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

Expanding Hydropower and Pumped Storage's Contribution
to Grid Resiliency and Reliability
RFI#: DE-FOA-0001886

DATE: February 21, 2018

SUBJECT: Request for Information (RFI)

RESPONSE DUE: April 6, 2018

DESCRIPTION: The United States Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE), Water Power Technologies Office (WPTO) seeks information from the public on understanding, accessing, and utilizing the full potential of the hydropower fleet, including pumped storage, to contribute to electric grid resiliency and reliability; as well as opportunities for the existing and potential pumped storage and hydropower fleet to expand its contribution in the future. This information will help WPTO develop a research portfolio that intends to lower system costs, bring insight to hydropower technology development and research investments, promote optimization of hydroelectric resources, and ultimately support a more secure and reliable electric power system. WPTO seeks concise feedback from all relevant stakeholders.

BACKGROUND: In the last two years, DOE produced foundational reports that describe the evolution of the nation's power system and the role of generating technologies, including hydropower, in assuring grid stability and performance. In July 2016, the Hydropower Vision Report provided a baseline condition for technical performance and illustrated challenges and opportunities to expansion.[1] In January 2017, the Quadrennial Energy Review (QER) Second Installment documented the rising importance of resiliency and stated that traditional methods of valuation are "strained" under the electric system's technology evolution.[2] In August 2017, the Staff Report to the Secretary on Electricity Markets and Reliability pointed out that along with traditional thermal resources, hydropower plants "provide essential reliability services… critical to system resilience."[3]

In Fiscal Year (FY) 2017, Congress directed WPTO to produce techno-economic analysis of the value of pumped storage hydropower at two sites with high levels of intermittent renewable energy generation. As a result, WPTO is requesting information through Topic 1 of this RFI about the most effective way to fulfill this direction. In addition, WPTO is requesting information about Topics 2 – 5, described below, including the following areas of inquiry: an assessment of how well hydropower capabilities and costs are aligned with system demands

[1] *Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Source*. July 2016. https://energy.gov/eere/water/articles/hydropower-vision-new-chapter-america-s-1st-renewable-electricity-source

[2] Available at https://www.energy.gov/epsa/quadrennial-energy-review-second-installment

[3] Available at https://www.energy.gov/staff-report-secretary-electricity-markets-and-reliability

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI.

[Topic 2: Hydropower Capability, Operational Impacts, and Costs]; a complete understanding of hydropower participation in the current energy landscape [Topic 3: Current Operations Landscape]; and forecasted future system conditions and subsequent effects on hydropower resources [Topic 4: Role and Value of Hydropower in Future Power Systems]. The final topic of the RFI is related to the extent and focus areas of future research, including the importance of financing models and international engagements [Topic 5: Additional Research Needs].

PURPOSE: Through this RFI, WPTO seeks input on new research to maximize the value of hydropower's contribution to grid resiliency and reliability today and into the future. This strategy includes pumped storage and traditional hydropower, and covers both new technology design as well as modeling and analysis to assess the range of value streams hydropower provides in the current and future power grid. This research will build targeted insight into economic, policy and technological barriers, inform future hydropower technology development, and improve the tools by which investment and operational decisions are made.

WPTO seeks feedback from electric utilities, reliability oversight entities, regulatory commissions, electricity market operators, electric storage developers, hydropower owners and operators, federal hydropower asset managers and marketers, hydropower facility regulators, public and private financing institutions, environmental and recreational non-profits, industry associations, academia, research laboratories, government agencies, and other stakeholders on issues related to pumped storage hydropower and existing hydroelectric facilities. WPTO is specifically interested in understanding critical gaps in pumped storage and hydropower valuation data and analysis; and in barriers to expanding pumped storage and hydropower's value proposition that could be overcome through research investments.

REQUEST FOR INFORMATION

TOPICS AND QUESTIONS

TOPIC 1: TECHNO-ECONOMIC ANALYSIS OF PUMPED STORAGE HYDROPOWER AT TWO SITES

As noted in the RFI preamble, Congress directed WPTO to conduct techno-economic analysis of "two sites with high-levels of intermittent renewable energy generation in the United States."

With respect to this direction, WPTO seeks comments from interested parties on the following issues:

- How should WPTO define "high-levels of intermittent renewable energy generation in the United States?" For example, how should we define proximity to renewable generation? What is the appropriate threshold for "high-levels?"
- What development status must a site achieve in order to provide the information and conditions necessary for successful performance of this techno-economic analysis? For

example, should WPTO require a preliminary permit, a draft license application, or letter from a potential off-taker?

TOPIC 2: HYDROPOWER CAPABILITY, OPERATIONAL IMPACTS, AND COSTS

Hydropower projects supply a unique suite of services to the nation's electrical grid. The capabilities of individual hydropower projects vary substantially due to a wide array of factors, including unit and project design choices, technology age and condition, competing water uses and environmental considerations which create operational constraints, and institutional arrangements. In addition, the demand for these capabilities is changing with a less predictable power system with new operational realities.

