DOE's Water Power Technologies Office (WPTO)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy









Overview of the Hydropower Program

Tim Welch

WPTO Peer Review

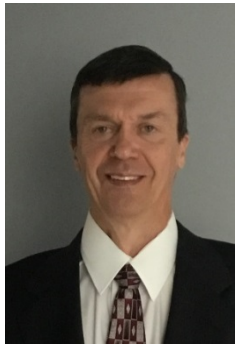
October 8, 2019

Thank you to our Hydro reviewers

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

New Technology and Modernization Panel

- **Greg D. Lewis,** Duke Energy (Hydro Chair/Panel Lead)
- **David Hanson,** Retired (formerly Sacramento Municipal Utility District)
- **David Sinclair,** Advanced Hydro Solutions
- **Steve Lewis,** Sapere Consulting



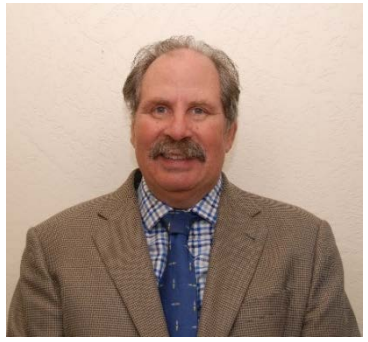

Environmental R&D and Data Management Panel

- **Tim Brush**, Inter-Fluve (Panel Lead)
- **Colleen McNally-Murphy**, American Rivers
- **Edith Zagona**, University of Colorado-Boulder
- **Juliusz Kirejczyk**, Independent Consultant




Grid Reliability and Resilience Panel

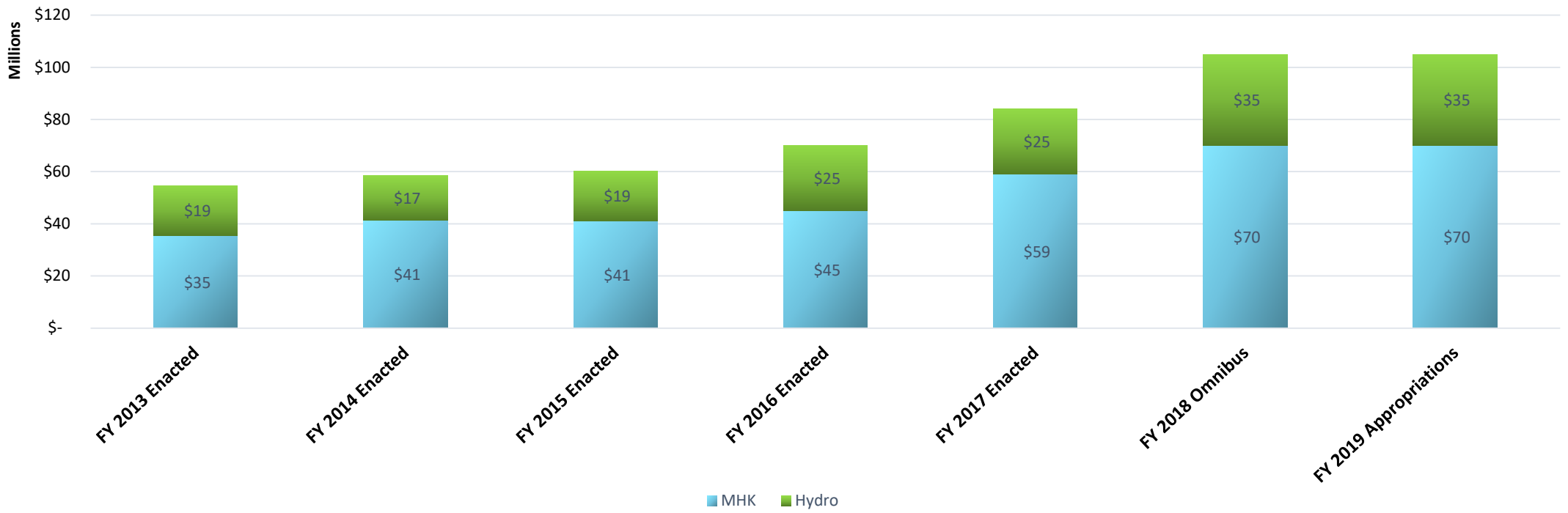
- **Scott Flake**, Independent Consultant (Panel Lead)
- **John Simonelli**, Retired (formerly ISO New England)
- **Charlton Clark,** formerly DOE
- **Tom Acker**, Northern Arizona University




Water Power Technologies Office – Topline Numbers

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Program	FY 2013 Enacted	FY 2014 Enacted	FY 2015 Enacted	FY 2016 Enacted	FY 2017 Enacted	FY 2018 Omnibus	FY 2019 Appropriations
MHK	$ 35,456,000	$ 41,275,000	$ 41,100,000	$ 45,000,000	$ 59,000,000	$ 70,000,000	$ 70,000,000
Hydro	$ 19,231,000	$ 17,290,000	$ 19,200,000	$ 25,000,000	$ 25,000,000	$ 35,000,000	$ 35,000,000
Total	$ 4,687,000	$ 58,565,000	$ 60,300,000	$ 70,000,000	$ 84,000,000	$ 105,000,000	$ 105,000,000



Funding mechanisms – Hydropower Program

Financial Assistance

- Funding Opportunity Announcements (FOAs) result in financial assistance to industry and academia through cooperative agreements. Cooperative agreements are similar to grants but provide for more involvement between the Federal awarding agency and the awardee. DOE requires at least a 20% cost share from these recipients (some exceptions – e.g. for universities)
- The Small Business Innovations Research (SBIR) and Small Business Technology Transfer (STTR) programs provide grants to small businesses or individuals who can form a small business within the required application timeline. This program is Congressionally mandated.

Prizes and Competitions

Prizes and Competitions are organized to achieve defined goals in a defined timeframe. They often use cash prizes and other incentives to reach beyond the "usual suspects" and increase the number of problem-solvers addressing a critical issue.

The Energy Policy Act (EPAct) 2005 Section 242 Hydro Incentive Program

The Hydro Incentive Program provides funding for projects adding hydroelectric power generating capabilities to existing dams throughout the United States. This is a Congressionally mandated program appropriated at $6.6M annually.

Annual Operating Plans (AOPs)

Annual contracts with national labs which define the scope, schedule, milestones, and cost for work. This is how WPTO funds national lab partners to conduct research, analysis, and develop tools and resources for the benefit of the hydropower field. Ongoing, multi-year efforts require merit review.

Lab Support to Industry

- "FOA support" – or payment to lab staff to support a FOA awardee
  - Labs are ineligible to apply for FOAs but they may be requested by a FOA recipient to partner on an awarded project. In these cases, WPTO pays the lab directly.
- Small Business Vouchers (SBV) has funded national labs' support to small businesses to help test, develop, and validate their innovative products.
- The Technology Commercialization Fund (TCF) enables industry to obtain a license to lab-developed technologies. This is a Congressionally mandated program which comprises .9% of annual program budgets and requires cost share.

Other

Additional program-led work including analysis, communications, stakeholder engagement, and dissemination activities.

