



SECTION

Hydropower Program

Innovations for Low-Impact Hydropower Growth

HydroWIRES Initiative

Fleet Modernization, Maintenance, and Cybersecurity

Environmental and Hydrologic Systems Science

Hydropower Data Access, Analytics,
and Workforce Development

Hydropower Program Peer Review

Hydropower Program Overview

The Hydropower Program at WPTO aims to conduct research, development, demonstration, and commercial activities to advance transformative, cost-effective, reliable, and environmentally sustainable hydropower and pumped storage technologies; better understand and capitalize upon opportunities for these technologies to support the nation's rapidly evolving grid; and improve energy-water infrastructure and security. In doing so, the program works in five major areas: Innovations for Low-Impact Hydropower Growth; Grid Reliability, Resilience, and Integration (Hydropower and Water Innovation for a Resilient Electricity System (HydroWIRES) Initiative); Fleet Modernization, Maintenance, and Cybersecurity; Environmental and Hydrologic Systems Science; and Data Access, Analytics, and Workforce Development.

Through these five activity areas, the Hydropower Program is working to enable a 100% clean energy future by leveraging hydropower's inherent flexibility and pumped storage's proven use as a cost-effective, long-duration storage asset. The program is looking to expand the value of sustainable hydropower by funding research, development, demonstration, and commercial activities that focus on retrofitting and rehabilitating dams, combining hydropower with water distribution, supply, and treatment systems in an energy-water nexus, and developing testing capabilities and facilities to commercialize technologies that can leverage these systems while preserving and enhancing stream functionality.

The program recognizes that hydropower can play a critical role in decarbonizing the electric grid to mitigate climate change but will also experience negative impacts due to climate change. Therefore, WPTO is advancing climate and hydrologic science, while also working to enhance environmental sustainability and, ultimately, build socioeconomic resilience in communities challenged by climate change.

Finally, WPTO realizes the challenges that can come from being the oldest source of renewable energy in the nation. As the hydropower fleet ages, maintaining efficient and cost-effective operations and ensuring the security of critical infrastructure becomes increasingly challenging. Modernization of the existing hydropower fleet through asset management, environmental mitigation, and relicensing reflects a significant opportunity to restore reliability and performance and add new, cutting-edge technologies.

Organization of Tracks and Review Panels

The Hydropower Program, activity areas, and individual projects were reviewed and scored during WPTO's 2022 Peer Review. Program and activity area overview presentations detailed the goals and objectives outlined in the [MYPP](#). For information about the structure, strategy, and implementation of the program and its relation to WPTO's overall mission, please refer to the corresponding [program overview presentation slide deck](#) presented during the review.

Four panels of reviewers reviewed program elements, as well as individual projects across all the Hydropower Program's activity areas. There were also three reviewers dedicated to reviewing the Hydropower Program's prizes and one reviewer dedicated to reviewing the crosscutting Science, Technology, Engineering, and Mathematics (STEM) and Workforce Development project. Finally, both the Innovations for Low-Impact Hydropower Growth and Environmental and Hydrologic Systems Science review panels reviewed the Data Access, Analytics, and Workforce Development Activity Area's strategy and implementation. The accompanying portfolio of projects was incorporated into the session most closely tied with the subject matter and with the relevant reviewer expertise. Figure 1 depicts the total number of hydropower presentations each panel reviewed.

Figure 1. Number of Hydropower Projects Reviewed by Review Panel

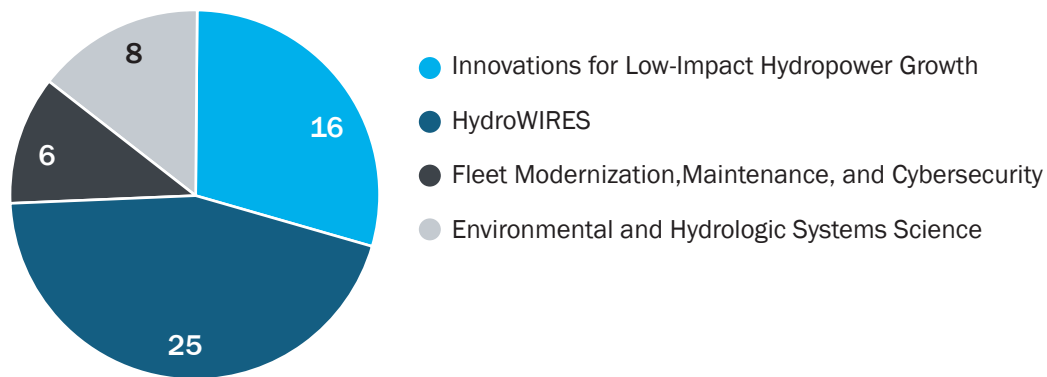


Table 5 summarizes the role, review panel, and affiliation of the external experts who served as reviewers for the Hydropower Program during WPTO's 2022 Peer Review.

Table 5. Hydropower Program Reviewers

HYDROPOWER PROGRAM			
Name	Role	Review Panel	Affiliation
Shannon Ames	Review Chair and Panel Lead	Environmental and Hydrologic Systems Science	Low-Impact Hydropower Institute
David Sinclair	Panel Lead	Innovations for Low-Impact Hydropower Growth	Advanced Hydro Solutions
Doug Spaulding*	Reviewer	Innovations for Low-Impact Hydropower Growth	Nelson Energy
Michael Kerr	Reviewer	Innovations for Low-Impact Hydropower Growth	New England Hydropower Company LLC
Tom Acker	Panel Lead	HydroWIRES	Northern Arizona University
Bente Brunnes	Reviewer	HydroWIRES	Rainpower
Debbie Mursch	Reviewer	HydroWIRES	GE Renewable Energy
Cathy Campbell*	Panel Lead	Fleet Modernization, Maintenance, and Cybersecurity	U.S. Army Corps of Engineers
Craig Bourassa	Reviewer	Fleet Modernization, Maintenance, and Cybersecurity	Avista Utilities
Twyla Cheatwood*	Reviewer	Environmental and Hydrologic Systems Science	National Oceanic and Atmospheric Administration
Wendy Bley	Reviewer	Environmental and Hydrologic Systems Science	Kleinschmidt Associates

HYDROPOWER PROGRAM			
Name	Role	Review Panel	Affiliation
John Bakken	Reviewer	Fleet Modernization, Maintenance, and Cybersecurity	McMillian Jacobs Associates
Ram Veeraraghavan	Reviewer	Fleet Modernization, Maintenance, and Cybersecurity	Tacoma Power
Donna Vincent Roa	Prize Reviewer	Prizes	USAID's Partnerships Incubator, The Kaizen Company
Sally Gutierrez	Prize Reviewer	Prizes	Environmental Protection Agency
Craig Connelly	Prize Reviewer	Prizes	New York State Energy Research and Development Authority
Linda Silverman	Reviewer	STEM/Workforce	Potential Energy DC

*Selected to also review the crosscutting Hydropower STEM and Workforce project.

Hydropower Program Scores

Reviewers were asked to evaluate WPTO's R&D programs at a strategic level, both numerically and with specific, concise comments to support each evaluation. Reviewers evaluated each program on the following equally weighted criteria: strategy and implementation and progress. Figure 2 summarizes reviewers' quantitative assessments of how the Hydropower Program is performing overall. Since the Data Access, Analytics, and Workforce Development portfolio crosscuts the Hydropower Program, the Innovations for Low-Impact Hydropower and Environmental and Hydrologic System Science review panels evaluated the activity area's strategy and implementation, which is summarized in Figure 3. Figure 4 shows average weighted scores for each of the Hydropower Program's activity areas (excluding Data Access, Analytics, and Workforce Development), with reference lines indicating the average project score and program score. The aggregated reviewer comments justifying these quantitative scores can be found in Volume II.

Figure 2. Hydropower Program Average Weighted Score by Evaluation Criterion

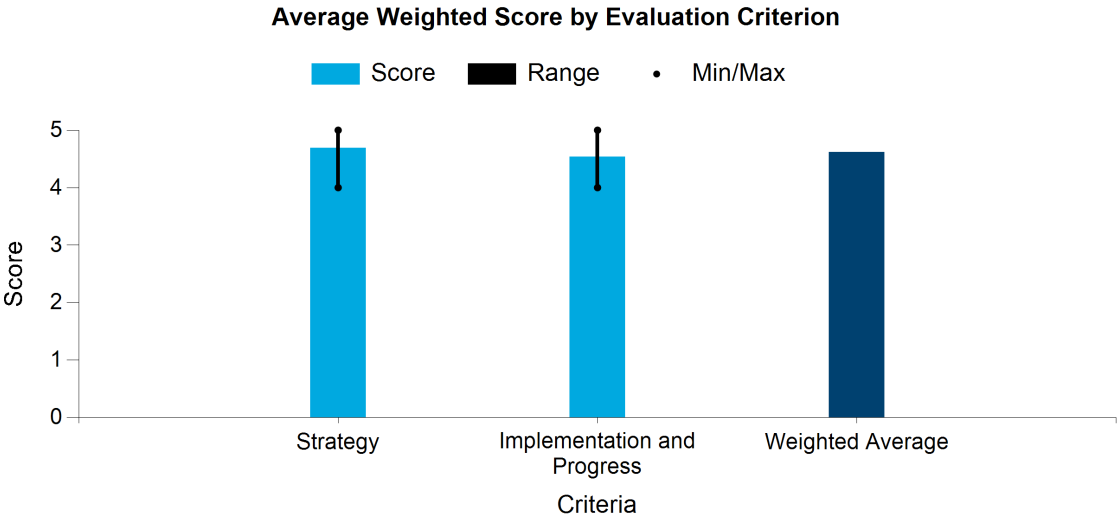


Figure 3. Hydropower Data Access, Analytics, and Workforce Development Activity Area Average Weighted Score by Evaluation Criterion

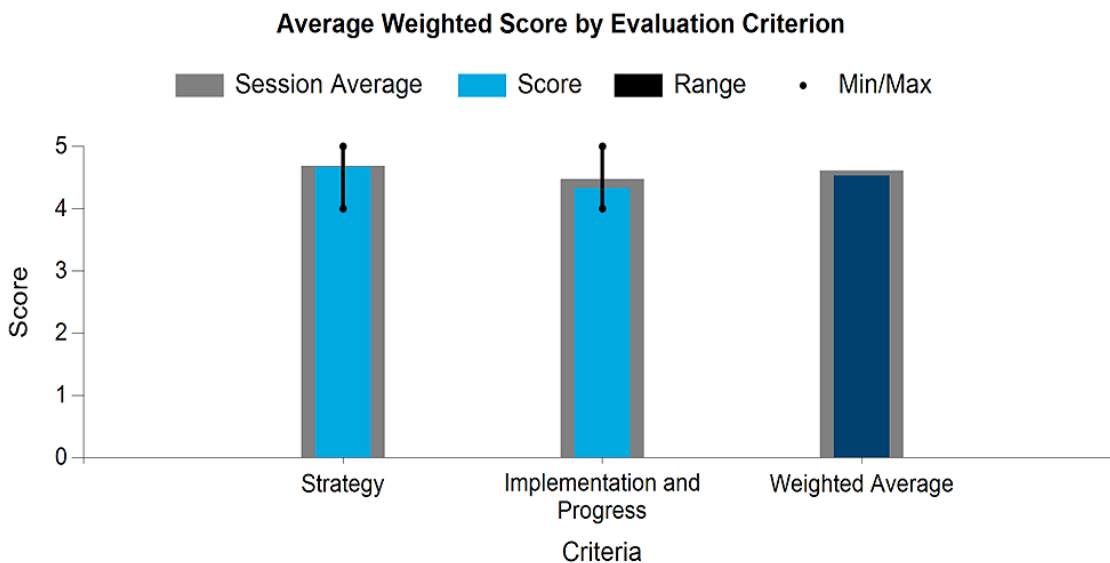
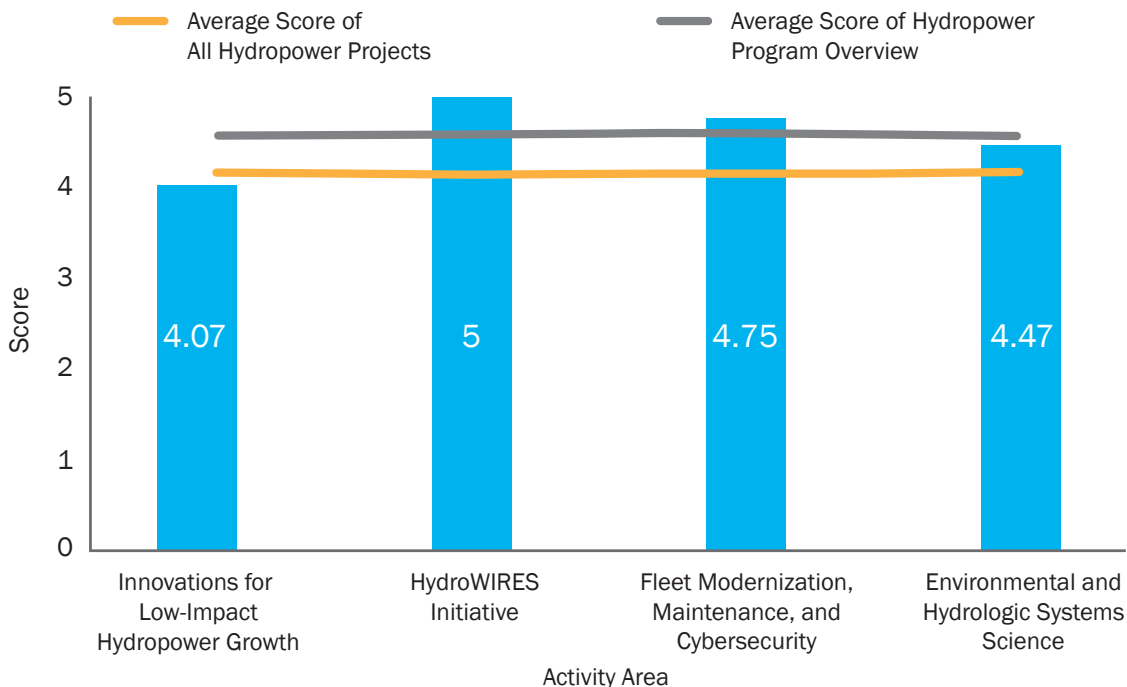


