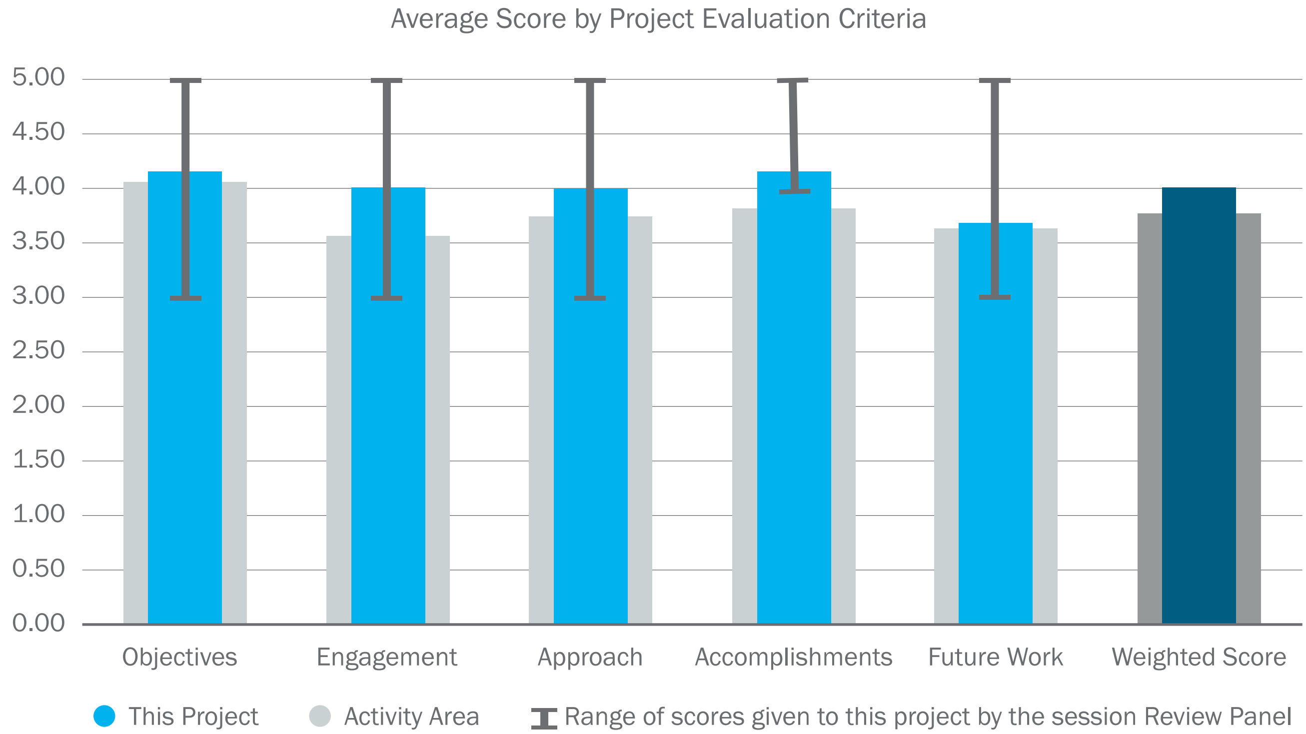
Project Description

The Triton Initiative, led by PNNL, aligns with the DOE objective to improve the efficiency and effectiveness of environmental monitoring. The initiative supports DOE-funded projects that advance environmental monitoring technologies, including sensor and software development for use in MHK energy projects (and potentially offshore wind where appropriate). Development of monitoring techniques and platforms associated with MHK deployments will reduce costs and timescales for permitting to enable widespread deployment of energy devices. Triton is composed of three tasks:

1. The continuation of the FY 2016 FOA support (FOA Support): PNNL provides technical expertise (engineers, oceanographers, data scientists, scientific divers, fisheries experts), research vessels, and permitted in-water testing sites available for use by instrumentation developers.
2. Fish Mesocosm Study: PNNL includes fundamental research focused on providing new data related to fish collision, avoidance, and evasion in response to interaction with a tidal turbine (developed by UW-APL for the navy).
3. Triton Field Trials: PNNL will produce criteria for standardized environmental measurements by developing guideline methodologies to inform environmental data collection and analysis, which will increase the robustness and comparability of datasets across the industry.

Weighted Project Score: 4.0

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The Triton Initiative is a project with a large scope and budget, with three distinct tasks. Reviewers agreed that there was not enough information given in the project summary or presentation time allocated to adequately evaluate each of the three tasks. The first task, FOA support for WPTO awardees, received outstanding reviews from these awardees and additional detail on the Triton initiative could be gleaned from collaborators' presentations. Several reviewers strongly suggested that the Triton Initiative be separated into its three components, even if only for peer review purposes. The reviewers made two pages of additional "Recommendations" on this project and suggested that WPTO carefully reviews them.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers agreed that this project aligns very well with the overall WPTO program and significantly contributes to its strategic goals. One of the project's goals (or products) is to provide support to existing MHK FOA projects engaged in environmental monitoring instrumentation development under WPTO's Reducing Barriers to Testing activity area, as well as provide access to in-water testing. This makes the project relevant, as it had and will have a meaningful impact on other projects. The reviewers' impression from other presentations under the Reducing Barriers to Testing activity area was that the FOA support of the Triton initiative was viewed very positively by the various collaborators.

In addition to the FOA Support task (Task 1), the Triton Initiative includes the Fish Mesocosm Study (Task 2) and a task to develop best practices for environmental monitoring (Triton Field Trials, Task 3). Two of the five reviewers commented that the three tasks appeared to be unrelated or distinct projects, which made it difficult to evaluate each task and the overall project.

End User Engagement and Dissemination Strategy

Reviewers agreed that the project clearly identified who will benefit from Task 1, FOA Support, and how it will help advance the MHK industry by facilitating field tests for various (environmental) instrumentation. Similarly, it was clear which end users were engaged under this task, and how they benefitted. Feedback from FOA collaborators (engaged as "end users") was very positive regarding responsiveness and project support.

Three of the five reviewers commented that the end user or stakeholder engagement strategy for the FMS (Task 2) was not clear. One reviewer commented that the end user engagement strategy for Task 3 lacked information about how conversations with subject matter experts will be translated into best practices.

The dissemination strategy mainly discussed Triton Field Trials (Task 3), with Task 1 being disseminated through website features and, presumably, through the FOA awardees being supported by this initiative. As Task 2 is still in its early stages, plans to disseminate the results were not specific.

Management and Technical Approach

All reviewers agreed that the FOA Support (Task 1) was well organized and managed. The technical approach to this task was sound and well received by collaborating FOA recipients.

Two reviewers thought that management and technical approach for the Triton Field Trials were good or appropriate, while two reviewers thought they were less clear and would have benefitted from additional specificity.

All reviewers expressed some form of concern for the Fish Mesocosm Study. Concerns ranged from requesting more specificity/clarity on management and technical approach, to the metrics of success and goals of this study, to questions about the (deepwater) fish species and the (shallow) test site in Sequim Bay. It was noted that the fish study was delayed since the installation of a tidal turbine was delayed. There is a lack of data on fish interaction with MHK turbines. It was noted in reviewer discussions that it is ironic that permitting is the cause of the delay for this task.

Technical Accomplishments and Progress

The reviewers agreed that the project has made excellent progress toward achieving the objectives of Task 1. Several field tests were supported, and reviewers generally found the context provided by the collaborators in later presentations very helpful for understanding the full scope of this part of the Triton project.

For the FMS, 100 sable fish were tagged with acoustic tags Juvenile Salmon Acoustic Telemetry System, and fish tracking was demonstrated in Sequim Bay.

Initial progress on Task 3 was reported. Two reviewers expressed concerns about the Triton Field Trials goals, as well as what level of detail "best practices" recommendations for environmental monitoring can be made at this stage of the still divergent MHK industry.

Future Work

Some goals for future work were listed in the project summary. No milestone schedule and go/no-go decision points were given.

Reviewers agreed that more details about future work, broader objectives, specific project goals, methodologies for the FMS, technical issues and challenges, etc., would have been helpful for assessing plans for future work.

VIDEO ANALYSIS SOFTWARE DEVELOPMENT

(WBS #: 2.3.2.602)

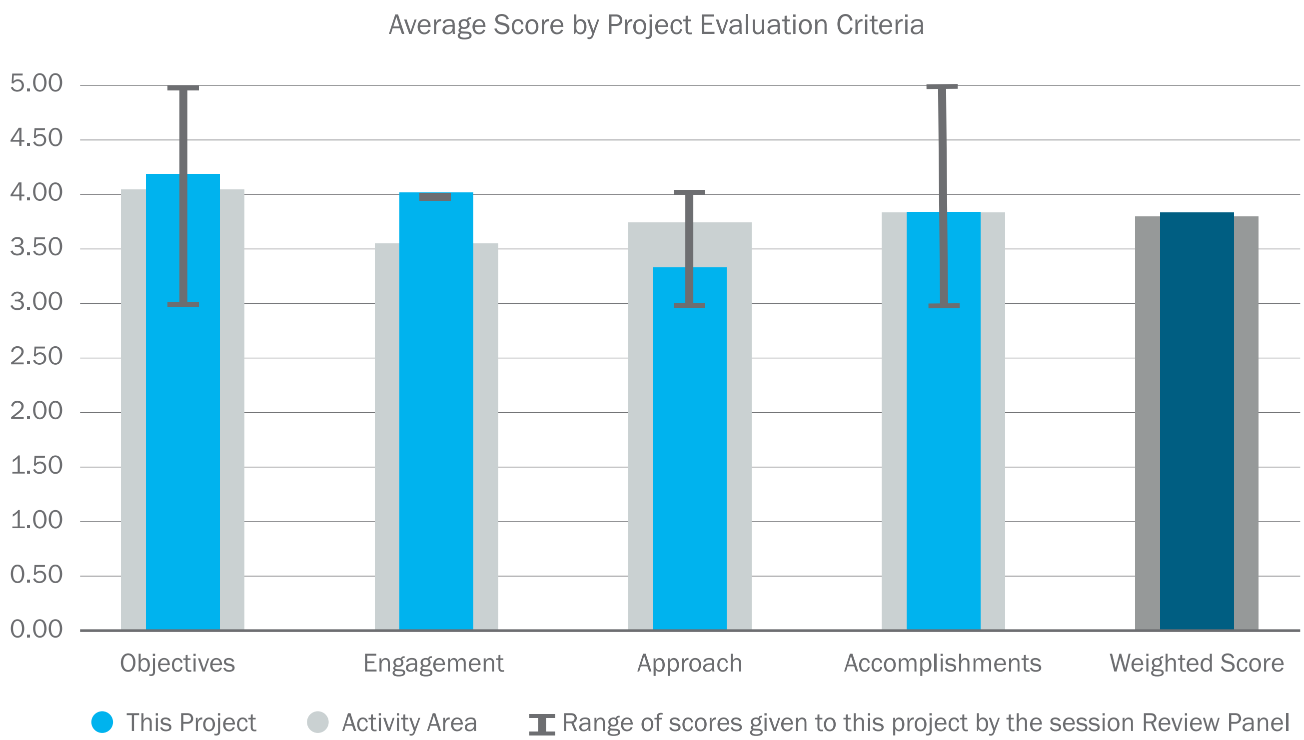
Recipient:	PNNL
Principal Investigator:	Shari Matzner
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$300K
Total Costed:	$300K

Project Description

The aim of this project was to develop software to expedite underwater video analysis. Underwater video camera systems are effective for recording fish and wildlife activity around MHK devices. But the process of reviewing and quantifying the information in underwater video is time consuming and costly due to the labor-intensive nature of the analysis. There is a need for automation to reduce labor costs. The EyeSea software was developed as a framework for the underwater video analysis workflow to make manual analysis more efficient by incorporating automated detection of the presence of wildlife.

Weighted Project Score: 3.8

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

This project summary was well written and addressed all of the topics in a concise manner. With the high false-positive rate, the most significant challenge remains the application to broader video datasets. This will require additional work/supervision and development investment. To avoid further reinvention in automated image processing approaches, there are lessons from other fields of study (such as fluid dynamics) that the project team could apply to capitalize on existing research investment. The project should also have an objective on how the tool will be implemented beyond automated detection. One recommendation is to work with NOAA and NMFS to come up with metrics and analysis approached to address monitoring questions.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project performers have described how the project contributes to the program's strategy/approaches. The reviewers agreed that the project aligns with the overall program strategy. There is a significant observer burden to review the data, and a tool like this is necessary if MHK is going to use video to detect fish. The major contribution of this project is an automation routine to detect fish in video data. The project performers have considered and described the use/applications of their expected products and outputs. This project is focused on detection for human assisted review of video data. Project objectives are well-defined in terms of in-situ application and technical goals (e.g., true positive and false-positive detection rates). Other than reducing workload to find segments with fish, it was not clear yet how it would be implemented to review data with specific monitoring objectives. The project will demonstrate relevancy as the open source software will be used by ORPC with the RivGen turbine deployment.

End User Engagement and Dissemination Strategy

The project performers have identified who will benefit from this project and how the success of the project will advance the industry or meet the needs of specific stakeholder/end user groups. The end users seem to be largely PNNL, contractor support, industry, and regulators. Stakeholders from relevant agencies such as NOAA, EPRI, and the U.S. Environmental Protection Agency were engaged via webinar and a follow-on survey, but the participation rate was too low to provide useful data. Planned software updates will be made available to the MHK community. There was a concern of whether there was planned future interaction with user groups to receive feedback for continued maintenance and feature development. The reviewers noted that a great project feature was the annotated video data sets that are publicly available for future development. The questions regulators want to answer with the monitoring data need to be identified to successfully develop the application of the software.

Management and Technical Approach

The roles and experiences of project contributors, all located at PNNL, were clearly described. Quarterly milestones were well defined for the one-year project. The project was initially conceived as one to simply develop algorithms for the application, but the project performers felt that the project would benefit from an expanded approach to emphasize the development of not only algorithms but an open source software application to allow for flexibility, outside development, and future integration with new algorithms in the field. This framework allows for users to automatically process video data to detect targets and then manually review data by removing false positives and annotating relevant targets. These data are written to a database for further post-processing. The primary noted challenges related to the lack of datasets from training algorithms and the low quality often associated with such data streams. To address these issues, the goal was to obtain at least four unique data sets for annotation, analysis, and algorithm verification. The issue of low-quality data was to be addressed by verifying that the developed algorithms worked in these circumstances.

Three reviewers had some concerns about the technical approach. First, the datasets were not annotated in a systematic way. From the presentations and questions, it seemed that the subset of data that were annotated in each data set were done ad hoc. This raises concerns about bias that may have entered into the validations of the auto detector because of this ad hoc approach. The creation of annotated datasets is well established in a number of fields. The literature should have been used to find appropriate systematic ways of annotating these data to minimize potential biases. Second, it is worrying that the deep learning algorithm did not seem to work consistently, even within the same data set. This inconsistency may be related to biases introduced by the ad hoc annotation.

Technical Accomplishments and Progress

The most significant technical achievements were the generation of datasets (i.e., annotated video appropriate for algorithm development), the creation of the open source software, and the successful application of deep learning techniques for the automatic detection of fish. In this process, six datasets (including two from MHK sites) were collected and analyzed. In addition to their use in the project, these annotated data have been made publicly available, and the project team has received multiple requests for access to the data. As a web-based system, the open source application is suitable for any operating system. In addition to text file outputs for database and statistical analysis, data summaries include heat maps for the location of the detections. False detection rate was higher than desired, and detection capability of fish was limited to those that were available in the training datasets. The goal of reaching the 30% false-positive rate was not reached, and algorithms trained by two of the datasets did not successfully detect targets when applied to all of the datasets. These false positives were primarily attributed to detection of the RivGen due to its rotation and changing ambient conditions during optical monitoring. This is a significant challenge since the use of artificial light could have an impact of behavior in this context. This challenge highlights the need for careful implementation. The detector also needed to be trained and evaluated on each dataset before use. This could lead to a significant investment of labor initially for each site, but would improve over time. Regardless, improvements in detection statistics will be successful application to a broader range of relevant data.

MHK REGULATORY INITIATIVES ANALYSIS

(WBS #: 2.3.2.603)

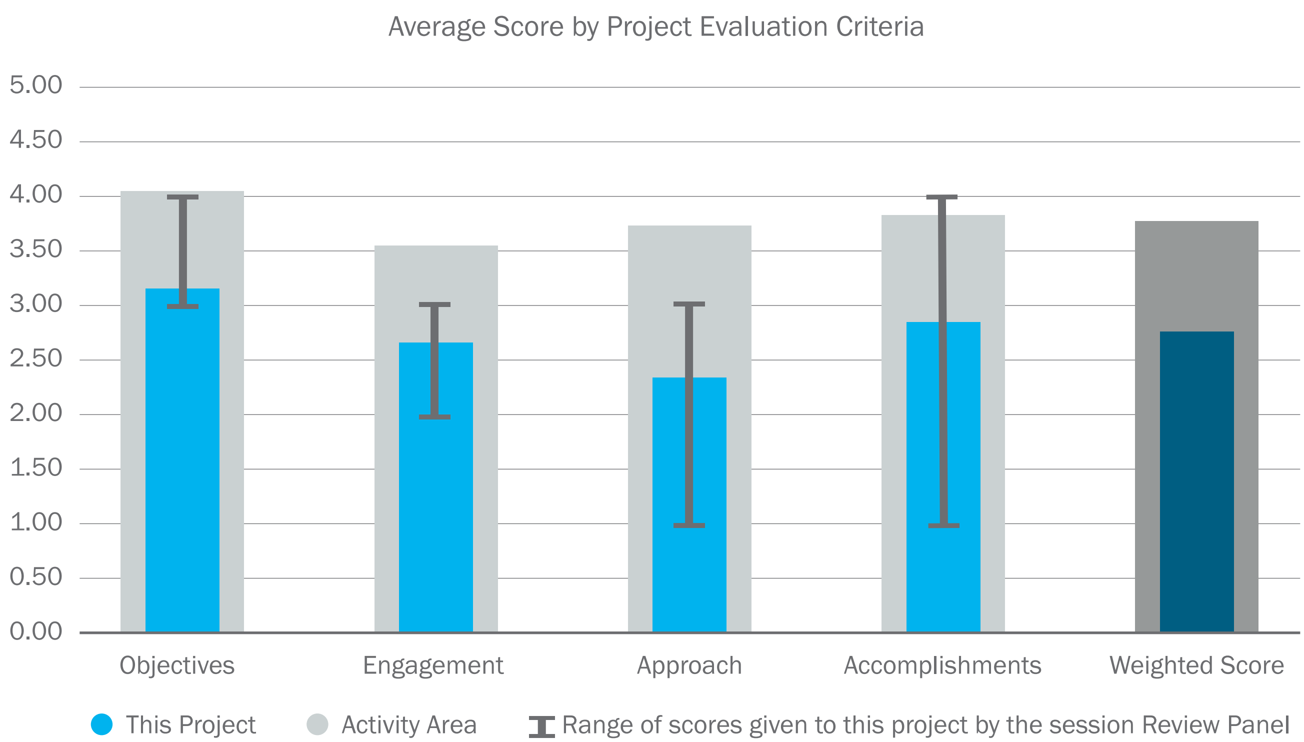
Recipient:	PNNL
Principal Investigator:	Bo Saulsberry
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$222K
Total Costed:	$211K

Project Description

The MHK Regulatory Initiatives Analysis project was created to review current regulatory conditions for MHK development, identify opportunities for greater regulatory success, and provide a set of recommendations for potential R&D that DOE might undertake in the near term to reduce the cost and time of regulatory activities. The project resulted in two laboratory publications—a formal literature review and a report detailing over 35 forward-looking regulatory research topics and potential actions—as well as an update to an existing compendium of state and federal regulations governing MHK projects, the *2019 Handbook of Hydrokinetic Regulatory Processes* (Publication Number DOE-EE1793).

Weighted Project Score: 2.8

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers did not feel that they received sufficient information to review this effort. Some reviewers acknowledged that this was likely a project that should have been exempt from the Peer Review, as the main purpose of the research was to inform internal WPTO decision making. The only external-facing product from this project was the update to the permitting handbook, which reviewers agreed was a valuable product.

The project was focused on using the results of interviews with industry and regulator representatives to inform the PI's programmatic recommendations to WPTO. While this is a good initial approach, the interpretation of the interview data could be subjective. A significant component missing from the presentation was the project's results beyond vague statements about the state of the regulatory environment. The presenter's discussion on technical achievements did not include details on the key findings, which made it difficult for the reviewers to evaluate this project.

The real challenge lies in making recommendations of best investment approaches to address the overarching themes in the matrix. The addition of this task would have made this a more valuable project. The approach would have benefitted from initial end user engagement. Result validation with the regulatory/stakeholder groups would benefit the products, particularly if they will be shared outside of DOE.

Some reviewers thought there may have been some overlap in scope between this project and the "MHK Environmental Compliance Cost Assessment" project.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project aligns with the overall program strategy, and the major contribution to the MHK community is the release of the Handbook. The project performers have considered and described the use/applications of their expected products and outputs. Regarding the report to DOE, the project performer's results were largely focused on DOE as the internal end user. Therefore, the application is purely internal agency guidance that may not be the best strategy in the regulatory view. Further, the interviewees or the regulatory community did not have the opportunity to provide feedback on the product. The resulting recommendation matrix in the synthesis report was underwhelming and did not make any significant recommendations on how to advance the knowledge of the overarching themes presented.

End User Engagement and Dissemination Strategy

The project performers identified and directly interviewed over 30 interviewees with a variety of stakeholder interests, representing a broad range of industry and regulator representatives. The choices made in direct stakeholder engagement were clearly made with the goal of representing a sufficiently diverse group of individuals to identify points of consensus or diverging attitudes about particular regulatory issues. A missed opportunity in this project was the lack of engagement with the regulatory entities to shape the project, which would have enabled buy-in and possibly the actual modification of policy/process. Stakeholders were engaged in the second phase of the project as interviewees; however, communication back to the end users on the results is unclear since the products to date are 'inwardly' facing. Further, there should be end user engagement to achieve the goal of the project. An oversight or advisory group would have improved this project.

Management and Technical Approach

The project performers have implemented technically sound R&D approaches. The whole project was focused on using the results of the interviews to inform the recommendations. While this is a good initial approach, the interpretation of the interview data can be subjective and biased. Reviewers recommended that the project performers have a feedback loop with the interviewees. This would have been a stronger project if there was a steering group, composed of peers and regulators that summarized the interview comments in the final report. The project outcome included two publications to DOE; however, it was not clear to reviewers whether the publications will be used to inform program strategy. It is possible that the Handbook will be reviewed by a significant number of regulators.

Technical Accomplishments and Progress

The project performers have made progress in reaching their objectives based on their project management plan, which included two publications; however, the project timeline was lengthened and shifted due to personnel rotations. While significant research products were described, no substantive information about key findings was presented. The primary results that were reported were quite vague and were mostly limited to broad statements that could have been identified by those familiar with the industry without having gone through the research program described. Likewise, the lack of discussion of the findings in the context of the evolution of the regulatory environment makes it difficult to identify the significant of the contributions from this work. The valuable product of this project is the update to the Handbook.

HYDRODYNAMIC AND ACOUSTIC MODELS FOR QUANTITATIVE ENVIRONMENTAL ASSESSMENT

(WBS #: 2.3.2.701)

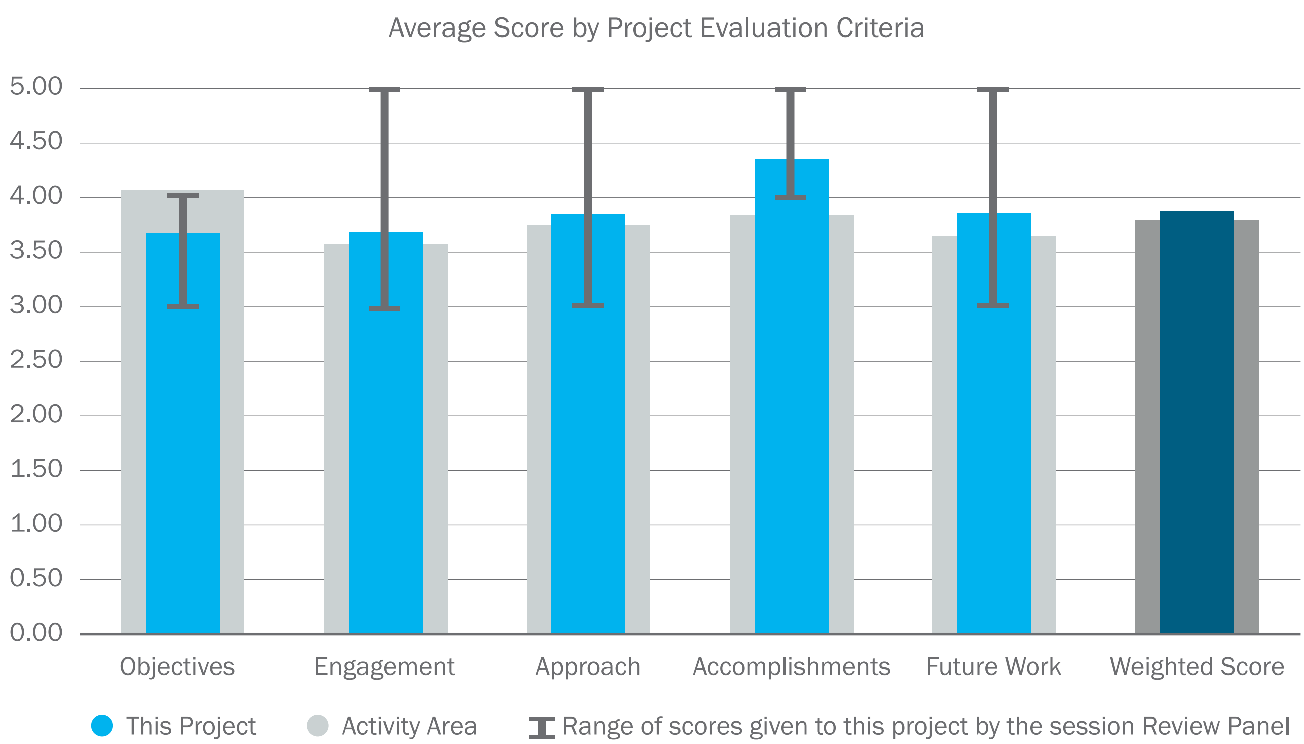
Recipient:	SNL
Principal Investigator:	Jesse Roberts
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$2,321K
Total Costed:	$1,889K

Project Description

The project fulfills an industry need for methodologies and open-source software tools that quantify, a priori, the effects of MHK-device interactions and MHK-generated noise in marine environments. The tools also support MHK-device design and array layouts to minimize environmental effects incurred through altered hydrodynamics and acoustics. The state-of-the-art modeling tools support accurate characterization, screening, and mitigation of environmental risk, while providing for cost-optimized MHK project planning that maintains environmental compliance. Ultimately, quantifying and minimizing uncertainty in regulatory processes increases investor confidence and decreases project risks, thereby improving developer funding and commercialization outlooks.

Weighted Project Score: 3.9

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers generally acknowledged the potential utility and complexity of these tools and seem positive about this project and the progress it has made. There are however some concerns about how the tool gets used. Three of the reviewers were concerned about who ultimately uses these tools. One recommendation was that only experienced users who understand the specific models should use them to ensure that erroneous input parameters aren't used and that outputs are properly interpreted. One reviewer raised a concern for how these tools would be supported in the longer term (bug fixes, training, etc.).