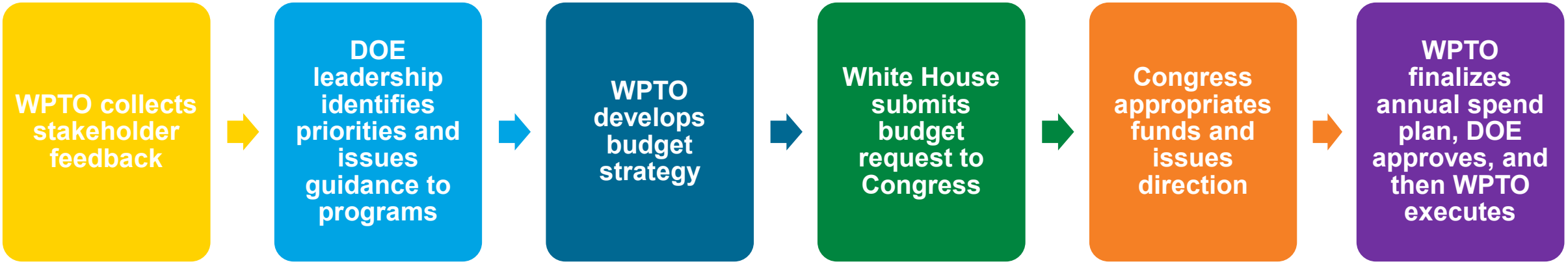
WPTO budget planning

Federal fiscal years (FY) run October – September. At any time, WPTO is working on budgets for three FYs:

- **Executing the current fiscal year** (e.g. implementing the budget appropriated by Congress for the current FY)
- **Formulating or developing for the next fiscal year** (e.g. justifying the President's budget request for the next FY by outlining how WPTO would use requested funds)
- **Planning for the fiscal year after next** (e.g. outlining funding needs/priorities for the FY after next)

WPTO is currently **executing** FY19, **formulating** FY20, and **planning** for FY21.

The simplified flow diagram below typically takes an entire year in practice.



Hydropower Program Vision and Mission

***Vision**:*

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

Mission:

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

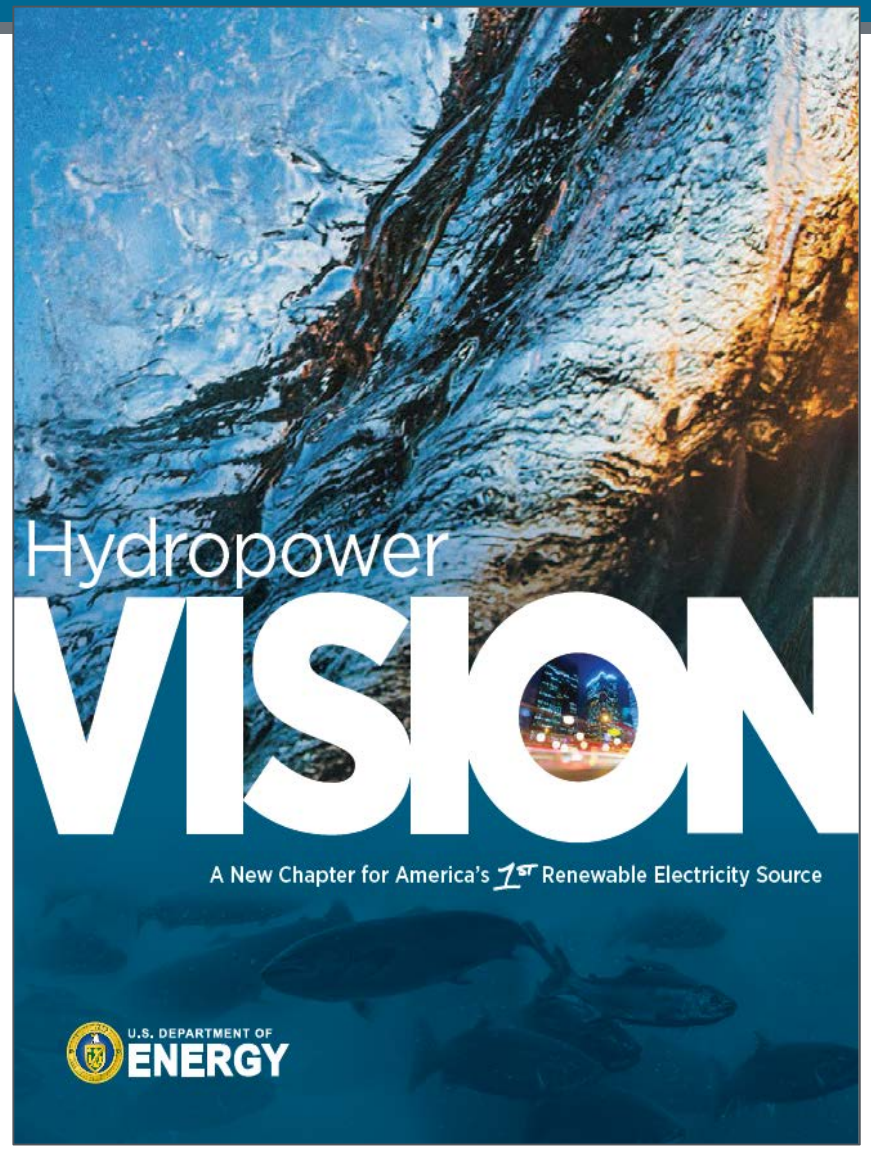
Relationship of a Hydropower Program Strategy to the Hydropower Vision Study

- In 2016, the DOE released the *Hydropower Vision* study, **which evaluated many different potential future opportunities for the U.S. hydropower** and pumped storage industry over the course of coming decades

- This study was developed with **input from dozens of organizations and hundreds of individuals from outside the Department**, and was based on three equally important foundational principles: opportunities for growth, the need to optimize and maintain existing assets, and the need to improve sustainability and environmental stewardship.

- **The study also contained a *Roadmap***, usable by all industry stakeholders to identify actions that could be taken to support the long-term advancement of the U.S. hydropower industry in-line with the foundational principals of the *Vision*

- WPTO's Hydropower Program Strategy seeks to identify those early stage R&D activities that would be appropriate for the Department to support over the next decade, that are aligned with the opportunities identified in the *Vision* study and objectives of the *Roadmap*



Relationship Amongst Approaches

DOE Hydropower Program Strategy

Hydropower Program's Strategic Approaches

Big-Data Access and Management

Environmental R&D and Hydrological Systems Science

Impact Hydro Growth	, Upgrades, and Security	Reliability, Resilience, and Storage

Big-Data Access and Management

Environmental R&D and Hydrologic Systems Science

Technology R&D for Low-Impact Hydropower

Modernization, Upgrades and Security

Grid Reliability, Resilience, and Storage

MORE COST-EFFECTIVE HYDRO & MORE FLEXIBLE / VALUABLE HYDRO AND PUMPED STORAGE

Challenges for Hydropower and Pumped Storage in the U.S.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Challenges

Untapped Potential for Hydro & PSH to Better Support Grid Reliability & Integration of Other Energy Resources

- The electric system is changing rapidly, and existing hydropower and PSH systems were originally optimized to operate under very different conditions
- **Significant gaps in information about the costs to hydro and PSH in providing grid reliability and resiliency services.**
- **Hydropower flexibility is constrained by a range of variables including licensing requirements and other water uses**
- **There has been relatively little attention or research into these areas, especially on the development of new PSH systems.**

Limited Opportunities for New, Affordable Generation Growth Given Existing Hydro Technologies

- Remaining new hydro resources (including non-powered dams and new stream-reaches) are smaller, lower-head, more diverse and distributed, and require new technologies to be cost-competitive
- There can be significant environmental impacts with existing hydro designs / systems; it has been difficult to develop more hydro using existing technologies and meet ecological objectives
- There is a lack of infrastructure and capabilities to test and validate new technologies and designs

Maintaining Cost-Competitiveness and Security of Existing Hydropower Assets Given Fleet Age

- Introduction of new technologies and upgrades of the existing fleet occur over long time periods given longevity of assets
- Hydropower facilities are extremely different from one another, with wide ranges of operational and physical characteristics and limited information availability
- Hydropower and PSH plants are increasingly connected to information technology systems which heighten cybersecurity risks
- Effective application of digitization requires a heretofore unestablished "right sized" focus on information and analytics