Figure 4. Average Weighted Score by Hydropower Program Activity Area



Organization of the Results

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

- **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 in consultation with each review panel lead and all hydropower reviewers. Consensus among the reviewers was not required, and the review chair was asked to include differences of opinion and dissenting views within the report.
- **Hydropower Program Response:** The WPTO program manager's official response to the recommendations provided in the review chair's program evaluation summary.
- **Hydropower Program Activity Area Results:** The results of the reviewers' quantitative scores on the program and activity areas. Activity area results follow the program results and begin with a summary chart that depicts the average score for each project in each activity area. Each activity area subsection includes the following components:
 - *Activity Area Evaluation Summary:* 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 the review panel leads were asked to include differences of opinion and dissenting views within the report.
 - *Activity Area Response:* The WPTO activity area lead's official response to the recommendations provided in the review panel lead's activity area evaluation summary.

Hydropower Program Evaluation Summary

Submitted by Shannon Ames, Chair

Key Takeaways

WPTO organized a well-planned, effective peer review that provided sufficient information for reviewers to assess the projects and program overall. Reviewers find the projects to be well-managed and designed and in line with the MYPP. They are led by impressive and effective project leads. With few exceptions, the projects provide opportunities to make significant impacts on hydropower's ability to blossom in the years to come, particularly in the broad area of sustainability. The projects' diversity covers all aspects of developing and operating hydropower facilities. Clearly, the program implemented key recommendations from the last peer review, in particular the suggestions around project management. The staff displays a wide array of expertise and is knowledgeable, professional, and connected to the hydropower community, open to feedback, and interested in engaging. WPTO is doing an exceptional job leading appropriate research and managing and investing taxpayer dollars.

Feedback from the Review Chair to WPTO

Virtually all projects presented are perceived as high value and each demonstrated a concerted effort to involve stakeholders.

WPTO has funded research in areas that would assist in new stream-reach development. The results of these projects will have positive impacts on hydropower's development but not on new stream-reach development, given regulatory and stakeholder reluctance to permit such projects. WPTO has already recognized this and is moving away from new stream reach specifically. The reviewers look forward to seeing the innovative projects implemented at non-powered dams (NPDs) and related to existing site improvements.

While progress has been made in terms of early and lasting involvement of hydropower stakeholders, two consistent themes emerged from this peer review. First, project leads referred to the hydropower community, but the list of stakeholders engaged in each project was inconsistently inclusive. Some projects did a great job identifying and involving stakeholders from all viewpoints—owners, operators, and developers, as well as conservation groups, resource agencies, and academics. This broad and inclusive approach needs to be embraced on all projects such that feedback is received from all viewpoints. The broader the outreach, the better the outcome.

Second, reviewers would like to see a comprehensive communication plan for each project. Reviewers consistently asked about the methods and frequency of communication efforts, and some would have liked to see examples of communication materials. Since stakeholder involvement is more important than ever, WPTO should consider including more comprehensive information on communication plans in the peer review.

The last broad recommendation is to incorporate additional resources related to end use and commercialization. The projects showed impressive progress and results (although some projects did a better job than others at presenting specific information about the results to date as well as stakeholder reception), but only a handful had a solid plan for commercialization, including whether the project would be cost effective in use, how it would be disseminated, who would be using it, etc. Reviewers recommend considering how the projects will be brought to end users' attention and ensuring an organized, easy means of access. Results should be broadly disseminated—bring the results to end users and do not wait for them to find the results themselves. Reviewers also recommend considering how the projects will benefit end users and clearly communicating that at all opportunities. In essence, make sure the project's end is not the end of the project. End-user implementation will be an essential mark of success.

Summary of Reviewer Feedback on the Program

Overall Impressions

The projects presented in all panels were well managed and aligned with the MYPP and represented good uses of taxpayer funds. The staff is impressive and knowledgeable and presented the key information well. The projects vary in their life cycles with some being closer to completion than others. Several of the projects presented important data that is needed before a broader objective could be met. Generally, the reviewers feel it would be important at the next peer review to clearly place the projects within the broader plan to achieve a particular objective. While all reviewers are impressive and knowledgeable of hydropower, some panels include a narrower set of perspectives. Reviewers would like to see more information about projects' end use and commercialization.

Program Strategy

Each activity area has a well-defined strategy, performance goals, and objectives. Project leads clearly articulated how the projects fit within the MYPP, and those goals are all still relevant and useful. Reviewers would like to see how the projects not only fit within the overall strategy, but how they connect and work together to meet the MYPP's goals and objectives.

The funding mechanisms are appropriate and varied. The prizes received the most discussion around whether they are attracting the broadest range of applicants possible, and reviewers note that only a few industry standards receive the bulk of the awards. In addition, reviewers wonder about the ideas not awarded and whether there are opportunities to push any alternative, but promising, ideas forward. Some reviewers specifically cite the lack of academic interest.

The portfolio is broad, addressing all key challenges for hydropower, including aging infrastructure, cyberthreats, lack of data, grid demand, funding constraints, and environmental impacts (especially fish passage). Some reviewers would like to understand the projects not funded to help them understand if these were the most relevant projects to fund. The project on reservoir methane emissions illustrated a good example of a project that successfully incorporates the needs of multiple viewpoints within the broad hydropower community. This approach should be maintained but articulated clearly and often. Reviewers would like to see a specific strategy focused on end use and commercialization with some suggesting a "pull" strategy to encourage stakeholders to embrace and owners to adopt technologies, rather than relying solely on hydropower owners to invest in new technologies they would then have to convince stakeholders to embrace.

Overall, the program is well organized. The activity areas are clearly articulated and rational in their categorization and approach. The projects fit clearly within the overall strategy.

Implementation and Progress

The projects are well managed, on budget, carefully designed, and aligned with the MYPP goals and objectives. The program is open, willing to engage with all stakeholders, and transparent. Their outreach efforts are impressive, even if many reviewers request they do more. All reviewers feel the projects are well managed and the program carefully stewards taxpayer funds.

Overall, reviewers feel the projects are relevant and meet the MYPP's objectives. Some reviewers question any continuing efforts to develop new stream-reach technologies, but WPTO is already moving away from this focus area. Another exception is the reservoir emission research. One reviewer is unconvinced it is an important area of study. However, other reviewers feel strongly that it is a critical area of study, filling a gap in existing science, and that the program is uniquely qualified to provide impartial data. Some reviewers question whether they could determine if the projects are the most relevant without comparing them to projects that were not funded.

Dissemination and commercialization were key topics of discussion and questioning in all activity areas. Multiple reviewers requested specific plans for implementation of project end results. It is premature for many projects to have fully articulated commercialization plans; however, it would be useful for commercialization and end-user implementation to have clear goals for successful implementation. Such implementation plans would consider cost effectiveness, ease of access, updates to data over time, and clear use cases.

Reviewers recommend sharing the comprehensive communication plan for not only each project, but the program as a whole—who stakeholders are, how they are being reached and involved, and what mechanisms or materials are being used in communications. Reviewers recommend considering a specific panel with reviewers with expertise in hydropower communications to review the plan, which would be consistent with the importance of involving the whole hydropower community in all stages of projects.

Hydropower Program Response

Submitted by Corey Vezina, Acting Program Manager

Response to the Review Chair's Key Takeaways

The Hydropower Program would like to thank the reviewers for the significant time and effort they spent evaluating the program's strategy and R&D portfolio, sharing their expertise, and providing constructive and robust feedback. The program will continue to benefit from feedback from the hydropower community regarding the program strategy and investment of taxpayer funds. The program thanks reviewers for acknowledging that the diverse portfolio of projects is well managed and aligned with the MYPP. The program also appreciates reviewers' recognition of its staff as "knowledgeable, professional, and connected to the hydropower community, open to feedback, and interested in engaging." The program also appreciates reviewers' acknowledgment of progress since the last peer review and implementation of reviewer recommendations, especially around project management.

Overall, reviewers outlined several areas for improvement to: (1) ensure broad and inclusive engagement across the hydropower community, (2) develop a comprehensive communication plan for each project, (3) enhance dissemination of results and improve commercialization outcomes, (4) expand and supplement existing workforce development efforts, and (5) focus peer review presentations on results and convey broader context in the portfolio. 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 specific recommendations noted across the review panels.

Recommendation 1: Ensure Broad and Inclusive Engagement Across the Hydropower Community

Reviewers recommended the program focus on broad, inclusive engagement of owners, operators, and developers, as well as conservation groups, resource agencies, and academia. The reviewers recognized some projects successfully engaged a broad swath of the hydropower community, while other projects fell short. WPTO agrees representatives from across all sectors of the hydropower community must be engaged to better understand the many complex and diverse issues affecting hydropower technologies and operational improvements. Stakeholders may include, but are not limited to, representatives from tribal nations, hydropower developers, owners/operators of hydropower facilities, research institutions, hydropower industry representatives, nongovernmental organizations, nonprofit organizations, and resource agencies.

WPTO will ensure broad and inclusive engagement across the hydropower community through several existing efforts, such as continuing dialogue with the hydropower community as the program develops short- and long-term goals through the Hydropower Vision Roadmap update. WPTO will also continue to engage the broader hydropower community through participation in national hydropower trade shows, conference panels and discussions, and regional meetings, as well as through industry and federal agency workshops designed specifically to identify high priority hydropower R&D needs. Since the last peer review, WPTO has convened several technical advisory groups that include diverse hydropower representatives and will continue to leverage the expertise of and expand its use of advisory groups. WPTO is also working to recruit diverse subject-matter experts to review research funding applications and the current water power portfolio.