WPTO seeks comments from interested parties on the following issues:

- The impacts and costs of operating hydropower in a changing grid, ranging from impacts on operations and maintenance costs to the opportunity cost of water
- The extent to which units in the existing hydropower and pumped storage fleet have the characteristics to provide anticipated high-value services
- Innovations or cost reduction pathways for enabling technologies, including new design specifications for turbines, pump-turbines, generators and hydropower components that reduce costs and/or increase efficiency in flexible operations (for example, frequent start-stops, operations at lower loads, faster ramping)
- Design and technology choices (for example, turbine design, pumped storage configuration, unit sizing) that affect a project's capabilities to deliver additional system benefits, and how a project proponent evaluates and selects among these options

In addition, interested parties are encouraged to answer any or all of the following questions.

1. Nationally, there is increasing demand for generating resources that can provide fast and accurate response, high-volume ramping of energy injection and absorption, resiliency and flexibility. Are there technical, market, or other limitations to hydropower and pumped storage projects in providing these services? What are the barriers to addressing those limitations?
2. Are there documented instances of dramatically changed operational practices of existing hydropower or pumped storage projects in response to new market designs, extreme events, or grid demands? For example, are units operating at broader ranges, increasing starts and stops, experiencing faster ramps, or other altered dispatch patterns to accommodate or take advantage of new system conditions or needs? Please provide material examples.
3. Are there potential technology innovations – for example, new governor controls and algorithms or electro-mechanical equipment components– that could significantly improve hydropower's capabilities to provide electric system reliability and resiliency?

Are there established technology solutions that could improve these capabilities but which are not utilized?

4. How are hydropower operations and maintenance (O&M) and capital budgeting practices informed by changing system conditions?

TOPIC 3: CURRENT OPERATIONS LANDSCAPE

Hydropower resources operate in a variety of environments and institutional frameworks, such as participating in organized markets, serving customer obligations through federal power marketing, independent power production under contract, and direct service in vertically-integrated utilities, which may be publicly owned or investor owned. These frameworks – as well as system conditions, market prices, and licensing requirements – present different value drivers to hydropower resources. The potential contribution of hydropower to grid operations has been explored in a general way in a variety of research and industry publications, including the Hydropower Vision.

WPTO seeks comments from interested parties on the following issues:

- Current operational practices of existing hydropower and pumped-storage units in support of balancing the power grid and the extent of their provisions of various grid services
- Data or knowledge gaps regarding hydropower contributions to grid resiliency and reliability
- Material examples of hydropower and pumped storage contributing to grid resiliency
- Benefits from hydropower resources that are not incentivized or compensated in US power markets
- Evaluation of system-wide benefits of hydropower resources
- Regulatory and market barriers to development of new pumped storage projects
- System characteristics in which bulk energy storage has the greatest value
- Unique bulk energy storage use cases or value streams
- Licensing requirements that limit expanded development or flexible operations

In addition, interested parties are encouraged to answer any or all of the following questions.

1. What system and market characteristics incentivize hydropower or pumped storage development? Provide specific examples.
2. Are there specific examples of systems or facilities where hydropower is not able or fully incentivized to maximize its value to ensuring grid reliability and resiliency? Examples could include license requirements or structural or functional aspects of regulated competitive markets that prevent hydropower resources from efficient contribution.
3. Is there published evidence of hydropower or pumped storage contributing critical resiliency benefits in the event of a grid disruption? Please provide citations or data references.

4. State and federal energy storage programs and policies are under development across the country. Do these programs and policies include pumped storage? Are there indirect effects of the program or policy design that promote or preclude pumped storage? For example, do programs or policies focus on specific applications and use cases?
5. Pumped storage represents over 95% of the deployed energy storage in the United States, with large projects dispersed across the country with decades of operating experience.[4]
    a. What if any challenges currently exist to optimized economic operation of pumped storage hydropower?
    b. How can the operation of pumped storage hydropower in today's electricity markets be optimized to maximize the economic and reliability benefits for the system?
    c. How do these challenges influence new pumped storage development and design decisions (scale, siting, and technology options)?
6. Other than renewable portfolio standards, are there examples of federal, state, or local *energy* policies that directly incentivize or limit hydropower operation?
7. Certain permitting and licensing requirements may change operating parameters and directly affect project economics. For example, gradually releasing water (i.e. slower ramp rates) may benefit river ecology and recreation downstream, but the limitation may also prevent hydropower projects from effectively contributing important energy benefits. Please share examples where this tradeoff was clear and substantial, where it created a particularly acute economic outcome, or where external conditions have changed from the time of the requirement to present day that would have led to a different result.