Project Objectives, Impacts, and Alignment with the Program Strategy

The review team agreed that the project performers described how the project contributes to the program's strategy; they considered the application of their products, and the project was relevant. Two concerns were raised about how this software is ultimately used. Both focused on the potential misuse of the software by non-expert users.

End User Engagement and Dissemination Strategy

The reviewers generally agreed that there has been outreach to industry and regulators, but were confused about outreach beyond that. There seems confusion in terms of what outreach has happened already and to whom and whether developers or other end users will have the capacity to use this kind of a tool.

Management and Technical Approach

Generally speaking, the reviewer found the project performers have implemented a technically sound research approach and project management plan. One reviewer felt there was not sufficient information to evaluate the management plan. Two reviewers raised concerns about the risk metric. One suggested engaging with the regulator to understand how they might want risk measured. The other asked that the project team provide details of how risk is measured.

Technical Accomplishments and Progress

All reviewers agreed that significant progress had been made in developing these tools, and objectives/milestones have been reached. One reviewer raised concerns about the risk metric and how various risks are combined into a single metric. One reviewer reminded the project team that tool validation will be particularly important before the tools are rolled out, while another reviewer commented that they were happy with the model validation to date.

Future Work

The review team generally agreed that future work was well outlined, with a few comments that more details were needed. One reviewer suggested an a priori decision on how the metric of tool 'uptake' is evaluated to determine success. Another reviewer raised concerns about how the risk metric is developed.

MHK ENVIRONMENTAL COMPLIANCE COST ASSESSMENT

(WBS #: 2.3.2.702)

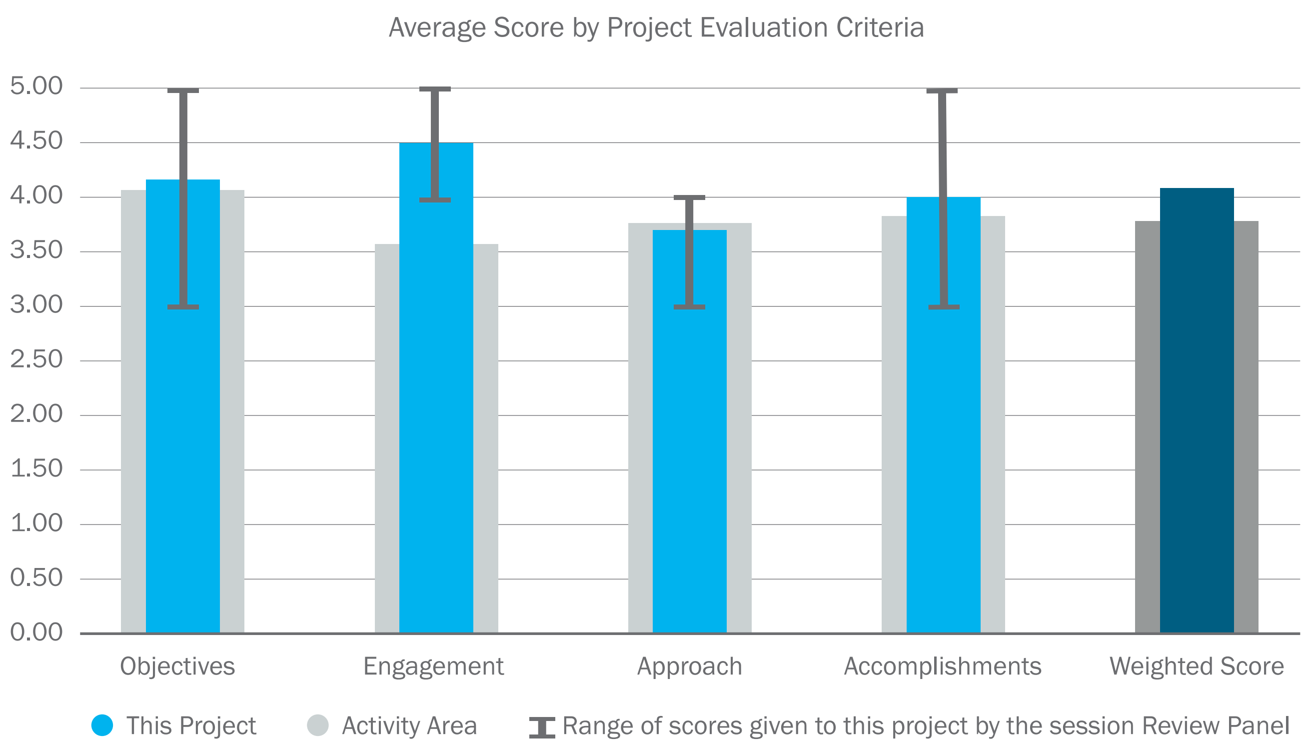
Recipient:	SNL
Principal Investigator:	Jesse Roberts
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$1,637K
Total Costed:	$1,246K

Project Description

This project seeks to reduce time and costs associated with successfully licensing and permitting MHK developments and maintaining environmental compliance throughout its lifecycle. This is accomplished by understanding the regulatory process, key costs, and their environmental uncertainty for licensing/permitting, monitoring, and license implementation. Strategic representatives from the MHK industry and state and federal regulatory agencies are engaged to gather first-hand, detailed data on environmental compliance costs and regulatory concerns, which are central to the development of successful cost reduction strategies, or the identification of improved effectiveness and permitting and compliance. Further, the project team benchmarks permitting and compliance costs with other renewable and marine technologies to understand their costs and how they changed over time with the technologies' advancement, regulatory processes, and project deployment experience.

Weighted Project Score: **4.1**

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The project was uniquely positioned to inquire in detail about what information would be needed to reduce regulatory burdens and to investigate what the broader impacts of those costs would have been to projects. Each project is, and will continue to be, unique in the sense that different sites have different social and political pressures, as these are complicated issues. It would have been helpful to have more details about what level of information would be acceptable in terms of risk from a management perspective.

Additionally, it would be helpful to come full circle and seek regulatory concurrence on the prioritization and action plan. Two reviewers commented that it may be helpful to investigate synergies with the emerging offshore wind regulatory processes. Additional project cost data from other small MHK deployments could be included to refine the project cost trend lines. The presenter linked the data to an LCOE comparison; however, based on WPTO's interest in discovering alternative metrics to LCOE, future linkages could be made with more complementary data.

Project Objectives, Impacts, and Alignment with the Program Strategy

The purpose of this project is to collect cost estimates associated with permitting, environmental monitoring, and similar issues from previously WPTO-funded projects, then use this information to identify approaches for increasing the effectiveness and efficiency of permitting processes in a quantitative way.

The project performers described how the project contributes to the program's approaches and showed good connection to Tech-Specific Design and Validation via cost estimates of permitting throughout the project's lifecycle. Two specific approaches to reduce barriers to testing include addressing regulatory efficiency and leveraging baseline data to inform future opportunities to reduce costs. Information from other sectors was used to inform strategies in the project. They used data collected to identify cost reduction strategies to improve the process for the industry and regulators. In the end, it was difficult for the reviewers to determine if the objective was fully achieved because of the limited amount of data that could be collected. Explanation of relevance and how the project will advance DOE's direction was very well done. Overall, this project will work across multiple applications.

End User Engagement and Dissemination Strategy

End users were engaged from the beginning of the project. The project performers have identified who will benefit from this project and how the success of the project will advance the industry or meet the needs of specific stakeholder/end user groups. The project team defined the end users and stakeholders, discussing how they are integrated in the overall project to be as transparent and end-user-focused as possible. The project team conducted interviews for 19 projects to get a diverse perspective on costs and challenges that are affecting MHK projects. The project performers have clearly described the rationale for the stakeholder/end user engagement strategy and how project results and information have been/are planned to be disseminated.

Project performers successfully engaged industry to identify their costs, which was a particularly valuable exercise. The project included an iterative process to inform, rank, and prioritize strategies.

Management and Technical Approach

Project performers had a comprehensive approach to determine permitting costs, as well as to identify and develop cost reduction pathways with a good management team. The stakeholder engagement approach was strong. Project responsibilities and division of labor among project participants appears well defined. Critical to the project was the participation of individuals involved with prior projects. To ensure that the results were representative, it was necessary to draw from the experiences of as many stakeholders as possible.

The benchmarking and quantitative economic analysis was less clear in the text. It was unclear how the lack of data affected the process and results.

Technical Accomplishments and Progress

The project is sunsetting, and the project largely accomplished its goals by collecting and analyzing information from a range of different projects. Project performers assessed costs for each category and have begun to make near- and long-term investment strategy to ultimately reduce costs. They demonstrated linkages in strategy, hosted a workshop, and developed an action plan. Project products were summarized, but additional information about key results would have been helpful.

There was limited quantitative information on the comparison of MHK project environmental compliance and permitting costs to other industries (e.g., other renewables or offshore oil and gas) or to other countries. Several reviewers commented that the “interconnectedness” diagram and linkages were not effective but recommended a social network analysis. Additionally, it would have been helpful to see concrete examples of cost savings.

MARINE MAMMAL BEHAVIORAL RESPONSE TO TIDAL TURBINE SOUND

(WBS #: EE0006385)

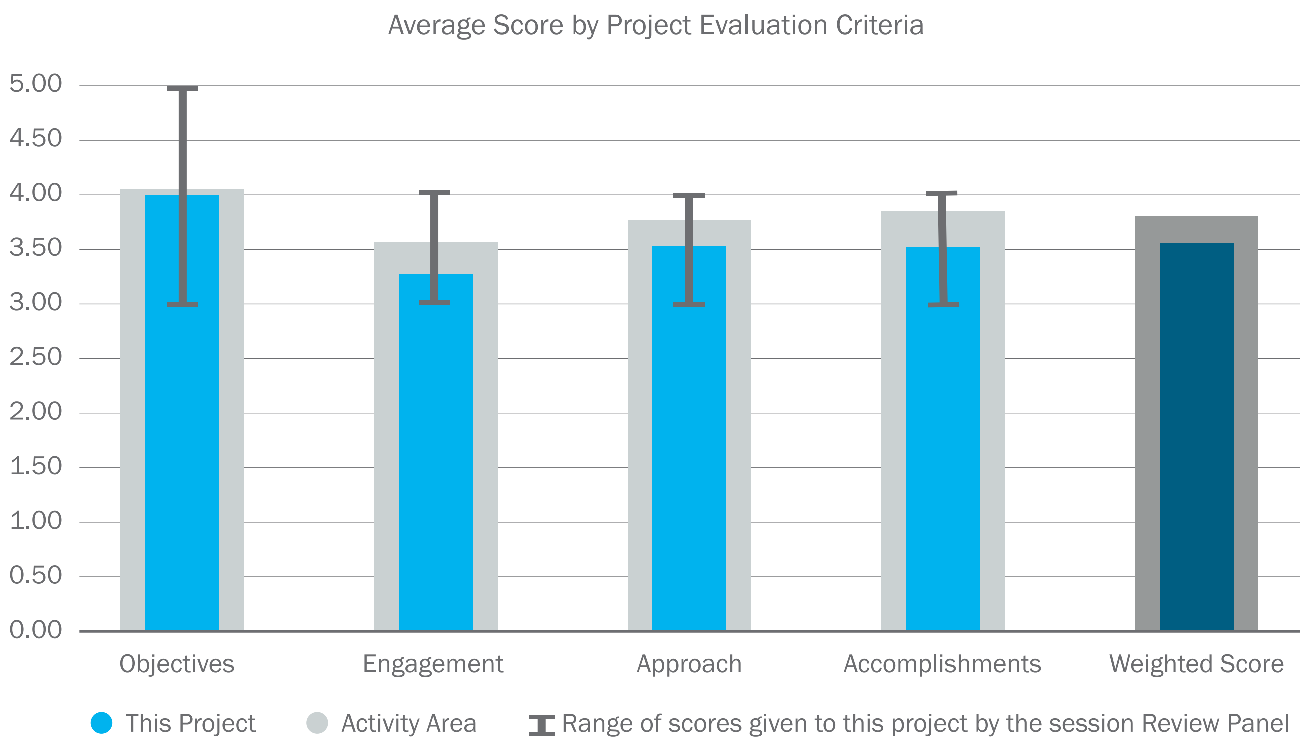
Recipient:	University of Washington
Principal Investigator:	Brian Polagye
Project Type:	FOA 816: Marine and Hydrokinetic Environmental Effects Assessment and Monitoring
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$500K
Total Costed:	$495K

Project Description

Originally conceived as a study of marine mammal behavioral responses to the sound produced by a small array of tidal turbines, the project was re-scoped to evaluate behavioral responses to a playback of turbine sound in Admiralty Inlet, Washington. Results suggest that harbor seals are unlikely to show a measurable response to turbine sound with a broadband source level of 158 dB re 1 μPa (0.030–10 kHz). An avoidance reaction to a range of 300 was observed for harbor porpoises during the initial trial, but this declined during the second trial and was not observable in the third.

Weighted Project Score: 3.6

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The project aligns with the overall program strategy and provides data on behavioral response of harbor porpoise and harbor seals to simulated playback of turbine sounds. There was overall concern about end user and scientific peer review engagement at the beginning and throughout the study. Regulators should be considered end users and should provide feedback on the study design and how the results would be interpreted in making policy decisions. There were sample size concerns, with a limited number of playbacks per seasons, and there were observer bias concerns from the visual presence of the playback boat without any controls. There was no mention of how the responses were scored or how their approach compares to the approaches of other marine mammal behavioral response studies. The results of this study need to be published in a peer reviewed journal to be considered by the regulators. Reviewers recommended an additional field year of data collection and an advancement of the methods to mitigate observer bias from the boat presence.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project performers have described how the project contributes to the program's strategy/approaches. Reviewers generally agreed that the project aligns with the overall program strategy. The major contribution is the assessment of behavioral response of two marine mammals to a simulated MHK signal. The project performers have considered and described the use/applications of their expected products and outputs. Results would be used to inform the regulators and action proponents about the potential behavioral impacts. However, several reviewers expressed concern about regulator engagement and the ability to "retire risk" from one study. The project performers have presented the relevance of this project and how the successful completion of the project will advance the state of technology, provide meaningful impacts, and/or contribute to the viability of any commercial applications.

End User Engagement and Dissemination Strategy

End users were listed as researchers and consultants who implement monitoring requirements. However, there was no mention of outreach to the end user community at the onset of the study to seek feedback. Only one peer review presentation was given in 2017. The project would benefit from presentations at relevant scientific conferences. Reviewers felt that the regulators should be considered an end user, and they should be given the opportunity to comment on the study design and analysis from the beginning. Results need to be published in a peer reviewed journal.

Management and Technical Approach

Despite the project's challenges, it appears to be very well managed. The project was forced to abandon its planned study in Europe due to the financial instability of the project partner, and the project team found a way to move forward in local waters with a turbine sound play-back approach. Observer bias based on presence of playback ship needs to be evaluated. While the PIs made the best of the situation they had, there is a big concern that playing back sounds collected in a River in a Bay system (even amplified) is not appropriate, and the reviewers questioned how relevant the responses observed will be for future applications in that Bay or even in a river situation. Seasonal changes in behavior could explain the change in responses of harbor porpoises. The timeframe for the project was not long enough to tease out these differences. Behavioral response severity scoring (such as in Southall 2007) should be considered in evaluating response data. As such, retiring or even reducing the uncertainty of acoustic production by turbines cannot be discerned with this study. The project duration should be extended to repeat project over different seasons and repeat seasons to have adequate sample size.

Technical Accomplishments and Progress

The project team has completed their stated modified and constrained project objectives. The performers overcame significant challenges in the study design and ultimately reverted to a simulated playback of the turbine. They effectively set up the experiment to conduct three trials within one year. However, this is a limited sample size when considering seasonal variability, breeding state, the effect of boat presence, and observer bias because the observer is not blind to the presence of the stimulus. There was concern from several reviewers if playback, with amplification, was the right approach. The project performers have described their most important accomplishments in achieving milestones, reaching technical targets, and overcoming technical barriers. Much of the focus was on effective source simulation and assessment of transmission loss. Very little data was presented in how the observations were conducted and response scored. There was limited focus on publishing the results, and this should be a main goal of this project. For the results to be utilized, they need to be published in a peer-reviewed journal.

NOISESPOTTER: COST-EFFECTIVE, REAL-TIME ACOUSTICCHARACTERIZATION AND LOCALIZATION SYSTEM

(WBS #: EE0007822)

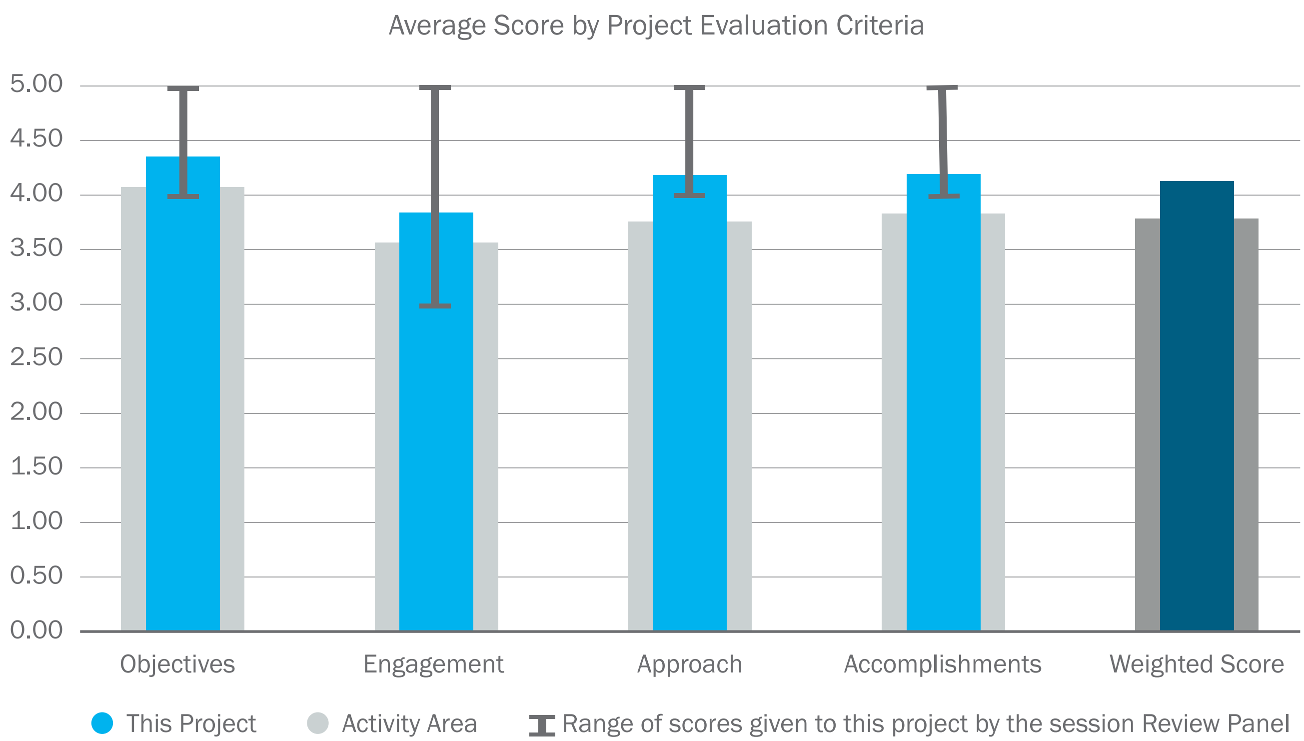
Recipient:	Integral Consulting Inc.
Principal Investigator:	Kaustubha Raghukumar
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Advancement
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$945K
Total Costed:	$710K

Project Description

The primary objective of this project is to develop a cost-effective, fit-for-purpose environmental monitoring system that characterizes, classifies, and provides accurate location information for anthropogenic and natural sounds in real-time. "NoiseSpotter" has been developed to support the evaluation of potential acoustic effects of MHK projects. By utilizing a compact array of three acoustic vector sensors, NoiseSpotter triangulates individual bearings to provide sound source localization, allowing for the ability to discern MHK device sounds relative to other confounding sounds in the environment, while providing location estimates to nearby marine mammals for environmental mitigation purposes.

Weighted Project Score: **4.1**

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The project team used a technically sound R&D approach to develop a system with a real-time passive acoustics array to characterize noise from MHK devices. All reviewers agreed that this was a well-executed project, which met or exceeded all of its technical goals. The ability of the system to localize sources to within 4 m at a range of 300 m is considered valuable. The NoiseSpotter is viewed as an interesting and promising system to measure noise from MHK devices.

Two general concerns were voiced by the reviewers: (1) that the flow-generated noise of the device was still too high for it to be suitable to characterize MHK devices in tidal energy sites with strong currents, and (2) that the system can only measure up to 3 kHz, while marine mammals' hearing extends to higher frequency, and some MHK devices may generate sound at higher frequencies as well.

Project Objectives, Impacts, and Alignment with the Program Strategy

The accurate measurement of radiated noise from MHK devices remains a significant challenge. The project performers are developing a system, called NoiseSpotter, which uses a real-time, passive acoustics array that can characterize noise from MHK devices at lower cost than comparable systems.

There was consensus among reviewers that the project aligns well with the overall WPTO strategy of reducing barriers to testing and demonstration deployments. The product would allow the MHK industry and regulators to assess acoustic impacts to fish and marine mammals, and thereby address a significant environmental concern. The product could be used both in MHK site characterization and for device noise measurements (i.e., environmental impact assessment). Compared to a single sensor, the vector array allows sound source location, which is necessary to distinguish MHK noise from other sounds.

Most reviewers thought that the successful development of this system will advance the state of the technology and have a meaningful impact in reducing barriers to testing and advancing the MHK industry.

End User Engagement and Dissemination Strategy

Reviewers generally agreed that the project performers identified industry needs and regulatory questions, as well as project beneficiaries.

The project team clearly described how project results have been disseminated to date. The majority of the reviewers were satisfied with the level of end user engagement and surveying of end user needs, although two reviewers questioned whether the dissemination of information about the system at various conferences and workshops allowed for true engagement of relevant stakeholders, as no outcomes of this type of engagement were reported.

The survey of industry and regulator needs was viewed positively, albeit one reviewer noted that it was not included in the milestone table and expressed concern whether sufficient importance was placed on this task.

Management and Technical Approach

The reviewers agreed that the project was well managed and executed by a capable research team. The R&D approach was viewed as technically sound by all reviewers. A strategy for development, testing/validation, and end user feedback was incorporated into the management approach. While one reviewer praised the clear and well laid-out milestone table and schedule, another commented that it was not clear from the milestone table whether the quantitative metrics to be used for decision making will be developed with input from stakeholders beyond the initial surveys.

A risk that was brought up by all reviewers (which was also extensively commented on under "Technical Accomplishments and Progress") was the issue of flow-generated noise. When compared to drifter hydrophones, e.g. DAISY, the NoiseSpotter has a significantly higher flow noise (between 20 and 40 dB higher). The flow noise reductions that were achieved with the NoiseSpotter make it suitable for wave environments and WECs, but not for energetic tidal sites. Two reviewers recommended establishing a metric to determine performance/utility for environments with strong currents (beyond the technical target table). Another risk that was mentioned was that the frequency response of the system, only goes to 3 kHz, while most of the acoustic energy from MHK devices will be below 3 kHz, marine mammal hearing goes to higher frequencies.

It was viewed very positively by all reviewers that the system has undergone a good amount of field testing already, and will undergo further testing with a deployed WEC at WETS.

Technical Accomplishments and Progress

The reviewers commended the project team on their accomplishments and agreed that the project met or exceeded its technical goals.

The system achieves a 50% cost savings over the baseline system. It can localize noise sources to within 4 m over a 300 m distance. A flow-noise reduction of 10–15 dB was achieved so far, but this is still a 20–40 dB higher flow noise than for the DAISY drifter.

The project performers clearly described their engineering goals and how they overcame technical barriers in a table that compares the current system scores to their target sores.

DAISY: A DRIFTING ACOUSTIC INSTRUMENTATION SYSTEM

(WBS #: EE0007823)

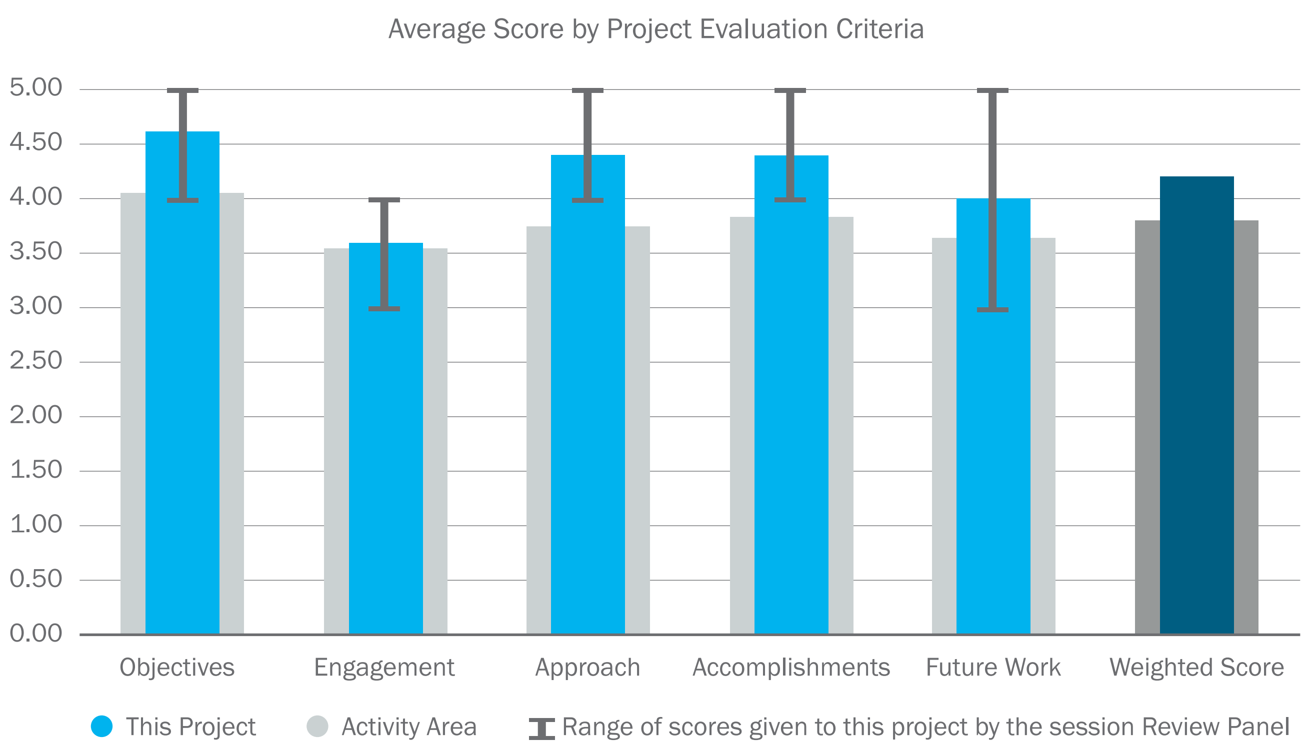
Recipient:	University of Washington
Principal Investigator:	Brian Polagye
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Advancement
Project Category:	Ongoing Projects
Total Authorized:	$835K
Total Costed:	$501K

Project Description

The objective of this project is to improve the cost effectiveness of high-fidelity measurements of underwater sounds in marine energy environments. To this end, the project team developed the Drifting Acoustic Instrumentation SYstems (DAISY) modular drifting system that can make accurate acoustic measurements in energetic waves and currents. Using arrays of georeferenced DAISYs, it will be possible to explore spatial variations in acoustic emissions from marine energy converters and localize these emissions to differentiate them from ambient noise. The latter is a critical limitation of existing measurement systems and their ability to retire environmental risks.