Two funding opportunities announced in fall 2022 support efforts to diversify and expand applicant pools and support stakeholder engagement. WPTO issued an approximately \$4 million funding opportunity to support the efforts of diverse hydropower stakeholders to discuss and find paths forward on topics that include U.S. hydropower fleet modernization, hydropower system sustainability, and hydropower facilities' environmental impact. Many of the issues intended to be addressed through this funding opportunity are "hot-button" issues from which stakeholders often back away. This opportunity intends to help engage stakeholders, using the services of a trained facilitator,

and bring these complex conversations to the forefront to drive real action. These efforts will enhance and inform current and future R&D needs for hydropower technologies and environmental mitigation efforts at DOE and in industry.

In addition, WPTO released a \$14.5 million funding opportunity to further the sustainable development of hydropower and pumped storage hydropower (PSH), with a topic area focused on hydropower R&D by emerging organizations. Both funding opportunities and any related activities will seek to encourage meaningful engagement and participation of workforce organizations, including labor unions, as well as underserved communities and underrepresented groups, including consultation with tribal nations. These new funding opportunities are also designed to help meet the goal that 40% of the benefits of the administration's investments in clean energy and climate solutions be delivered to disadvantaged communities.

Recommendation 2: Develop a Comprehensive Communication Plan for Each Project

Reviewers recommended WPTO consider developing a comprehensive communication plan for each project and share the program's communication plan as a whole, including details on who stakeholders are, how they are being reached and involved, and what mechanisms or materials are being used in communications. The program agrees with reviewer feedback that there is room to improve communication and results dissemination. WPTO will continue to use various communications tactics, such as newsletters and webinars, to increase awareness of funding opportunities and effectively disseminate projects' results and tools. Just last year, WPTO began including communications plans as a requirement in all lab projects to better identify target end users and plan how results will reach the appropriate stakeholders. WPTO will also evaluate using this same process for projects funded under other funding opportunities.

Reviewers also recommended considering a specific panel with reviewers with expertise in hydropower communications to review both program and project-level communications plans to ensure the hydropower community is broadly and inclusively engaged in all stages of projects. WPTO will consider incorporating communications subject-matter experts into future peer review panels. WPTO will also work to include additional communications requirements in future peer review presentations and materials, such as including a specific communications criterion for evaluation.

Recommendation 3: Enhance Dissemination of Results and Improve Commercialization Outcomes

Reviewers noted that for some projects, the results or lessons learned were not clear in the presentation and/or some key R&D findings may not reach interested and relevant stakeholders. In the past few years, WPTO has developed a variety of tools to better share project findings and lessons learned, such as its R&D Deep Dive Webinar series (announced in WPTO's Water Wire and Hydro Headlines newsletters), a comprehensive map of all projects (updated annually with links to project deliverables and a summary of the work), and Annual Accomplishments Report (to highlight project success stories and their results). Internally, WPTO also requires projects to develop logic models to define their target end users, outputs produced, and how activities relate to program-level outcomes. This a recent effort WPTO is considering expanding across the office and will help track progress on goals and objectives.

In addition, reviewers stated that only a few projects had a comprehensive commercialization plan. The program fully agrees with reviewers that every project should have a clear plan for commercialization that identifies how results will be disseminated and the end users who will benefit. WPTO is taking a comprehensive approach toward technology commercialization, which includes making robust investments in the Small Business Innovation Research (SBIR) program (targeted toward R&D of commercially relevant technologies in the private sector), providing lab vouchers for winning prize teams to enable commercialization of promising technology innovations, incorporating end-user-focused commercialization activities in funding opportunities and cooperative agreements, and building an innovation ecosystem network through incubators and accelerators to bring promising technology innovations to market.

WPTO will continue to develop outreach materials to tell the story of where the office is and has been, what does and does not work, and the ultimate vision for its R&D and a society that uses it. WPTO will continue to identify methods to make information and results from projects more accessible, such as with search engine optimization on the office's website and by tagging or labeling to bring this information up in internet searches. Finally, WPTO will identify stakeholders for which project information is relevant but who are not currently engaged and determine ways to target dissemination of project results for such audiences. WPTO will also continue to improve how it shares key results and lessons learned from projects.

Recommendation 4: Expand and Supplement Existing Workforce Development Efforts

The reviewers expressed high praise for WPTO's hydropower workforce development and STEM outreach activities, stating the relatively new portfolio has been well designed, stakeholder engagement has been well prioritized, and future work plans are strategic. Reviewers commented that this work is "vital" to the hydropower industry and recommended WPTO build on this foundation by increasing the budget and resources dedicated to workforce development, supporting additional programs, coordinating with more federal agencies and broader workforce initiatives, and expanding reach to more students and potential hydropower workforce entrants. At the same time, reviewers emphasized that industry partners need to remain central to this work, and some future activities should be owned by industry directly. Additionally, reviewers suggested WPTO try to provide more granularity in future workforce analyses to help the industry better understand how to address retirement and recruitment challenges and target students in specific majors.

WPTO appreciates the reviewers' praise for its workforce development portfolio, which is still a relatively new but growing area of emphasis for the Hydropower Program. The program is not surprised by the reviewers' recommendations to expand this portfolio as industry outreach has indicated that hydropower employers are even more concerned about recruitment, retainment, and skills development than they were in 2018 when WPTO, the National Renewable Energy Laboratory (NREL), and the Hydropower Foundation first initiated the water power workforce project. The program knows this sense of urgency is partially due to the COVID-19 pandemic's impacts on the energy sector generally, but the hydropower sector is facing a wave of retirements at the very moment when new workers and skillsets are needed to realize the historic opportunities presented by the Bipartisan Infrastructure Law and the Inflation Reduction Act. The program is actively engaging the National Hydropower Association (NHA) staff and hydropower employers in discussions about how to better align and scale efforts to recruit new workers to the sector, recognizing opportunities to have a larger impact by working together and leveraging different perspectives, platforms, and convening powers. The program is proud of the foundation it has built with new programs like the Hydropower Collegiate Competition and wants to inspire a larger and more diverse audience to consider a career in hydropower. The program looks forward to working with NHA, the Hydropower Foundation, and hydropower employers to realize this goal together.

Recommendation 5: Focus Peer Review Presentations on Results and Convey Broader Context in the Portfolio

Many reviewers stated they would like to better understand a project's findings or results, which may not have been clearly conveyed in the peer review presentations. As reviewers understand, time was limited, and project presenters had to be concise. However, the program agrees conveying results should be a priority in future peer review presentations. WPTO will work to modify the presentation template to put greater emphasis on project results and develop additional guidance for the presenters that outlines best practices and shares a good example presentation.

In addition, reviewers wanted a better understanding of how projects fit together within the overall portfolio and connect and work together to meet the goals and objectives outlined in the MYPP. The program agrees it is critically important for reviewers to understand how projects and activity areas fit together and contribute toward the office's goals. The program also agrees with the suggestion to provide a presentation at the end of each session (after the projects have been presented) that summarizes the activity area strategy to show how the projects fit together and the program strategy to show how the activity areas fit together.

Hydropower Program Activity Area Results

Innovations for Low-Impact Hydropower Growth

The Innovations for Low-Impact Hydropower Growth Activity Area aims to develop, test, and validate cost-effective, sustainable technologies for non-conventional hydropower applications in new-stream reaches, NPDs, and conduits. Through this activity area, WPTO is working to:

- Enable new technology development for both existing water infrastructure and new stream-reach applications that incorporate ecological and social objectives.
- Leverage advancements in manufacturing and materials to dramatically lower costs of components and system designs.
- Support testing of new technologies, including development of necessary testing infrastructure.
- Explore new development opportunities in which hydropower is a critical enabler of a larger suite of benefits.

The review panel was impressed by the number and variation of projects contained within this activity area, though there were specific suggestions on how to improve communication of the projects and how they fit into the overarching WPTO strategy as a whole. Figure 5 summarizes reviewers' quantitative assessments of how the activity area is performing overall, and Figure 6 provides an overview of the scoring for all projects within the Innovations for Low-Impact Hydropower Growth Activity Area.

Figure 5. Innovations for Low-Impact Hydropower Growth Activity Area Average Weighted Score by Evaluation Criterion

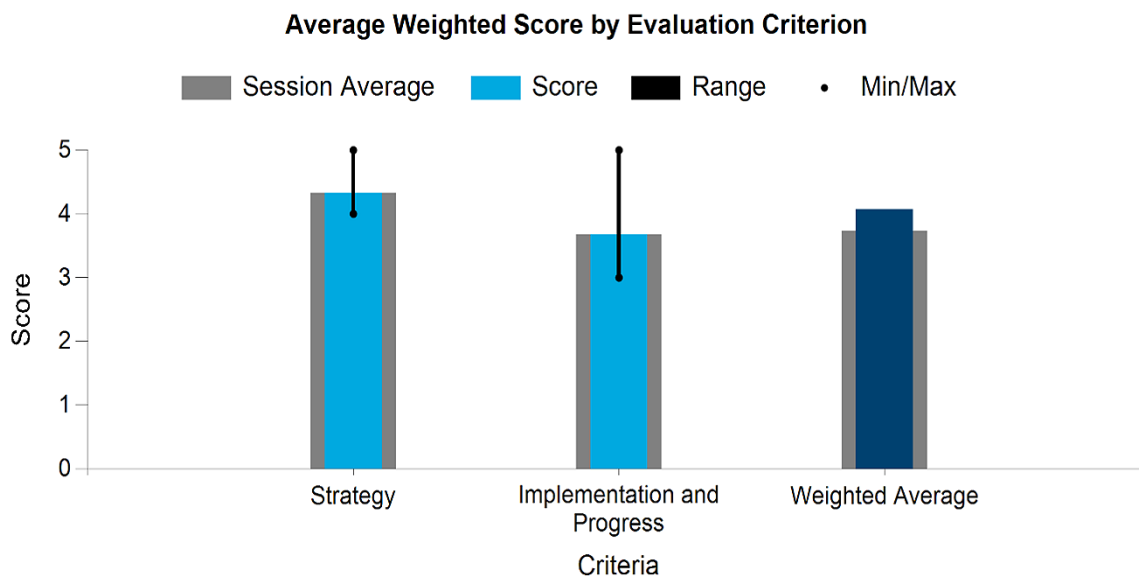
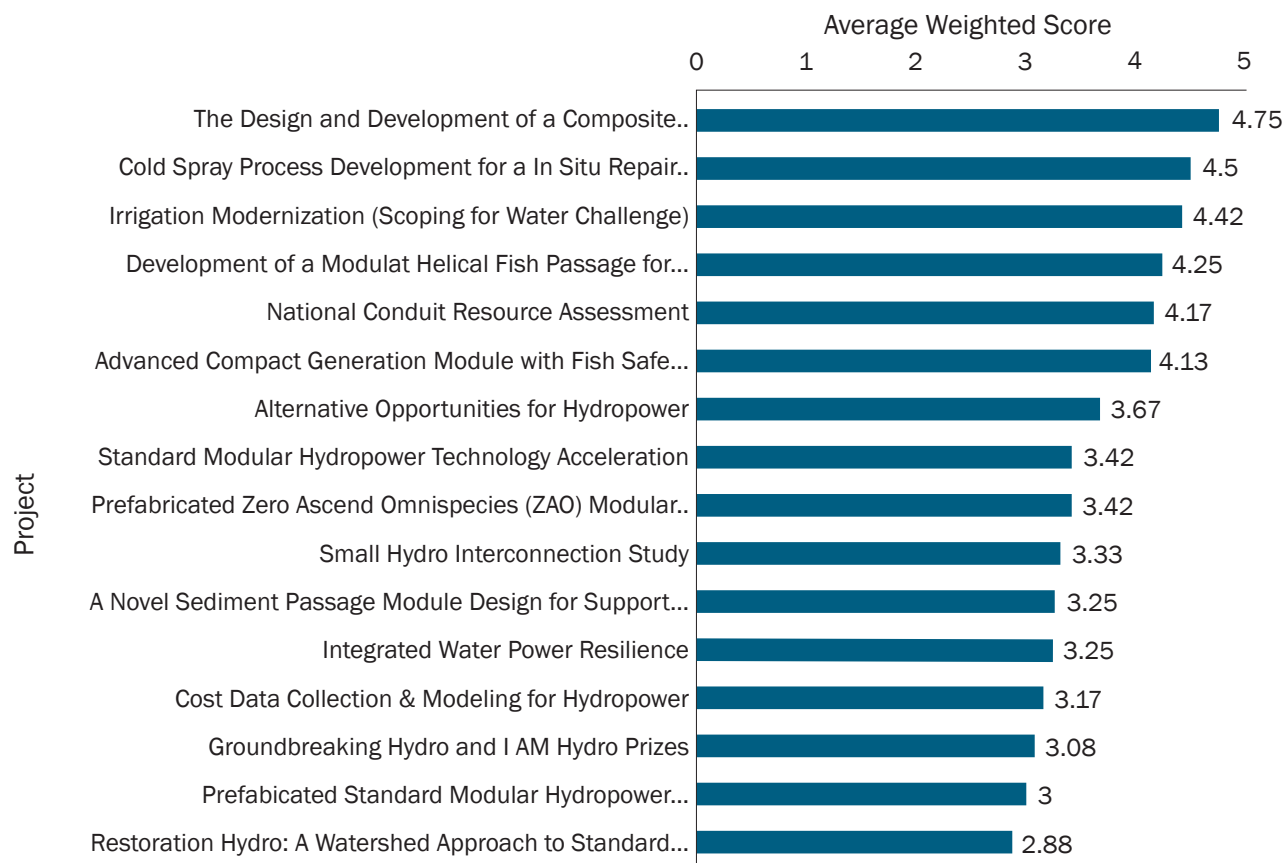


Figure 6. Innovations for Low-Impact Hydropower Growth Activity Area Weighted Average Score by Project



The following subsections include the review panel lead’s summary of reviewer comments and the WPTO activity area lead’s response to reviewer feedback. The full evaluation results for the activity area and the portfolio of projects can be found in Volume II of this report. For more information about the activity area’s structure, strategy, and R&D priorities, please refer to the [MYPP](#) or the corresponding [activity area overview slide deck](#) presented during the review.