Addressing Environmental Impacts and Balancing Multiple Uses for Water

- The many uses of/for water itself make development and operation of hydropower complicated, with many different variables and sensitivities to be considered
- There are analytical challenges in evaluating tradeoffs, and management objectives (environmental, recreational, irrigation, etc.) that are changing, and sometimes unclear and difficult to reconcile
- Hydropower plants and the environments they are deployed in are both extremely diverse
- There are remaining scientific knowledge gaps around biology, behavior and interaction of many species with hydropower facilities (including

Lack of Access to Information Necessary to Support Decision-Making

- Information on technologies, available resources, species distribution, markets, etc. is widely dispersed, of differing qualities, and difficult to identify and gain access to
- Regulatory processes are cost and time-intensive, and there is poor information and data available / accessible on regulatory process outcomes and drivers

Challenges

Untapped Potential for Hydro & PSH to Support Grid Reliability & Integration	Limited Opportunities for New, Affordable Growth Given Existing Technologies	Maintaining Cost-Competitiveness and Security of Existing Assets Given Fleet Age	Addressing Environmental Impacts and Balancing Multiple Uses for Water	Lack of Information Necessary to Support Decision-Making

Approaches

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

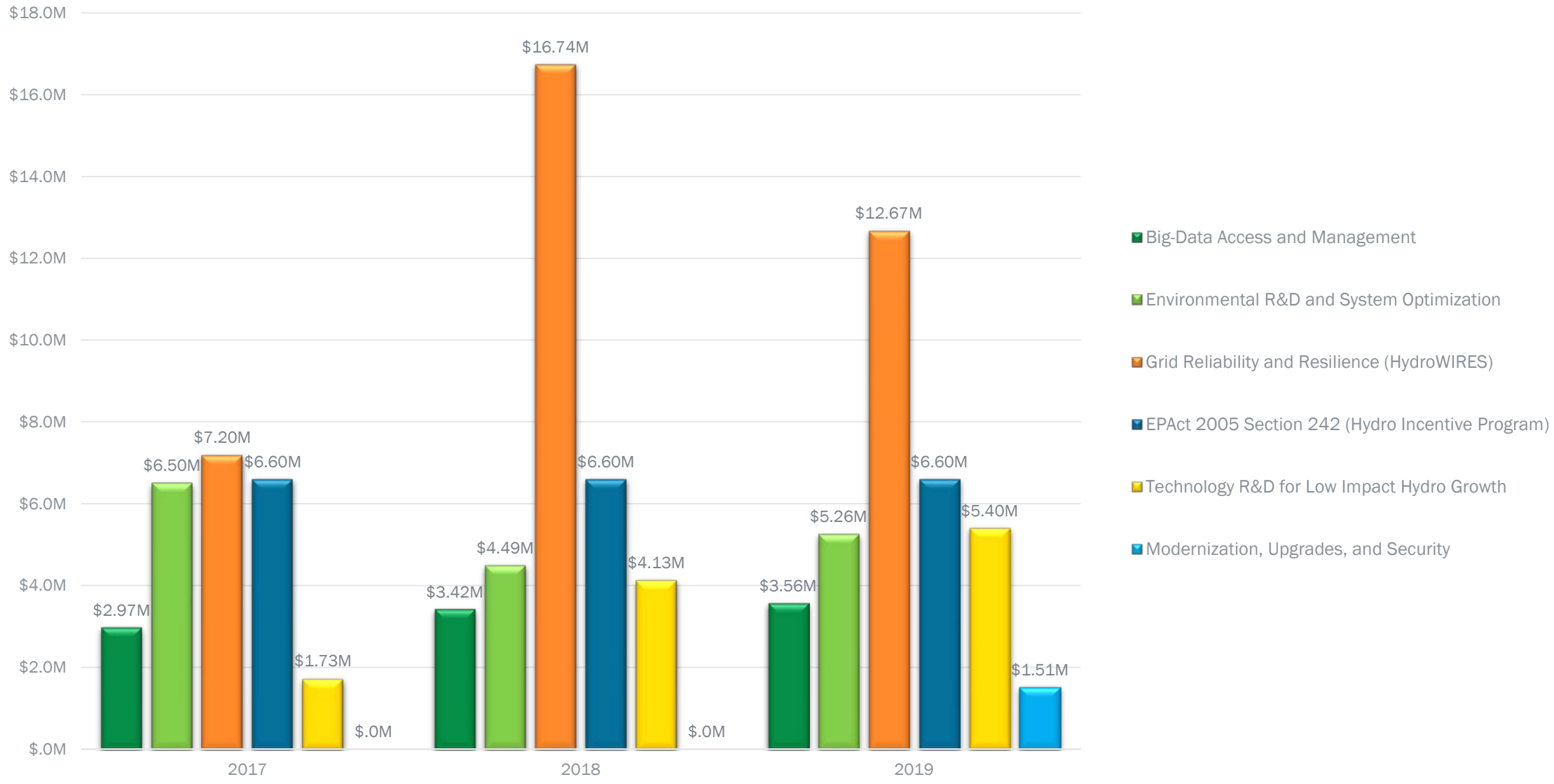
WPTO will post its Hydropower Program Strategy for public comment

The Hydropower Program has plans to launch a public Request for Information (RFI) to solicit feedback from stakeholders on its revised programmatic strategy in 2019. The objectives of the revised hydropower strategy is to:

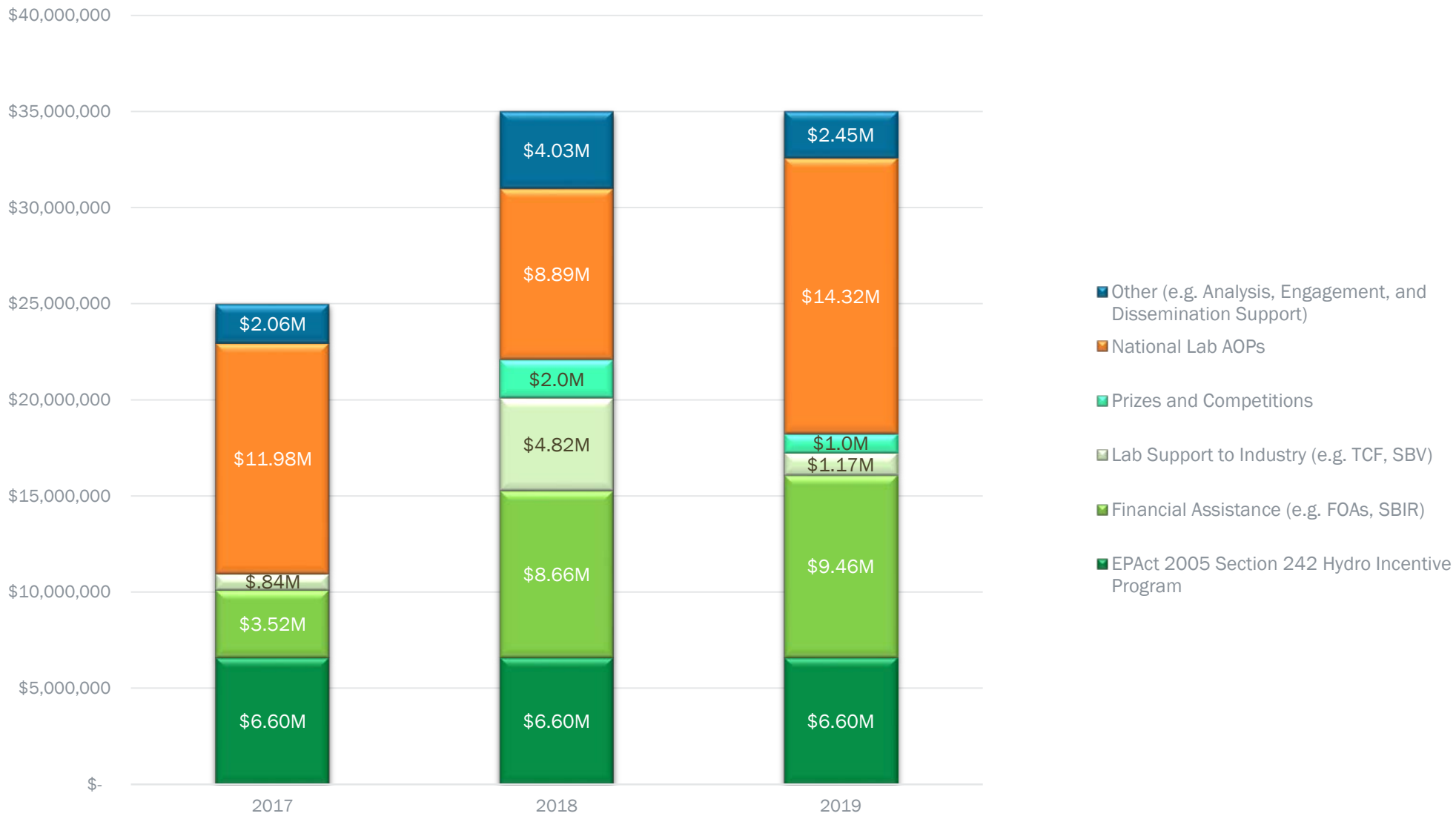
- Clearly communicate the rationale for and organization of possible DOE supported Hydropower R&D from now to 2030
- Identify activities that the DOE Hydropower Program can take to increase the competitiveness and grid resiliency / reliability contributions of U.S. hydropower and pumped storage
- Understand where DOE can have the most important impacts related to needs identified in the *Hydropower Vision Roadmap*
- Help to focus Program activities to create greatest impact on new technology and industry advancement
- Clearly communicate the potential benefits and opportunities for hydropower to a wide audience