Weighted Project Score: 4.2

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The reviewers generally agreed that this project has been well managed and made significant progress. Particular strengths have been benchmarking and comparing to other technologies (e.g. the OSU spar buoy). A weakness that was noted by all of the reviewers was that similar technologies have been developed with support from other agencies and in other fields, and engaging with them could have avoided some duplication of effort and lessons learned.

Project Objectives, Impacts, and Alignment with the Program Strategy

All reviewers felt that this project aligned with the program's objectives (characterizing potential noise impacts) and that end use had been considered (a version for both current and wave devices have been developed).

End User Engagement and Dissemination Strategy

There was general agreement that engagement and dissemination on this project was good. However, one reviewer felt the engagement approach was unclear. Another reviewer felt the engagement was one way (via publications) with not enough feedback from regulators or developers. Two reviewers felt that outreach to related fields/equipment (e.g., sonobuoy) earlier on would have been beneficial. Reviewers felt that there are other interagency users that would be interested in this technology. The team should continue to think about who the end users operating DAISY would be and how they will be made commercially available. Broader, interagency application may foster commercial success.

Management and Technical Approach

All reviewers agreed that the management and technical approach were strong. Strengths that were noted included recovery from a delay due to component availability and benchmarking against the OSU spar buoy.

Technical Accomplishments and Progress

The reviewers agreed that the technical accomplishments and progress on this project have been strong. Two reviewers thought it was beneficial that this project compared the DAISY performance to other assets (e.g., OSU spar buoy, fixed hydrophones). One reviewer noted that some of the same technical challenges have been dealt with during NOAA and Navy projects and that these other projects could have helped inform the DAISY project.

Future Work

The review team was positive about the future testing of DAISY at WETS. One reviewer noted that dates were not given for this testing. Another reviewer asked how testing on a current energy converter device will be conducted in the future, and another reviewer suggested that it would be good to test DAISY at a current energy converterlocation.

LONG-RANGE TARGET DETECTION AND CLASSIFICATION SYSTEM FOR ENVIRONMENTAL MONITORING AT MHK SITES

(WBS #: EE0007824)

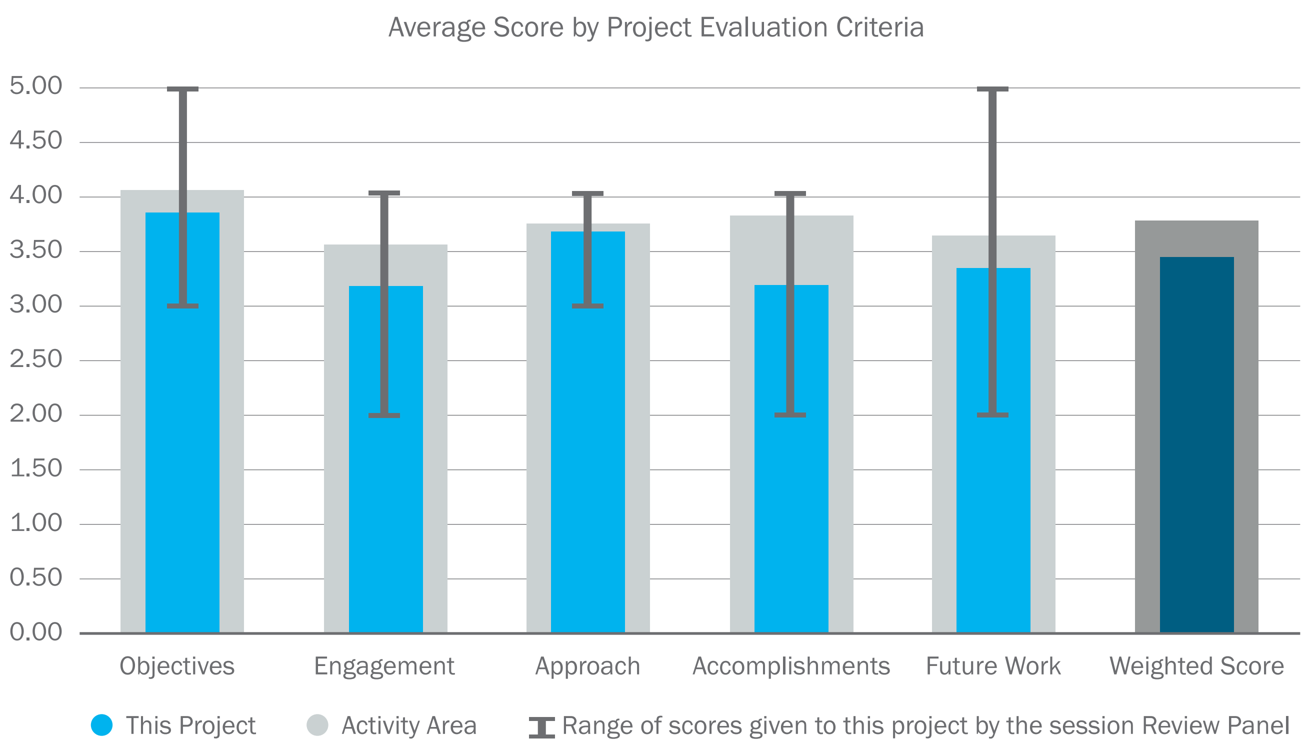
Recipient:	BioSonics, Inc.
Principal Investigator:	James Dawson
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Advancement
Project Category:	Ongoing Projects
Total Authorized:	$938K
Total Costed:	$762K

Project Description

BioSonics, Inc. will deliver a practical, robust, and cost-effective, long-range (200–300 m) active acoustic monitoring system, with innovative shaped pulse and Chirp capabilities to suppress off-frequency sound energy within the hearing range of marine mammals and to automatically assess marine life behavior at MHK sites. The one-of-a-kind sonar system successfully integrates a 360-degree perimeter detector to automatically detect and geolocate targets at range and a focused split beam directed classifier to track and classify target types. Initial target type classification is accomplished by analyzing target size, swimming speed, and behavior. Further target classification is accomplished by analyzing the phase coherence from reflected echoes via the split bream technique (i.e., point source versus nonpoint source targets). The system will automatically send low bandwidth, real-time reports on detected targets to project operators.

Weighted Project Score: 3.4

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The greatest strength of this project is the large detection range of large marine animals, which has the potential to improve monitoring around MHK sites. The greatest weakness is that there are still side lobes from the sonar that will be audible to many of these large animals. These side lobes have not been adequately addressed (from a biological perspective), and the use of this technology at WETS needs to be considered before deployment. Reviewers questioned if the system still has the potential to alter behavior of marine mammals and if a permit has been secured for the WETS testing.

Project Objectives, Impacts, and Alignment with the Program Strategy

The review team generally agreed that this project successfully described how it contributes to the program's strategy and approaches. There was less consensus on whether the project performers considered and described the use and applications of their expected product. Three reviewers agreed that this project has considered its use and application, while two reviewers did not specifically address this criterion, and one felt that this project had not sufficiently considered use and application in terms of concerns about the ability of marine animals to detect the side lobes of this sonar technology. There was most concern about the chance of success of this project in advancing the state-of-the-art technology and its impact and/or commercial applications. The concern here was not that a successful project would not have impact but rather that there seemed to be some doubt about the ability of this project to adequately deal with end user concerns (e.g., regulators), and some of this doubt was caused by not enough detail from the project.

End User Engagement and Dissemination Strategy

There seemed to be general agreement that this project has identified its beneficiaries. The reviewers also agreed that MHK developers and technical stakeholders were engaged, but the regulators and biologists (i.e., other stakeholders) were not engaged adequately or in a meaningful way, and the project team needs to address this.

Management and Technical Approach

Reviewers also agreed that the project performers had a sound project management plan and used a technically sound approach. Four of the reviewers raised concerns about the out-of-band noise from this sonar technology. These concerns were largely focused on regulator/biologist buy in and their concerns about audibility of these out-of-band peaks to marine animals and whether it was technically feasible to reduce the out-of-band peaks sufficiently.

Technical Accomplishments and Progress

Reviewers generally agreed that the project has been reaching its milestones and making progress, but there was still general concern about the metrics being used to describe success. One reviewer thought the metrics of success should relate out-of-band noise to marine mammal hearing thresholds.

Future Work

In general, the reviewers were positive about the next steps of testing at WETS. However, half of the reviewers raised questions about how marine mammals will be managed during the WETS testing (i.e., will they need special permits, or will a shutdown be needed for mitigation is unknown). Reviewers were generally interested in more details on this planned testing at WETS.

A COMBINED ELECTRIC/ MAGNETIC FIELD INSTRUMENT FOR MHK ENVIRONMENTAL MONITORING

(WBS #: EE0007825)

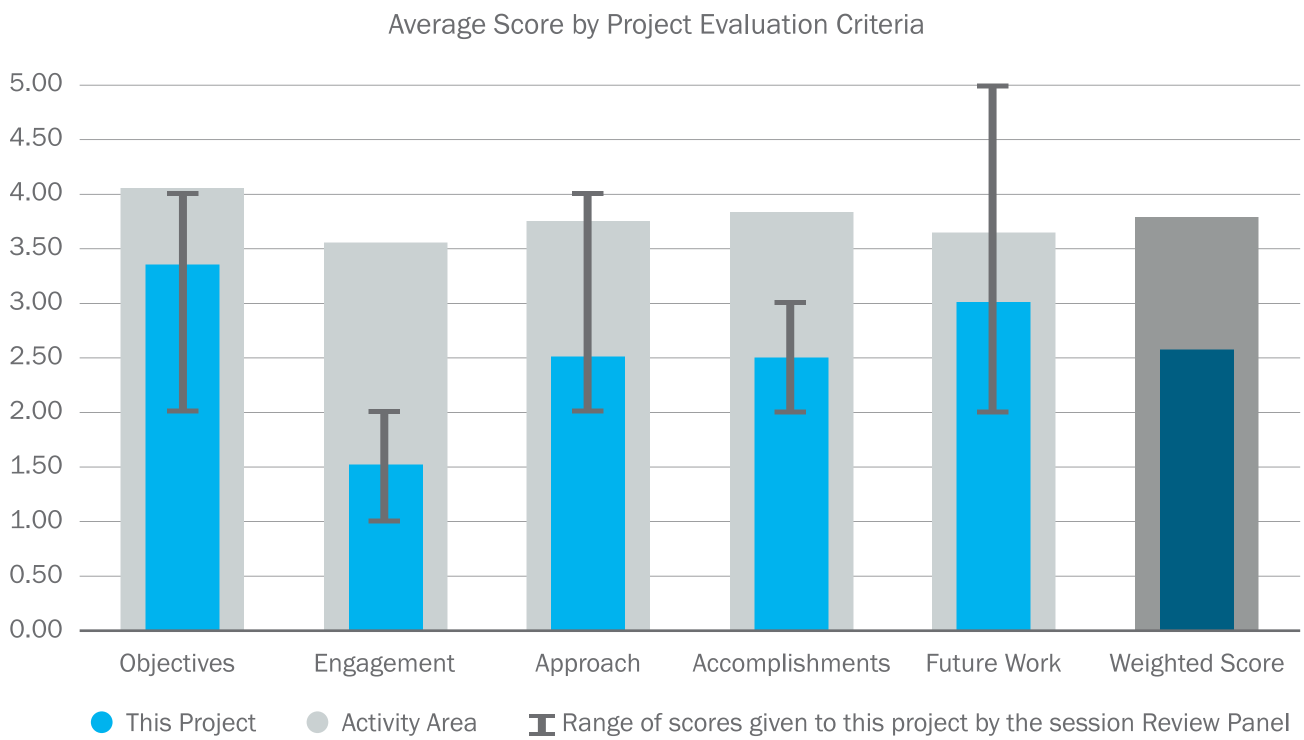
Recipient:	Woods Hole Oceanographic Institution
Principal Investigator:	Alan Chave
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Advancement
Project Category:	Ongoing Projects
Total Authorized:	$833K
Total Costed:	$668K

Project Description

The scientific/technical goal is measurement of the direct and indirect effects of MHK systems on the seafloor vector magnetic and electric fields with a resolution of 0.1 nT and 0.1µ V/m, respectively, over the range of 10-4-100 Hz. An instrument design that is a modification of a Technology Readiness Level 9 one designed and built at WHOI was proposed. Four units of the instrument were constructed and tested at PNNL during Budget Periods 1 and 2. In addition, a Geometrics G-882 scalar cesium vapor magnetometer with altimeter was used to measure the magnetic field in the water column.

Weighted Project Score: 2.6

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The project team demonstrated an insufficient understanding of biological considerations of their work, and the presenter seemed to have a general lack of knowledge of the overall project. A biologist should have been included on the team (mentioned by three reviewers). End user engagement was dismissed, along with the need to consider stakeholders and their needs. Reviewers recommended that the project team set criteria of what they plan to accomplish at WETS based on lessons learned at PNNL before moving forward. This project needs a better developed end user strategy since right now it is solution seeking for a problem that is not well defined. Project performers should work to better demonstrate how their project fits into the WPTO program. Tests should be made on cables at higher power levels (>10 kW). The project team should consider a more integrated approach to the application that would link to risk reduction associated with permitting. Such an approach would require engagement with regulators or biologists who could provide information on animal detection of electromagnetic field. There is a body of literature to consider in this area that the project team did not seem to be familiar with.

Project Objectives, Impacts, and Alignment with the Program Strategy

While some text was provided that linked reducing barriers to testing, particularly the ability to measure electromagnetic field from cables, project implementation did not link tightly to addressing larger program objectives. Two reviewers felt the project generally aligned with the program strategy. The regulatory nexus was not clearly stated, and the tool development did not consider the biological sensitivities that would be used for considering risk to animals. Additionally, reviewers felt that the performers had not considered biological level sensitivities and, as such, questioned if the project was addressing regulatory needs. The commercial viability of the technology was also not discussed.

End User Engagement and Dissemination Strategy

All reviewers were surprised at the lack of end user engagement and what appeared to be the performer's lack of understanding of how information would be used/applied by the MHK community. While regulatory concerns about the electromagnetic field were mentioned, equipment sensitivity or testing was not shaped around that need. The sensitivity of the equipment (uV/m) is well below what animals can detect, (e.g., nV/cm for sharks 9000 W). This needs to be considered/addressed. The threshold of sensitivity for the equipment should be determined with the regulators.

Management and Technical Approach

The management and technical approach included a single academic institution's management with quarterly interaction with WPTO staff for approval for testing. This approach seemed acceptable to most reviewers (3) but several mentioned the lack of a biologist on the team. The tool development and testing seemed appropriate for the academic development of a tool, but applied less to the overall goals of the program.

Metrics and standards for developing the tool should have been better vetted with a group from WPTO and/or regulators. Critical success factors seemed to be related to making something that would work, rather than a tool that is useful to achieve the goals at hand.

Technical Accomplishments and Progress

Progress toward stated objectives was made, and lessons learned were included for instrument simplification. As previously mentioned, reviewers were concerned about equipment sensitivities, as well as whether or not the project team was addressing regulatory needs.

Future Work

The majority of the reviewers noted that the future work plan was brief and did not include milestones. Most reviewers recommended that tests be conducted at sites closer to the home institution, near cables with higher power load.

BENTHIC HABITAT MONITORING TOOLS FOR MHK ENVIRONMENTAL ASSESSMENTS

(WBS #: EE0007826)

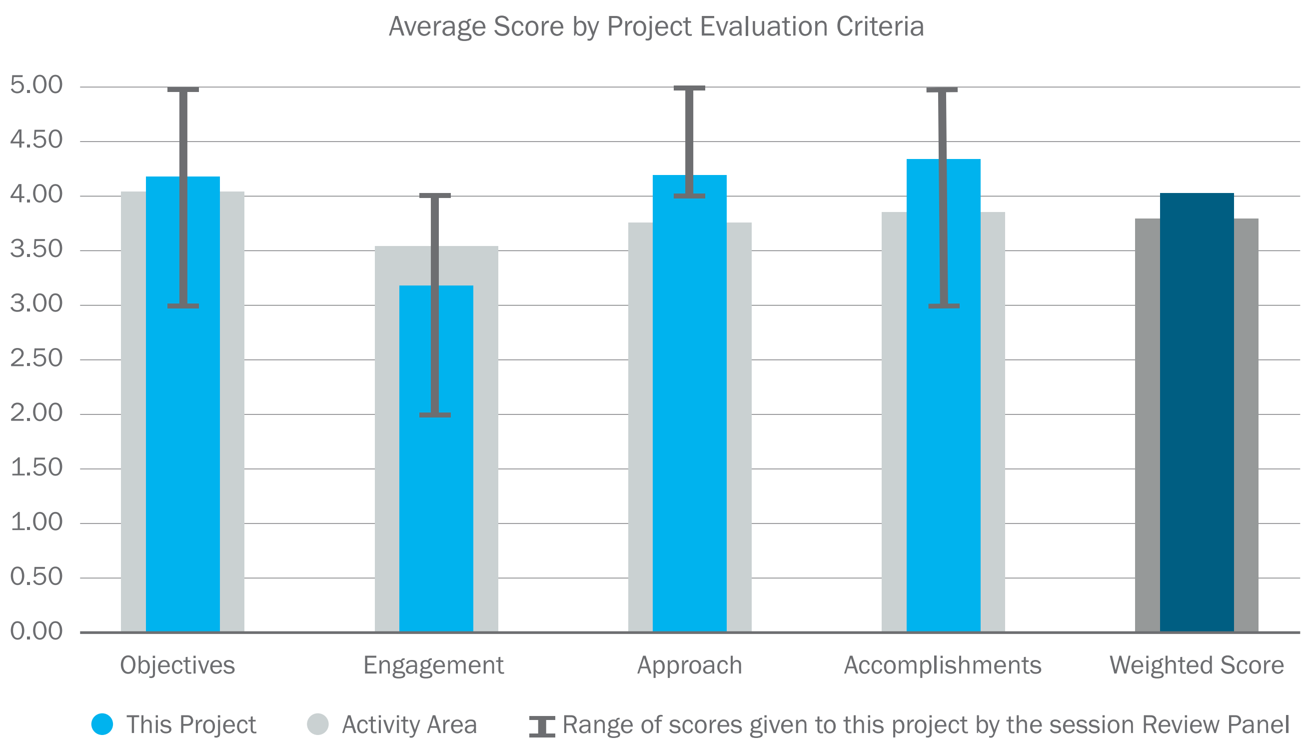
Recipient:	Integral Consulting Inc.
Principal Investigator:	Eugene Revelas
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Advancement
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$856K
Total Costed:	$632K

Project Description

The goal of this project was to develop a consistent and semi-automated seafloor survey method for generating high-resolution benthic habitat maps, essential for environmental assessments and monitoring of MHK sites. Sediment profile and plan view imaging technology was combined with multibeam bathymetry and acoustic backscatter methods to demonstrate a rapid, cost-effective benthic mapping protocol. A key technical innovation was the development of a computer-automated image processing platform that automatically identifies key features in the sediment profile images. We also designed and tested a prototype power sediment profile imaging camera that is effective in sampling firm substrates.

Weighted Project Score: 4.0

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

The project performers described how the project contributes to the program's strategy/approaches, and they noted that the project aligns with the overall program strategy. Overall, the reviewers were impressed with the technical approach, management, and progress of this project. However, it was unclear on the regulators' needs for this tool at the WEC sites. The project team should be clear about the utility of this tool in MHK applications in that it is limited to certain bottom types that are more consistent with WEC device installations than current installations. It was unclear on how this technology will be transitioned to the broader MHK and scientific community beyond the technology developer, Integral Consulting. The reviewers recommended that the project team consider transitioning this MATLAB developed software into a standalone application if the target user group is beyond the development team.

Project Objectives, Impacts, and Alignment with the Program Strategy

The reviewers believe this project aligns with the overall program strategy. The major contribution is increased efficiency in processing benthic imagery data. The project performers have considered and described the use and application of their expected products and outputs, which they note are largely internal to the developers. Improvements in imagery automation would advance the utility of this method of benthic mapping. Applying these project techniques would result in more consistent and semi-automated benthic habitat surveys than current techniques. The project team was also able to quantify the project's impact in equipment costs and time savings (2 days without the tool vs. 37 minutes with the tool). Assuming lower costs when compared to traditional benthic habitat surveys, the use of a similar technique in other offshore industries suggests the approach could be more widely adopted. However, the tool is mostly limited to soft sediment. One reviewer felt it was not articulated what the current challenges are with respect to seafloor surveys and what the cost savings would be with the project. The tool itself is currently not available to the broader community as it's developed by a for-profit company. This raises future application concerns. They did not discuss commercial applications.

End User Engagement and Dissemination Strategy

The project performers have identified who will benefit from this project and how the success of the project will advance the industry or meet the needs of specific stakeholder/end user groups. They identified the stakeholders as the technology developers and project proponents, federal and state regulators, environmental groups, and the public. But they did not describe the technical end users of the technology. They plan to engage stakeholders for feedback through a webinar and include a regulatory outreach plan. The intent is to facilitate stakeholder acceptance. The performers also had a good variety of conferences/workshops in different sectors (e.g., dredging association) and had a follow-up questionnaire for regulators who attended the webinar. The reviewers felt the project team was missing further plans to disseminate results beyond the MRE industry. The reviewers felt that the end user was unclear, as the performer seemed to develop a proprietary system. It was unclear how the project fits within existing regulatory needs or guidelines (e.g., BOEM guidelines).

Management and Technical Approach

The project performers have implemented technically sound R&D approaches, and they have demonstrated and validated the results needed to meet their targets. The goal of this project was to design and test a computer-vision system to automatically extract data from sediment profile/plan-view imaging. The project team used an established means of defining criteria from manual methods of evaluating parameters (such as grain size) and implemented automated routines to find and identify the features. The project performers identified a project management plan that includes well-defined milestones and adequate methods for addressing potential risks. The project performers clearly described critical success factors, which will define technical viability, and they explained and understand the challenges they must overcome to achieve success. The performers validated their tool with several approaches. They did not define success factors in their technical approach, but they listed technical challenges from the previous budget period that they wanted to achieve. A noted remaining challenge is securing funds to commercialize the sediment profile imaging camera used in budget periods 2 and 3 to penetrate firmer substrates.

Technical Accomplishments and Progress

The project performers have made progress in reaching their objectives based on their project management plan. They were able to automate the imagery processing and were able to evaluate the performance. They gave several examples of how well the imagery processing algorithm worked and provided a brief description of how the neural networks used in processing were trained. Everything except the biological features meet the performance criteria. However, specifying that it met performance criteria is not the only indication that should be evaluated. It would have been good to know the limitations of the system (i.e. missed and false classifications). The project performers have clearly described the progress since any last review period. Additionally, the tool has limited benthic habitat applicability (works with sandy bottom only) and will not be suitable for most tidal environments.

THIRD-GENERATION ADAPTABLE MONITORING PACKAGE (3G-AMP)

(WBS #: EE0007827)

Recipient:	University of Washington
Principal Investigator:	Brian Polagye
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Advancement
Project Category:	Ongoing Projects
Total Authorized:	$1,555K
Total Costed:	$1,028K

Project Description

Retiring high-priority environmental risks for marine energy projects (e.g., collision, entanglement) requires environmental monitoring systems that can make observations without biasing animal behavior, capture important information about rare events, and archive only essential data. The third-generation Adaptable Monitoring Package (3G-AMP) achieves these objectives by classifying targets in real time using a modular approach to hardware and software. This has been demonstrated at PNNL's Marine Science Laboratory and will be deployed at WETS in the next phase of the project.

Weighted Project Score: 4.3

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.

Summary of all Reviewers' Comments

Overall Impressions

This project was well managed and leveraged for a good return on investment, despite many challenges. This relatively mature tool seems to be important to present to regulators carefully since there is some question of collecting lots of data, and perhaps that will impress the idea that all the data that can be collected should be without bounding the questions that might be used to help decision making for regulation. Since this is the third generation of the tool, and devices have not been in the water for true testing, the reviewers questioned if the need for the technology is still there, noting that it is important to frame the current regulatory questions for the tool. Progress on sensor integration and triggering, a primary goal in early generations of the tool, have still not been tested. It would have been good to see backbone costs quantified. The tool may be useful in other applications, and WPTO or the project team should consider discussions with other agencies (e.g., the Navy) to evaluate their needs for the tool. Moving to WETS may be good validation data, but may not be useful data collection since the tool's application has been focused on tidal sites.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project is an application of a suite of environmental monitoring tools that could ultimately contribute to MHK site monitoring when devices are deployed. Goals were clearly defined; they were relevant to advance technology for commercial application; and they aligned with WPTO strategy. One way to quantify the impact of the project was presented as a cost reduction in monitoring, but cost reduction was presented relative to scaling the number of tools added to the backbone of the device, rather than overall costs. The true cost of operation and data analysis to provide answers to monitoring questions was unclear. This is a "Swiss army knife" of monitoring, with impressive capabilities, integration, and form factor. The question remains whether the monitoring goals could be attained with a simpler integration of fewer instruments. The technical approach built on previous success, and the reviewers thought it would be good to check in to be sure the utility of the tool is still relevant since its inception.

End User Engagement and Dissemination Strategy

End users are identified as consultants, regulators and, indirectly as developers, as permitting may be streamlined based on this. If the project team cannot quantify how this project streamlines/changes the permitting process, they need to update their impact statement. The developer and researcher communities were engaged at the start of the project to receive feedback prior to development, and the project team intends to for market the device to developers/consultants. Engagement has included discussions with researchers and developers, but not regulators (end user target). Other dissemination strategies include publications and presentations. One reviewer questioned the use of the "responsibly retiring risk" terminology when engaging additional end users to discuss the tool's future use. Several reviewers wondered what questions would be answered with the tool and felt that regulators should be engaged directly to define the questions.

Management and Technical Approach

The project team holds bi-weekly meetings, which reviewers felt was a great management practice. The project has a diverse group of knowledgeable participants building on previous success, and the team does a great job of leveraging additional activities and involving students. Milestones were defined and adequate methods for addressing potential risks to the project were provided.

Technical Accomplishments and Progress

There have been delays, but the project is on track for on time completion. The performers did improve automated detection performance and had a reliable device with 97% uptime, which impressed reviewers. However, target classification is still questionable. Reviewers questioned if regulators would accept the tool's rate of error and misclassification, and they recommended the project team evaluate this. In addition, the difficulty of getting the random forest classifier to work in different locations is worrying since training may be needed in each new location and perhaps even for different seasons (something to consider for all automated detection systems). The performers stated that they hope to demonstrate the ability to retire risk, but evidence that "retiring" any risk was not provided and is unlikely to be able to be provided in the timeframe of this project. As such, these types of statement should be avoided.

Future Work

Two reviewers wondered if the shift to WETS is the right next step. This tool was developed for current energy converters, and several reviewers suggested that the nearfield of a WEC may not be an effective monitoring strategy for a WEC. More details of how sensors will be evaluated there would have been helpful. However, the majority of the reviewers thought the WETS testing would be worthwhile.