Activity Area Evaluation Summary

Submitted by David C. Sinclair

Feedback from the Review Panel to WPTO

The Hydropower Program has a sound foundation, strategy, and approach for implementing and achieving its goals. The program team did an excellent job ensuring reviewers understood the details about the program and its foundation and outlining and providing the supporting documentation.

The mass of programs and projects must be difficult to track and organize. It is certainly daunting to an outsider to understand all the facets of the program’s work. Notable strengths of the program execution include a focus on current needs for environmental sustainability, including improved data collection techniques and technology. Notable weaknesses include an inefficient communication strategy to promote prizes and competitions and to disseminate information.

Overall, the peer review was a resounding success, promoting stronger links between researchers and industry. These linkages are important to maintain and build upon during the interim between these reviews.

Summary of Reviewer Feedback on the Activity Area

Overall Impressions

The review panel consists entirely of developers, and as a result, there is consistency in their thoughts and responses to the individual projects. There are two follow-on projects (cold spray and composite runners) that were applauded as truly innovative efforts that will yield major advances in equipment construction and maintenance. Projects supporting the standard modular hydropower (SMH) concept had mixed success with the design of turbine and fish passage packages leading the pack.

Other data-related assessments were found to be less focused on the industry and more on providing high-level datasets for a certain point in time to illustrate specific issues or opportunities.

Activity Area Strategy

The sheer volume of work undertaken and funded by WPTO is laudable and multipronged. While each of the project presenters identified how their project fit into the different facets of the MYPP, one could not see how the projects all work together to fulfill the office's goals as identified.

Reviewers recommend WPTO establish a point of contact for the new technologies arena specifically to guide any inquirer as to which program and funding opportunity would be the best fit for their idea. WPTO should also undertake a gap analysis and create a chart that shows how past, current, and planned projects fit into the MYPP. Further, while competitive bidding on funding opportunities may be required, this results in winners and losers wherein a loser may have had a great idea that was not funded. Thus, the number of winners should not be pre-determined.

It will be challenging to encourage developer interest in other value propositions for hydropower that do not provide additional income for the developer/operator, especially during this era of low wholesale electricity pricing. This suggests the need for a "pull" strategy from agricultural, local government, and environmental stakeholders rather than hydropower being the driver.

There is a consistent pattern of certain national labs and independent firms receiving significant funding every year along with a few small firms securing funds for work that does not result in market-ready solutions. No new entrants appeared in the projects presented, which speaks to insufficient industry appeal to work with WPTO to advance R&D.

The Hydropower Collegiate Competition is a great idea that should be expanded and supplemented with a broader reach for the competition and a supporting scholarship program. The workforce development goal would benefit from both. This would also help expand reach into the academic community and create avenues to connect with more students to present the industry's available opportunities. Only a small budget supports this important program, and the reviewers recommend expanding funding for these important hydropower education and workforce development programs.

The Groundbreaking and Innovations in Advanced Manufacturing for Hydropower (I AM Hydro) prizes were disappointing and clearly did not understand how to attract good, innovative offerings. Whether because of too tight a specification or too low a prize value or both, the reviewers recommend a rethinking of this undertaking.

Reviewers also recommend adding to the process, where relevant, financial metrics or the need for awardees to keep their eye on and test the potential challenges new products face in gaining investor/banking support.

The addition of hydropower to NPDs is the most likely opportunity for new hydropower. In particular, the many U.S. Army Corps of Engineers (USACE) navigation dams are generally similar in configuration and provide an opportunity for modular intake and waterway passages involving siphons or other schemes to avoid coffer dams and significantly reduce construction costs. Additional research in this area could stimulate a large amount of NPD hydropower development.

Implementation and Progress

The reviewers agree that projects tackling real-world problems facing hydropower owners and developers have progressed, albeit slowly, toward meeting their objectives. It is important that ongoing reviews by end users help direct the projects going forward and avoid project myopia.

Reviewers also agree that innovative approaches to small hydro development are having some success in creating packaged solutions for generation and fish passage that should be further funded. However, it would be a mistake to link them solely to SMH and new stream-reach development. New stream-reach development is not going to happen in any significant quantity, which implies that investment in this area should be limited.

Sediment transport is an admirable objective for which cost-effective solutions need to be found. The reviewers agree the design approach currently proposed by the sediment transport module project is ill conceived and would not be practical. Data collection is an interesting academic undertaking but of little value unless creating such information also provides tools for the evaluation and development of specific sites, whether in conduits or new NPD sites.

Activity Area Response

Submitted by Katie Jackson, Technology Manager

The program would like to thank the review panel for their excellent reviews and active engagement throughout the presentations related to the Innovations for Low-Impact Hydropower Growth portfolio. This includes a wide range of work, and reviewers' feedback as members of the industry is valuable. The comments on both individual projects and the portfolio's overall strategic direction are a crucial way for the program to get external feedback and make sure its work is supporting the industry's needs.

The program was very excited to see positive feedback on much of its work in the advanced manufacturing for hydropower space. For example, the cold spray project is currently considering next steps for better enabling in-situ repair and looking forward to potential partnerships with external groups, which is in line with the review panel's feedback. Additionally, the program is developing an advanced manufacturing strategy for hydropower to encourage the hydropower and advanced manufacturing industries to work together to consider the opportunity space.

The program also appreciates the recommendations provided to help guide and improve the value of the portfolio's R&D efforts. The program recognizes the challenges in encouraging developer interest in some of the alternative opportunities for hydropower and will continue to engage with hydropower developers, as well as agricultural, local government, and environmental stakeholders. The program is considering a deeper dive into understanding the value proposition for each opportunity, partnerships with external stakeholders, and potential technical assistance opportunities.

Reviewers expressed serious concern with the sediment transport project under the SMH project. The program understands and has heard similar feedback about feasibility from other external reviewers. However, the cost modeling tasks are worth pursuing to investigate cost effectiveness and feasibility. Additionally, this is a unique project on sediment passage for the portfolio, and like the reviewers, the program believes this is an area of research in which to consider investing. Lessons learned from this project will inform future efforts related to sediment passage at dams.

Overall, reviewers outlined several recommendations to (1) focus efforts on the largest potential for new hydropower: powering NPDs; (2) engage new partners on projects, including through different mechanisms; and (3) ensure industry can leverage the work supported by WPTO. The following sections outline the activity area's response to the reviewers' key recommendations.

Recommendation 1: Focus Efforts on the Largest Potential for New Hydropower: Powering NPDs

The program agrees with this recommendation and recognizes this is feedback also received in the last peer review. The program currently has national laboratory projects and external funding opportunities (either ongoing or new) focused on NPDs. The SMH project was focused on a concept that standardization and modularity could help reduce costs and enable new low-impact hydropower. While the SMH project initially focused on new stream-reach development, more recent efforts led to the development of the NPDamCAT and NPD Explorer tools on which the reviewers provided positive feedback. The current SMH project is nearing completion, and the national lab team will finish technical support related to advanced manufacturing and modeling to the external awardees connected to the project in FY 2023.

Moving forward, the program will take lessons learned from SMH and apply those to NPDs as appropriate. Additionally, the program has several new efforts related to powering NPDs:

- The program issued a funding opportunity related to innovative approaches to powering NPDs. The goal is to address current challenges with NPDs including, but not limited to, high development costs, permitting challenges, grid connection, and utilization of the full range of flow and head fluctuations that occur for dams that were built for purposes other than power generation.
- The program plans to update the NPD resource assessment in FY 2023 and FY 2024 to include better available data and evolving interests since the last assessment was published in 2012.
- Two new SBIR awardees will work to address the costs associated with the water conveyance systems at NPD projects.
- The program recently selected six new national lab projects as “seedlings” to explore early-stage concepts for improving the value of or reducing the costs associated with powering NPDs. This seedlings approach involves relatively low budgets and short timelines to explore innovative ideas before down-selecting those that may be more promising.

Recommendation 2: Engage New Partners on Projects, Including Through Different Mechanisms

The program agrees with reviewer feedback that there is room to improve communication and results dissemination. Within the Innovations for Low-Impact Hydropower Growth portfolio, the program will continue efforts to better match the technical need with the appropriate solver audience and funding mechanism. The program appreciates the feedback related to the I AM Hydro and Groundbreaking Hydro prizes and recognizes there may not have been a perfect pairing of the technical challenge and intended prize applicants. The program will continue to use prizes to engage new communities beyond the hydropower industry, while also considering lab calls, SBIR, and other funding opportunities when the challenge problem is better suited for these mechanisms.

As reviewers are very aware, the hydropower industry is relatively small, but the program also recognizes the need to expand applicant pools to new parties, including students and early-career innovators. In future hydropower innovation funding opportunities, the program plans to encourage a more diverse set of applications and topics as done in a recent funding opportunity (Innovative Technologies to Enable Low-Impact Hydropower and PSH Growth, Topic 3: Hydropower R&D by Emerging Organizations). The program appreciates the positive interest in the Hydropower Collegiate Competition and looks forward to how that may also impact interest in funding opportunities.

Lastly, reviewers noted to continue to look outside the United States for additional best practices and technologies. The program has been actively engaged in the International Energy Agency (IEA) Hydropower Task 16, which is focused on “hidden hydropower,” and leads the task on NPDs. The program plans to continue that engagement and look for further opportunities for international partnerships.

Recommendation 3: Ensure Industry Can Leverage the Work Supported by WPTO

The program appreciates the positive feedback related to the efforts to identify and characterize NPD opportunities. The program recognizes that some of the portfolio's efforts are more academic in nature but will make a greater effort to ensure those efforts feed into information and tools that are useable by the industry. The program has planned efforts related to technical assistance and looks forward to those as a method to ensure industry adoption of technical work. Moving forward, the program will also put an emphasis on market transformation plans in funding opportunities like that in the Innovative Technologies to Enable Low-Impact Hydropower and PSH Growth opportunity.

Additionally, the program will prioritize efforts to ensure it utilizes the correct metrics for targeting adoption. The feedback related to cost modeling efforts and industry engagement will be considered in next steps to ensure reasonable representation of the development potential. Industry consultants have been actively engaged through subcontracts for the cost modeling projects.