Note: The strategy focuses on the Water Power Technology Office's (WPTO) Hydropower Program support for early-stage research and development, and therefore does not focus on challenges, approaches or activities that are outside of the authority or mission of the DOE.

FY17-FY19 Hydropower budget by activity area/program approach



FY17-FY19 Hydropower budget by funding mechanism



Alignment with the Program

Hydropower Program Strategic Priorities

Big-Data Access and Management

Environmental R&D and Hydrologic Systems Science

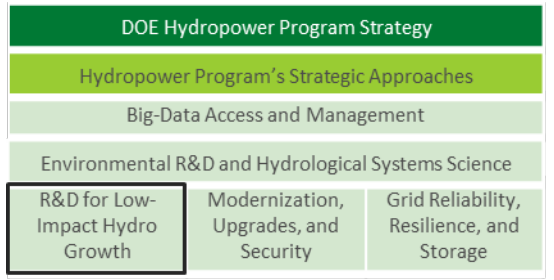
Technology R&D for Low-Impact Hydropower Growth

R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet

Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

Technology R&D for Low-Impact Hydropower Growth

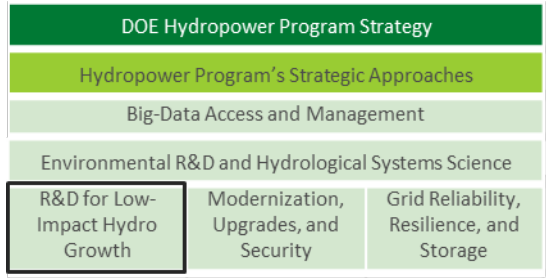
- Understand the needs of the rapidly evolving grid and how they create opportunities for hydropower and PSH.
- Investigate the full range of hydropower's capabilities to provide grid services, as well as the machine, hydrologic, and institutional constraints to fully utilizing those capabilities.
- Optimize hydropower operations and planning—alongside other resources—to best utilize hydropower's capabilities to provide grid services.
- Invest in innovative technologies that improve hydropower capabilities to provide grid services.



Non-Powered Dams and Conduits

New Stream-Reach Development

Composite Archimedes Hydrodynamic Screw (CAHS) turbine



35kW prototype testing at Utah Water Research Laboratory

Courtesy of Percheron Power and Utah State University

- Lower installed costs and improved hydraulic efficiencies compared to steel
- Individual blade segments produced using advanced manufacturing techniques
- Prior to testing, Percheron received assistance from Pacific Northwest National Laboratory to optimize and validate the CAHS shape and design

Alignment with the Program

Hydropower Program Strategic Priorities

Big-Data Access and Management

Environmental R&D and Hydrologic Systems Science

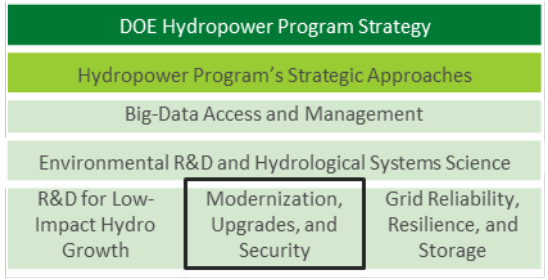
Technology R&D for Low-Impact Hydropower Growth

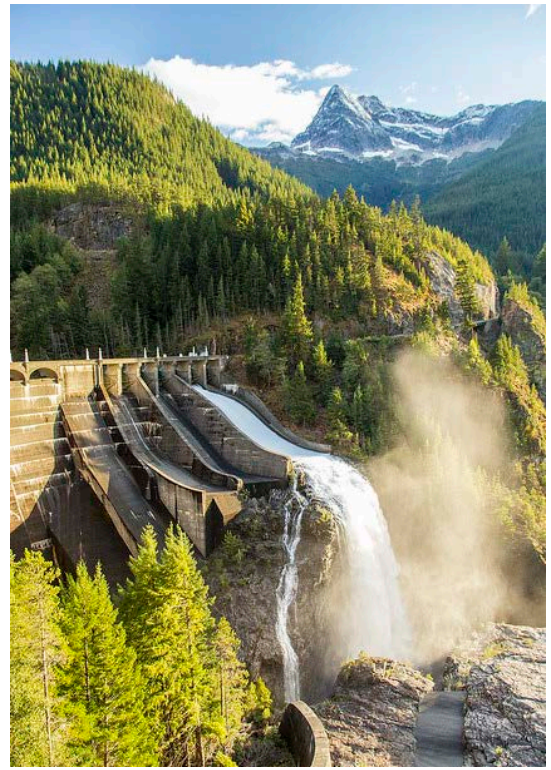
R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet

Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet

- Create mechanisms to classify diverse hydropower plants by mechanical and cyber-physical systems, providing better characterization of the fleet and allowing identification of exemplary facilities / practices
- Advanced technology solutions and data evaluation to improve equipment longevity and condition based repair
- Creation of cybersecurity tools and studies which help enhance the security of critical dam infrastructure by articulating the cybersecurity target, risk and recovery landscape
- Develop cross-cutting digitalization systems and advanced sensor suites to empower data driven decisions on O&M and asset management