UNOBTRUSIVE MULTI-STATIC SERIAL LIDAR IMAGER FOR WIDE-AREA SURVEILLANCE AND IDENTIFICATION OF MARINE LIFE AT MHK INSTALLATIONS

(WBS #: EE0007828)

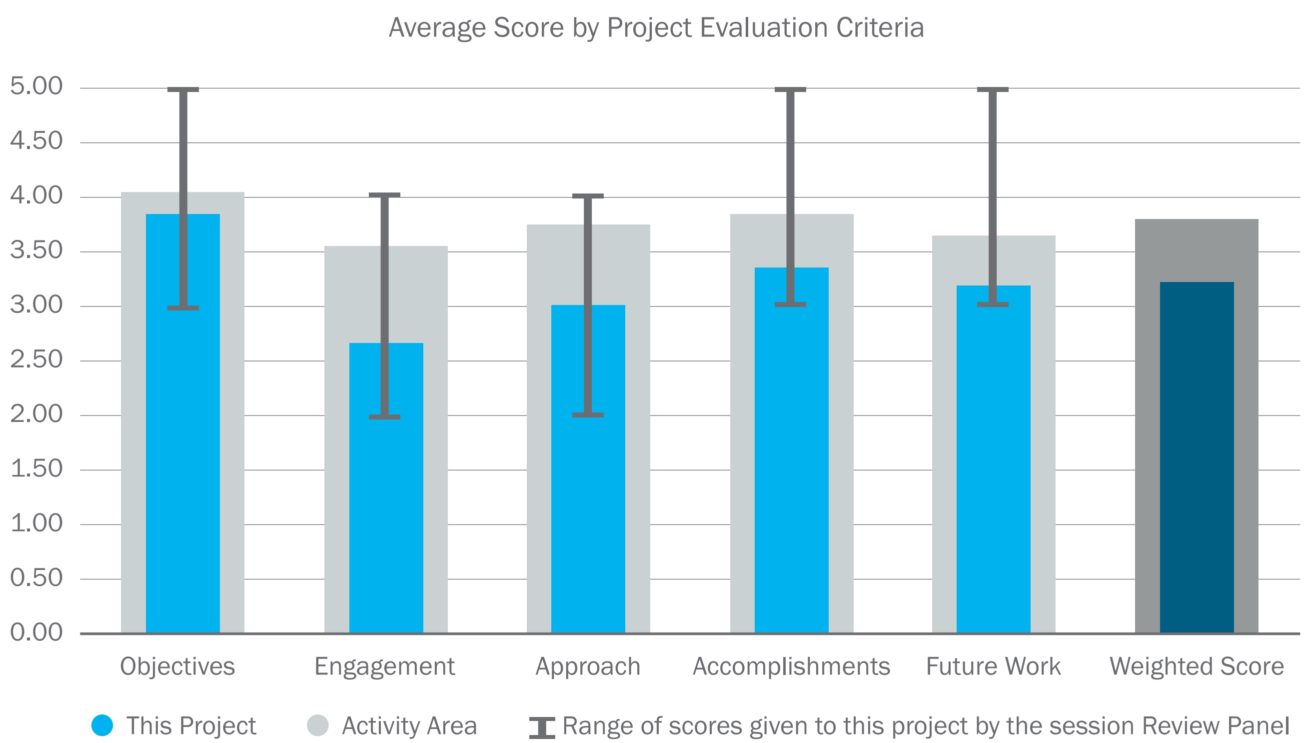
Recipient:	Florida Atlantic University
Principal Investigator:	Anni Dalgleish
Project Type:	FOA 1418: Marine and Hydrokinetic Energy Conversion and Environmental Monitoring Technology Advancement
Project Category:	Ongoing Projects
Total Authorized:	$944K
Total Costed:	$492K

Project Description

This project will increase the technical performance and cost effectiveness of an optical monitoring system designed and validated for an MHK project lifecycle observation and automated in real-time for the classification of marine animals. This system, called the Unobtrusive Multi-static Serial LiDAR Imager can be deployed to collect pre-installation baseline species observations at a proposed deployment site with minimal manual post-processing overhead, such as feature detection and classification. To satisfy deployed MHK project endangered/threatened species monitoring requirements, the Unobtrusive Multi-static Serial LiDAR Imager provides automated tracking and notification of the presence of managed animals around MHK equipment and provides high-resolution imagery of their behavior through a wide range of conditions.

Weighted Project Score: 3.2

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

This project seeks to provide a cost-effective tool/instrument to measure and monitor animal behavior in MHK sites. While the project is low cost, the ROI is also low. The original assumption of the project was that infrared light could be used since it is (based on literature) outside of the visual range of most marine animals (although this is questionable since studies supporting this for most marine animals are still quite limited, e.g., seals). However, due to the short transmission range of red light in water, which limited the range of the equipment, they changed their system to green light, which is more likely to be visualized and compromised the tool's use. This tool is likely to have only very near field value, and the classification goal will be expanded to only four species, two of which are only found in warm climates. The tool that will be produced in the end will have value for addressing risk and uncertainty in limited regions and requires further investigation of effects on marine animals.

It is unclear how an intended end user would use the device to meet regulatory requirements. As such, it would be good to engage outside end user feedback on the device utility, including the questions that would be answered with the resulting data. Most reviewers thought 20 m is limiting for distribution surveys, but the device may offer better applications for monitoring device interactions/strike. The assumption of animal detectability of the laser must be tested in this project (or as part of another project).

Project Objectives, Impacts, and Alignment with the Program Strategy

The performers did state how the project fits within the Reducing Barriers to Testing activity area by addressing the issues associated with monitoring marine animals in MHK environments. They described how the tool could be applied and how funding from EERE is pivotal to developing the tool since others would not necessarily be interested/fund this work otherwise. Successful development could address needs to image animal behavior. The performers did achieve a test within the accepted scope of work, but processing architecture is still in development. However, it was unclear how this tool would be better than other monitoring tools; the most important addition would be utility under low light conditions. The definitions of "long range" are unclear and not likely "long" because of the short transmission of red light in water, resulting in a possible low ROI. Low ROI is also related to the scope of species (four) and number of regions the tool could be applied (warm climates).

End User Engagement and Dissemination Strategy

While end users are identified, they are very broadly defined and yet to be engaged. There are plans to engage with end users once the prototype has been refined. To date, the project team's outreach has been through conference presentations. Most reviewers commented that no real engagement strategy was communicated. The presenter stated that there were publications, but these were not mentioned in the project summary, and one reviewer commended the dissemination of information at conferences and workshops along with the development of a commercialization plan.

Management and Technical Approach

Management is within the investigator group, but there is support from PNNL through the Triton Initiative. Milestones were not clearly identified and did not include timelines, but the performers specified that they will be moving onto a second phase of refining the tool. Technical approaches were poorly defined in the report, but better presented at the review. The performers did identify the switch to green lasers, which will define the technical viability of the tool. The reviewers were unclear whether or not the performers completely understand how critical this wavelength shift will be to achieving success/viability of the tool. Additionally, reviewers were concerned about the project team's assumptions of animals not being able to detect the monitoring device, which, if inaccurate, will subsequently affect animal behavior and impact successful monitoring. The reviewers agreed this would be a fundamental problem to applying this tool to non-invasively studying animal behavior.

Technical Accomplishments and Progress

The performers have made progress to develop and test a device in the first budget period. They made significant progress in building the prototype and successfully collecting data. They were able to detect four sample species and evaluated a green laser, which increased detection range. Progress was demonstrated, but detection and classification rates at different ranges were not clear, making it difficult to fully evaluate the project progress. Also, they are experiencing challenges "*to achieve long range omni-directional volumetric coverage of MHK equipment*," which was one of their goals. The tool is not "long range" relative to the environment that must be monitored. Being more specific in relative terms like "long range" would be useful.

Future Work

Performers intend to complete modifications to the first-generation tool and will test it at two facilities (PNNL and WETS). It is unclear how decision points and remaining issues will be addressed, what the expectations of the 2020 testing will be, and how detection/classification rates will be quantified. The tool will have limited application to four species total: turtle, barracuda, sea, amberjack; and two/three of these are only applicable to southern applications. One reviewer felt the future work plan was adequate.

ENABLING COST EFFECTIVE ELECTRICITY FROM OCEAN WAVES - PACWAVE

(WBS #: EE0007899)

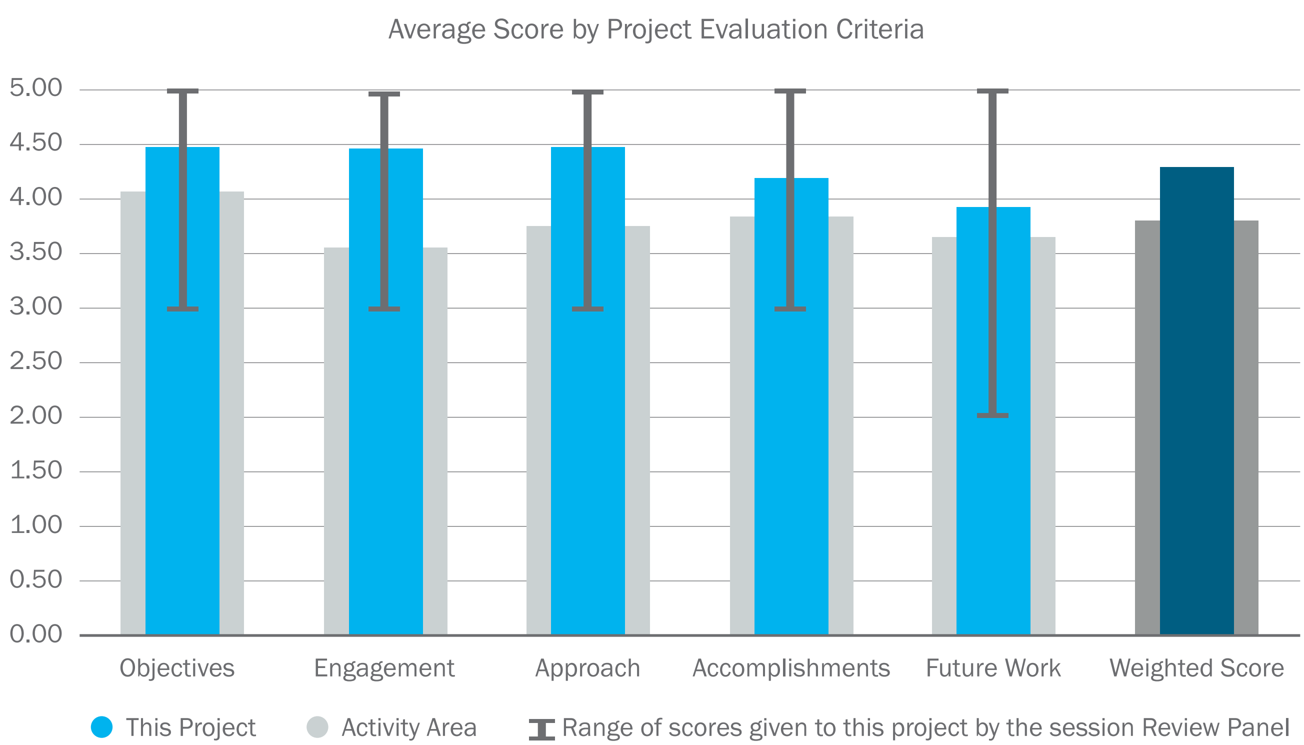
Recipient:	Oregon State University
Principal Investigator:	Burke Hales
Project Type:	FOA 1419: Wave Energy Test Facility
Project Category:	Ongoing Projects
Total Authorized:	$46,924K
Total Costed:	$6,186K

Project Description

OSU is developing PacWave, a grid-connected test facility, to evaluate utility-scale WEC performance, environmental interactions, and survivability. Intended to be the first of its kind in the United States, PacWave will support the development and testing of innovative wave energy systems that have the potential to be cost competitive with other forms of electricity generation. As the nation's first, pre-permitted, grid-connected facility for utility-scale WEC array testing, PacWave will play an integral role in advancing wave energy from early-stage, ocean testing through final demonstration for commercialization, serving as an integrated research center, as well as a training ground for future jobs in the ocean energy industry. PacWave will consist of four individual test berths over a 2 square nautical mile area, each with a separate 5-MW cable back to shore. Each berth can accommodate multiple devices for array testing. A fifth power and data cable will use the land-based power grid to supply power to the site for associated environmental monitoring and/or other uses. Total project capacity is 20 MW and up to 20 devices can be tested at any one time. PacWave will be pre-permitted for all currently known device types (point absorber, attenuator, oscillating water column, or hybrid), with an option to amend the license if needed in the future if a new device type is developed.

Weighted Project Score: 4.3

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

There is broad consensus among the reviewers on the merits of the project in terms of DOE's stated strategy to accelerate device development by removing hurdles and providing open water testing facilities. Reviewers had common concerns regarding the pipeline of projects for the facility and requested the project team focus on ensuring the initial tests are well planned to successfully deliver outputs that will justify the effort and cost. There was some confusion among the reviewers regarding the relationship of the site with PBE strategy mainly due to scaling issues. The presentation was well planned and delivered.

Project Objectives, Impacts, and Alignment with the Program Strategy

There is broad consensus among the reviewers on the merits of the project in terms of DOE's stated strategy to accelerate device development by removing hurdles to site development and access and by providing open water testing facilities to gauge performance. There were a few concerns raised here regarding the lack of pipeline of projects for the site when it comes online.

There was some confusion among reviewers regarding the relationship of the site with the PBE strategy, largely due to scaling concerns. Reviewers recognized outputs from the regulatory process as valuable and expressed some concerns regarding capturing the impact from the learning. Reviewers would have liked to hear more detail regarding how this facility addresses needs that aren't already addressed by other facilities.

End User Engagement and Dissemination Strategy

The end user engagement of the project was broadly recognized as a strength but would have benefitted from clearer details. The dissemination of the regulatory process received some attention, but there was a concern that OSU needs to appropriately capture the valuable lessons learned therein. More broadly, the dissemination strategy was recognized as a strength of the project. The reviewers recognized that the nature of the project requires collaboration and engagement with stakeholders, industry partners, developers, and national labs. There was broad recognition that the performers communicated this but could have provided better detail.

Management and Technical Approach

The scope of PacWave required robust management strategies and development that meets the technical needs of industry and is critical for the project's long-term support to industry. The project performers have implemented technically sound R&D approaches, and they have demonstrated/validated the results needed to meet their targets. The project performers identified a project management plan that includes well-defined milestones and adequate methods for addressing potential risks.

A few reviewers noted the delays mentioned within the summary and presentation but recognized that a one-of-a-kind project of this scope would be expected to run into such delays. Some concern was focused on ensuring project outputs effectively capture the experience and learning from these challenges.

Technical Accomplishments and Progress

The performers delivered clear, detailed descriptions of accomplishments and a well detailed project plan for this presentation. Significant milestones were detailed, but reviewers were confused by the takeaways. One reviewer thought the FERC license and BOEM lease had been issued, while another noted that they were yet to be issued. There were a few concerns focused on the project pipeline, as well as related interest in a clearer business development plan.

A few reviewers noted the delays mentioned within the summary and presentation but recognized that a one-of-a-kind project of this scope would be expected to run into such delays. Some concern was focused on ensuring project outputs effectively capture the experience and learning from these challenges.

Future Work

There was a wide variety of opinions offered by the reviewers on this criterion. Reviewers had drastically different opinions about the amount of detail the PI provided regarding future work, with some thinking a good amount of detail was provided, and others thinking more should have been provided. Similarly, reviewers offered a variety of perspectives regarding their confidence in the project plan. This may be more indicative of the broad range of experience brought to the table by the reviewers.

There was a desire expressed to see some detailed consideration for how this project could support different aspects of the PBE effort. A few reviewers expressed concern about whether the project schedule would be successful, and others expressed concerns regarding budget overruns.

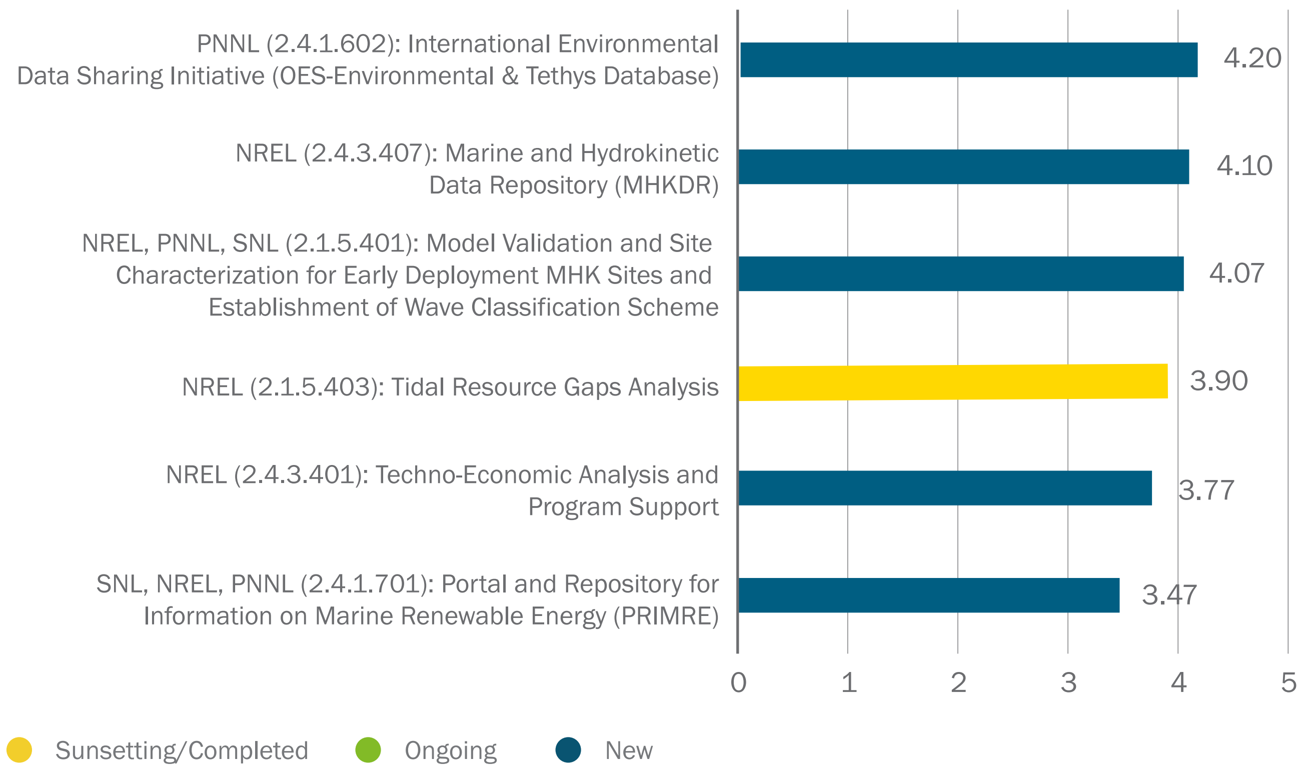
Data Sharing and Analysis

This section provides an overview of the scoring for all projects within the Data Sharing and Analysis activity area (see Figure 26); the review panel lead's summary of reviewer comments in response to the evaluation criteria; and full evaluation results for individual projects.

Activity Area Score Results

Name	Average Weighted Score of All Projects
Data Sharing and Analysis	**3.92**

Figure 26. Data Sharing and Analysis activity area—average weighted score by project



Activity Area Summary Report

Prepared by the Review Panel Lead

Feedback from the Review Panel to WPTO

Projects within the Data Sharing and Analysis activity area fall into two categories: data sharing and resource assessment. Although there is some overlap, the comments below treat them independently.

1. Data Sharing:

WPTO efforts to support data and information dissemination were recognized as important investments by all reviewers. Both Tethys and MHKDR were viewed as relatively inexpensive projects that are in operational states. To ensure that these investments and their accomplishments are sustained long term, a reviewer suggested that WPTO consider identifying an alternative funding stream.

The *State of the Science* report was identified by multiple reviewers as valuable product resulting from these investments. As with the upcoming 2020 report, when it can be justified by availability of new information, additional *State of the Science* reports were seen by multiple reviewers as important tools to synthesize up-to-date information.

Even though reviewers agreed in the high value of the knowledge hubs, challenges remain in this area. To be specific, there are concerns that the data curation approach does not ensure that the best available information rises to the top and is easily identifiable to those searching for information. In fact, multiple reviewers commented that they had experiences where they had to spend considerable time searching through results from search terms to identify the best available information or results that were relevant. While valuable, this points out a flaw with knowledge hubs that is difficult to solve, but an effort should be made to identify solutions to place reliable and relevant information (e.g., *State of the Science* reports) at the top of searches.

An issue identified by all reviewers was the evolution of the knowledge hub ecosystem. Given the development, the need to consolidate all the databases to make them accessible from one location makes sense. Reviewers were unconvinced that PRIMRE is the solution to this problem and believe that WPTO should consider alternative approaches. Multiple reviewers felt that the existing structure was driven by the desire to allow the other remaining knowledge hubs to exist in their current form, even if that was not the most efficient approach. Project performers stated that the unique databases had unique architectures that made integration difficult. Reviewers recommended that WPTO strongly consider restructuring these programs, thinking about the long-terms costs of knowledge hub management.

2. Resource Assessment:
Resource assessment maps are necessary guides to available resources but insufficient for detailed project planning. Reviewers' primary concerns with these projects were that the need was poorly defined. For example, are improved numerical models needed by the developers that are interested in tidal energy development; or, are existing models sufficient to drive site-specific assessments that would be performed in project planning stages? Likewise, given the state of the tidal energy industry, are site-specific measurements of currents and turbulence necessary to advance the industry? Finally, are the high-resolution hindcasts for wave energy of critical importance to potential wave energy developers? The answers to these questions may be yes, but it would have been helpful for program managers and project participants to better emphasize the need for this work. Despite these concerns, the model outputs the products of these projects do address program strategies, and the productivity in terms of data products and publications in this area was high.

Summary of all Reviewers' Comments

Overall Impressions

Reviewers broadly feel like the programs align well. The Data Sharing and Analysis activity area can be effectively broken into two components. The first is the projects to improve the available resource assessments, and the second is the creation and maintenance of the WPTO-supported knowledge hub ecosystem. Investments in improved resource assessments, both using numerical models and *in situ* measurements, are clearly broader strategies of WPTO. While improvements to existing models are a welcome advance, concerns were raised about the degree to which these improvements provide value to industry. The knowledge hub projects are important investments not just for WPTO and industry, but for the public at large. Reviewers recognized the value of these investments but questioned whether the ongoing development of the knowledge hub ecosystem is the most efficient solution for data dissemination and use of taxpayer funds. While questions were raised regarding the efficiency, this work is well aligned with the program and is an important investment.

Program Strategy and Objectives

The program strategies regarding the importance of data sharing and ensuring the results of public funding are made available was effectively conveyed during the review. To facilitate the use of this data for accomplished near and long-term goals, the program has invested heavily in infrastructure to make data and other information available to industry, stakeholders, and the public at large. The resource assessment components of the Data Analysis and Sharing activity area are not early-stage research, but reflect the need to have the best possible information available to industry and other stakeholders. Knowledge hub projects reflect an effort to ensure the results of early-stage research and other developments are widely available to address not only not environmental issues, but the breadth of research areas relevant to the marine energy community. Three of the projects in this portfolio have relatively small budgets and well-defined goals. The goals of these projects are an appropriate use of taxpayer funds, although reviewers did raise concerns regarding the strategy (not the goals or results) behind the investments, as described above.

Program Portfolio

The projects within this portfolio contribute directly to program strategies to provide access to original research, to aggregate data for dissemination, and to leverage experience from the MHK community and other sectors. Throughout the review, the goals of WPTO to provide access to this important information was emphasized. Although reviewers recognize the need for data sharing investments, the project performers and WPTO could have provided examples of how these investments are succeeding in addressing key challenges in the industry.

One area in which the program did not perform well was in conveying the rationale for and organization of the funded projects. While two of the knowledge hub projects are small and largely operational, the budget for the third was expensive, and reviewers uniformly agreed that project performers failed to make a compelling case regarding the direction of the development of the MHK knowledge hub ecosystem. Likewise, while accurate resource assessments are important, a compelling case was not made for the investments in resource assessments. This does not necessarily mean these investments were not important. Rather, if these investments are necessary, then it is incumbent on the program and project performers to demonstrate the need. For example, at this point, areas with relatively high-power densities driven by tidal currents are known. However, if a developer is interested in a site, they will need more information than can be provided using large-scale numerical models. WEC developers may benefit from long-term wave hindcasts. While some reviewers were able to speak to the value of different models and measurements for industry, it could not be expected from all reviewers given their diverse backgrounds. For this reason, the program should work to better define the need for and benefits of these projects.

Program Management Approach

All the projects within the Data Sharing and Analysis activity area are meeting important milestones and progressing toward project objectives, suggesting the program team effectively manages the individual projects. The main concern that was identified by reviewers was why WPTO has chosen the current path for ongoing development of the knowledge hub ecosystem. Investments in data sharing are important, but their impact of the industry and technological development is difficult to quantify. All reviewers thought that program team members and the projects they support should seek ways to quantify the impact of this work that are more meaningful than the number of downloads of datasets or visits to a site.

Program team members have the professional and technical capabilities needed to guide the projects in the portfolio, and necessary oversight procedures to ensure the efficient direction of office activities exist.

Stakeholder Engagement, Outreach, and Dissemination

Existing projects in the Data Sharing and Analysis activity area are inherently transparent given that their goals are to improve available data or disseminate existing information. Multiple projects in this portfolio are relatively expansive and successful, with products widely recognized and used. Regardless of their use or costs, WPTO generally provides transparent information about program expenditures. For the projects whose scopes and budgets are larger, it would be helpful for WPTO to include additional reporting about the budget details. If there is a particularly expensive, but important, component of a project, it is valuable to reviewers to understand how that money is spent and why. This information is not currently provided, and the project performers could not reasonably be expected to convey this information within the dictated framework.

Existing data sharing program efforts funded by WPTO are successful in providing information, but they could improve in multiple ways. The first way is to develop additional metrics to better understand how information is being used. One reviewer suggested that data sharing platforms should be subject to a peer review with the goal of understanding how individuals use the sites and how they can be improved to better achieve program goals.

Projects within this track are generally successful at making their efforts known to MRE community members and can be found relatively easily online. Although reviewers do not have first-hand knowledge, it seems likely that broader engagement with stakeholders has led to broader awareness of available resources. Improving engagement with stakeholders requires identifying their needs and ensuring that the best available information is the most easily accessible information.

Throughout these efforts, the program provides access to accurate and objective information. The remaining challenge is ensuring that in an emerging industry, the most relevant information is easily accessible.