The program was also excited to see comments related to a need for a test facility and agrees a test facility would be of great interest to and use for the industry. At congressional direction, the program conducted a scoping study through Oak Ridge National Laboratory (ORNL) regarding existing and emerging hydropower testing needs, existing capabilities, and gaps between the two that could be filled with federal investment. This scoping study included a request for information that aimed to incorporate valuable feedback from industry and federal labs/agencies. The study proposed two initiatives that are currently being evaluated for implementation. The first includes a hydropower testing network that better connects innovators to available testing capabilities across national, federal, academic, and private labs, particularly for early-stage innovations. The second is a full-scale, flow-through, federal hydropower test facility that is constructed at existing federal infrastructure, like an NPD or hydropower plant. This facility would aim to target first adoption challenges for late-stage innovations. WPTO will continue to support this effort and leverage feedback from the reviewers. Additionally, the program sees the availability of in-situ testing as a big need to validate new technologies developed by the labs and industry to support industry adoption.

The interest in the Interconnection Study was positive, and the program understands reviewers' request for further work on understanding how to help developers and planners improve the process. Next steps for the ongoing project are being considered and will incorporate reviewer feedback to ensure production of useful tools. The program anticipates the guidebook and best practices for hydropower interconnection, expected in FY 2023, will be of interest to the industry.

Grid Reliability, Resilience, and Integration (HydroWIRES)

The HydroWIRES Initiative aims to understand, enable, and improve hydropower’s and PSH’s contributions to reliability, resilience, and integration in a rapidly evolving electricity system. Through this activity area, WPTO is working to:

- Understand the needs of the rapidly evolving grid and how they create opportunities for hydropower and pumped storage.
- Investigate hydropower’s full range of capabilities to provide grid services, accounting for the machine, hydrologic, and institutional constraints to fully utilizing those capabilities.
- Optimize hydropower operations and planning—alongside other resources—to best utilize hydropower’s capabilities to provide grid services.
- Develop innovative technologies, including new pumped storage system designs, which improve hydropower capabilities to provide grid services.

The review panel was impressed with the way that the initiative had grown since last reviewed in 2019 and found its projects to be an excellent representation of the presented strategy. However, the panel suggested there could be better focus on communicating this work to the larger industry, especially once a project concludes. Figure 7 summarizes the reviewers’ quantitative assessment of how the activity area is performing overall, and Figure 8 provides an overview of the scoring of all projects within the HydroWIRES Initiative.

Figure 7. HydroWIRES Initiative Average Weighted Score by Evaluation Criterion

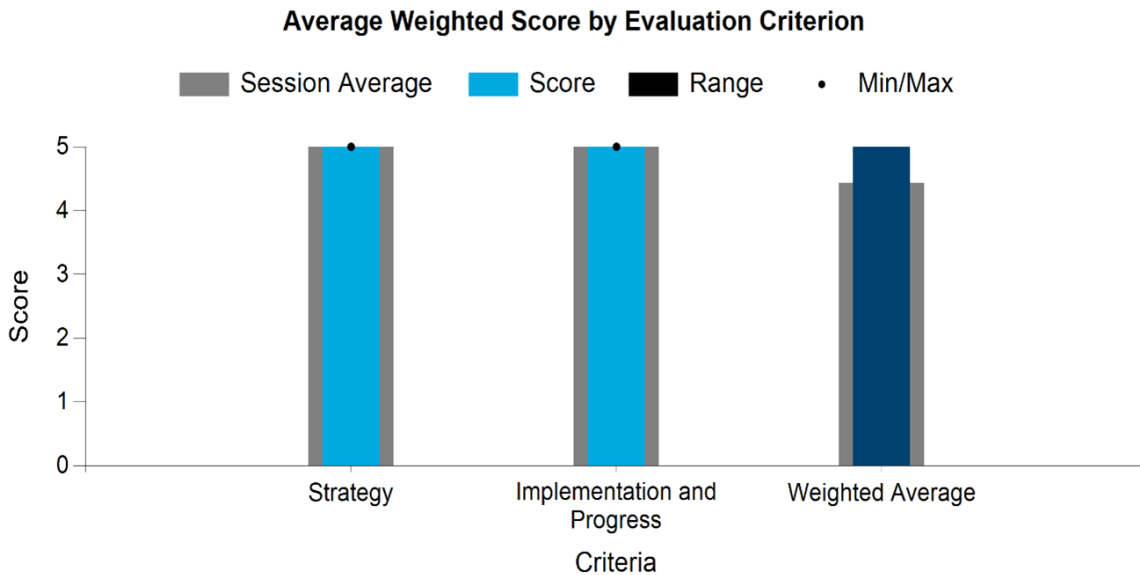
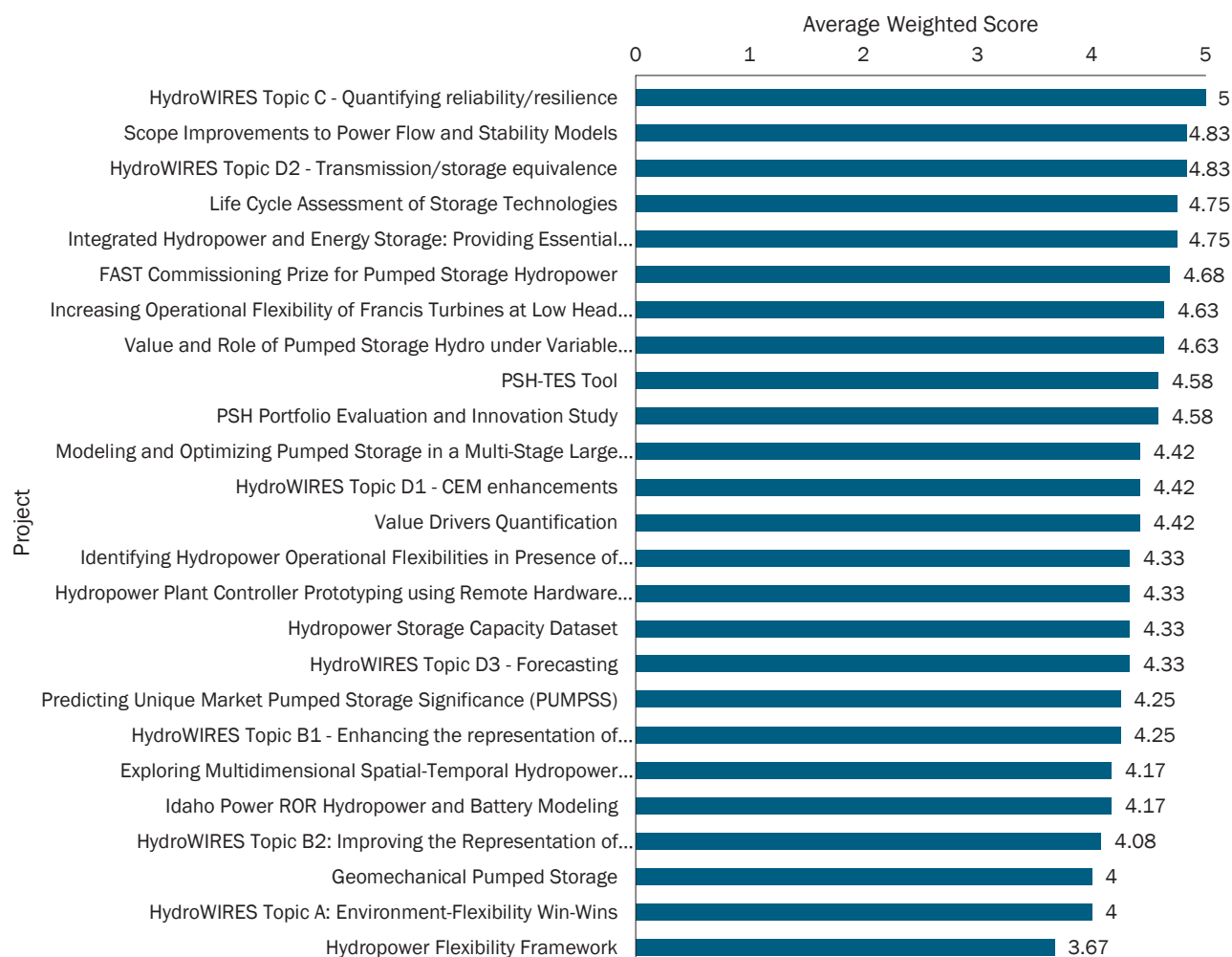


Figure 8. HydroWIRES Initiative Weighted Average Score by Project



The following subsections include the review panel lead’s summary of reviewer comments and the WPTO activity area lead’s response to reviewer feedback. The full evaluation results for the activity area and the portfolio of projects can be found in Volume II of this report. For more information about the activity area’s structure, strategy, and R&D priorities, please refer to the [MYPP](#) or the corresponding [activity area overview slide deck](#) presented during the review.

Activity Area Evaluation Summary

Submitted by Dr. Tom Acker

Feedback from the Review Panel to WPTO

The review panel finds the HydroWIRES Initiative to be well defined, led, and executed. Reviewers recommend increased dissemination and outreach to relevant communities (e.g., hydropower professionals, utility planners, environmental organizations, and interested citizens) and other stakeholders. While project leads generally did a good job engaging with relevant stakeholders, these interactions go away after a project’s end. It is important to continue communicating projects’ results until it is clear the outcomes are impacting the industry and society.

Many projects have been funded through the HydroWIRES Initiative, and by the very nature of this type of work, it is often difficult to make the results readily accessible to potential users. It would be beneficial for the program to find an organized way to simply access all key project outputs (such as reports, articles, tools, and software). Reviewers recommend continuing to support and develop online tools.

The HydroWIRES Initiative has 15 technical objectives. It would be good to map projects back to HydroWIRES' logic model and/or its Research Roadmap to assess the projects' comprehensiveness in addressing these objectives and the underlying challenges. For example, the HydroWIRES roadmap includes "examples of current and prospective work" under each technical objective, and a condensed version of this could be created to show the actual projects and prizes that were funded.

Several R&D projects developed comprehensive datasets for their own modeling. Some of these sets can probably be used for future research with other objectives, both individually and combined. This increases the value of the datasets but may require a more aligned approach in how researchers name and tag the same data points, variables, parameters, etc. Reviewers recommend WPTO explore the possibilities for unified nomenclature for datasets.

Research for a flexible, reliable, and resilient grid can also enable hybrid power plants that use hydropower as the main source to enable and increase generation with any other renewable energy source. The HydroWIRES Initiative already funds several activities needed to achieve this, and it may be interesting to explore and identify R&D areas that may benefit from more funding to enable a hybrid plant.

Summary of Reviewer Feedback on the Activity Area

Overall Impressions

Reviewers' overall impression is that the HydroWIRES Initiative has evolved very well since its inception and initial review in 2019. The program is now very useful and well defined and run. The staff is professional, experienced, knowledgeable, and well connected to the hydropower community and stakeholders. It is a good and appropriate use of taxpayer dollars, and the program is effective and efficient in using those funds.

Activity Area Strategy

Reviewers unanimously agree the HydroWIRES Initiative has a defined strategy as presented in the MYPP and the HydroWIRES Initiative Research Roadmap. Activities have been devised based on near- and long-term challenges identified by industry and relevant stakeholders. The HydroWIRES Initiative considers industry and stakeholder needs in defining its strategic objectives and research areas via the Hydropower Vision report and many interactions with industry and stakeholders. The projects build upon past work.

As presented in its logic model and as detailed in the HydroWIRES Initiative Research Roadmap, a solid rationale is presented that defines activity areas and research priorities. To execute its program, the HydroWIRES Initiative leverages appropriate funding mechanisms, such as financial assistance, prizes and competitions, national lab-led R&D, and others.

Implementation and Progress

Reviewers evaluated 25 projects under the HydroWIRES Initiative. These projects are diverse and appear to have addressed all 15 of the technical objectives described in the HydroWIRES Initiative Research Roadmap. Understanding that with its finite, albeit substantial, budget, it is impossible to fund all of the most relevant technologies, tools, and studies, those receiving funding certainly are relevant and important. Based upon the well-defined goals and objectives of the HydroWIRES Initiative and the project presentations, it is clear the program will very likely meet all of the performance goals and objectives set forth in the MYPP.