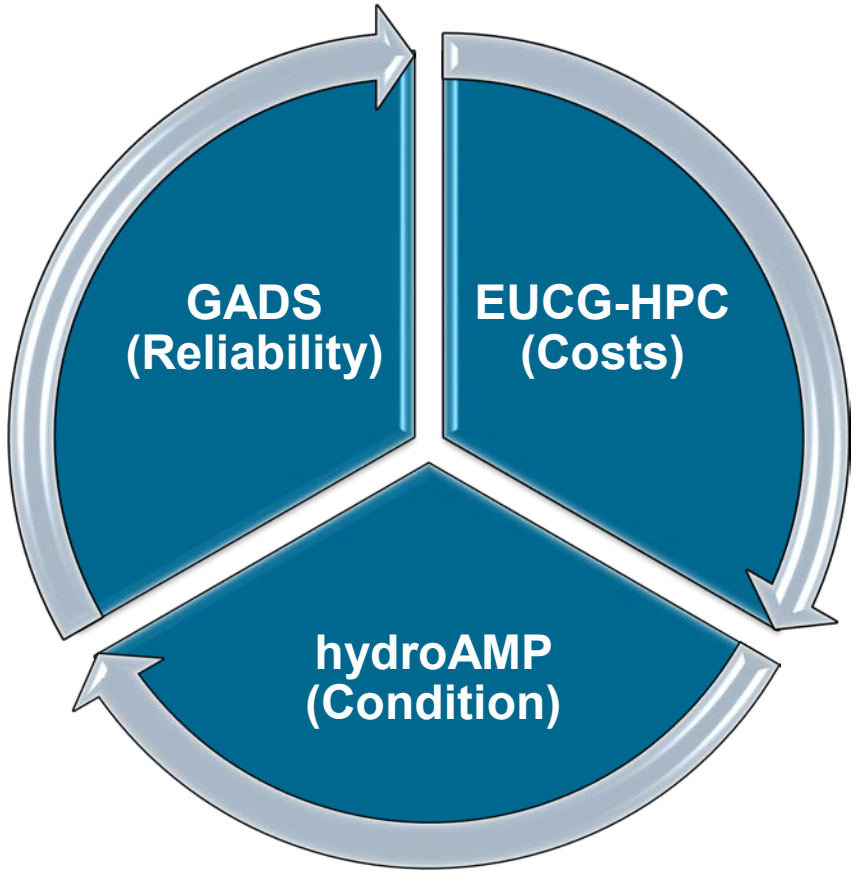


Hydropower Fleet Intelligence

Data collection, synthesis and analysis to assess relationships between cost, condition, and reliability in the context of changing operations

OAK RIDGE National Laboratory

DOE Hydropower Program Strategy		
Hydropower Program's Strategic Approaches		
Big-Data Access and Management		
Environmental R&D and Hydrological Systems Science		
R&D for Low-Impact Hydro Growth	**Modernization, Upgrades, and Security**	Grid Reliability, Resilience, and Storage



Example Questions

- How can operational variability/cycling be classified?
- Is operational variability changing? If so how/where?
- Is there a measureable maintenance/cost impact of operational variability?
- How can plants be run to minimize maintenance requirements?

Alignment with the Program

Hydropower Program Strategic Priorities

Big-Data Access and Management

Environmental R&D and Hydrologic Systems Science

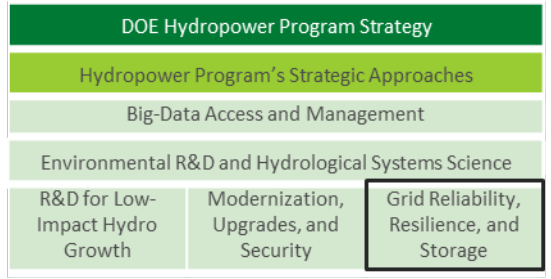
Technology R&D for Low-Impact Hydropower Growth

R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet

Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

HydroWIRES (Water Innovation for a Resilient Electricity System)

The HydroWIRES (Water Innovation for a Resilient Electricity System) portfolio is organized into four interrelated research areas. Five national laboratories are investigating **the contribution of hydropower resources to the reliability and resiliency of the national electric power system**.



Value under Evolving System Conditions
Understand the needs of the rapidly evolving grid and how they create opportunities for hydropower and PSH.
"What will the grid need?"

Capabilities and Constraints
Investigate the full range of hydropower's capabilities to provide grid services, as well as the machine, hydrologic, and institutional constraints to fully utilizing those capabilities. *"What can hydropower do?"*

Operations and Planning
Optimize hydropower operations and planning—alongside other resources—to best utilize hydropower's capabilities to provide grid services.
"How can hydropower best align what it can do with what the grid will need?"

Technology Innovation
Invest in innovative technologies that improve hydropower capabilities to provide grid services.
"What new technology could expand what hydropower can do to meet grid needs?"

HydroWIRES
U.S. DEPARTMENT OF ENERGY

Argonne NATIONAL LABORATORY

INL Idaho National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

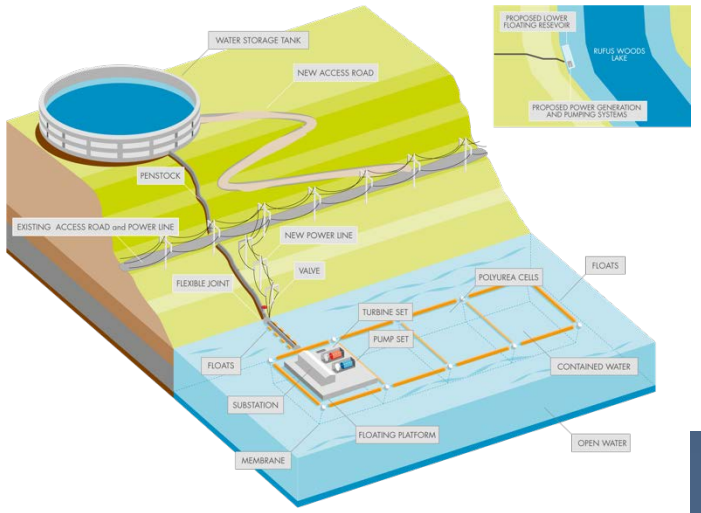
OAK RIDGE National Laboratory

Pacific Northwest NATIONAL LABORATORY

Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

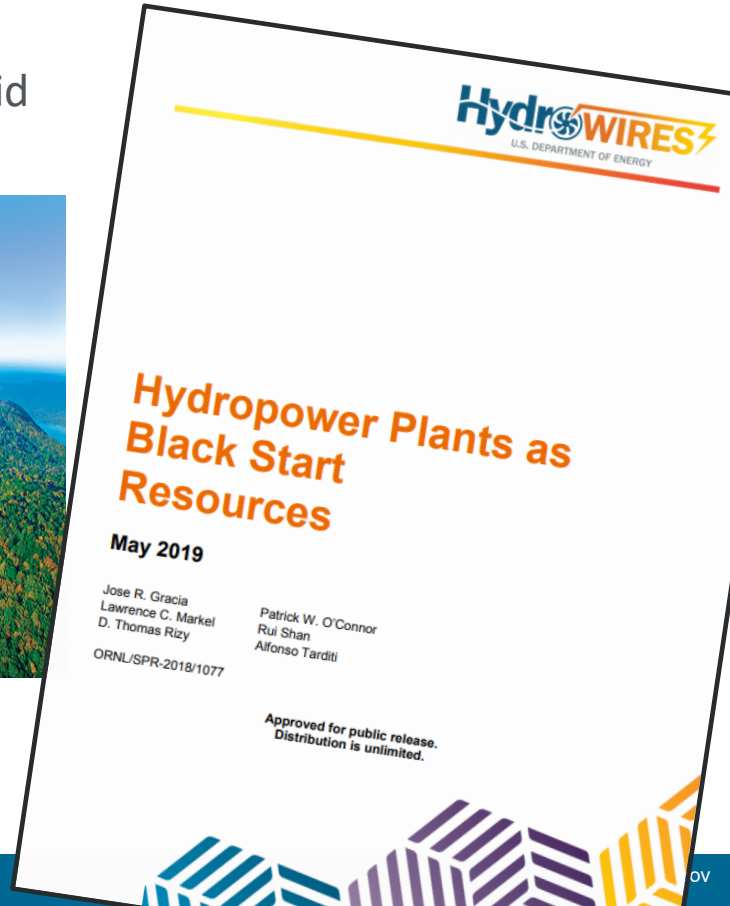
- Understand the needs of the rapidly evolving grid and how they create opportunities for hydropower and PSH.
- Investigate the full range of hydropower's capabilities to provide grid services, as well as the machine, hydrologic, and institutional constraints to fully utilizing those capabilities.
- Optimize hydropower operations and planning—alongside other resources—to best utilize hydropower's capabilities to provide grid services.
- Invest in innovative technologies that improve hydropower capabilities to provide grid services.