MODEL VALIDATION AND SITE CHARACTERIZATION FOR EARLY DEPLOYMENT MHK SITES AND ESTABLISHMENT OF WAVE CLASSIFICATION SCHEME

(WBS #: 2.1.5.401)

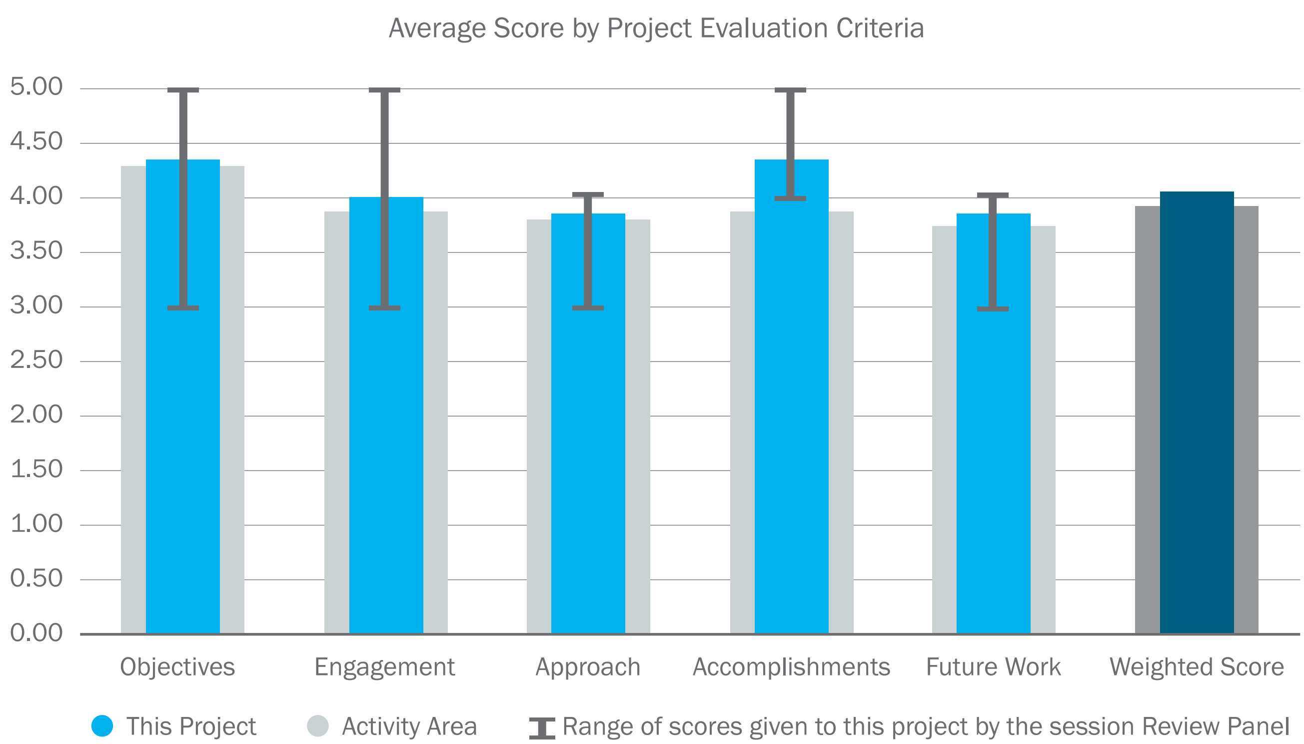
Recipient:	NREL
Principal Investigator:	Levi Kilcher
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$7,320K
Total Costed:	$5,291K

Project Description

This project combines the expertise and resources of three national labs (NREL, PNNL, and SNL) to coordinate the strategic use of resource measurements, high-resolution models, and expert analysis that deliver the data and analytical tools needed to engineer the next generation of MRE devices and projects. In particular, the project measures resource details at commercially promising U.S. wave and tidal energy sites, runs high-resolution numerical models of promising sites and regions across the entire U.S. Exclusion Economic Zone (EEZ), and develops classification schemes that will streamline device development and project engineering and increase investor confidence in power performance data.

Weighted Project Score: **4.1**

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The project was viewed as a good example of collaboration among national labs, as well as of collaboration between the national labs/WPTO and NOAA for the maintenance of wave buoys.

The reviewers thought the project summary did not provide sufficient detail for the scope and budget associated with this effort. For example, the presenters gave a list of nine subcontractors, but it was not clear how big of a role each of them had. The project summary template developed by WPTO was insufficient for this particular project, and the limited amount of information (5-page summary ahead of time and 19 slides delivered at the event) made it difficult to review. Further, reviewers considered it important for a project of this budget to explain why certain tasks are important; two examples mentioned included (1) fatigue loading of tidal turbines caused by turbulence and (2) long-term hindcasting of the wave energy resource to properly capture both wave heights and periods as components of project siting and system design. Neither of these points were made to support the statements about the project's relevance to WPTO's portfolio.

Project Objectives, Impacts, and Alignment with the Program Strategy

The objective of this continuing project is to improve the quality and coverage of the resource data available to future MRE developers. The project performers refine and implement improved resource assessment techniques, extend the spatial coverage of validated wave models to the entire U.S. Exclusion Economic Zone, combine these models with measurements at specific sites for validation and the development of classification schemes, and develop resource classifications applicable to both resource characterization and design standards.

Reviewers agreed that this project aligns well with WPTO strategy and that it addresses multiple program priorities related to site characterization, standards, and dissemination. The improved resource assessment supports the viability of commercial projects due to its relationship to project financing, long-term power production projections, and device survivability under extreme conditions.

While the majority of reviewers thought the MHK community would benefit from this project, one reviewer thought that it was unclear whether this work would significantly benefit the MHK community and what the ROI was.

End User Engagement and Dissemination Strategy

The project team identified the public and MHK community at large as its end users, and engagement and data dissemination occurs through presentation of results at relevant conferences, the MHK Atlas, and the MHK data repository. End users/stakeholders are also engaged through meetings with a steering committee composed of experts from industry, academia, and government.

The collaboration with the U.S. Integrated Ocean Observing System (IOOS) community and a pathway to partner with NOAA to extend deployment times was viewed as a good ROI.

Reviewers thought that the project steering committee could benefit from public participation to ensure end user relevance of the data. It would be helpful to articulate the planned data dissemination strategy better, especially with regards to hosting large datasets (i.e., how will the results be published and archived?).

Management and Technical Approach

Overall the reviewers viewed the management approach between the different national labs as good, and they viewed the technical approaches as strong/robust. The project involves three national labs and the management of the different components of the project is split based on expertise (i.e., NREL – resource assessment and measurements; PNNL – modeling; SNL – classification). NREL leads the project, but decisions are made collaboratively between project teams at the different labs during calls and in-person meetings scheduled at regular intervals. Additional feedback and direction come from meetings with the steering committee on a quarterly basis.

Although project goals were broadly identified, several reviewers commented that the project team did not identify project milestones, success factors, or challenges to overcome. The project summary or presentation would have benefitted from additional discussion of project details, challenges, and subtleties of extending and improving models over such a large range.

Model validation is very important for resource characterization and can be difficult and time consuming. A reviewer thought that the extent of model validation being conducted was rather limited relative to the size of the resource being characterized.

Technical Accomplishments and Progress

The project performers made significant progress toward reaching their project objectives. The project has collected long-term data sets at 11 different wave and tidal energy sites that are classified as "early market sites."

The project team presented new tidal and wave models for the priority sites. A new wave resource assessment method was developed that accounts for remote and local resources, and provides updated priorities on wave site selection.

Additionally, a number of technical publications have resulted from this work.

Future Work

Objectives and milestones were given for future work, with approximate timelines and with methods for disseminating the information. Some reviewers felt that, given the size of the project, a more detailed schedule could have been provided. The proposed incorporation of site classification standards under International Electrotechnical Commission 62600 marine energy standards/technical specifications was viewed positively.

Two of the reviewers expressed concern that there was insufficient information on how and when the models will be released to the public, as well as how the results and models will be shared and maintained.

Information on how project performers will deal with upcoming decision points and any remaining technical issues was not provided.

TIDAL RESOURCE GAPS ANALYSIS

(WBS #: 2.1.5.403)

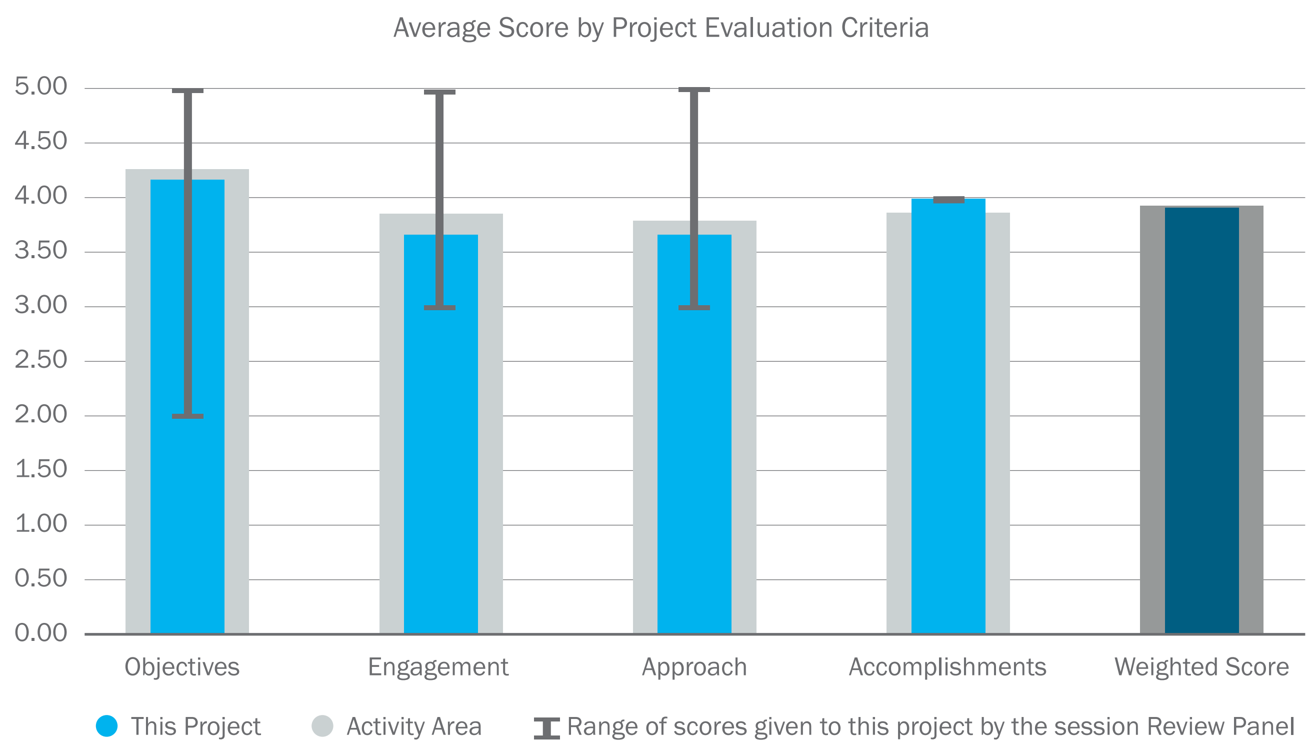
Recipient:	NREL
Principal Investigator:	Kevin Haas
Project Type:	AOP
Project Category:	Completed and Sunsetting Projects
Total Authorized:	$273K
Total Costed:	$235K

Project Description

The tidal resource gaps project was created to address a growing body of evidence that models under-predict tidal current speeds compared to measurements at a number of the top-ranking tidal energy sites. This led to concerns from industry and DOE that the U.S. tidal energy resource assessment, which is based primarily on models, may be an underestimate. The goal of this project, therefore, is to perform a systematic review of the tidal energy resource assessment methodology—including a detailed investigation of the model validation datasets and procedures—and to propose changes or update results, where possible.

Weighted Project Score: 3.9

Weighting: Objectives–20%; Engagement–20%; Approach–20%; Accomplishments–40%.



Summary of all Reviewers' Comments

Overall Impressions

Numerical simulations were conducted for selected tidal sites to resolve discrepancies between earlier resource modeling efforts and tidal current speed measurements. Several reviewers cautioned against overly broad conclusions from the model data, particularly at energetic sites with high spatial variability, and they suggested comparing the simulations against additional available measurement data. Several reviewers noted that the data currently in the MHK Atlas need to be updated and fixed soon if they are to remain in the public domain.

Project Objectives, Impacts, and Alignment with the Program Strategy

Additional simulations at selected tidal energy sites were conducted to resolve discrepancies between tidal current speed measurements and resource models of these sites, using primarily refined numerical grids and different types of grids for different cases.

The reviewer consensus is that this project aligns well with the WPTO program and that the project performers have described how the project contributes to program strategy. The project results are relevant for the MHK community to better understand resource assessment methodology and for developers to perform an initial course exploration of potential deployment locations.

A reviewer commented that it was not very clear what the connection to international resource assessment standards was and whether the data will be made available in more detailed form beyond the average metrics of the MHK Atlas.

End User Engagement and Dissemination Strategy

The project performers engaged with the Marine Energy Council, who identified the need to refine resource assessments to reduce discrepancies. In general, MHK project developers will benefit from having better resource data available to help identify potential deployment sites. Several reviewers commented that the project could have benefitted from including additional end users who have field measurement datasets at sites under consideration.

The dissemination strategy includes conference presentations, a technical report, and inclusion of the new tidal resource data in the MHK Atlas. Some reviewers thought that the dissemination strategy was credible and likely to reach end users, particularly when coupled to TC 114 marine energy standards, while others questioned whether the full use of the data will be realized with the identified communication strategy.

Management and Technical Approach

The general consensus among reviewers was that the project management plan identified well-defined milestones and that the project research/modeling approach was technically sound.

The project leveraged resources and coordinated with other projects to maximize spatial coverage, which was viewed favorably.

One reviewer expressed concern that the high spatial variability in tidal energy resource commonly encountered at energetic sites is sometimes not adequately captured by the public dataset used here (C-MIST).

Another reviewer expressed concern that using different methodologies for different sites to improve model predictions (i.e., nested grids vs unstructured grids) may lend itself to “tweaking” models for each site without broader insights into modeling methodology.

Technical Accomplishments and Progress

Overall, the well-defined project goals appear to have been met, and a summary of results was provided. Several examples of model improvement were presented, although one comment was that it was not clear what metrics were used to demonstrate model improvement.

A refinement of site “rankings” was presented, and some sites changed significantly in terms of their assessed resource (i.e., average tidal power density).

A reviewer commented that it was not clear whether the new data would spur any new development since developers likely have already measured resource data at their sites at a finer scale than that provided by the new modeling.

A technical publication based on this work was highly recommended. The publication would benefit from explaining the modifications in implementation of the tidal channel theory (Garret & Cummins)—which is known to be problematic in flows with significant cross-stream variability—in more detail.

INTERNATIONAL ENVIRONMENTAL DATA SHARING INITIATIVE (OES-ENVIRONMENTAL & TETHYS DATABASE)

(WBS #: 2.4.1.602)

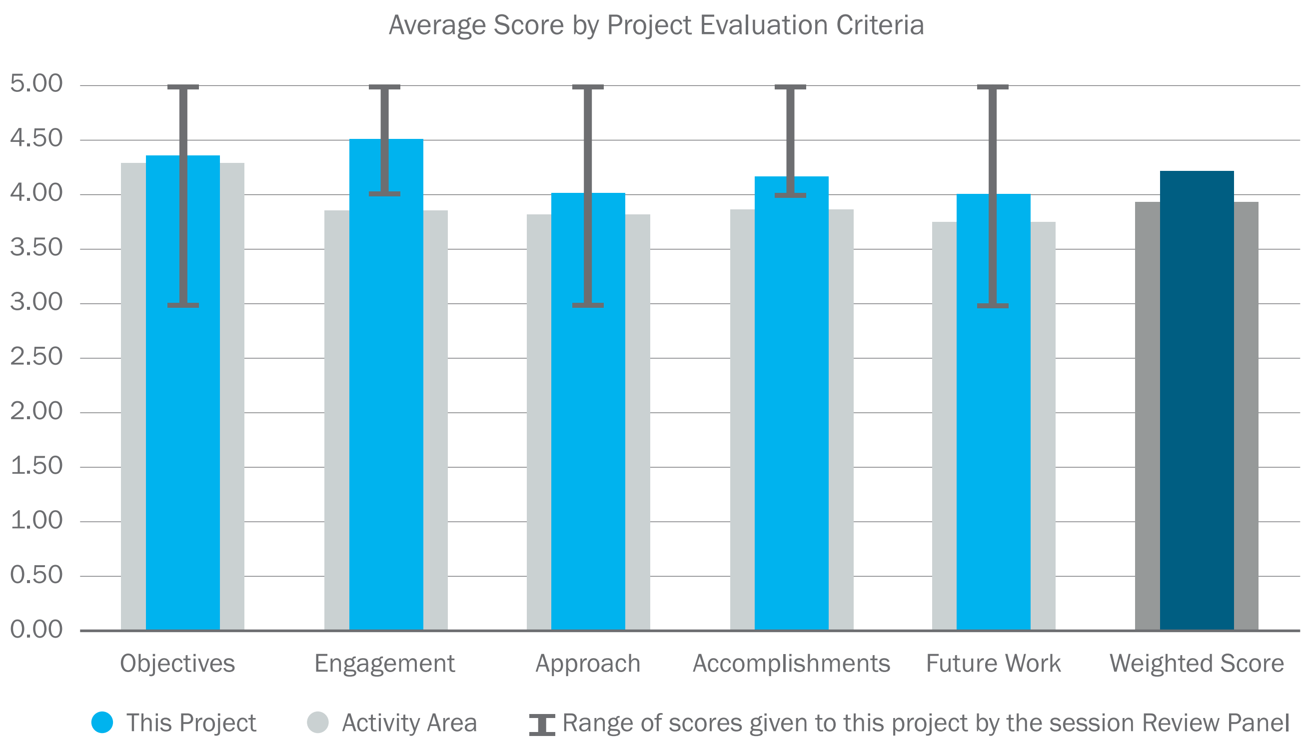
Recipient:	PNNL
Principal Investigator:	Andrea Copping
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$2,526K
Total Costed:	$1,678K

Project Description

This project examines the environmental effects of MRE development to facilitate siting and permitting. Existing information from MRE/environmental interactions is gathered, categorized, and made widely available on the Tethys knowledge base in the form of scientific papers, reports, and other media. Working with over a dozen nations, PNNL implements the U.S.-led, OES-Environmental (formerly Annex IV) initiative under IEA-OES. OES-Environmental seeks to gather, analyze, and provide access to the most up-to-date understanding of potential environmental risks of MRE devices and arrays, reducing the uncertainty that has slowed development and cost MRE developers dearly for data collection.

Weighted Project Score: 4.2

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The availability of information through Tethys and the upcoming State of the Science report are of considerable value to the community. Reviewers recommended that WPTO consider this project as an operation function in the budget structure and not R&D. Additionally, as Tethys has grown in its 10+ years, it is recommended to have a deep-dive review. Review topics may include the following: evaluate the return on investment, identify how to provide better Tethys search results for end users, perform a gap analysis to identify priorities and decrease uncertainties, engage more effectively with the regulatory community, and define metrics of success.

All reviewers recommended to stop the use of "retiring risks" terminology, as risks are not retired but can be reduced or minimized.

Project Objectives, Impacts, and Alignment with the Program Strategy

The project's objective is to examine the environmental impacts of MRE to reduce barriers to siting and permitting for projects. All reviewers agreed that the project aligns well with overall program strategy and approach on data sharing. Tethys has been a keystone project that enables the end users to keep up with the latest developments in environmental research with application to MHK devices. To this end, existing information is gathered and categorized in a single location with the purpose of making up-to-date information readily available. Project performers are also managing the development of publications synthesizing the state of knowledge on the subject. The goals of this project are clearly relevant to the WPTO program strategies, with end products used by the MHK community. Successful project execution is measured primarily through improvements in the aggregation and distribution of results.

End User Engagement and Dissemination Strategy

End users are well-defined and include international analysts (from IEA-OES), regulators, researchers, and developers to better understand the environmental impacts of MHK. Stakeholder engagement includes interactions with international analysts, outreach to regulators, researchers, and developers/consultants. The scope and strategy behind these communications largely reflects the role that these different communities play in the existing MRE environment. Efforts to inform stakeholders of the availability of this effort are robust, and reviewers noted the variety of means in which information is disseminated, including the email blasts and short stories/summaries. The State of the Science report work is valuable to the MHK community as it has subject matter experts synthesizing the information.

One reviewer suggested evaluating the effectiveness of stakeholder engagement, and another reviewer suggested transparency of how review of the engagement strategy informs subsequent decisions in the project.

Management and Technical Approach

The project effectively uses resources to gather information on new research, disseminate and apply findings in environmental assessments, and present the summary in a user-friendly document for the audience. Reviewers suggested additional synopsis efforts, such as the State of the Science report, as it is most valuable to end users. They also recommended instituting a process to remove "grey literature" to ensure all sources are as up to date as possible. Three reviewers suggested a weighted criteria or other type of quality control for Tethys searches in order to distill from dated or less relevant information, or they suggested removing this information entirely.

Technical Accomplishments and Progress

The project is mature; key technical accomplishments include hosting expert workshops, producing two publications, improving access to existing data through search functions, and developing a data transferability process for information relevant to permitting. The website is well known and is widely used, which speaks to the utility of the resource. Accomplishments were somewhat forward facing in that the product was defined, but accomplishments were not clearly conveyed from the end user perspective (e.g., demonstration of what the end user was able to accomplish because of Tethys).

Future Work

The future plan is to continue the operation of Tethys and to complete the the State of the Science 2020 report. There was not a description of decision points in the milestones. Project performers are working to extend the project for a fourth phase.

PORTAL AND REPOSITORY FOR INFORMATION ON MARINE RENEWABLE ENERGY (PRIMRE)

(WBS #: 2.4.1.701)

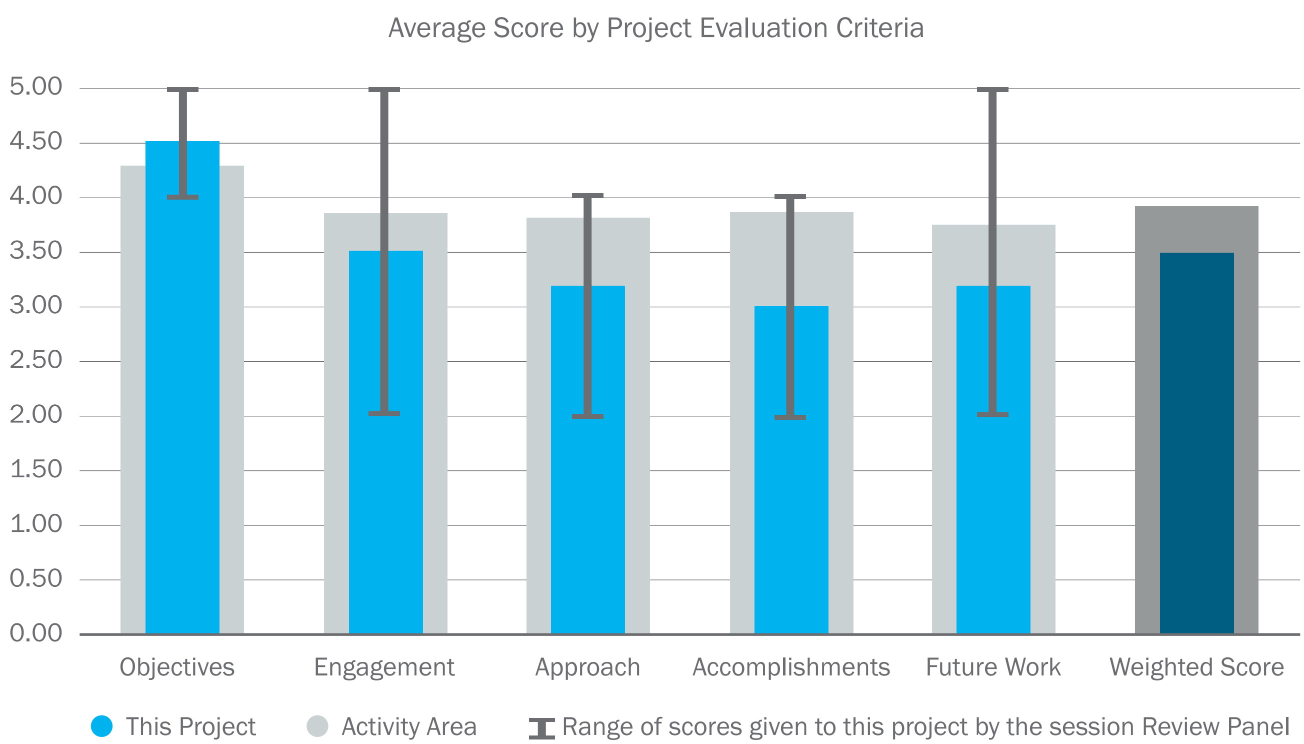
Recipient:	SNL, NREL, and PNNL
Principal Investigator:	Kelley Ruehl
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,854K
Total Costed:	$1,055K

Project Description

The Portal and Repository for Information on Marine Renewable Energy (PRIMRE) provides centralized access, standardization, community building, and integration of federally funded marine energy data repositories and knowledge bases. The objective of the PRIMRE project is to overcome data and information barriers to technology, research, design, and testing in support of MRE stakeholders.

Weighted Project Score: 3.5

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

There are numerous data and information hubs related to the MHK industry. The appeal of integrating or consolidating this information is obvious; however, reviewers generally agree that a compelling case for PRIMRE as a good, cost-efficient, approach has not been made. Project performers stated that existing knowledge hub architectures are not well-suited for consolidation. If this is true, then WPTO should consider whether a more efficient approach is to restructure programmatically. This should be considered along with the long-term costs of maintaining multiple knowledge hubs plus PRIMRE to identify the most efficient approach.

A point of discussion among reviewers was how to measure success in such a project. Short of integrating the knowledge hubs, success was largely undefined. As with other knowledge hubs, PRIMRE should consider efforts to quantify the ROI that go beyond basic analytics. Identifying and quantifying meaningful metrics is challenging but important to understand the impact of these investments.

It was difficult to understand the budget and work involved with the various tasks. This made PRIMRE appear more expensive and development-intensive than was actually the case. Restructuring the presentation of the tasks, particularly as they relate to the budget, would clarify these points and improve project transparency.

As with other knowledge hub investments, it would be helpful to understand long-term costs and WPTO plans to maintain these developments.

Project Objectives, Impacts, and Alignment with the Program Strategy

PRIMRE contributes to the program's strategies and approaches by working to streamline the MHK data repository and information database ecosystem. Project performers adequately described the end goals and database integration efforts, which are needed given that information is currently distributed between multiple locations. Meaningful impacts derived from PRIMRE are related to increased discoverability of MHK-related data and information covering the full breadth of topics related to MRE.

End User Engagement and Dissemination Strategy

As with other data and information repositories, the project team identified end users as those interested in identifying and accessing existing information related to MRE projects. Identified end user engagement strategies included both direct outreach and the formation of a steering committee, which includes diverse representatives to guide PRIMRE development activities to directly address community needs. The summarized engagement and dissemination strategy were robust, but multiple reviewers noted that more detail about how this outreach has informed PRIMRE development would have been helpful. A concern identified by multiple reviewers was that this approach to integrating the MHK data/information ecosystem would not result in improved dissemination when compared to the status quo.

Management and Technical Approach

Project performers succeeded in conveying the management strategies necessary to achieve the project's goals. This includes strong communication and coordination efforts between the multiple labs experienced in managing the different MHK knowledge hubs. Project performers have the capacity to achieve project goals, and factors critical to the successful implementation of PRIMRE were identified. All reviewers did express concern about whether this technical approach to knowledge hub integration was the most efficient method and if it is appropriate for the different knowledge hubs to retain their unique architectures. Project performers did not make a compelling case in favor of maintaining separate knowledge hubs, thereby necessitating PRIMRE for integration across the MHK information ecosystem.