Activity Area Response

Submitted by Sam Bockenbauer, HydroWIREs Initiative Lead

The program would like to thank reviewers for their excellent evaluations and active participation throughout the HydroWIREs presentations. The comments on both individual projects and the HydroWIREs Initiative's overall strategic direction are a crucial way for the program to get focused external feedback and make sure its work is technically sound and getting into the hands of external users.

The program is pleased by reviewers' comments that the HydroWIREs program is well defined in its strategy and making strong technical progress. All reviewers awarded HydroWIREs perfect overall scores for both the activity area's strategy and implementation and progress. Reviewers noted that HydroWIREs is well defined, led, and executed, and the team is professional, experienced, knowledgeable and well connected to the hydropower community and stakeholders. In addition, the reviewers noted that it was "effective and efficient" at using taxpayer dollars for public benefit. The program is particularly pleased the review panel noted significant progress since the previous review in 2019 when HydroWIREs had just been launched. The panel was unanimous in its feedback that the strategic direction and technical focus were fully clarified, and projects reviewed were very strong. The program would also like to emphasize that HydroWIREs is a team effort, and the team of technical leads at DOE, as well as project leads at the national labs and industry, share the credit for this successful progress.

Overall, reviewers outlined several recommendations to (1) increase dissemination of results and tools for potential users, (2) develop performance metrics at the initiative level, (3) sharpen focus on technical work in hybrids and data sharing, and (4) continue international engagement to gain insight for U.S. research. The following sections outline the activity area's response to the reviewers' key recommendations.

Recommendation 1: Increase Dissemination of Results and Tools for Potential Users

Reviewers noted that projects across HydroWIREs are valuable and address important questions, but further focus on end-user engagement would be helpful. For instance, several projects address hydropower and PSH valuation in different ways, but tools developed in these projects are not housed in a single centralized location. The idea of a "developer's corner" on NHA's website or a similar industry-oriented portal was raised, and the program agrees this could be very useful.

Reviewers also remarked that engagement with industry in the projects themselves is often present, but some projects last only a few years, after which time the collaboration may end abruptly. The program agrees with this concern but sees a need to balance open-ended stakeholder engagement goals with well-defined project milestones to be achieved in a set amount of time. With lab projects, there are fewer limitations, as successful projects can be continued with additional merit review and/or new projects can be started based on successful relationships developed with industry partners. With funding opportunity awards, however, significantly extending the duration is less straightforward and would generally require a new award. The program will continue to explore new options that can support long-term industry relationships while maintaining rigor in project management. A new technical assistance opportunity, released in November 2022, may meet some of these requirements.

To better increase the likelihood of dissemination and outreach for HydroWIRES, the program has preliminary plans including:

- Continue to prioritize end-user engagement in project selection, scoping, review, management, and communication. While HydroWIRES has made strong efforts in these areas, continued focus is critical, especially given the highly technical nature of many of the HydroWIRES projects.
- Engage with NHA and other industry groups on how to create a one-stop shop for HydroWIRES tools for developers and other users. Key needs include a place to reference tools for PSH developers, such as the PSH Valuation Tool, but a broader “developer’s corner” across hydropower could be valuable.
- Consider mechanisms to support research for longer-term industry engagement beyond typical one-to-three-year lab projects and funding opportunity awards. This would enable continued relationships for sharing data among labs and industry partners, such as utilities, which is especially important in HydroWIRES modeling projects but could also be applied across hydropower.
- Develop new technical assistance processes that lower the barrier to industry participation and enhance national laboratory engagement. Streamlining requirements for data sharing are especially important for HydroWIRES modeling projects but are also generally applicable.

Recommendation 2: Develop Performance Metrics at the Initiative Level

Reviewers noted a need for performance metrics and visuals for strategic plans across the hydropower program. In HydroWIRES, this could be particularly useful due to the large budget and number of projects, as well as the projects’ complexity and interrelationships. Project- and portfolio-level success in HydroWIRES is not easily captured by traditional technology metrics such as levelized cost of energy (LCOE) or other types of cost reduction. New metrics for modeling efficacy and uptake, for example, could be developed, especially as the current portfolio of projects continues to progress. Visuals for the strategic plans in HydroWIRES could also be enhanced to more clearly show where various projects fit. Reviewers also suggested a “tying together” presentation at the end of the peer review to reiterate the strategy once reviewers have seen project presentations, and this idea would be easy to implement.

In future peer reviews, and in other outreach before the new peer review, the program will develop visuals for future peer reviews to better categorize projects within each activity area and highlight remaining research gaps. Due to the number of projects in HydroWIRES, these visuals can help reviewers better understand the initiative’s scope and goals. Additionally, there are preliminary plans to begin a more comprehensive study of programmatic performance metrics, informed by other DOE efforts.

Recommendation 3: Sharpen Focus on Technical Work in Hybrids and Data Sharing

In addition to broader strategic feedback, reviewers identified several specific research areas that may deserve even greater focus in HydroWIRES. One example was hydropower hybrids, which reviewers noted as a strong area of interest in industry and internationally. The program agrees with this sentiment and has new and planned future work to explore hydropower hybrid use cases in greater depth than the current cohort of projects. While preliminary, the program will build on existing work in hydropower hybrids to consider broader use cases related to multi-resource hybrids, environmental and machine benefits, and enhanced market participation. While this hybrids work is specific to HydroWIRES, results from other activity areas will be incorporated.

Another cross-cutting idea reviewers proposed was more uniform warehousing and tagging of datasets generated by HydroWIRES projects. While many projects create this data, it was not immediately obvious to reviewers how other researchers (in the national labs or outside) would be able to use it for additional studies. The program agrees this is an important need; currently datasets are shared on an ad-hoc basis. A centralized repository on DOE or national lab websites would be a helpful first step. The program will examine processes for organizing and sharing data—including data tagging, consistent descriptions, and sharing protocols—generated in HydroWIRES projects for use across the national labs and interested external partners.

Recommendation 4: Continue International Engagement to Gain Insight for U.S. Research

Across multiple activity areas, reviewers highlighted the value of international collaboration, noting that new hydropower technology and large-scale projects are, in many cases, led by other countries. The program fully agrees the international perspective is valuable, and insights from international partners (e.g., Norway) can be applicable in the United States. In HydroWIRES and across the hydropower program, WPTO leads or contributes to various international initiatives and expects to continue to expand these mutually beneficial relationships.

The program will continue (for HydroWIRES and other activity areas) strong collaboration with Norway and other countries where hydropower is highly advanced. This has provided value to U.S. efforts. Additionally, the program will promote research collaboration through the IEA Technology Cooperation Programme on Hydropower chairmanship and other international venues and develop new ways to streamline collaboration between countries.

Fleet Modernization, Maintenance, and Cybersecurity

The Fleet Modernization, Maintenance, and Cybersecurity Activity Area aims to develop digitalization, maintenance, and cybersecurity tools and capabilities to enable data-driven decision making, improve system reliability and reduce costs, and enhance infrastructure security. Through this activity area, WPTO is working to:

- Create mechanisms to classify diverse hydropower plants by mechanical and cyber-physical systems and identify exemplary facilities and best practices.
- Research advanced technologies and data evaluation approaches to improve equipment longevity and condition-based repair.
- Develop cross-cutting digitalization systems and advanced sensor suites to empower data-driven decisions on operations and maintenance (O&M) and asset management.
- Create cybersecurity tools and studies to articulate the cybersecurity target, risk, and recovery landscape in order to enhance the security of critical dam infrastructure.

The review panel found that the activity area’s strategy was in line with the strategy outlined in the MYPP but did note they would have liked to see some additional focus on and work done in the maintenance part of the portfolio. Figure 9 summarizes the reviewers’ quantitative assessment of how the activity area is performing overall, and Figure 10 provides an overview of the scoring of all projects within the Fleet Modernization, Maintenance, and Cybersecurity Activity Area.

Figure 9. Fleet Modernization, Maintenance, and Cybersecurity Activity Area Average Weighted Score by Evaluation Criterion

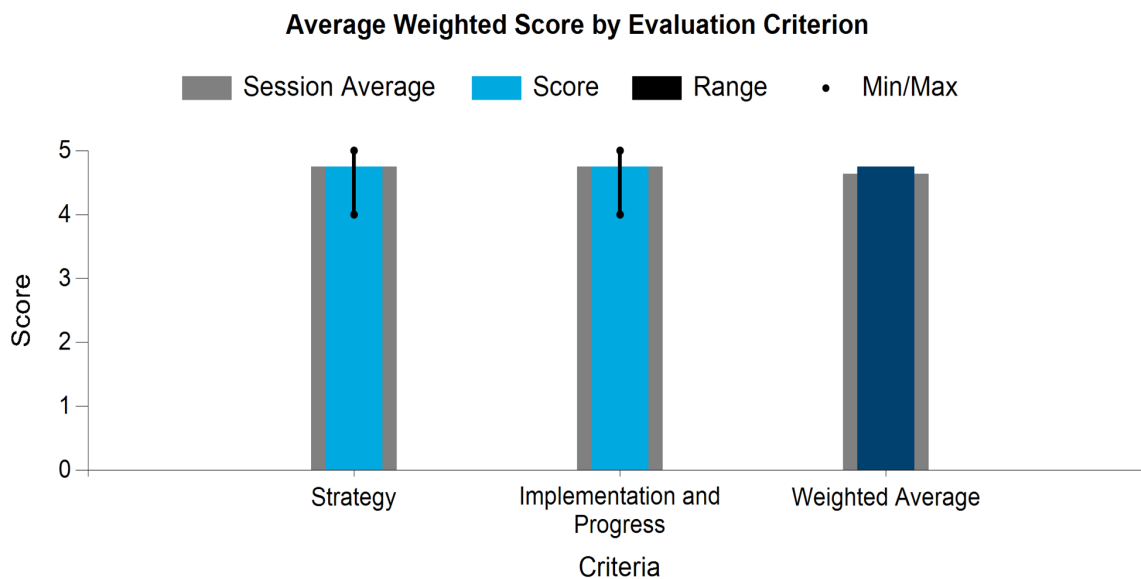
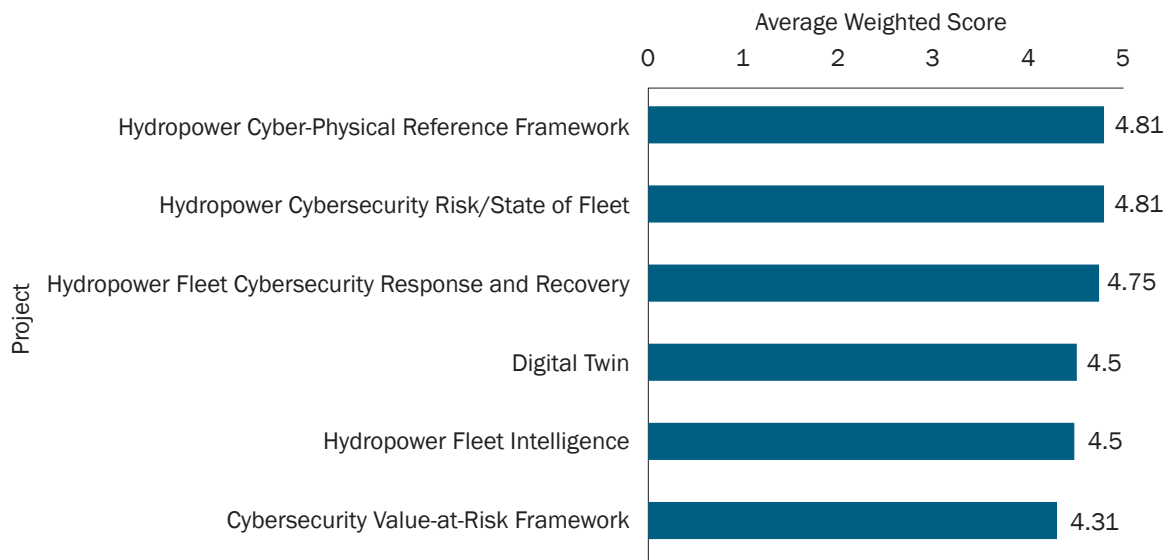


Figure 10. Fleet Modernization, Maintenance, and Cybersecurity Activity Area Weighted Average Score by Project



The following subsections include the review panel lead’s summary of reviewer comments and the WPTO activity area lead’s response to reviewer feedback. The full evaluation results for the activity area and the portfolio of projects can be found in Volume II of this report. For more information about the activity area’s structure, strategy, and R&D priorities, please refer to the [MYPP](#) or the corresponding [activity area overview slide deck](#) presented during the review.