DOE Hydropower Program Strategy		
Hydropower Program's Strategic Approaches		
Big-Data Access and Management		
Environmental R&D and Hydrological Systems Science		
R&D for Low-Impact Hydro Growth	Modernization, Upgrades, and Security	Grid Reliability, Resilience, and Storage



AMERICAN MADE WATER PRIZE
U.S. DEPARTMENT OF ENERGY

American-Made FAST Commissioning for Pumped-Storage Hydropower Prize
Furthering Advancements to Shorten Time to Commissioning


HydroWIRES
U.S. DEPARTMENT OF ENERGY

Hydropower Plants as Black Start Resources

May 2019

Jose R. Gracia
Lawrence C. Markel
D. Thomas Rizy
Patrick W. O'Connor
Rui Shan
Alfonso Tarditi

ORNL/SPR-2018/1077

Approved for public release.
Distribution is unlimited.

Techno-economic studies of pumped storage

DOE national labs are developing a **methodology guidebook and tool** to improve PSH valuation under different system conditions.

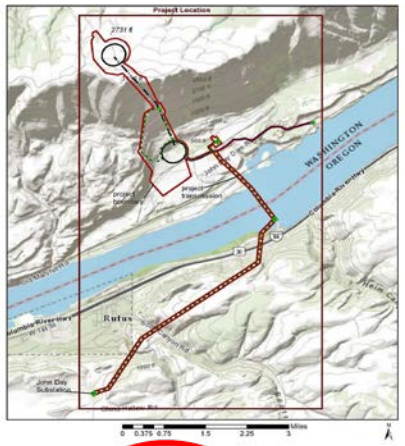
DOE Hydropower Program Strategy		
Hydropower Program's Strategic Approaches		
Big-Data Access and Management		
Environmental R&D and Hydrological Systems Science		
R&D for Low-Impact Hydro Growth	Modernization, Upgrades, and Security	Grid Reliability, Resilience, and Storage

Two proposed pumped storage projects – Goldendale and Banner Mountain -- will receive **a detailed valuation analysis of the economic value of the project based on the market, location, and plant characteristics.**

Goldendale

GridAmerica Holdings, Inc.

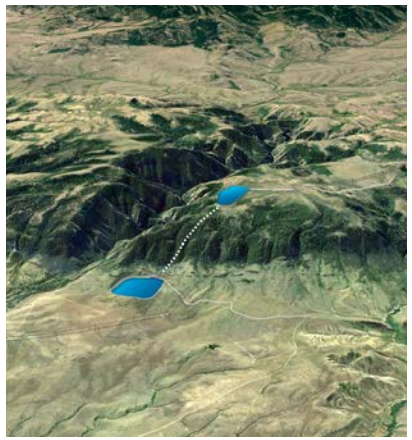
Closed loop, variable speed, 1.2 GW project in the WA/OR border

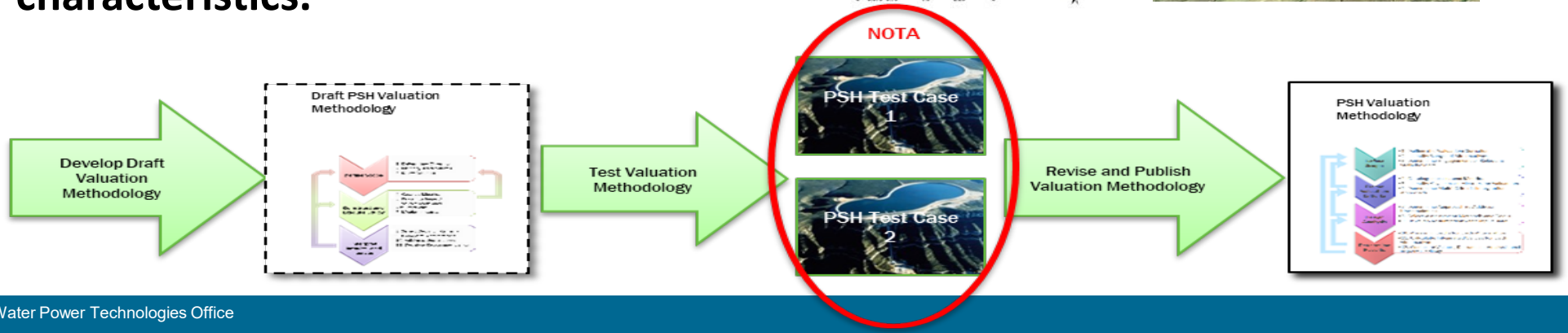


Banner Mountain

Absaroka Energy, LLC

Closed loop, ternary, 400 MW project in central Wyoming





Alignment with the Program

Hydropower Program Strategic Priorities

Big-Data Access and Management

Environmental R&D and Hydrologic Systems Science

- Technology R&D for Low-Impact Hydropower Growth
- R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet
- Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

Big-Data Access and Management

- Help industry to manage large, disparate and dissimilar datasets relevant for performance, operations, costs, maintenance, permitting, and environmental mitigation
- Support comprehensive reviews of historical regulatory process drivers and outcomes
- Identify information-sharing mechanisms that could increase coordination among permitting agencies
- Develop effective methods of communicating process complexities to non-technical stakeholders

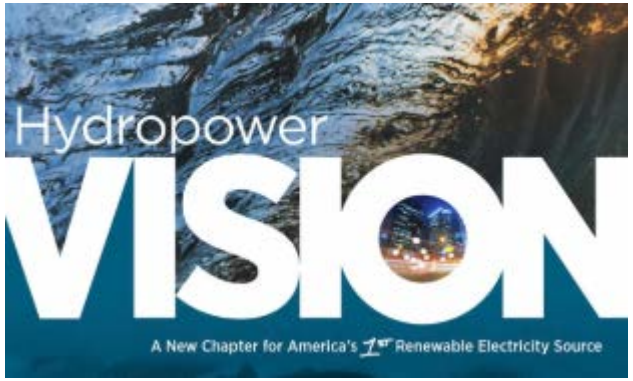
DOE Hydropower Program Strategy

Hydropower Program's Strategic Approaches

Big-Data Access and Management

Environmental R&D and Hydrological Systems Science

R&D for Low-Impact Hydro Growth	Modernization, Upgrades, and Security	Grid Reliability, Resilience, and Storage



OAK RIDGE National Laboratory

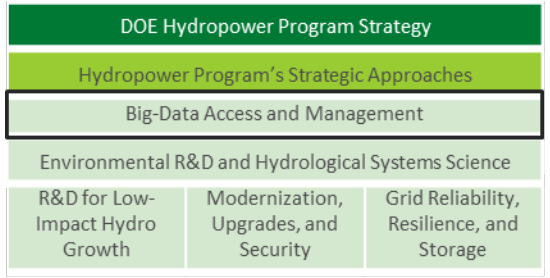
Search

HydroSource

Geospatial Tools | Market Info and Data | Hydropower Potential | Environmental Information | Resources | Contact Us

Regulatory & Permitting Information Desktop Toolkit (RAPID) for hydropower & pumped storage

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



The RAPID Toolkit is designed to **increase transparency, decrease uncertainty and reduces time and costs** of developing and re-licensing hydropower projects.