Technical Accomplishments and Progress

Progress is being made both by standing up Tethys Engineering and developing the PRIMRE interface and standardized search results. Changes have also been made to improve the integration with MHKDR. Despite these successes, one reviewer noted that statements made in the project summary were inconsistent with their recent experience during a visit to PRIMRE.

Future Work

Future work identified four key tasks covering content development, development and maintenance, stakeholder engagement, and international engagement efforts. Some reviewers considered the descriptions of future work to be well-defined, while others were unclear of expected project outcomes or of the added value of the future work.

TECHNO-ECONOMIC ANALYSIS AND PROGRAM SUPPORT

(WBS #: 2.4.3.401)

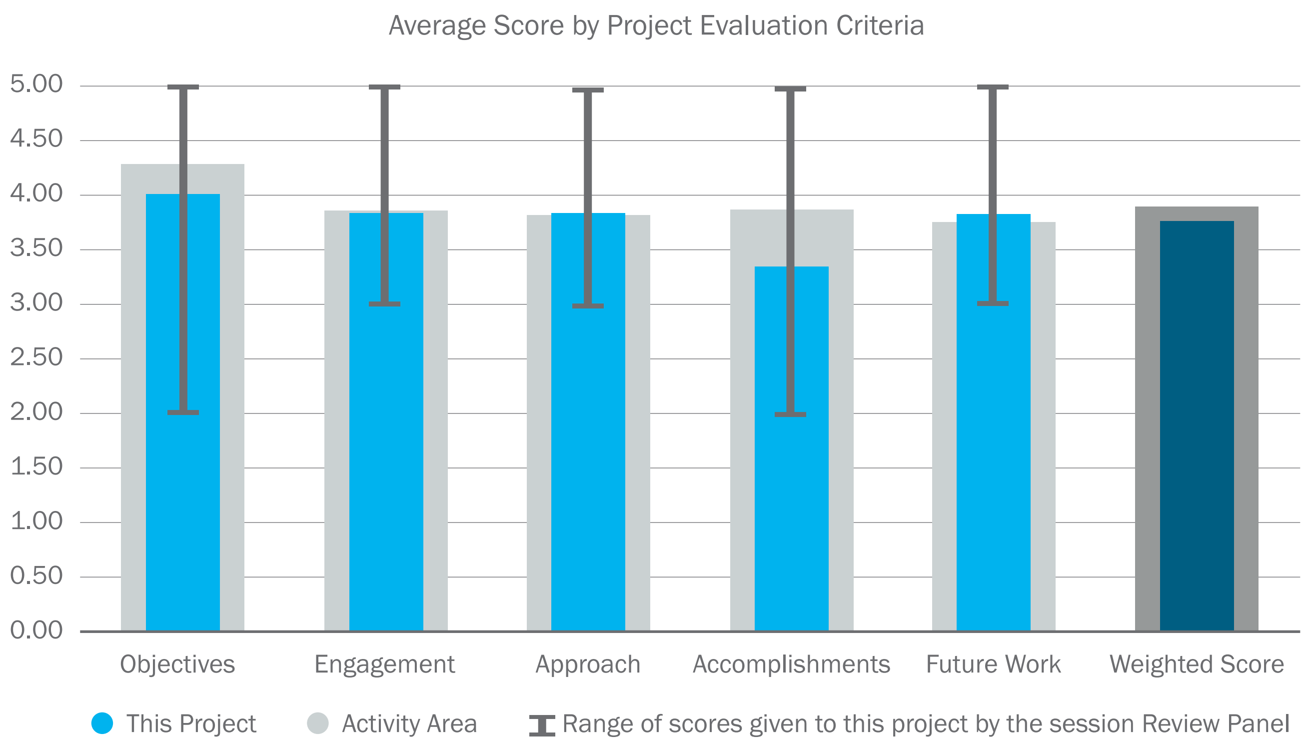
Recipient:	NREL
Principal Investigator:	Scott Jenne
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$1,330K
Total Costed:	$435K

Project Description

This project provides techno-economic due diligence for WPTO, develops tools for cost of energy analysis, and provides feasibility analysis for new and emerging technologies. Specifically, this task has been used to identify areas of opportunity, quantify the impact of program-level investments, guide WPTO program R&D decisions, develop and provide economic analysis tools, and support the marine energy industry members. This work has been conducted in collaboration with international marine energy experts and techno-economic activities (e.g., IEA-OES), the U.S. marine energy industry, other national laboratories, and universities to ensure that research objectives are aligned with the needs of utilities and other end users. This project has been the foundation for a number of WPTO initiatives that have since grown into their own projects. Notably, the Waves to Water: Desalination Prize was initiated with desalination techno-economic analysis (FY16–FY18) and PBE work that was previously known as Alternative Market Analysis (FY17) and Maritime Markets (FY18).

Weighted Project Score: 3.8

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

It is interesting that this project seems to be multiple things simultaneously: (1) an evaluation service to help WPTO evaluate the techno-economic performance of specific projects and (2) a tool development project to empower others to evaluate particular concepts. These are both expected, but what is a bit more surprising is this project also seems to be the germination point in some cases for new directions for the WPTO, including much of the thinking behind non-grid markets.

Project Objectives, Impacts, and Alignment with the Program Strategy

This project is extremely important for the WPTO program. The techno-economic evaluation of wave energy projects is simultaneously extremely challenging and extremely important. This project is an excellent fit with the program. This tool should be fully utilized for the assessment of the demonstration of projects in the program portfolio.

End User Engagement and Dissemination Strategy

There are references to engagement such as with the IEA-OES and Wave Energy Scotland; however, it was not stated whether the project has held workshops or how the engagement was managed or planned. There is no mention of advisory group or a survey utilized. There is however mention of a presentation at Water Power Week in 2019. More current dissemination outreach is expected.

Management and Technical Approach

It appears that this project has very similar objectives, impacts, and outcomes as the NREL Wave-SPARC project, and there does not appear to be explicit reference on how it complements or will integrate with Wave-SPARC. The System Advisory Model assessment tool does have similarities with the TPL/TRL assessment tool. The PI mentioned that the project has modified its approach over time as the budget has increased; however, many of the key technical methods are leveraged from NREL's experience in other renewable energy techno-economic analysis activities.

Technical Accomplishments and Progress

The project appears productive, although there is not sufficient information presented to see how the outputs of these projects characterize the viability of the large-scale MHK projects under development. There is also an emphasis on tool development and dissemination, and while helpful, reviewers suggested that the main value of this project would be as an evaluation service to WPTO.

Future Work

Adequate plans for future work were outlined by the project performers, including key milestones and go/no-go decision points. It appears this project will continue to play an important role in WPTO activities moving forward, both as an evaluator of projects and in supporting the development of new ideas and directions.

MARINE AND HYDROKINETIC DATA REPOSITORY (MHKDR)

(WBS #: 2.4.3.407)

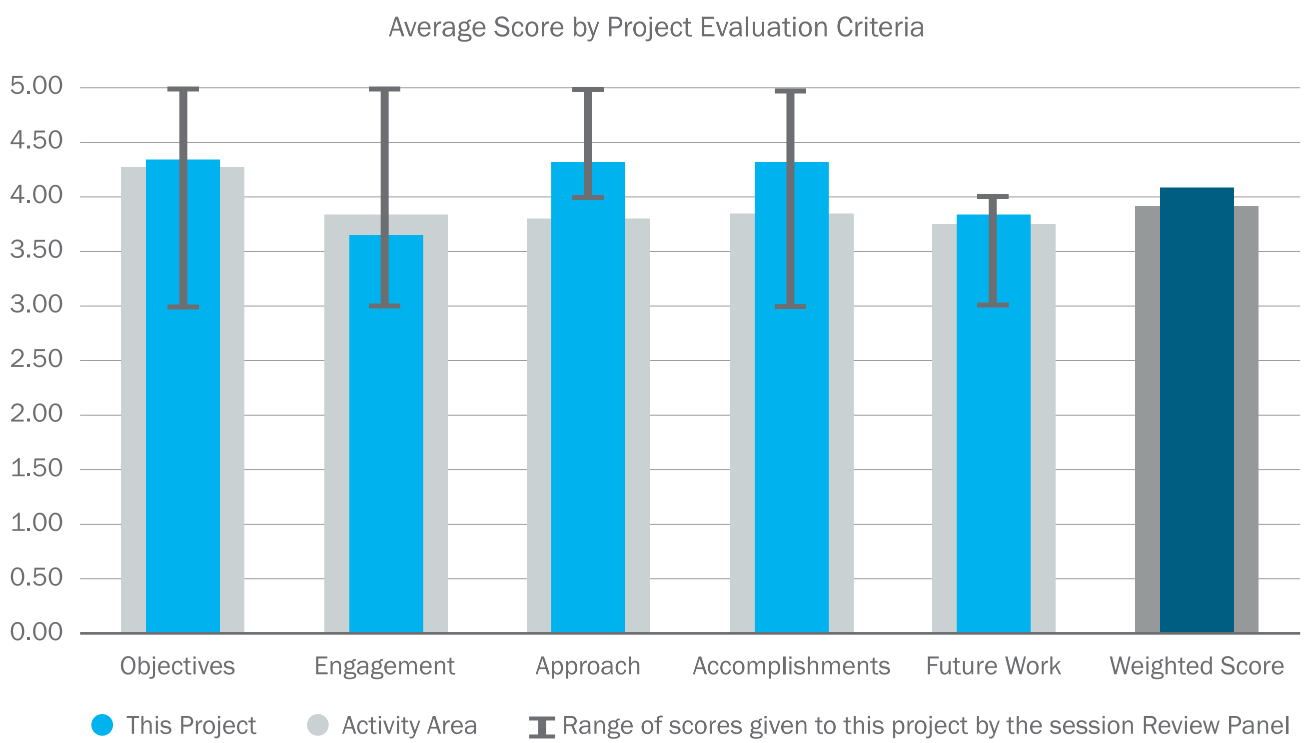
Recipient:	NREL
Principal Investigator:	Jon Weers
Project Type:	AOP
Project Category:	Ongoing Projects
Total Authorized:	$515K
Total Costed:	$308K

Project Description

The MHK Data Repository (MHKDR) makes available MHK-related data generated from WPTO-funded projects. The MHKDR protects WPTO's R&D investment by preserving and providing access to data, disseminating its data catalog to a network of data sharing partners, supplying context and metadata to search engines, and disseminating the findings from WPTO projects to MHK communities and others, so they may leverage the knowledge and experience gained, build upon prior successes, avoid duplication of effort, reduce costs and risks associated with MHK development, and accelerate the rate of innovation.

Weighted Project Score: 4.1

Weighting: For ongoing projects, there is equal weighting across all five evaluation criteria: Objectives, Engagement, Approach, Accomplishments, and Future Work.



Summary of all Reviewers' Comments

Overall Impressions

The MHKDR project is a self-contained project that not only addresses program goals but also federal requirements and general best practices for transparency and data availability. Reviewers uniformly agreed that project management strategies and technical progress were indicative of a project that is best classified as being in an operational state, as opposed to being under development. To ensure the long-term viability of MHKDR, multiple reviewers recommended that WPTO consider defining this project as operational in budget considerations and separate it from other technological advancement tasks within the program.

Reviewers identified two key recommendations:

1. Budgetary support for data management and curation for integration with MHKDR should be provided to FOA recipients to ensure that project performers are aware of expectations upon funds being rewarded.
2. Downloads are insufficient to measure impact or ROI. Additional efforts should be made to identify new metrics for measuring impact. One recommendation includes soliciting those who download data for information about their motivation and following up with them to understand whether the data were ultimately meaningful and if these data are contributing to an end product. Although identifying better metrics for impact assessment was identified as a priority by numerous reviewers, it was also widely recognized that this is a difficult task.

Project Objectives, Impacts, and Alignment with the Program Strategy

MHKDR contributes to program goals by providing a discoverable database of MHK-relevant data that is actively managed and curated. Project performers are actively working to improve and increase the availability of information, thereby addressing broader program strategies to advance the MHK industry. In addition to addressing program strategies, MHKDR also addresses federal requirements for data availability.

End User Engagement and Dissemination Strategy

The end user engagement strategy was well-defined, credible, and multi-faceted as it relates the goals of increasing the availability of existing data. This engagement and dissemination strategy involves both direct engagement and efforts to increase data discoverability across websites. Project performers adequately described the interactions they have with those who provide data to make their data available and ensure that metadata are sufficient for distribution. In addition to directly working with these parties, project performers make modifications to MHKDR based on user feedback. Increasing volumes of data downloads suggests that end user engagement strategies and integration to increase discoverability are succeeding. Although reviewers uniformly agreed that the end user engagement strategies were appropriate, multiple reviewers also commented that the project team should solicit feedback from those that access the data to understand how it was used and whether it was ultimately found to be useful.

Management and Technical Approach

MHKDR has taken leveraged existing data repository architecture to make MHK data available that is consistent with best practices using a small, but capable, project team. Successful integration with other federal databases in addition to MHK-specific resources demonstrates that the project is meeting targets and there are no significant risks for the project. Reviewers unanimously agreed that the project is well-managed. This project addresses existing data dissemination needs, but it does have inherent challenges (e.g., quality control) that cannot be reasonably addressed by the project performers.

Technical Accomplishments and Progress

MHKDR project performers have made progress in achieving their objectives and currently host hundreds of gigabytes of data from hundreds of datasets. Download rates are increasing, which was attributed to improvements in data discoverability. By successfully hosting and curating data with the repository fully operational, all major technical barriers and critical milestones have been achieved. Multiple reviewers identified quality control of datasets as a potential challenge with MHKDR given that project performers cannot be expected to have the expertise or time to identify concerns in MHK datasets.

Future Work

MHKDR is operational, and future work on the project is structured around collecting and curating data, integrating with other data dissemination platforms, and improving the usability and functionality based on user feedback. Reviewers uniformly agreed with the value and direction of the project. Likewise, all reviewers agreed that identifying additional metrics for measuring impact (i.e., moving beyond analytics) is critical to understanding the impact of the data repository. Multiple reviewers commented on the long-term funding mechanisms and whether it was appropriate to identify a different funding mechanism for MHKDR given it has entered into the O&M stage.

GENERAL FEEDBACK AND LESSONS LEARNED

In planning the 2019 Peer Review, the Water Power Technologies Office (WPTO) aimed to gather in-depth feedback from the reviewers while offering all attendees the opportunity to share their thoughts on WPTO-funded work and the future of water power research and development (R&D). Attendees were given multiple opportunities to directly or anonymously share feedback—on both the programs and the peer review process—through the following mechanisms: (1) dedicated networking breaks and discussion time throughout the week, in addition to Q&A sessions; (2) comment boxes in all session rooms for attendees to submit feedback anonymously; (3) a town hall-style open feedback forum with WPTO staff and all attendees; and (4) a post-event survey via email to submit feedback anonymously.

The end-of-session networking activities ensured that all reviewer questions were answered and enabled the audience to ask any remaining questions to all previous presenters in a session. The additional time at the end of each session also served as an opportunity for WPTO to gather feedback from the audience, noting any themes, takeaways, or recommendations shared. Comment cards were also provided to allow the audience to submit anonymous feedback on the program, such as gaps in WPTO's research portfolio or recommendations for building partnerships, and event execution. The comment cards and session notes informed the agenda for the town hall at the end of peer review, which brought together reviewers, WPTO staff, PIs, and the general audience to discuss key themes, takeaways, and recommendations to inform the program's future direction and approaches. The town hall provoked a lively discussion and sharing of ideas after days of attendees learning about the programs. Finally, the post-event survey focused on the peer review process to evaluate WPTO's efforts and improve future reviews.

The following is a sample of comments and actionable recommendations made by individual review panelists, general peer review attendees, and PIs aimed at improving both the program and the peer review process.

Summary of Feedback from all Attendees on the Programs

Office-Level (Relevant to Both Programs)

- WPTO's use of a variety of funding mechanisms is exciting. Early stage R&D often requires flexible funding mechanisms that allow people to fail fast and small.
- Meaningful, early, and frequent stakeholder engagement and impactful dissemination is important.
- WPTO may need to do more in the areas of performance metrics, quantifying WPTO's impact and ROI, as well as tracking commercialization. There should be more focus on translating R&D into near-term commercial market success.

Hydropower Program

- It will be impossible to build new hydropower if we keep doing it the same way, and trying new things is not only promising, it's necessary.
- HydroWIRES is an important area of research for the program, and there are opportunities to further expand and refine the scope of research.
- More engagement of ISOs and RTOs and other grid/power system stakeholders would be valuable to the success of the program, especially for HydroWIRES.
- More specificity is needed for performance metrics, especially related to environmental performance.
- The FERC eLibrary is difficult for hydropower stakeholders to use, and it would be helpful if the Hydropower Program could in any way collaborate with FERC to make this more valuable.

Marine and Hydrokinetic (MHK) Program

- The national labs are doing great work and have proven responsive to feedback from stakeholders. Industry wants to work with them, but industry members also need easy and cost-effective mechanisms to do so. TEAMER is a step in the right direction.
- We need specificity in performance metrics, and if not LCOE, what else?
- There is a lot of interest in risk management strategies, including how to track, record, document, and share mitigation strategies and lessons learned.
- Marine energy developers face supply chain challenges; it is difficult to incentivize vendors to reduce costs without the guarantee of scaling. It would be valuable if WPTO could help address this.
- The MHK Program could do more to coordinate with offshore wind researchers and stakeholders, including on environmental research and regulator engagement, as well as with BOEM's research arms, but also on the foundational research side of the program, like on materials.
- Powering the Blue Economy (PBE) has the potential to "grow the pie" for the PBE markets by bringing greater visibility to the critical missions that they support. With the potential to scale these "win-win" opportunities, WPTO, in coordination with other federal agencies and philanthropic organizations, is in an excellent position to spur MHK industry growth.
- Despite a general optimism around the PBE approach, there are inherent challenges in developing technologies for markets that are in early stages of development and have unclear growth potential. Strong partnerships should be continuously pursued, and a clear vision of the near, mid and long-term applications of MHK should be regularly refined to ensure that MHK development efforts remain in sync with PBE markets.

Summary of Feedback from all Attendees on the Peer Review Process

- Review instructions were provided in a timely manner and were clear and well described. The WPTO team did a great job organizing information, and sufficient resources and tools were provided to prepare reviewers for assigned tasks. The peer review was very well organized and executed. The WPTO team did a great job communicating and setting expectations.
- The accessibility to all WPTO and lab staff prior to the review was impressive. Clearly, there are good people involved in this program. The team did a tremendous job. During a meeting at the end of the week between reviewers and WPTO staff, several reviewers expressed ideas they thought could improve the process and we heard that some of these ideas had been tried in the past with mixed results. Overall, reviewers would not change much about the process.
- The process improves with every iteration, and overall, this was an excellent job by the WPTO team. The peer review process was well-organized and well-supported by the staff managing the process.
- WPTO staff running the event were great, and the balance struck between sticking to the agenda and having flexibility for a discussion running over was appreciated. All staff members were very open and approachable, and the work put into this event by everyone was truly appreciated.
- The peer review tool worked great for reviewers, and the scoring seemed clear. The agenda for the peer review event was much better than expected, and the morning panels were fantastic.
- WPTO has built a tremendous peer review process and should be proud of the method of project evaluation.

- Instructions were provided well in advance and were clear and well described. Enough time was allocated to deliberate and modify reviews, and there was plenty time for panels to confer. Evaluation criteria was quite good—meaningful and appropriate in most cases. Online tools/website were useful and well-designed.
- The many opportunities to provide feedback directly to PIs and WPTO were appreciated.
- The panels with outside speakers were inspiring and relevant. The end-of-review town hall really helped round out the week and tie everything together.
- There were great opportunities to network with a broad cross section of the industry, as well as WPTO and national lab staff.
- A few more dynamic sessions or more Q&A seemed warranted, as many participants want to ideate and could offer valuable direction in more formative sessions.
- It was not clear in the case of a few projects why they needed to be reviewed, especially very small or internal-facing projects that did not seem relevant for reviewing the program strategy/direction and impact.
- Several attendees and reviewers expressed that they would have appreciated more of an overview of the DOE budget process and timelines, the whole thing from appropriations to awards, as well as WPTO's project management (such as more information on the go/no-go decisions).
- WPTO could do a better job of managing the Q&A session (e.g., keeping time and not letting a few people dominate the Q&A).
- A few of the projects reviewed did not seem relevant for reviewing the program strategy/direction and impact.
- The peer review gave attendees a chance to show all the work WPTO funds and how the portfolio really fits together and supports the advancement of the industry.
- The dynamic viewpoints of the reviewers and audience were appreciated, and it allowed researchers to think of a different perspective and audience for their work.

Lessons Learned and Opportunities for Improving the Peer Review Process

- **Set objectives from the beginning**. Whether planning a DOE program peer review or any other event, report, or public facing effort, it is important that a project team agree to key objectives or intentions for the process from the beginning. Doing so helped the WPTO team stay focused on the tasks they considered most important for achieving the office's vision for the review.
- **Review projects that are only relevant for a program-wide review**. WPTO acknowledges the feedback received that a few projects reviewed did not seem relevant for reviewing the program strategy and impact. For the 2019 WPTO Peer Review, the office followed an EERE guide to determine the percentage of the portfolio to review and the evaluation criteria to use. WPTO agrees that some projects, especially very small or internal-facing projects, likely do not need to be reviewed for the purpose of evaluating the program at a high level; alternatively, in some cases, WPTO staff could quickly cover certain projects in their own presentations. The office will incorporate this feedback when planning the next review while still adhering to organizational guidance.

- **Gather feedback from all attendees, not just the reviewers, for a valuable public review**. WPTO sought to provide many opportunities for all peer review participants—reviewers, PIs, and others—to provide feedback directly to WPTO anonymously or openly. This added significant value to discussions during the review. Also, this broadened the WPTO staff's understanding of partners' perspectives, as thoughtful suggestions were received from attendees with varying levels of familiarity with the programs. A town hall can be very productive and provoke lively discussion at the end of the week if organized well.
- **Offer a variety of sessions to maintain engagement at such a long event**.WPTO organized panels with outside speakers, networking sessions, an end-of-review town hall, and scheduled breaks as often as possible given the time constraints. These were all clearly appreciated by the attendees. WPTO would consider other ways to break up the agenda in the future, such as offering longer breaks, one-on-one speed networking sessions, sign-ups for meeting space, or lightning round sessions to introduce attendees to new researchers and ideas.
- **Consider the pace at which reviewers can work best**.WPTO deeply appreciates the substantial amount of time and effort required by the reviewers. In future reviews, the office will consider ways to structure the sessions so that reviewers have more time throughout the review week to record their comments and have closed-door, reviewer-only meetings. WPTO will also consider the 2019 reviewers' recommendations to balance the amount of work required before, during, and after peer review.
- **Provide thorough presentations on programmatic decision-making and timelines**.WPTO heard from a number of attendees and reviewers that they would have appreciated more of an overview of the DOE budget process and timelines (the whole thing from appropriations to awards), as well as WPTO's project management (such as more information on the Go/No-Go decisions). WPTO will work to emphasize these details in future reviews.
- **Encourage crosspollination among technology areas and disciplines**.The 2019 review week was busy, with almost three full days of four concurrent tracks. Attendees' feedback suggested that they overwhelmingly agreed the tracks were organized logically in terms of subject matter, but WPTO recognizes this limited the number of sessions participants could attend. Most importantly, the tracks did not always encourage mixed audiences when it would have been advantageous, such as program areas where different stakeholder groups need to share varying perspectives. WPTO will try to improve this in future reviews, acknowledging that this could be challenging due to time and budget constraints.