Activity Area Evaluation Summary

Submitted by Catherine Campbell

Feedback from the Review Panel to WPTO

WPTO demonstrates a clear understanding of the nation’s hydropower owner-operator needs and concerns, chooses relevant R&D projects in alignment with the MYPP and the Hydropower Vision report, and organizes activity areas such that the projects complement each other. Reviewers agree the Hydropower Program has a sound foundation, strategy, and approach for implementation.

Most of this panel’s reviewers were from hydropower owner-operators. The reviewers requested more details regarding the program’s stakeholder outreach process, the overall landscape of hydropower R&D, and how the chosen projects compare to other projects that would also have been in alignment with the MYPP. Some areas of interest might be considered too far along to require the R&D investments, some might be premature, and some might have not been proposed. It would be informative to see how the chosen work ranks with other areas of interest. The reviewers understand there are communication plans in place to reach stakeholders, but they were not provided to reviewers, which left some gaps in their understanding of how progress and results were disseminated as well as how projects originate.

The introductory presentations on the program and the activity area are important and were very well done. The level of detail regarding the strategies, how the activity areas fit together within the program, and how the projects fit together within the activity area was at the right level. This information bears repeating after the individual project presentations when it will have more meaning for the reviewers. With few exceptions, the individual projects did not describe how they fit with each other or within the activity area’s strategy. Reviewers recommend each project include a slide depicting their place within the activity area and which other projects complement theirs and how. After the projects have been presented, consider another brief presentation of the activity area strategy to show how the projects fit together and of the program strategy to show how the activity areas fit together.

Summary of Reviewer Feedback on the Activity Area

Overall Impressions

Reviewers would have liked to hear about selected, rejected, and deferred projects and how they ranked with each other. However, the reviewers acknowledge this may be outside the scope of the review.

The reviewers noted there are several cybersecurity projects, which is in line with the MYPP. The cybersecurity projects themselves seem to be cost effective, were selected to avoid redundancy, and work well together strategically. In future, it would be desirable to include more maintenance projects. Hydropower Fleet Intelligence (HFI) is a great project, but there is still room in the activity area for more maintenance-centered efforts (such as around baselining maintenance costs, benchmarking plant outage causes, or quantifying common failure modes and frequencies for typical systems) while maintaining diversity among projects.

The development of wear-and-fatigue models is starting and seeks to cover critical hydropower components while avoiding one-off models that do not translate across the industry. This is an exciting but challenging task for complex hydropower components that have a great deal of variation, especially in details relevant to wear and fatigue. If models can be accurate without having to be unique, that would represent a major step forward for predictive/smart maintenance.

Modernization projects like the digital twin can be seen by end users as requiring significant initial investment of time and funds with potentially tremendous returns someday. According to the activity area presentation, “value sensitivity and articulation” will be critical to success. For outreach and results dissemination on digitalization projects, reviewers recommend explicitly pointing out that an all-or-nothing approach is not necessary, and benefits can be gained with a gradual approach to installation of machine condition monitoring, for example. In general, reviewers would like to see more details about how owner-operators could use project outputs and the business case to invest in the results given competing needs in hydropower to keep costs low, maintain fleet readiness and resilience, and remain in compliance with environmental, safety, and other requirements.

Activity Area Strategy

Reviewers find this activity area has a well-defined strategy in alignment with the MYPP with clear goals and objectives. Reviewers agree this activity area's strategy shows an understanding of the industry's challenges, such as aging infrastructure, cyberthreats, lack of data, grid demand, and funding constraints. It would be desirable to have more focus on short-term benefits to end users in addition to long-term benefits such as the lure of a fantastic digital twin model after many years of input and calibration.

It appears the cybersecurity R&D activities build on work completed during the last two to three years. However, in the fleet modernization and maintenance areas, it is not clear to what extent future activity builds on past work, except that the digital twin project description indicates a feasibility study was completed in FY 2021.

The activity area presentation did a great job outlining the strategy. For this activity area, there might be an opportunity to use a case study to demonstrate how each of the projects can provide benefits, and how those benefits integrate to accomplish the activity area's goals. Such a case study could serve as proof-of-concept for the activity area.

It appears all funding comes from government. It is not clear if industry and academia or prizes/competitions are part of any of the funding. Also, funding is explained for the development of wear-and-fatigue models and cybersecurity research, but it is not clear to reviewers how the maintenance and digitalization areas are funded.

Implementation and Progress

The digital twin, wear-fatigue lab call, and HFI projects are complementary to each other. Cybersecurity projects were not intuitively complementary to these other projects; cybersecurity is just necessary. The cybersecurity projects are diverse in nature, and reviewers believe they complement each other and cover different needs for WPTO and the industry.

The activity area is funding relevant tools and studies. Without seeing the unfunded studies, it is not possible for reviewers to determine whether these are the most relevant. According to the MYPP, maintenance research priorities include the development of first-generation condition sensors, but this does not appear to be included this year. The activity area looks likely to fulfill all the 2021–2025 key results and performance goals defined in the MYPP.

Activity Area Response

Submitted by Kyle DeSomber

The program would like to extend its thanks to reviewers for their participation in the review of the Fleet Modernization, Maintenance, and Cybersecurity Activity Area. Their participation and specific hydropower experience helps to ensure the products the program is developing and studies it is undertaking are both useful and valuable to the industry. The program understands time is a limited resource, and these efforts required reviewers to go above and beyond their daily duties. Their participation, through review comments and discussions, helps to create the collective future.

An observation from reviewers' general comments was to continue to utilize industry groups for feedback and communication of project outcomes. This is an important reminder to WPTO that industry groups represent the larger industry. WPTO is an active member in many of these groups and will continue to rely on the expertise of these groups to form and guide projects and research with the national laboratories. To address reviewers' recommendations, it will be important for WPTO to coordinate efforts with industry groups seeking feedback to align work products with ongoing efforts occurring through the industry groups.

Reviewers also commented that the MYPP discusses the development of first-generation condition sensors, but none of the projects appeared to include the development of sensors. WPTO agrees with this observation. The current portfolio includes projects developing strategies and observations, not physical devices. The portfolio is working to diversify its approach through a new round of lab funding for wear-and-fatigue models and cybersecurity projects, as well as a recently released SBIR topic on cybersecurity. It is clear that funding mechanisms, such as small business grant programs, are better suited for development of physical devices than those that lead to lab studies. This observation will also be shared with the selection teams, so they can be mindful of the goal when selecting the next projects to undertake.

Overall, reviewers outlined several recommendations to (1) incorporate project implementation and financial considerations for end users, (2) include more maintenance projects in the portfolio, and (3) share project perspectives with how they fit in the larger portfolio strategy. The following sections outline the activity area's response to the reviewers' key recommendations.

Recommendation 1: Incorporate Project Implementation and Financial Considerations for End Users

A common, multi-layered theme emerged from reviewers' feedback and was interpreted as follows:

- Project dissemination does not have to be all or nothing; the industry may realize benefits through the presentation of project progress.
- Project presentations and projects as a whole need to include business cases and implementation strategies for end users to evaluate the necessity and benefits of implementation against competing interests, notably environmental, safety, and North American Electric Reliability Corporation (NERC) requirements.

This is great feedback that is not necessarily stated within project objectives individually but is important to consider as these projects and this program continue to evolve. This also ties to the overall theme of continued coordination between WPTO and industry groups. As a first action, WPTO will examine annual operating plans within the Fleet Modernization, Maintenance, and Cybersecurity portfolio and look for opportunities to assess value and share project deliverables throughout the year. Further, the program invites suggestions from industry groups with ongoing work that may benefit from collaboration. A recent example of this collaboration was meeting with the start/stop working group at the Centre for Energy Advancement through Technological Innovation's hydropower conference to discuss ORNL's HFI project. This recommendation is valid and will be incorporated into plans for FY 2023.

Recommendation 2: Include More Maintenance Projects in the Portfolio

The projects presented are maintenance related and may lead to best practices in the future, but reviewers noted they do not necessarily address maintenance as it currently occurs. This comment is well received, as one value proposition of the HFI and Digital Twin projects is to enable predictive maintenance activities that reduce outages and maintenance costs. These projects approach predictive maintenance from different angles: HFI uses data-driven analysis that benefits well-monitored and recorded sensor systems, while Digital Twin uses a parallel, model-driven approach to simulate systems. Work to date has addressed several challenges related to data collection (cleaning, assimilation, sufficiency) and the construction of models. In FY 2023, both projects will develop concrete case studies to demonstrate the value of their approach related to current maintenance practices.

Additionally, WPTO funded two wear-and-fatigue projects this fiscal year that will select critical components and create user-friendly models to assess remaining useful life. These projects will complement the HFI and Digital Twin projects with more specificity to individual components. However, WPTO recognizes the need to develop and communicate the value proposition of predictive maintenance activities, and this need is reflected in revised project scopes. Further, the program will coordinate with industry groups to examine opportunities or pain points where WPTO and the national labs can assist hydropower owners and operators through applications of the existing portfolio (case studies), new funding opportunities, and dissemination of results. Engagement with plant operators will be beneficial in assessing existing data and gaps, allowing these software-centric projects to scale quickly.

Recommendation 3: Share Project Perspectives with How They Fit in the Larger Portfolio Strategy

Reviewers recommended a larger strategy beyond the MYPP be shared for cybersecurity and noted it would be worthwhile for individual projects to reiterate how they fit within the larger portfolio and WPTO strategies. The current cybersecurity strategy is based on Pacific Northwest National Laboratory's (PNNL) Cybersecurity in Hydropower Landscape Assessment and Roadmap. This document has not yet been made public but was used internally to ensure the recent FY 2023 cybersecurity project selections did not overlap and addressed all the perceived gaps. The program is working to publish this report publicly, while simultaneously incorporating it into a WPTO-led strategic plan for the Fleet Modernization, Maintenance, and Cybersecurity portfolio. This strategic plan will better tell the story of WPTO goals and investments and how they relate to each other and within the larger energy and cyber communities. In particular, the cybersecurity strategy will be overlaid with the fleet modernization and maintenance strategies to show the holistic picture as reviewers recommended.

Environmental and Hydrologic Systems Science

The Environmental and Hydrologic Systems Science Activity Area aims to research and develop new technologies to better characterize river systems and evaluate potential impacts; avoid, minimize, or mitigate environmental impacts; and improve understanding of various hydrologic risks and uncertainty. Through this activity area, WPTO aims to:

- Develop better monitoring technologies to study river systems and evaluate environmental impacts.
- Develop technologies and strategies to avoid, minimize, or mitigate environmental impacts.
- Support development of metrics to better evaluate environmental sustainability for new hydropower developments.
- Assess potential impacts of long-term climate and hydrologic changes to hydropower.
- Improve abilities to assess risk of potential methane emissions from water bodies.

The review panel thought the strategy presented was in line with the MYPP, and the projects were all representative of the overall strategy, though they did recommend a greater focus on communicating results and commercialization. Figure 11 summarizes the reviewers' quantitative assessment of how the activity area is performing overall, and Figure 12 provides an overview of the scoring of all projects within the Environmental and Hydrologic Systems Science Activity Area.