RAPID *Regulatory and Permitting Information Desktop Toolkit*

OpenEI

RAPIDToolkit.org

Regulations and Permitting Database

Regulatory and permitting information by jurisdiction, including comparisons between jurisdictions

Reference Library

A collection of links to regulatory and permitting documents, regulations, and tools available on other websites

Best Practices

A collection of best practices for efficiently permitting renewable energy and bulk transmission projects

Alignment with the Program

Hydropower Program Strategic Priorities

Big-Data Access and Management

Environmental R&D and Hydrologic Systems Science

Technology R&D for Low-Impact Hydropower Growth

R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet

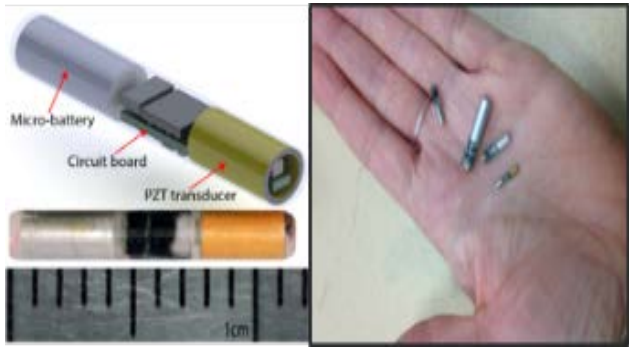
Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

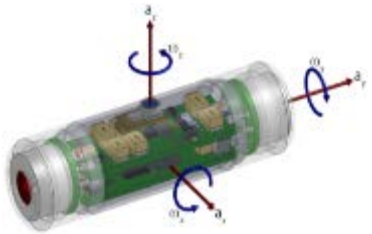
Environmental R&D and Hydrologic Systems Science

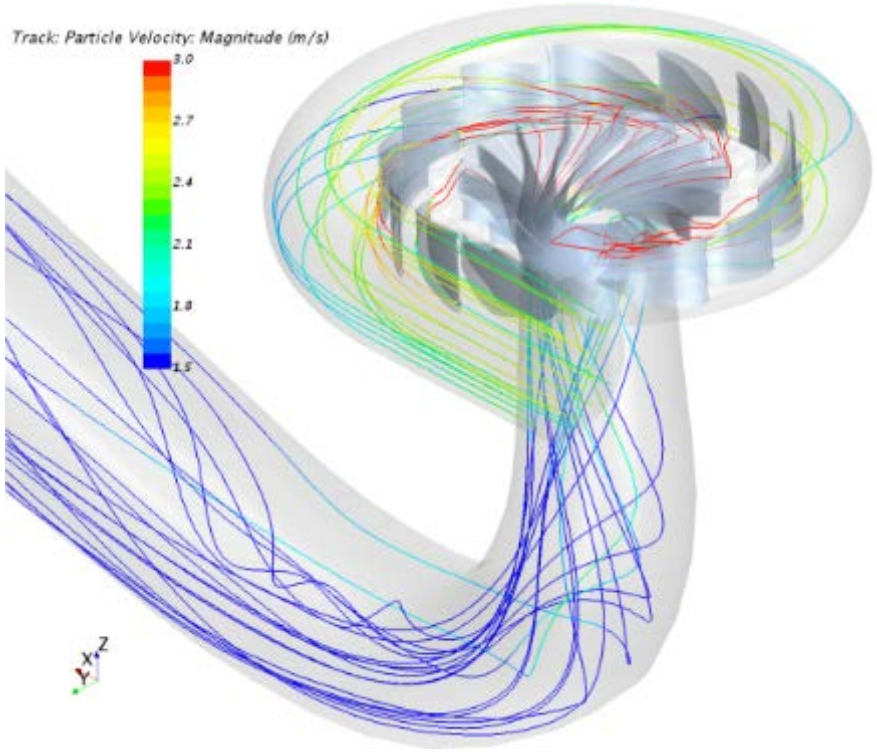
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Develop better monitoring technologies to evaluate environmental impacts
- Develop technologies and strategies that avoid, minimize, or mitigate ecological impacts
- Support development of metrics for better evaluating environmental sustainability for new hydropower developments
- Assess potential impacts of long-term hydrologic variations to hydropower generation and flexibility
- Improve abilities to assess potential methane emissions from reservoirs
- Better identify opportunities and weigh potential trade-offs across multiple objectives at basin-scales

DOE Hydropower Program Strategy		
Hydropower Program's Strategic Approaches		
Big-Data Access and Management		
Environmental R&D and Hydrological Systems Science		
R&D for Low-Impact Hydro Growth	Modernization, Upgrades, and Security	Grid Reliability, Resilience, and Storage







Fish passage funding

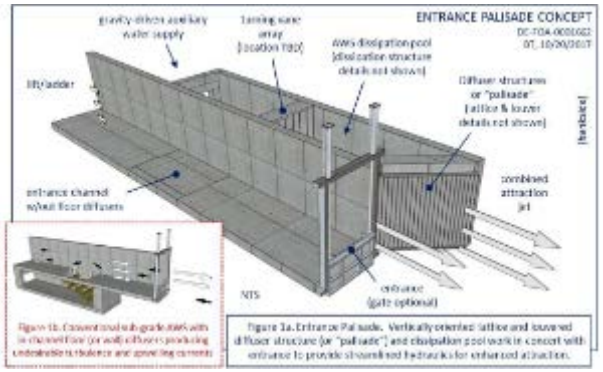
DOE Hydropower Program Strategy		
Hydropower Program's Strategic Approaches		
Big-Data Access and Management		
Environmental R&D and Hydrological Systems Science		
R&D for Low-Impact Hydro Growth	Modernization, Upgrades, and Security	Grid Reliability, Resilience, and Storage

Testing the Effects of Innovative Fish Passage Technologies

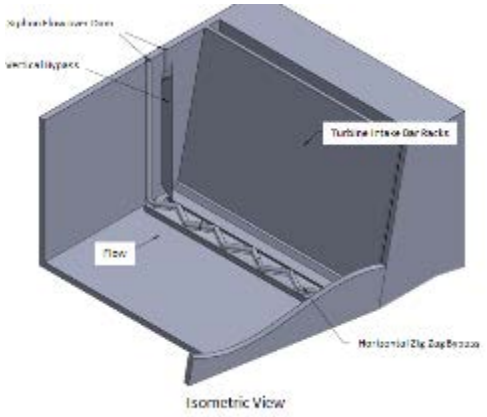
- Alden Research Laboratory, Inc.:
  - ***Modular and Scalable Downstream Passage Systems for Silver American Eels***
- University of Massachusetts Amherst
  - ***Fishway Entrance Palisade***

Advancing Innovative Methods and Technologies to Improve Fish Passage

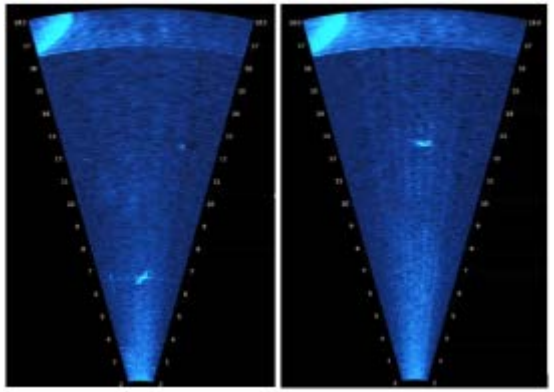
- Electric Power Research Institute
  - ***Machine Learning and Data Analytics for Automated Detection, Identification, Enumeration, and Tracking of Migrating Adult Eels from Sonar Data***