APPENDIX A: PEER REVIEW AGENDA

Hydropower Track

Tuesday, October 8, 2019 Hydropower Track 1 | Grid Reliability and Resilience, New Technology and Modernization						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
8:00 AM	8:45 AM	Check-in, Breakfast				
8:45 AM	9:15 AM	U.S. Department of Energy (DOE) Water Power Technologies Office (WPTO) Overview	Alejandro Moreno	WPTO	Plenary	Grand Ballroom A/B/C
9:15 AM	9:25 AM	Remarks from Department of Energy Deputy Assistant Secretary for Renewable Power	David Solan	DOE	Plenary	Grand Ballroom A/B/C
9:25 AM	9:40 AM	Keynote - Paul Bunje, Co-Founder & CSO/COO, Conservation X Labs	Paul Bunje	Conservation X-Labs	Plenary	Grand Ballroom A/B/C
9:40 AM	9:55 AM	Keynote - Emily Reichert, CEO, Greentown Labs	Emily Reichert	Greentown Labs	Plenary	Grand Ballroom A/B/C
9:55 AM	10:25 AM	Fireside Chat with Keynote Speakers and Alejandro			Plenary	Grand Ballroom A/B/C
10:25 AM	10:45 AM	Peer Review Logistics	Allison Johnson	WPTO	Plenary	Grand Ballroom A/B/C
10:45 AM	11:00 AM	Coffee Break and Transition				
11:00 AM	11:45 AM	Hydropower Program Overview	Tim Welch	WPTO	Hydro Plenary	Washington/ Jefferson
11:45 AM	12:30 PM	Hydropower Vision Roadmap Update	TJ Heibel	PNNL, ANL, INL, NREL, ORNL	Hydro Plenary	Washington/ Jefferson
12:30 PM	1:20 PM	Lunch				
1:20 PM	2:05 PM	Overview of HydroWIRES	Sam Bockenhauer	WPTO	Hydro Plenary	Washington/ Jefferson
2:05 PM	2:15 PM	Break and Transition				
2:15 PM	2:25 PM	Introduce Lab Projects	Sam Bockenhauer	WPTO	Grid	Washington/ Jefferson
2:25 PM	3:10 PM	Hydropower Value Study	Abhishek Somani	PNNL, ANL, INL, NREL, ORNL	Grid	Washington/ Jefferson
3:10 PM	3:40 PM	North American Renewable Integration Study	Greg Brinkman	NREL	Grid	Washington/ Jefferson
3:40 PM	3:50 PM	Coffee Break				
3:50 PM	4:00 PM	Introduce Lab Projects	Sam Bockenhauer	WPTO	Grid	Washington/ Jefferson
4:00 PM	4:30 PM	Valuation Guidance and Techno-Economic Studies for Pumped Storage Hydropower	Vladimir Koritarov	ANL	Grid	Washington/ Jefferson
4:30 PM	5:00 PM	Integrated Hydropower and Storage Systems Operation for Enhanced Grid Services	Thomas Mosier	INL	Grid	Washington/ Jefferson
5:00 PM	5:30 PM	Modeling the Value of Networked, Small Hydro Generators to the Grid	Greg Stark	NREL	Grid	Washington/ Jefferson
5:30 PM	5:50 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Grid	Washington/ Jefferson
5:50 PM	6:30 PM	Hydro-Grid Peer Reviewer Only Meeting				Madison

Tuesday, October 8, 2019 Hydropower Track 2 | Environmental R&D & Data Management						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
8:00 AM	8:45 AM	Check-in, Breakfast				
8:45 AM	9:15 AM	U.S. Department of Energy (DOE) Water Power Technologies Office (WPTO) Overview	Alejandro Moreno	WPTO	Plenary	Grand Ballroom A/B/C
9:15 AM	9:25 AM	Remarks from Department of Energy Deputy Assistant Secretary for Renewable Power	David Solan	DOE	Plenary	Grand Ballroom A/B/C
9:25 AM	9:40 AM	Keynote - Paul Bunje, Co-Founder & CSO/COO, Conservation X Labs	Paul Bunje	Conservation X-lab	Plenary	Grand Ballroom A/B/C
9:40 AM	9:55 AM	Keynote - Emily Reichert, CEO, Greentown Labs	Emily Reichert	Greentown Labs	Plenary	Grand Ballroom A/B/C
9:55 AM	10:25 AM	Fireside Chat with Keynote Speakers and Alejandro			Plenary	Grand Ballroom A/B/C
10:25 AM	10:45 AM	Peer Review Logistics	Allison Johnson	WPTO	Plenary	Grand Ballroom A/B/C
10:45 AM	11:00 AM	Coffee Break and Transition				
11:00 AM	11:45 AM	Hydropower Program Overview	Tim Welch	WPTO	Hydro Plenary	Washington/ Jefferson
11:45 AM	12:30 PM	Hydropower Vision Roadmap Update	TJ Heibel	PNNL, ANL, INL, NREL, ORNL	Hydro Plenary	Washington/ Jefferson
12:30 PM	1:20 PM	Lunch				
1:20 PM	2:05 PM	Overview of HydroWIRES	Sam Bockenhauer	WPTO	Hydro Plenary	Washington/ Jefferson
2:05 PM	2:15 PM	Break and Transition				
2:15 PM	2:45 PM	Overview of Big-Data Access and Management	Hoyt Battey	WPTO	Enviro+Data	Potomac
2:45 PM	3:15 PM	Annual Hydropower Market and Trends Report	Rocio Uria-Martinez	ORNL	Enviro+Data	Potomac
3:15 PM	3:45 PM	Hydropower Regulatory and Permitting Information Desktop (RAPID) Toolkit	Aaron Levine	NREL	Enviro+Data	Potomac
3:45 PM	3:55 PM	Coffee Break				
3:55 PM	4:25 PM	An Examination of the Hydropower Licensing and Federal Authorization Process	Aaron Levine	NREL	Enviro+Data	Potomac
4:25 PM	4:45 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Enviro+Data	Potomac
4:45 PM	5:15 PM	Hydro Enviro + Data Peer Reviewer Only Meeting				Madison
6:30 PM	8:30 PM	Optional, No-Host Social Event				Details pending
5:50 PM	6:30 PM	Hydro-Grid Peer Reviewer Only Meeting				Madison

Wednesday, October 9, 2019 Hydropower Track 1 | Grid Reliability and Resilience, New Technology and Modernization						
Start	End	Agenda Session	Presenter	Affiliation	Track	Room
8:00 AM	8:30 AM	Check-in, Breakfast				
8:30 AM	8:35 AM	Introduction: Malcolm Woolf, President and CEO of the National Hydropower Association (NHA)	Alejandro Moreno	WPTO	Hydro Plenary	Washington/ Jefferson
8:35 AM	8:45 AM	The Evolution to a Carbon-Free Electric Grid: Perspectives on Getting from Here to There and Hydro's Role	Malcolm Woolf	NHA	Hydro Plenary	Washington/ Jefferson
8:45 AM	9:30 AM	Panel discussion featuring Steve Capanna, Environmental Defense Fund; Steve Clemmer, Union of Concerned Scientists; and Jeremy Harrell, ClearPath	Malcolm Woolf (moderator)	NHA	Hydro Plenary	Washington/ Jefferson
9:30 AM	9:45 AM	Break and Transition				
9:40 AM	9:45 AM	Introduce Lab Projects	Marisol Bonnet	WPTO	Grid	Washington/ Jefferson
9:45 AM	10:15 AM	Transforming the U.S. Market with a New Application of Ternary- Type Pumped-Storage Hydropower Technology	Mark Jacobson	NREL	Grid	Washington/ Jefferson
10:15 AM	10:45 AM	Ground-Level Integrated Diverse Energy Storage (GLIDES)	Ahmad Abuheiba	ORNL	Grid	Washington/ Jefferson
10:45 AM	10:55 AM	Coffee Break				
10:55 AM	11:00 AM	Introduce FOA Projects	Marisol Bonnet	WPTO	Grid	Washington/ Jefferson
11:00 AM	11:30 AM	Hydro Battery Systems Catalog Development	JT Steenkamp	Shell Energy North America (US), L.P.	Grid	Washington/ Jefferson
11:30 AM	12:00 PM	Cost Effective Small Scale Pumped Storage Configuration	Henry Obermeyer	Obermeyer Hydro Accessories, Inc.	Grid	Washington/ Jefferson
12:00 PM	12:15 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Grid	Washington/ Jefferson
12:15 PM	12:30 PM	Closing Remarks on Grid Integration	Sam Bockenhauer	WPTO	Grid	Washington/ Jefferson
12:30 PM	1:15 PM	Lunch				
1:15 PM	1:35 PM	Overview of Technology R&D for Low-Impact Hydro Growth	Marisol Bonnet	WPTO	New Tech+Mod	Washington/ Jefferson
1:35 PM	1:45 PM	Introduce FOA Projects	Marisol Bonnet	WPTO	New Tech+Mod	Washington/ Jefferson
1:45 PM	2:15 PM	Modular Roots-Based Rotor Turbine-Generator System for Small Hydro	David Yee	Eaton Corporation	New Tech+Mod	Washington/ Jefferson
2:15 PM	2:45 PM	Rapidly Deployable Advanced Integrated Low Head Hydropower Turbine Prototype	Arnie Fontaine	Pennsylvania State University	New Tech+Mod	Washington/ Jefferson

Wednesday, October 9, 2019 Hydropower Track 1 | Grid Reliability and Resilience, New Technology and Modernization						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
2:45 PM	2:55 PM	Coffee Break				
2:55 PM	3:25 PM	Optimized Composite Prototype for Archimedes Turbine Manufacture	Marisol Bonnet (on behalf of Percheron)	Percheron Power, LLC	New Tech+Mod	Washington/ Jefferson
3:25 PM	3:55 PM	The Design and Development of a Composite Hydropower Turbine Runner	Paul Fabian	Composite Technology Development, Inc.	New Tech+Mod	Washington/ Jefferson
3:55 PM	4:25 PM	A Cost-Disruptive, Low-Impact, Modular Form Factor Low-Head Hydropower System	David Duquette	Littoral Power Systems, Inc.	New Tech+Mod	Washington/ Jefferson
4:25 PM	4:55 PM	Efficient, Modular Low-Head Linear Pelton Turbine with Simple, Low-Cost Civil Works	Abe Schneider	Natel Energy	New Tech+Mod	Washington/ Jefferson
4:55 PM	5:40 PM	Standard Modular Hydropower Technology Acceleration	Brennan Smith	ORNL	New Tech+Mod	Washington/ Jefferson
5:40 PM	6:00 PM	End of Session Networking Activity	All recent presenters	All recent presenters	New Tech+Mod	Washington/ Jefferson
6:15 PM	8:30 PM	Optional, No-Host Trivia at Port City Brewing Pre-Pay and Registration Required				

Wednesday, October 9, 2019 Hydropower Track 2 | Environmental R&D & Data Management						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
8:00 AM	8:30 AM	Check-in, Breakfast				
8:30 AM	8:35 AM	Introduction: Malcolm Woolf, President and CEO of the Na-tional Hydropower Association (NHA)	Alejandro Moreno	WPTO	Hydro Plenary	Washington/ Jeffer-son
8:35 AM	8:45 AM	The Evolution to a Carbon-Free Electric Grid: Perspectives on Getting from Here to There and Hydro's Role	Malcolm Woolf	NHA	Hydro Plenary	Washington/ Jefferson
8:45 AM	9:30 AM	Panel discussion featuring Steve Capanna, Environmental Defense Fund; Steve Clemmer, Union of Concerned Scientists; and Jeremy Harrell, ClearPath	Malcolm Woolf (moderator)	NHA	Hydro Plenary	Washington/ Jefferson
9:30 AM	9:45 AM	Break and Transition				
9:45 AM	10:10 AM	Overview of Environmental R&D and Hydrologic Systems Science	Dana McCoskey	WPTO	Enviro+Data	Potomac
10:10 AM	10:20 AM	Introduce 9505, Water Modeling	Simon Gore	WPTO	Enviro+Data	Potomac
10:20 AM	10:50 AM	Third SECURE Water Act Section 9505 Assessment	Shih-Chieh Kao	ORNL, PNNL	Enviro+Data	Potomac
10:50 AM	11:05 AM	Coffee Break				
11:05 AM	11:35 AM	Advancing Modeling Tools for Assessment of Long-Term Energy/Water Risks for Hydropower	Mark Wigmosta	PNNL	Enviro+Data	Potomac
11:35 AM	12:05 PM	Monitoring Technology Development for Sensitive Species (Eel/ Lamprey Tag Development)	Daniel Deng	PNNL	Enviro+Data	Potomac
12:05 PM	12:30 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters		Potomac
12:30 PM	1:15 PM	Lunch				
1:15 PM	1:20 PM	Introduce BioDE, EDS	Dana McCoskey	WPTO	Enviro+Data	Potomac
1:20 PM	2:05 PM	Biologically-Based Design and Evaluation of Hydropower Turbines	Alison Colotelo	PNNL, ORNL	Enviro+Data	Potomac
2:05 PM	2:50 PM	Environmental Decision Support: Science-Based Tools for Hydropower Stakeholder Collaboration	Brenda Pracheil	ORNL	Enviro+Data	Potomac
2:50 PM	3:00 PM	Coffee Break				
3:00 PM	3:10 PM	Introduce 1662 projects	Dana McCoskey	WPTO	Enviro+Data	Potomac
3:10 PM	3:40 PM	Deep Learning for Automated Identification of Eels in Sonar Data	Paul Jacobson	Electric Power Research Institute (EPRI)	Enviro+Data	Potomac

Wednesday, October 9, 2019 Hydropower Track 2 | Environmental R&D & Data Management						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
3:40 PM	4:10 PM	Modular and Scalable Downstream Passage Systems for Silver American Eels	Steve Amaral	Alden Research Laboratory, Inc.	Enviro+Data	Potomac
4:10 PM	4:40 PM	Fishway Entrance Palisade	Kevin Mulligan	University of Massachusetts Amherst	Enviro+Data	Potomac
4:40 PM	5:00 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Enviro+Data	Potomac
5:00 PM	5:30 PM	Hydro Enviro + Data Peer Reviewer Only Meeting				Madison
6:15 PM	8:30 PM	Optional, No-Host Trivia at Port City Brewing Pre-Pay and Registration Required				

Thursday, October 10, 2019 Hydropower Track 1 | Grid Reliability and Resilience, New Technology and Modernization						
Start	End	Agenda Session	Presenter	Affiliation	Track	Room
8:15 AM	9:00 AM	Check-in, Breakfast				
9:00 AM	9:10 AM	Introduction: Dan Reicher, Lecturer and Research Scholar at Stanford Univesity	Hoyt Battey	WPTO	Hydro Plenary	Washington/ Jefferson
9:10 AM	9:20 AM	Hydropower: Climate Solution and Conservation Challenge	Dan Reicher	Stanford University	Hydro Plenary	Washington/ Jefferson
9:20 AM	10:10 AM	Panel discussion featuring Shannon Ames, Low Impact Hydro-power Institute; Mark Lambrides, The Nature Conservancy (invited); Ben Longstreth, Natural Resources Defense Council; and Chris Williams, American Rivers	Dan Reicher (moderator)	Stanford University	Hydro Plenary	Washington/ Jefferson
10:10 AM	10:20 AM	Break and Transition				
10:20 AM	10:30 AM	Introduce Lab Projects	Tim Welch	WPTO	New Tech+Mod	Washington/ Jefferson
10:30 AM	11:00 AM	An Assessment of Conduit Hydropower Potential at Public Drinking Water Systems—Pilot Study	Shih-Chieh Kao	ORNL	New Tech+Mod	Washington/ Jefferson
11:00 AM	11:30 AM	Solid State Processing for Improved Performance of Current and Next-Generation Hydropower Components	Ken Ross	PNNL	New Tech+Mod	Washington/ Jefferson
11:30 AM	11:50 AM	End-of-Session Networking Activity	All recent presenters	All recent presenters	New Tech+Mod	Washington/ Jefferson
11:50 AM	12:25 PM	Hydro New Tech + Mod Peer Reviewer Only Meeting				Madison
12:25 PM	1:15 PM	Lunch				
1:15 PM	1:35 PM	Overview of R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet	Mark Christian	WPTO	New Tech+Mod	Washington/ Jefferson
1:35 PM	2:05 PM	Hydro Fleet Database Development and Analyses (Hy-dro Source)	Brennan Smith	ORNL	New Tech+Mod	Washington/ Jefferson
2:05 PM	2:35 PM	Low-Head, Short-Intake Flow Measurement Research	Sam Harding	PNNL	New Tech+Mod	Washington/ Jefferson
2:35 PM	3:05 PM	Hydropower Fleet Intelligence	Stephen Signore	ORNL	New Tech+Mod	Washington/ Jefferson
3:05 PM	3:15 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	New Tech+Mod	Washington/ Jefferson
3:15 PM	3:35 PM	WPTO's Closing Words from the New Tech+Mod Panel	Marisol Bonnet	WPTO	New Tech+Mod	Washington/ Jefferson
3:35 PM	3:45 PM	Coffee Break and Transition				
3:45 PM	5:30 PM	“Town Hall” with WPTO Staff (open feedback forum for all attendees)	All attendees	All attendees	Plenary	Grand Ballroom A/B/C
5:30 PM	6:00 PM	Peer Reviewer Only Meetings (all hydro reviewers)				Madison

Thursday, October 10, 2019 Hydropower Track 2 | Environmental R&D & Data Management						
Start	End	Agenda Session	Presenter	Affiliation	Track	Room
8:15 AM	9:00 AM	Check-in, Breakfast				Foyer
9:00 AM	9:10 AM	Introduction: Dan Reicher, Lecturer and Research Scholar at Stanford University	Hoyt Battey	WPTO	Hydro Plenary	Washington/ Jefferson
9:10 AM	9:20 AM	Hydropower: Climate Solution and Conservation Challenge	Dan Reicher	Stanford University	Hydro Plenary	Washington/ Jefferson
9:20 AM	10:10 AM	Panel discussion featuring Shannon Ames, Low Im-pact Hydropower Institute; Mark Lambrides, The Nature Con-servancy (invited); Ben Longstreth, Natural Resources Defense Council; and Chris Williams, American Rivers	Dan Reicher (mod-erator)	Stanford University	Hydro Plenary	Washington/ Jefferson
10:10 AM	10:20 AM	Coffee Break and Transition				
10:20 AM	10:30 AM	Introduction: Lab Projects	Dana McCoskey	WPTO	Enviro + Data	Potomac
10:30 AM	10:55 AM	Commercialization of Sensor Fish Technology to Support Hydropower Development (TCF)	Daniel Deng	PNNL	Enviro+Data	Potomac
10:55 AM	11:20 AM	Self-Powered Acoustic Transmitter	Daniel Deng	PNNL	Enviro+Data	Potomac
11:20 AM	11:50 AM	Evaluation of the Whooshh Fish Transport System	Alison Colotelo	PNNL	Enviro+Data	Potomac
11:50 AM	12:05 PM	End-of-Session Networking Activity	All recent present-ers	All recent present-ers	Enviro+Data	Potomac
12:05 PM	12:25 PM	Closing Remarks on Enviro + Data	Dana McCoskey	WPTO	Enviro+Data	Potomac
12:25 PM	1:15 PM	Lunch				
1:15 PM	3:30 PM	Hydro Enviro + Data Peer Reviewer Only Meeting				Madison
3:30 PM	3:45 PM	Coffee Break and Transition				
3:45 PM	5:30 PM	“Town Hall” with WPTO Staff (open feedback forum for all attendees)	All attendees	All attendees	Plenary	Grand Ballroom A/B/C
5:30 PM	6:00 PM	Peer Reviewer Only Meetings (all hydro reviewers)				Madison

MHK Track

Tuesday, October 8, 2019 MHK Track 1 I Foundational R&D, Technology Design, and Validation						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
8:00 AM	8:45 AM	Check-in, Breakfast				
8:45 AM	9:15 AM	U.S. Department of Energy (DOE) Water Power Technolo-gies Office (WPTO) Overview	Alejandro Moreno	WPTO	Plenary	Grand Ballroom A/B/C
9:15 AM	9:25 AM	Remarks from Department of Energy Deputy Assistant Sec-retary for Renewable Power	David Solan	DOE	Plenary	Grand Ballroom A/B/C
9:25 AM	9:40 AM	Keynote - Paul Bunje, Co-Founder & CSO/COO, Conserva-tion X Labs	Paul Bunje	Conservation X Labs	Plenary	Grand Ballroom A/B/C
9:40 AM	9:55 AM	Keynote - Emily Reichert, CEO, Greentown Labs	Emily Reichert	Greentown Labs	Plenary	Grand Ballroom A/B/C
9:55 AM	10:25 AM	Fireside Chat with Keynote Speakers and Alejandro			Plenary	Grand Ballroom A/B/C
10:25 AM	10:45 AM	Peer Review Logistics	Allison Johnson	WPTO	Plenary	Grand Ballroom A/B/C
10:45 AM	11:00 AM	Coffee Break and Transition				
11:00 AM	11:45 AM	MHK Program Overview	Tim Ramsey	WPTO	MHK Plenary	Grand Ballroom A&B
11:45 AM	12:30 PM	WPTO Support to Testing featuring Ryan Coe, Sandia National Laboratories; Jonathan Colby, Verdant Power; Steve DeWitt, WPTO; Lauren Moraski Ruedy, WPTO; Brian Polagye, Pacific Marine Energy Center & University of Washington	Tim Ramsey (moderator)	WPTO	MHK Plenary	Grand Ballroom A&B
12:30 PM	1:20 PM	Lunch				
1:20 PM	1:40 PM	Overview of Foundational & Crosscutting R&D	Bill McShane	WPTO	Foundational R&D	Grand Ballroom A&B
1:40 PM	1:50 PM	Introduce FOA Projects	Yana Shininger	WPTO	Foundational R&D	Grand Ballroom A&B
1:50 PM	2:20 PM	Reduction of System Cost Characteristics through Innovative Solutions to Installation, Operations and Maintenance	Michael Ondusko	Columbia Power Technologies, Inc.	Foundational R&D	Grand Ballroom A&B
2:20 PM	2:50 PM	Demonstration of an Advanced Multi-Mode Point Absorber for Wave Energy Conversion	Tim Mundon	Oscilla Power, Inc.	Foundational R&D	Grand Ballroom A&B
2:50 PM	3:20 PM	Advanced TidGen Power System	Jarlath McEntee	Ocean Renewable Power Company (ORPC) - Maine	Foundational R&D	Grand Ballroom A&B
3:20 PM	3:35 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Foundational R&D	Grand Ballroom A&B
3:35 PM	3:50 PM	Coffee Break				

Tuesday, October 8, 2019 MHK Track 1 I Foundational R&D, Technology Design, and Validation						
Start	End	Agenda Session	Presenter	Affiliation	Track	Room
3:50 PM	4:00 PM	Introduce Lab Projects	Jeff Rieks	WPTO	Foundational R&D	Grand Ballroom A&B
4:00 PM	4:30 PM	Wave Energy Converter (WEC) Modeling	Yi-Hsiang Yu	NREL, SNL	Foundational R&D	Grand Ballroom A&B
4:30 PM	5:00 PM	DTOcean (Optimal Design Tools for Ocean Energy)	Jesse Roberts	SNL	Foundational R&D	Grand Ballroom A&B
5:00 PM	5:30 PM	Material Design Tools for Marine and Hydrokinetic Composite Structures	Bernadette Hernandez-Sanchez	SNL, PNNL, NREL	Foundational R&D	Grand Ballroom A&B
5:30 PM	5:45 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Foundational R&D	Grand Ballroom A&B
5:45 PM	6:15 PM	Peer Reviewer Only Meetings				Madison

Tuesday, October 8 MHK Track 2 | Reducing Barriers to Testing and Data Sharing						
Start	End	Agenda Session	Presenter	Affiliation	Track	Room
8:00 AM	8:45 AM	Check-in, Breakfast				
8:45 AM	9:15 AM	U.S. Department of Energy (DOE) Water Power Technologies Office (WPTO) Overview	Alejandro Moreno	WPTO	Plenary	Grand Ballroom A/B/C
9:15 AM	9:25 AM	Remarks from Department of Energy Deputy Assistant Secretary for Renewable Power	David Solan	DOE	Plenary	Grand Ballroom A/B/C
9:25 AM	9:40 AM	Keynote - Paul Bunje, Co-Founder & CSO/COO, Conservation X Labs	Paul Bunje	Conservation X-Labs	Plenary	Grand Ballroom A/B/C
9:40 AM	9:55 AM	Keynote - Emily Reichert, CEO, Greentown Labs	Emily Reichert	Greentown Labs	Plenary	Grand Ballroom A/B/C
9:55 AM	10:25 AM	Fireside Chat with Keynote Speakers and Alejandro			Plenary	Grand Ballroom A/B/C
10:25 AM	10:45 AM	Peer Review Logistics	Allison Johnson	WPTO	Plenary	Grand Ballroom A/B/C
10:45 AM	11:00 AM	Coffee Break and Transition				
11:00 AM	11:45 AM	MHK Program Overview	Tim Ramsey	WPTO	MHK Plenary	Grand Ballroom A&B
11:45 AM	12:30 PM	WPTO Support to Testing featuring Ryan Coe, Sandia National Laboratories; Jonathan Colby, Verdant Power; Steve DeWitt, WPTO; Lauren Moraski Ruedy, WPTO; Brian Polagye, Pacific Marine Energy Center & University of Washington	Tim Ramsey (moderator)	WPTO	MHK Plenary	Grand Ballroom A&B
12:30 PM	1:20 PM	Lunch				
1:20 PM	1:40 PM	Overview of Reducing Barriers to Testing	Steve DeWitt	WPTO	Testing & Data	Grand Ballroom C
1:40 PM	1:50 PM	Introduce Lab Projects	Simon Gore	WPTO	Testing & Data	Grand Ballroom C
1:50 PM	2:20 PM	MHK Regulatory Initiatives Analysis	Bo Saulsbury	PNNL	Testing & Data	Grand Ballroom C
2:20 PM	2:50 PM	MHK Environmental Compliance Cost Assessment	Jesse Roberts	SNL	Testing & Data	Grand Ballroom C
2:50 PM	3:20 PM	Hydrodynamic and Acoustic Models for Quantitative Environmental Assessment	Jesse Roberts	SNL	Testing & Data	Grand Ballroom C
3:20 PM	3:35 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Testing & Data	Grand Ballroom C
3:35 PM	3:50 PM	Coffee Break				
3:50 PM	4:00 PM	Introduce Lab Projects	Dana McCoskey	WPTO	Testing & Data	Grand Ballroom C
4:00 PM	4:30 PM	MHK Performance Measurement and Instrumentation	Rick Driscoll	NREL	Testing & Data	Grand Ballroom C
4:30 PM	5:00 PM	Video Analysis Software Development	Shari Matzner	PNNL	Testing & Data	Grand Ballroom C
5:30 PM	5:45 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Testing & Data	Grand Ballroom C
5:45 PM	6:15 PM	Peer Reviewer Only Meetings				Madison

Wednesday, October 9 MHK Track 1 | Foundational R&D, Technology Design, and Validation						
Start	End	Agenda Session	Presenter	Affiliation	Track	Room
8:00 AM	8:30 AM	Check-in, Breakfast				
8:30 AM	8:45 AM	Review of Major International Developments in Marine Energy	Henry Jeffrey	International Ener-gy Agency-Ocean Energy Systems	MHK Plenary	Grand Ballroom A&B
8:45 AM	8:50 AM	Introduction: PacWave	Steve DeWitt	WPTO	MHK Plenary	Grand Ballroom A&B
8:50 AM	9:20 AM	Enabling Cost-Effective Electricity from Ocean Waves - PacWave	Burke Hales	Oregon State Uni-versity	MHK Plenary	Grand Ballroom A&B
9:20 AM	9:40 AM	PacWave Q&A	Burke Hales	Oregon State Uni-versity	MHK Plenary	Grand Ballroom A&B
9:40 AM	9:50 AM	Break and Transition				
9:50 AM	10:00 AM	Introduce Lab & FOA Projects	Bill McShane	WPTO	Foundational R&D	Grand Ballroom A&B
10:00 AM	10:30 AM	Optimal Wave Energy Converter (WEC) Controls using Causal and MPC Methods	Mirko Previsic	Re Vision Consulting, LLC	Foundational R&D	Grand Ballroom A&B
10:30 AM	11:00 AM	Wave Prediction Leveraging Multiple Measurement Sources – A Sensor Fusion Approach	Mirko Previsic	Re Vision Consulting, LLC	Foundational R&D	Grand Ballroom A&B
11:00 AM	11:10 AM	Coffee Break				
11:10 AM	11:40 AM	Advanced Wave Energy Converter (WEC) Dynamics and Controls	Ryan Coe	SNL	Foundational R&D	Grand Ballroom A&B
11:40 AM	12:10 PM	Wave Energy Converter (WEC) Design Optimization	Ryan Coe	SNL	Foundational R&D	Grand Ballroom A&B
12:10 PM	12:30 PM	End-of-Session Networking Activity	All recent present-ers	All recent present-ers	Foundational R&D	Grand Ballroom A&B
12:30 PM	1:15 PM	Lunch				
1:15 PM	1:35 PM	Overview of Technology-Specific Design and Validation	Lauren Moraski Ruedy	WPTO	Foundational R&D	Grand Ballroom A&B
1:35 PM	1:45 PM	Introduce FOA Projects	Erik Mauer	WPTO	Foundational R&D	Grand Ballroom A&B
1:45 PM	2:05 PM	HydroAir Power Take Off System	Rod Blunk	Siemens Govern-ment Technologies	Foundational R&D	Grand Ballroom A&B
2:05 PM	2:25 PM	Demonstration of the Ocean Energy (OE) Buoy at US Navy's Wave Energy Test Site	Erik Mauer			
2:25 PM	2:45 PM	Joint Q&A for Siemens & OE			Foundational R&D	Grand Ballroom A&B
2:45 PM	3:00 PM	Coffee Break				
3:00 PM	3:30 PM	Azura Demonstration at the Navy's Wave Energy Test Site (WETS)	Bradley Ling	Northwest Energy Innovations	Foundational R&D	Grand Ballroom A&B
3:30 PM	3:35 PM	Introduce Lab Projects	Carrie Schmaus	WPTO	Foundational R&D	Grand Ballroom A&B

Wednesday, October 9 MHK Track 1 | Foundational R&D, Technology Design, and Validation						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
3:35 PM	4:05 PM	WaveSPARC	Jochem Weber	NREL	Foundational R&D	Grand Ballroom A&B
4:05 PM	4:35 PM	Flexible Material WEC Technology Techno-Economic Performance	Jochem Weber	NREL	Foundational R&D	Grand Ballroom A&B
4:35 PM	5:05 PM	Standards Development for Marine Energy	Walt Musial	NREL	Foundational R&D	Grand Ballroom A&B
5:05 PM	5:25 PM	End-of-Session Networking Activity	All recent present-ers	All recent present-ers	Foundational R&D	Grand Ballroom A&B
5:25 PM	5:55 PM	Peer Reviewer Only Meetings				Madison
6:15 PM	8:30 PM	Optional, No-Host Trivia at Port City Brew-ing Pre-Pay and Registration Re-quired				