Figure 11. Environmental and Hydrologic Systems Science Activity Area Average Weighted Score by Evaluation Criterion

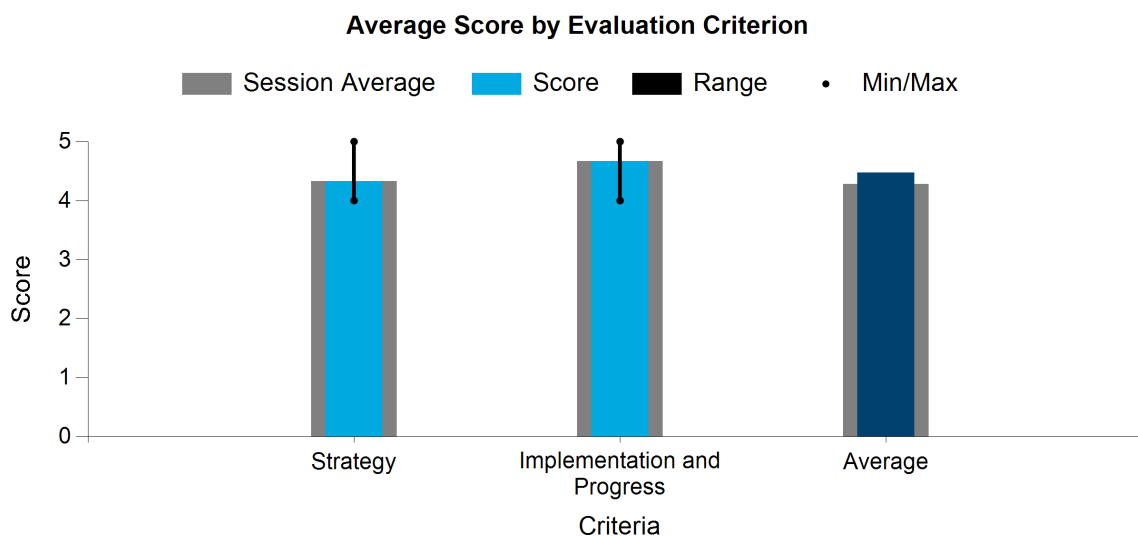
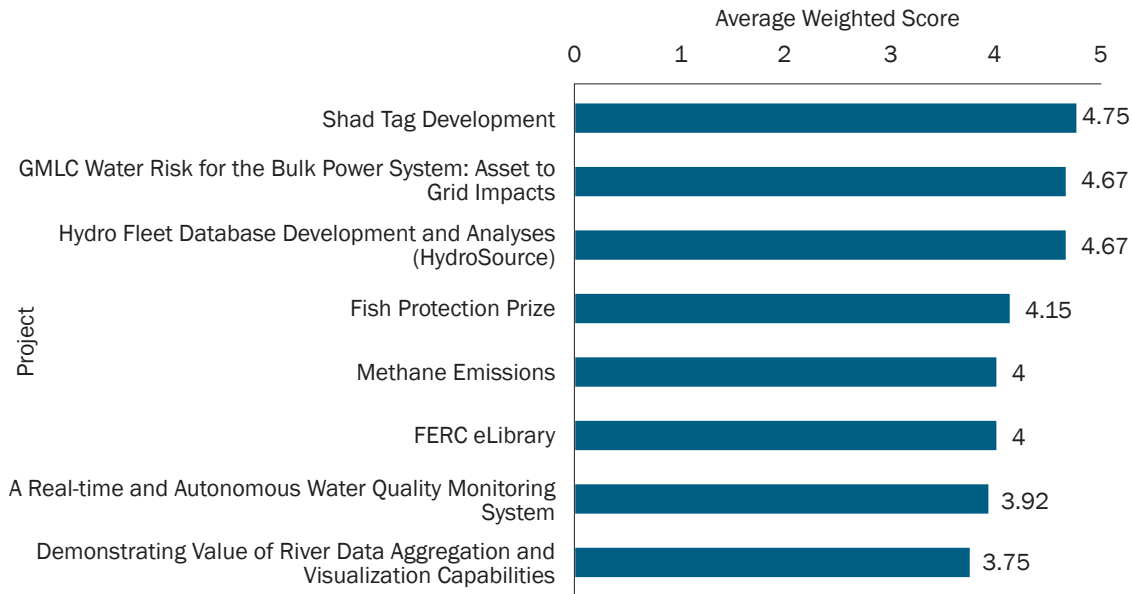


Figure 12. Environmental and Hydrologic Systems Science Weighted Average Score by Project



The following subsections include the review panel lead’s summary of reviewer comments and the WPTO activity area lead’s response to reviewer feedback. The full evaluation results for the activity area and the portfolio of projects can be found in Volume II of this report. For more information about the activity area’s structure, strategy, and R&D priorities, please refer to the [MYPP](#) or the corresponding [activity area overview slide deck](#) presented during the review.

Activity Area Evaluation Summary

Submitted by Shannon Ames

Feedback from the Review Panel to WPTO

The projects in this activity area are valuable, worthwhile, and strategically aligned with the MYPP. The reviewers agree the projects have made significant progress against their original project plans. There is no question the projects are being managed carefully, thoughtfully, and responsibly.

All reviewers, however, would have appreciated more detail on the results of or lessons learned from the projects to date. Each project, and the activity area as a whole, has thoughtfully considered communications and stakeholder outreach. Reviewers agree, though, that the effectiveness of outreach differed by project. The notion of “hydropower industry community” needs to be clearly defined and must include a broad array of those who interface with hydropower—owners and operators, agencies, river conservation organizations, universities, etc.—and tailored to the specific project. The dissemination of this work must result in the average person’s ability to quickly access research results. The success of these projects will be determined by their ability to get through the next stage, be it dissemination and adoption, commercialization, or additional research.

Summary of Reviewer Feedback on the Activity Area

Overall Impressions

Reviewers agree the summary of the activity area was effective in placing the projects within the overall strategy of the MYPP. The reviewers would like to see more comprehensive and frequent outreach and incorporation of feedback from the hydropower community to ensure projects and their strategy align in this quickly changing landscape. In addition, reviewers would like to see a clearly articulated strategy for commercialization.

Commercialization, in this case, would incorporate both how to get products to market, as well as deployment of research, so stakeholders can incorporate it as quickly and effectively as possible.

Activity Area Strategy

Reviewers agree the activity area has a well-defined strategy that is outlined in the MYPP. There are clear performance goals, objectives, and research priorities associated with the strategy.

It is clear to reviewers that the strategy reflects an understanding of the short- and long-term challenges facing the industry. The strategy incorporates the challenges facing industry and, to a lesser extent, the broader hydropower stakeholder community. Some reviewers think the strategy should be more focused on meeting the needs of the hydropower industry, while other reviewers believe the strategy should reflect a better balance between hydropower development and broader stakeholder community interests. Maintaining a balance in research priorities to address the needs of the hydropower industry and broader stakeholder community should remain a top focus for the program.

The activity area's activities build on past work and address real needs within the industry. Shad tagging is a good example of this attempt to fill a data gap with new technologies applicable to multiple species and watersheds. While the reviewers are not united on whether the reservoir emissions research is valuable to the industry, it is addressing a key need for hydropower stakeholders at large and the ongoing need to understand hydropower's role in a carbon-free future. This is a clear case where additional details on the results of past and current work would help to demonstrate the value and relevance of the research to the hydropower community.

The shad tag and methane projects are good examples of the slight variation in communication effectiveness. The findings of the shad tag work have been presented to appropriate audiences, which are excited to commercialize and use the technology. The methane research has been published, but information has been presented to select audiences without clearly articulating to the industry why this work is important.

The activity area primarily leverages national labs and prizes for the sub-activity areas. These mechanisms appear to be appropriate for the projects reviewed, but reviewers would like to see more involvement of academia.

Implementation and Progress

The projects within the Environmental and Hydrologic Systems Science Activity Area are closely tied to the program's strategic direction. The projects are diverse—they incorporate product development (e.g., shad tags and robots for water quality monitoring), data dissemination (via HydroWIRES, HydroSource, and Federal Energy Regulatory Commission (FERC) eLibrary search capabilities), and new research in a nascent field (e.g., reservoir emissions). However, the projects all address the central need to provide scientific information, in coordination with stakeholders, to allow hydropower generation to continue to grow responsibly with improved environmental outcomes at hydropower facilities and to contribute to the clean energy future through modeling, design, and analysis of environmental effects and stakeholder involvement. These areas are all relevant. The data access tools will be important but depend on effective dissemination. The mechanical tools are demonstrably in demand but will depend on affordable commercialization.

Provided these projects are either effectively commercialized or funded in future years so the full scope of research can be completed, they all do or will meet performance goals and objectives.

Activity Area Response

Submitted by Dana McCoskey, Technology Manager

WPTO would like to express its sincere thanks to reviewers for their critical feedback, active engagement, and thoughtful recommendations on the Hydropower Program's Environmental and Hydrologic Systems Science portfolio. The program also expresses additional thanks to the panel chair for leading the group and facilitating conversations to create a productive environment where all reviewers' thoughts could be respectfully voiced. While this review is only a snapshot of the types of projects WPTO has funded in this activity area, the range of comments, impressions, questions, and dialogue from reviewers help WPTO to better understand how to further develop projects for greater benefits and provide valuable insights into the overall strategy. This input will support future investments in technically sound and relevant R&D, help to deliver commercial products and key research findings to diverse stakeholders, and assist in improving outreach and engagement.

Overall, reviewers outlined several recommendations to (1) develop mechanisms and metrics to evaluate the effectiveness of outreach and engagement at the project level, (2) develop and clearly articulate strategies for commercialization, and (3) maintain a balance in research priorities to address hydropower industry and broader stakeholder community needs. The following sections outline the activity area's response to the reviewers' key recommendations.

Recommendation 1: Develop Mechanisms and Metrics to Evaluate the Effectiveness of Outreach and Engagement at the Project Level

Reviewers recommended WPTO evaluate whether outreach is working. Reviewers also commented on examples of projects where they believed communications varied in effectiveness by pointing out the differences between the Shad Tag and Methane Emissions from Reservoirs projects. Some of these differences could be attributed to the fact that the shad tag project is related to multiple past WPTO-funded projects that aimed to deliver different fish-tracking tags to the hydropower industry, resulting in a mature existing network of interested researchers and practitioners. It may also be attributed to the principal investigator's (PI) participation in formal training (DOE's Energy I-Corps) on commercialization.

Meanwhile, the Methane Emissions from Reservoirs project is relatively new to WPTO and the laboratory, so networks with industry and other hydropower stakeholders are in the process of being developed. However, the methane emissions team has engaged the hydropower community by presenting its findings to the Uncommon Dialogue, which is an established group with diverse viewpoints on emissions from reservoirs. In addition, WPTO developed a webpage highlighting the results of the Methane Emissions from Reservoirs project and will continue to provide transparent and objective information related to this topic.

But there are ways that the program will strengthen both the methods and evaluation of mechanisms to engage with the industry and environmental industry. This includes the following – which is inclusive of the activity area but also broadly applicable to the WPTO portfolio:

- Support PIs' development through peer mentoring and trainings, prioritizing new staff for professional development.
- Support PIs in sharing best practices for outreach from successful projects with the WPTO laboratory research community.
- Add more emphasis on outreach and engagement, including stakeholder identification, for all new laboratory projects early in the project work plan with funding to support efforts.

WPTO will continue to utilize existing outreach and engagement tactics and pilot new efforts.

Recommendation 2: Develop and Clearly Articulate Strategies for Commercialization

WPTO appreciates this feedback and agrees that such planning is helpful for internal, longer-term planning and engagement with potential external partners. WPTO is currently developing materials for awardees on commercialization processes and options for intellectual property. WPTO also works closely with national laboratory commercialization offices to understand the options for technology transfer of WPTO-funded tools and technologies. In this activity area, national laboratories frequently use a licensing pathway for both hardware and software, although some software is open source. WPTO will develop methods to make this information clearer and to evaluate plans to progress.

Recommendation 3: Maintain a Balance in Research Priorities to Address Hydropower Industry and Broader Stakeholder Community Needs

The program appreciates the feedback that there are a variety of stakeholders that have research needs related to hydropower and the recommendation that there should be a balance between industry needs and those of other stakeholders. WPTO's Hydropower Program has strategically focused resources on projects that have a hydropower nexus, assisted projects in developing partnerships with industry for testing and demonstrations, and often prioritized R&D in this activity area that benefits stakeholders from multiple hydropower sectors. WPTO will critically review projects in terms of primary stakeholders and categorize projects to assess gaps and evaluate R&D services by sectors. WPTO strives to maintain such balance and will intentionally review priorities with this in mind.