University of Massachusetts Amherst

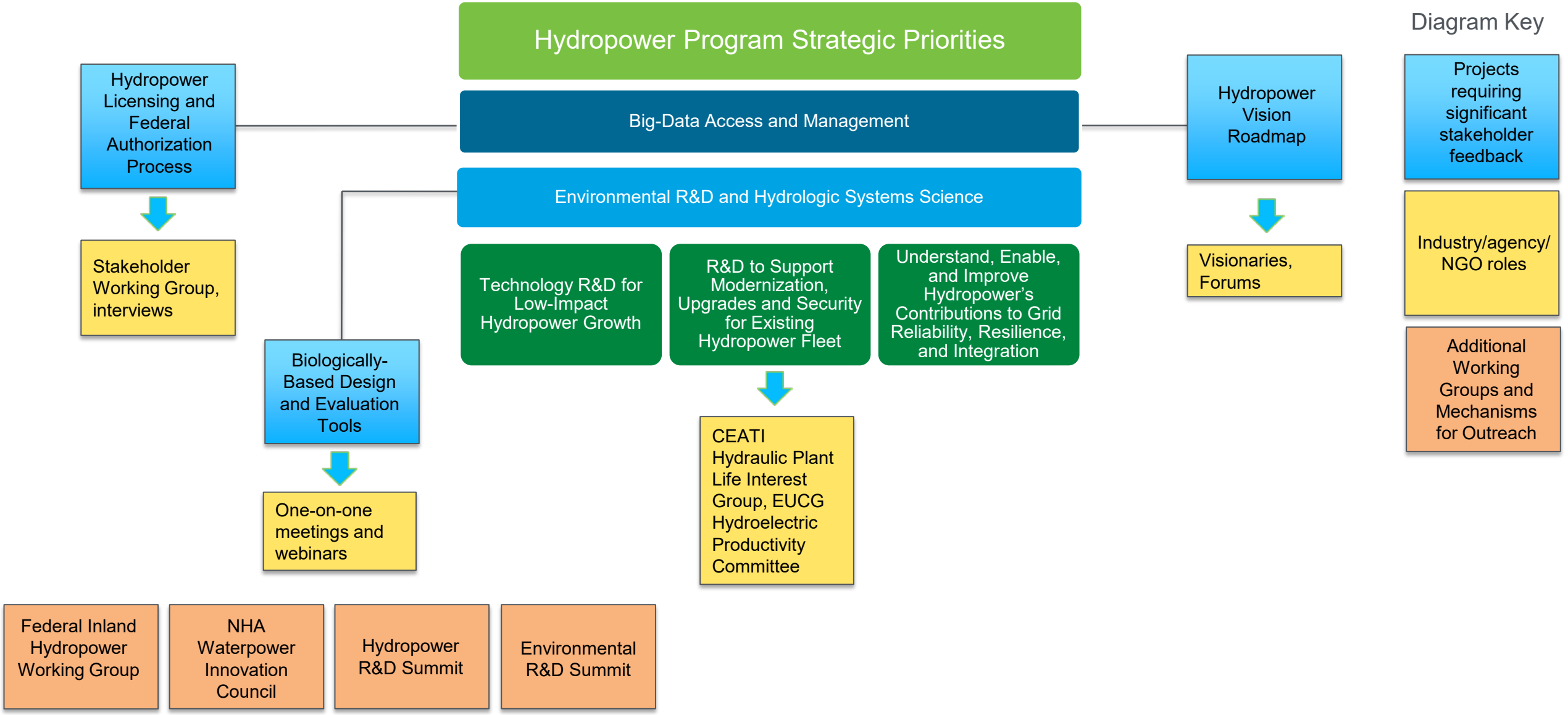


Alden Research Lab



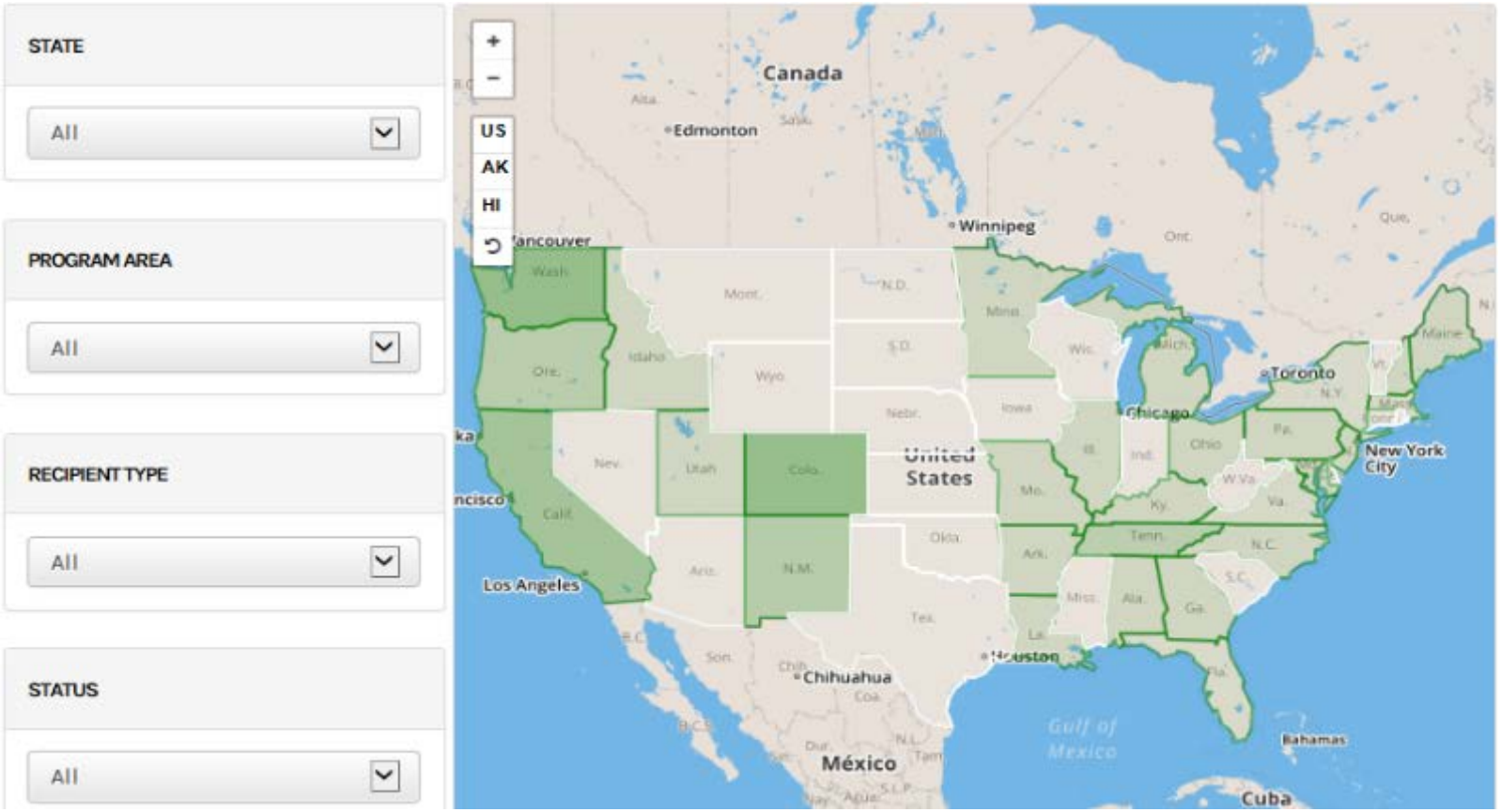
Electric Power Research Institute

Vision, Approaches, and Projects: Stakeholder Feedback



Learn about more WPTO projects with our projects map

- Interactive map
- Provides information on WPTO's R&D portfolio
- Features multiple filters to isolate specific details on DOE hydropower and marine energy projects throughout the U.S.
- Contains historical information on completed projects with associated materials, research findings, and publication links



https://energy.gov/eere/water/water-power-technologies-office-projects-map