Wednesday, October 9 MHK Track 2 | Reducing Barriers to Testing and Data Sharing						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
8:15 AM	8:30 AM	Check-in, Breakfast				
8:30 AM	8:45 AM	Review of Major International Developments in Marine Energy	Henry Jeffrey	International Energy Agency-Ocean Energy Systems	MHK Plenary	Grand Ballroom A&B
8:45 AM	8:50 AM	Introduction: PacWave	Steve DeWitt	WPTO	MHK Plenary	Grand Ballroom A&B
8:50 AM	9:20 AM	Enabling Cost-Effective Electricity from Ocean Waves - PacWave	Burke Hales	Oregon State University	MHK Plenary	Grand Ballroom A&B
9:20 AM	9:40 AM	PacWave Q&A	Burke Hales	Oregon State University	MHK Plenary	Grand Ballroom A&B
9:40 AM	9:50 AM	Break and Transition				
9:50 AM	9:55 AM	Introduce Mammal Study	Corey Vezina	WPTO	Testing & Data	Grand Ballroom C
9:55 AM	10:25 AM	Marine Mammal Behavioral Response to Tidal Turbine Sound	Brian Polagye	University of Washington	Testing & Data	Grand Ballroom C
10:25 AM	10:35 AM	Introduce Triton & FOA 1418	Dana McCoskey	WPTO	Testing & Data	Grand Ballroom C
10:35 AM	11:15 AM	Triton Initiative	Meg Pinza	PNNL	Testing & Data	Grand Ballroom C
11:15 AM	11:30 AM	Coffee Break				
11:30 AM	12:00 PM	NoiseSpotter: Cost-effective, Real-time Acoustic Character-ization and Localization System	Kaus Raghukumar	Integral Consulting Inc.	Testing & Data	Grand Ballroom C
12:00 AM	12:30 PM	DAISY: A Drifting Acoustic Instrumentation System	Brian Polagye	University of Washington	Testing & Data	Grand Ballroom C
12:30 PM	1:15 PM	Lunch				
1:15 PM	1:45 PM	A Combined Electric/Magnetic Field Instrument for MHK Environmental Monitoring	Alan Chave	Woods Hole Oceano-graphic Institution	Testing & Data	Grand Ballroom C
1:45 PM	2:15 PM	Benthic Habitat Monitoring Tools for MHK Environmental Assessments	Gene Revelas	Integral Consulting Inc.	Testing & Data	Grand Ballroom C
2:15 PM	2:45 PM	Long-Range Target Detection and Classification System for Environmental Monitoring at MHK Sites	Jim Dawson	BioSonics Inc.	Testing & Data	Grand Ballroom C
2:45 PM	3:00 PM	Coffee Break				
3:00 PM	3:30 PM	Unobtrusive Multi-Static Serial LiDAR Imager for Wide-Area Surveillance and Identification of Marine Life at MHK Installations	Anni Dalgleish	Florida Atlantic University	Testing & Data	Grand Ballroom C
3:30 PM	4:00 PM	Third-Generation Adaptable Monitoring Package (3G-AMP)	Brian Polagye	University of Washington	Testing & Data	Grand Ballroom C
4:00 PM	4:30 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Testing & Data	Grand Ballroom C
4:30 PM	4:50 PM	End-of-Session Triton & 1418 discussion as a group	All attendees	WPTO	Testing & Data	Grand Ballroom C
4:50 PM	5:20 PM	Peer Reviewer Only Meetings				Madison
6:15 PM	8:30 PM	Optional, No-Host Trivia at Port City Brewing Pre-Pay and Registration Required				

Thursday, October 10 MHK Track 1 | Foundational R&D, Technology Design, and Validation						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
8:15 AM	9:00 AM	Check-in, Breakfast				
9:00 AM	9:05 AM	Introduce FOA & Lab Projects	Carrie Noonan	WPTO	Foundational R&D	Grand Ballroom A&B
9:05 AM	9:35 AM	Kinetic Hydropower System TriFrame Mount Integrated Development and IO&M Testing at RITE	Dean Corren	Verdant Power, Inc.	Foundational R&D	Grand Ballroom A&B
9:35 AM	10:05 AM	CalWAVE Open Water Demonstration	Thomas Boerner	CalWave Power Technologies Inc.	Foundational R&D	Grand Ballroom A&B
10:05 AM	10:35 AM	A Hermetically Sealed Magnetically Geared Marine Hydrokinetic Generator	Jonathan Bird	Portland State University	Foundational R&D	Grand Ballroom A&B
10:35 AM	10:45 AM	Coffee Break				
10:45 AM	11:15 AM	Robotic Juggler Offshore WEC	Vassilios Vamvas	Enorasy LLC	Foundational R&D	Grand Ballroom A&B
11:15 AM	11:45 AM	Techno-Economic Analysis and Program Support	Scott Jenne	NREL	Foundational R&D	Grand Ballroom A&B
11:45 AM	12:05 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Foundational R&D	Grand Ballroom A&B
12:05 PM	12:25 PM	Closing Remarks on Foundational R&D	Lauren Moraski Reudy & Bill McShane	WPTO	Foundational R&D	Grand Ballroom A&B
12:25 PM	1:15 PM	Lunch				
1:15 PM	1:45 PM	Powering the Blue Economy: WPTO Strategy Presentation	Simon Geerlofs	WPTO	MHK Plenary	Grand Ballroom A&B
1:45 PM	2:00 PM	Remarks from Deerin Babb-Brott, Principal Assistant Director for Oceans and Environment, White House Office of Science and Technology Policy	Deerin Babb-Brott	White House	MHK Plenary	Grand Ballroom A&B
2:00 PM	3:00 PM	PBE Panel – Perspectives from End Users featuring Jenn Garson, WPTO; Carl Gouldman, NOAA; Karl Hill, Igiugig Village Council; Dana Manalang, University of Washington; Richard Schilke, Nishati, Inc. Reenst Lesemann	Reenst Lesemann (moderator)	NHA Marine Energy Council	MHK Plenary	Grand Ballroom A&B
3:00 PM	3:10 PM	WPTO Presentation on Mechanisms for PBE	Jenn Garson	WPTO	MHK Plenary	Grand Ballroom A&B
3:10 PM	3:30 PM	Open Q&A and Discussion	Multiple	Multiple	MHK Plenary	Grand Ballroom A&B
3:30 PM	3:45 PM	Coffee Break and Transition				
3:45 PM	5:30 PM	"Town Hall" with WPTO Staff (open feedback forum for all attendees)	All attendees	All attendees	Plenary	Grand Ballroom A/B/C
5:30 PM	6:00 PM	Peer Reviewer Only Meetings (all MHK reviewers)				Madison

Thursday, October 10 MHK Track 2 | Reducing Barriers to Testing and Data Sharing						
Start	**End**	**Agenda Session**	**Presenter**	**Affiliation**	**Track**	**Room**
8:15 AM	8:45 AM	Check-in, Breakfast				
8:45 AM	9:05 AM	Overview of Data Sharing & Analysis and Introduction of Lab Projects	Hoyt Battey	WPTO	Testing & Data	Grand Ballroom C
9:05 AM	9:35 AM	Tidal Resource Gaps Analysis	Kevin Haas (on behalf of NREL)	NREL	Testing & Data	Grand Ballroom C
9:35 AM	10:05 AM	Model Validation and Site Characterization for Early Deployment MHK Sites and Establishment of Wave Classification Scheme	Levi Kilcher	NREL, PNNL, SNL	Testing & Data	Grand Ballroom C
10:05 AM	10:35 AM	International Environmental Data Sharing Initiative (OES-Environmental & Tethys Database)	Andrea Copping	PNNL	Testing & Data	Grand Ballroom C
10:35 AM	10:45 AM	Coffee Break				
10:45 AM	11:15 AM	Marine and Hydrokinetic Data Repository (MHKDR)	Jon Weers	NREL	Testing & Data	Grand Ballroom C
11:15 AM	11:45 AM	MHK Data Products and User Community Development	Kelley Ruehl	SNL, NREL, PNNL	Testing & Data	Grand Ballroom C
11:45 AM	12:05 PM	End-of-Session Networking Activity	All recent presenters	All recent presenters	Testing & Data	Grand Ballroom C
12:05 PM	12:25 PM	Closing Remarks on Testing & Data	Steve DeWitt	WPTO	Testing & Data	Grand Ballroom C
12:25 PM	1:15 PM	Lunch				
1:15 PM	1:45 PM	Powering the Blue Economy: WPTO Strategy Presentation	Simon Geerlofs	WPTO	MHK Plenary	Grand Ballroom A&B
1:45 PM	2:00 PM	Remarks from Deerin Babb-Brott, Principal Assistant Director for Oceans and Environment, White House Office of Science and Technology Policy	Deerin Babb-Brott	White House	MHK Plenary	Grand Ballroom A&B
2:00 PM	3:00 PM	PBE Panel – Perspectives from End Users featuring Jenn Garson, WPTO; Carl Gouldman, NOAA; Karl Hill, Igiugig Village Council; Dana Manalang, University of Washington; Richard Schilke, Nishati, Inc.	Reenst Lesemann (moderator)	NHA Marine Energy Council	MHK Plenary	Grand Ballroom A&B
3:00 PM	3:10 PM	WPTO Presentation on Mechanisms for PBE	Jenn Garson	WPTO	MHK Plenary	Grand Ballroom A&B
3:10 PM	3:30 PM	Open Q&A and Discussion	Multiple	Multiple	MHK Plenary	Grand Ballroom A&B
3:30 PM	3:45 PM	Coffee Break and Transition				
3:45 PM	5:30 PM	“Town Hall” with WPTO Staff (open feedback forum for all attendees)	All attendees	All attendees	Plenary	Grand Ballroom A/B/C
5:30 PM	6:00 PM	Peer Reviewer Only Meetings (all MHK reviewers)				Madison

APPENDIX B: EVALUATION CRITERIA

Evaluation Criteria – Hydropower Program

Using the following criteria, reviewers are asked to evaluate the Office's major R&D Programs and significant initiatives at a strategy-level, both numerically and with specific, concise comments to support each evaluation.

DOE Hydropower Program Strategy		
Hydropower Program's Strategic Approachers		
Big-Data Access and Management		
Environmental R&D and Hydrological Systems Science		
R&D for Low-Impact Hydro Growth	Modernization, Upgrades, and Security	Reliability, Resillience, and Storage

Score Weighting

Program Evaluation Criteria	
Program Strategy and Objectives	**25%**
Program Portfolio	**25%**
Program Management Approach	**25%**
Stakeholder Engagement, Outreach, and Dissemination	**25%**
Recommendations/Supplemental Questions	**0%**

1. Program Strategy and Objectives

Please evaluate the degree to which:

- The program's long-term strategy, strategic approaches, and future direction was effectively conveyed during the peer review.
- The program's strategy reflects an understanding of the near and long-term challenges facing industry and other stakeholders.
- The program invests in early-stage research to accelerate development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed.
- The program supports efforts to validate performance and grid-reliability for new technologies, develop and increase accessibility to necessary testing infrastructure, and evaluate systems-level opportunities and risks.
- The program invests taxpayer funds wisely to drive the greatest impact.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

2. Program Portfolio

Please evaluate the degree to which:

- The projects within this program portfolio contribute to meeting the program's strategy and objectives.
- The projects within this program portfolio are addressing key challenges and reducing barriers to advance water power technologies.
- The rationale for and organization of the funded projects and program approaches has been effectively conveyed during the peer review.
- The program portfolio effectively balances research priorities and allocates resources appropriately.
- The projects within this program portfolio are appropriate for WPTO's role as a public research and development organization.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

3. Program Management Approach

Please evaluate the degree to which:

- The program team effectively manages and directs the activities needed to meet its objectives.
- The program team focuses on priority research areas that create the greatest impact on new technology and industry advancement.
- The program team effectively communicates priority research areas and the allocation of resources.
- The program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects.
- The program team has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

4. Stakeholder Engagement, Outreach, and Dissemination

Please evaluate the degree to which:

- The program demonstrates good stewardship of taxpayer funds by persistently and transparently communicating how WPTO funds are being utilized and evaluates project impacts.
- The program gathers feedback from stakeholders to inform and improve WPTO projects and strategy.
  - Provide suggestions for ways WPTO should engage thought leaders and other interested stakeholders to inform the direction of the program.
- The program maximizes the impact of WPTO-supported research by effectively disseminating results of projects and tracking usage of various products.
  - Provide any suggestions for ways WPTO should be disseminating information to thought leaders and other interested stakeholders.
- The program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision-makers.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

5. Recommendations (Not Scored)

Please provide any notable strengths or weaknesses to the program portfolio content or direction that you would like to point out. What recommendations would you like to convey to the manager(s) of this program?

(Maximum 1000 words)

6. Additional Hydropower Program Questions (Not Scored)

a. Is there language in Vision or Mission statements that you find problematic, or are there issues which you feel are missing or not adequately addressed in the language?

(Maximum 1000 words)

b. Do you agree with the framing of industry challenges and potential approaches DOE could take in helping to address them? If not, please explain

(Maximum 1000 words)

c. Do you agree with the representation of the relationship between these approaches? Is anything missing or not adequately addressed? Please provide specifics.

(Maximum 1000 words)

Evaluation Criteria – HydroWIRES

Using the following criteria, reviewers are asked to evaluate the Office's major R&D Programs and significant initiatives at a strategy-level, both numerically and with specific, concise comments to support each evaluation.

Program Evaluation Criteria	
Program Strategy and Objectives	**25%**
Program Portfolio	**25%**
Program Management Approach	**25%**
Stakeholder Engagement, Outreach, and Dissemination	**25%**
Recommendations/Supplemental Questions	**0%**

1. Program Strategy and Objectives

Please evaluate the degree to which:

- The program's long-term strategy, strategic approaches, and future direction was effectively conveyed during the peer review.
- The program's strategy reflects an understanding of the near and long-term challenges facing industry and other stakeholders.
- The program invests in early-stage research to accelerate development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed.
- The program supports efforts to validate performance and grid-reliability for new technologies, develop and increase accessibility to necessary testing infrastructure, and evaluate systems-level opportunities and risks.
- The program invests taxpayer funds wisely to drive the greatest impact.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

2. Program Portfolio

Please evaluate the degree to which:

- The projects within this program portfolio contribute to meeting the program's strategy and objectives.
- The projects within this program portfolio are addressing key challenges and reducing barriers to advance water power technologies.
- The rationale for and organization of the funded projects and program approaches has been effectively conveyed during the peer review.
- The program portfolio effectively balances research priorities and allocates resources appropriately.
- The projects within this program portfolio are appropriate for WPTO's role as a public research and development organization.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

3. Program Management Approach

Please evaluate the degree to which:

- The program team effectively manages and directs the activities needed to meet its objectives.
- The program team focuses on priority research areas that create the greatest impact on new technology and industry advancement.
- The program team effectively communicates priority research areas and the allocation of resources.
- The program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects.
- The program team has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

4. Stakeholder Engagement, Outreach, and Dissemination

Please evaluate the degree to which:

- The program demonstrates good stewardship of taxpayer funds by persistently and transparently communicating how WPTO funds are being utilized and evaluates project impacts.
- The program gathers feedback from stakeholders to inform and improve WPTO projects and strategy.
    - Provide suggestions for ways WPTO should engage thought leaders and other interested stakeholders to inform the direction of the program.
- The program maximizes the impact of WPTO-supported research by effectively disseminating results of projects and tracking usage of various products.
    - Provide any suggestions for ways WPTO should be disseminating information to thought leaders and other interested stakeholders.
- The program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision-makers.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

5. Recommendations (Not Scored)

Please provide any notable strengths or weaknesses to the program portfolio content or direction that you would like to point out. What recommendations would you like to convey to the manager(s) of this program?

(Maximum 1000 words)

6. Additional HydroWIRES Questions (Not Scored)

a. Is there language in the HydroWIRES mission statement that you find problematic, or are there issues which you feel are missing or not adequately addressed in the language?

(Maximum 1000 words)

b. Do you agree with the way the HydroWIRES initiative frames industry challenges and the opportunities DOE envisions for hydropower and pumped storage to support a rapidly evolving grid? If not, please explain why.

(Maximum 1000 words)

c. Do you agree with the identified research areas and objectives? Are there any key research questions missing or not adequately addressed that you think are within the DOE role? Please provide specifics.

(Maximum 1000 words)

Evaluation Criteria – Marine and Hydrokinetic (MHK) Program

Using the following criteria, reviewers are asked to evaluate the Office's major R&D Programs and significant initiatives at a strategy-level, both numerically and with specific, concise comments to support each evaluation.

DOE MHK Program Strategy		
MHK Program's Strategic Approachers		
Foundational and Crosscutting R&D	Technology-Specific Design and Validation	Reducing Barriers to Testing
Data Sharing Analysis		

Score Weighting

Program Evaluation Criteria	
Program Strategy and Objectives	**25%**
Program Portfolio	**25%**
Program Management Approach	**25%**
Stakeholder Engagement, Outreach, and Dissemination	**25%**
Recommendations/Supplemental Questions	**0%**

1. Program Strategy and Objectives

Please evaluate the degree to which:

- The program's long-term strategy, strategic approaches, and future direction was effectively conveyed during the peer review.
- The program's strategy reflects an understanding of the near and long-term challenges facing industry and other stakeholders.
- The program invests in early-stage research to accelerate development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed.
- The program supports efforts to validate performance and grid-reliability for new technologies, develop and increase accessibility to necessary testing infrastructure, and evaluate systems-level opportunities and risks.
- The program invests taxpayer funds wisely to drive the greatest impact.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

2. Program Portfolio

Please evaluate the degree to which:

- The projects within this program portfolio contribute to meeting the program's strategy and objectives.
- The projects within this program portfolio are addressing key challenges and reducing barriers to advance water power technologies.
- The rationale for and organization of the funded projects and program approaches has been effectively conveyed during the peer review.
- The program portfolio effectively balances research priorities and allocates resources appropriately.
- The projects within this program portfolio are appropriate for WPTO's role as a public research and development organization.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

3. Program Management Approach

Please evaluate the degree to which:

- The program team effectively manages and directs the activities needed to meet its objectives.
- The program team focuses on priority research areas that create the greatest impact on new technology and industry advancement.
- The program team effectively communicates priority research areas and the allocation of resources.
- The program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects.
- The program team has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

4. Stakeholder Engagement, Outreach, and Dissemination

Please evaluate the degree to which:

- The program demonstrates good stewardship of taxpayer funds by persistently and transparently communicating how WPTO funds are being utilized and evaluates project impacts.
- The program gathers feedback from stakeholders to inform and improve WPTO projects and strategy.
  - Provide suggestions for ways WPTO should engage thought leaders and other interested stakeholders to inform the direction of the program.
- The program maximizes the impact of WPTO-supported research by effectively disseminating results of projects and tracking usage of various products.
  - Provide any suggestions for ways WPTO should be disseminating information to thought leaders and other interested stakeholders.
- The program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision-makers.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

5. Recommendations (Not Scored)

Please provide any notable strengths or weaknesses to the program portfolio content or direction that you would like to point out. What recommendations would you like to convey to the manager(s) of this program?

(Maximum 1000 words)

6. Additional MHK Programs Questions (Not Scored)

a. Do you agree with the framing of industry challenges and potential approaches DOE could take in helping to address them? If not, please explain why.

(Maximum 1000 words)

b. Do you agree with the representation of the relationship between these approaches, including the balance of funding? Is anything missing or not adequately addressed? Please provide specifics.

(Maximum 1000 words)

c. Do you agree with the balance between funding mechanisms (FOAs, lab projects, prizes, etc.)? If not, please explain why.

(Maximum 1000 words)

d. Do you agree with the funding balance between MHK resources (wave, current [tidal/river/ocean], ocean thermal, and crosscutting)? If not, please explain why.

(Maximum 1000 words)

Evaluation Criteria – Powering the Blue Economy

Using the following criteria, reviewers are asked to evaluate the Office's major R&D Programs and significant initiatives at a strategy-level, both numerically and with specific, concise comments to support each evaluation.

Score Weighting

Program Evaluation Criteria	
Program Strategy and Objectives	**25%**
Program Portfolio	**25%**
Program Management Approach	**25%**
Stakeholder Engagement, Outreach, and Dissemination	**25%**
Recommendations/Supplemental Questions	**0%**

1. Program Strategy and Objectives

Please evaluate the degree to which:

- The program's long-term strategy, strategic approaches, and future direction was effectively conveyed during the peer review.
- The program's strategy reflects an understanding of the near and long-term challenges facing industry and other stakeholders.
- The program invests in early-stage research to accelerate development of innovative water power technologies, while ensuring that long-term sustainability and environmental issues are addressed.
- The program supports efforts to validate performance and grid-reliability for new technologies, develop and increase accessibility to necessary testing infrastructure, and evaluate systems-level opportunities and risks.
- The program invests taxpayer funds wisely to drive the greatest impact.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

2. Program Portfolio

Please evaluate the degree to which:

- The projects within this program portfolio contribute to meeting the program's strategy and objectives.
- The projects within this program portfolio are addressing key challenges and reducing barriers to advance water power technologies.
- The rationale for and organization of the funded projects and program approaches has been effectively conveyed during the peer review.
- The program portfolio effectively balances research priorities and allocates resources appropriately.
- The projects within this program portfolio are appropriate for WPTO's role as a public research and development organization.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

3. Program Management Approach

Please evaluate the degree to which:

- The program team effectively manages and directs the activities needed to meet its objectives.
- The program team focuses on priority research areas that create the greatest impact on new technology and industry advancement.
- The program team effectively communicates priority research areas and the allocation of resources.
- The program team demonstrates the professional and technical capabilities needed to identify, monitor, and guide its portfolio of projects.
- The program team has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 500 words)

4. Stakeholder Engagement, Outreach, and Dissemination

Please evaluate the degree to which:

- The program demonstrates good stewardship of taxpayer funds by persistently and transparently communicating how WPTO funds are being utilized and evaluates project impacts.
- The program gathers feedback from stakeholders to inform and improve WPTO projects and strategy.
    - Provide suggestions for ways WPTO should engage thought leaders and other interested stakeholders to inform the direction of the program.
    - Provide recommendations for ways WPTO could continue to convene diverse stakeholders to advance energy innovation in the Blue Economy. In particular, can you identify any additional groups (public or private) that WPTO should engage?
- The program maximizes the impact of WPTO-supported research by effectively disseminating results of projects and tracking usage of various products.
    - Provide any suggestions for ways WPTO should be disseminating information to thought leaders and other interested stakeholders.
- The program provides access to accurate and objective information and data that can help to accelerate industry development and inform decision-makers.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 1000 words)

5. Recommendations (Not Scored)

Please provide any notable strengths or weaknesses to the program portfolio content or direction that you would like to point out. What recommendations would you like to convey to the manager(s) of this program?

(Maximum 1000 characters)

6. Additional Powering the Blue Economy Questions (Not Scored)

a. Which Blue Economy market applications and associated R&D challenges should WPTO focus on both in the near and long term?

(Maximum 1000 characters)

b. Once a particular Blue Economy market has been identified, what would recommend WPTO do to encourage end users and the associated supply chain to be involved in advising the development of a project from the outset?

(Maximum 1000 characters)

c. From your perspective, what is the right balance between market-specific research versus market-agnostic research that crosses multiple markets and market themes (such as grid, power at sea, and resilient coastal communities)?

(Maximum 1000 characters)

d. Do you have opinions on the best way to fully integrate PBE into the broader WPTO MHK program in order to leverage or complement existing investments (such as TEAMER, PACWAVE, etc.)?

(Maximum 1000 characters)

Evaluation Criteria – Individual Projects

Using the following criteria, reviewers are asked to rate the project work presented in the context of the program objectives, both numerically and with specific, concise comments to support each evaluation.

1. Project Objectives, Impacts, and Alignment with the Program Strategy

Please evaluate the degree to which:

- The project performers have described how the project contributes to the program's strategy/approaches.
- The project performers have considered and described the use/applications of their expected products and outputs.
- The project performers have presented the relevancy of this project and how successful completion of the project will advance the state of technology, meaningful impacts, and/or the viability of any commercial applications.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 300 words)

2. End-User Engagement and Dissemination Strategy

Please evaluate the degree to which:

- The project performers have identified who will benefit from this project and how the success of the project will advance the industry or meet the needs of specific stakeholder/end-user groups.
- The project performers have explained whether specific industry or end-users were engaged / are planned to be engaged and at which points in the project, (i.e. whether an advisory group was set up, whether end-user needs were surveyed / assessed, if and how progress / preliminary results are communicated).
- The project performers have clearly described the rationale for the stakeholder/end-user engagement strategy and how project results and information have been/are planned to be disseminated.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 300 words)

3. Management and Technical Approach

Please evaluate the degree to which:

- The project performers have implemented technically sound research and development approaches, and have demonstrated/validated the results needed to meet their targets.
- The project performers have identified a project management plan that includes well-defined milestones and adequate methods for addressing potential risks.
- The project performers have clearly described critical success factors which will define technical viability, and have explained and understand the challenges they must overcome to achieve success.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 300 words)

4. Technical Accomplishments and Progress

Please evaluate the degree to which:

- The project performers have made progress in reaching their objectives based on their project management plan.
- The project performers have described their most important accomplishments in achieving milestones, reaching technical targets, and overcoming technical barriers.
- The project performers have clearly described the progress since any last review period.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 300 words)

5. Future Work (New and Ongoing Projects Only)

Please evaluate the degree to which:

- The project performers have outlined adequate plans for future work, including key milestones and go/no go decision points.
- The project performers have communicated key planned milestones and addressed how they plan to deal with upcoming decision points and any remaining issues.

Score: 1–5

Please explain your score by commenting below. Provide both strengths and any weaknesses to support your score. (Maximum 300 words)

6. Recommendations (Not Scored)

Please provide any additional notable comments on the project content or direction that you would like. What, if any, recommendations would you like to convey to the manager(s) of this program or the PI of this project?

(Maximum 300 words)

Project Categories

- **Completed & Sunsetting Projects** – completed projects and projects with a planned end date prior to January 1, 2020
- **Ongoing Projects** – started before October 1, 2017 and continuing after January 1, 2020
- **New Projects** – started after October 1, 2017

Score Weighting

	Completed & Sunsetting Projects	Ongoing Projects	New Projects
Project Objectives, Impacts, and Programmatic Alignment	**20%**	**20%**	**20%**
End-User Engagement and Dissemination Strategy	**20%**	**20%**	**20%**
Management and Technical Approach	**20%**	**20%**	**20%**
Technical Accomplishments and Progress	**40%**	**20%**	**0%**
Future Work	**0%**	**20%**	40%

Score Scale

Superior	Good	Satisfactory	Marginal	Unsatisfactory
5	4	3	2	1
All aspects of the criterion are comprehensively addressed. There are significant strengths and no more than a few—easily correctable—weaknesses.	All aspects of the criterion are adequately addressed. There are significant strengths and some weaknesses. The significance of the strengths outweighs most aspects of the weaknesses.	Most aspects of the criterion are adequately addressed. There are strengths and weaknesses. The significance of the strengths slightly outweighs aspects of the weaknesses.	Some aspects of the criterion are not adequately addressed. There are strengths and significant weaknesses. The significance of the weaknesses outweighs most aspects of the strengths.	Most aspects of the criterion are not adequately addressed. There may be strengths, but there are significant weaknesses. The significance of the weaknesses outweighs the strengths.

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DOE/EE-2059 • April 2020