TOPIC 4: ROLE AND VALUE OF HYDROPOWER IN FUTURE POWER SYSTEMS

In the past decade, there has been a transformation in how the grid and power system are operated, influenced by the integration of variable renewable generation from wind and solar resources. In the future, electric vehicles, distributed energy resources, smart grid functions, emerging technologies, and other changes could further affect grid operations. Flexible hydropower plants historically allowed thermal resources such as nuclear and coal generating facilities to maintain optimal operations, which in turn permitted efficient use of fuel and reduced life-cycle plant costs. Continued evolution of market products, regulatory climate, and resource composition may offer new opportunities and challenges for hydropower. It is unclear how near-term and long-term system scenarios make hydropower more or less valuable.

WPTO seeks comments from interested parties on the following issues:

- Role of hydropower in the national energy future
- Data and modeling gaps in quantifying the physical and economic contribution of traditional hydropower resources and pumped storage hydropower

[4] *See* Chapter 2.7 Pumped Storage Hydropower, from the Hydropower Vision, 2016.

In addition, interested parties are encouraged to answer any or all of the following questions.

1. Significant research has evaluated system effects of wind and solar resources at scales, deployment scenarios, and penetration levels over various time horizons, with assumptions regarding energy efficiency and natural gas. Are there published studies that demonstrate significant benefits of, or a reliance on, hydropower resources, growth in hydropower generation, or other notable findings for the hydroelectric sector in order to achieve future energy system goals? For example, do these studies make a connection between the presence of hydroelectric resources and lower system costs, increased unit availability, lower emissions, and increased variable generation? Please provide citations and an explanation.
2. What specific essential reliability services are likely to be of greatest value to grid conditions in the near- to medium-term future? What (if any) new or changed market or procurement mechanisms would be beneficial to appropriately incentivize those high-value services and characteristics?
3. As an energy storage technology, pumped storage hydropower benefits many aspects of grid operation. What should be improved in valuation analysis to properly capture and assess the value of pumped storage services and contributions to the grid?
4. Do available models adequately provide an effective assessment of pumped storage capabilities, the costs of providing those capabilities, and the respective benefits?
    a. If not, do these gaps create a significant effect on outcomes? Are these modeling gaps comparable with outcomes for other generating resources, or exclusive to pumped storage?
5. Are there gaps in resource or transmission planning and operational models that limit effective characterization of hydropower performance and economic optimization? Are these gaps data-driven, computational, or an inherent limitation of the modeling approach?

TOPIC 5: ADDITIONAL RESEARCH NEEDS

As described in the RFI preamble, WPTO intends to develop a long-term research strategy. In this topic, we request additional recommendations and feedback on the proper bounds of that strategy, as well as on any other topics that should be considered and are not expressly stated in this RFI.

WPTO seeks comments from interested parties on the following issues:

- Complementary investment in bulk energy storage research
- Key partnerships
- Novel large infrastructure financing mechanisms
- Lessons from international developments
- Multi-purpose projects
- Priority areas for research focus

In this context, interested parties are encouraged to answer any of the following questions.

1. As the dominant bulk energy storage system worldwide, how should pumped storage hydropower research be developed in cooperation with other energy storage technologies? Are there opportunities for research that would integrate bulk energy storage with the family of storage technologies and applications?
2. What critical organizational partnerships and outreach mechanisms are under-utilized for the pumped storage development? In past budgets, for example, Congress has directed WPTO to engage with the National Association of Regulatory Utility Commissioners (NARUC). Is there a need for education about pumped storage?
3. A challenge for new pumped storage hydropower is the initial capital expenditure and construction lead time for development.
    a. How do these challenges differ by ownership structure (e.g. third-party owned)?
    b. Are there novel financing mechanisms that could respond to these barriers?
    c. Is there a clear role for the U.S. Department of Energy in responding to this challenge?
4. Are there innovative aspects of international pumped storage or hydropower development – for example, planning approaches, business models, or research programs – that are important to consider for these research efforts?
5. Should multi-purpose projects or co-located facilities which include an element of hydropower or pumped storage be further evaluated under this research?
6. A distinguishing feature of hydropower resources is that they are capable of providing an unusually broad range of services and benefits to the power system.[5] Given the broad range of reliability and resiliency benefits and the scope of inquiry proposed above, where should WPTO focus its research efforts?

DISCLAIMER AND IMPORTANT NOTES:
This RFI is not a Funding Opportunity Announcement (FOA) or a Notice of Technical Assistance (NOTA); therefore, no funding will result from responding to this RFI, and WPTO is not accepting applications at this time. WPTO may issue a FOA or NOTA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA or NOTA. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA or NOTA regarding the subject matter.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. WPTO will review and consider all responses in its formulation of program

[5] References illustrating the resource comparison include the Pacific Northwest Utilities Conference Committee, *The Value of Hydropower to the Northwest Grid*, November 2016. See Appendix B: Hydro as Compared to Other Resources. http://www.pnucc.org/sites/default/files/Value%20of%20Hydro%20PNUCC%20Nov%2022%202016.pdf or PJM Interconnection, *PJM's Evolving Resource Mix and System Reliability,* March 30, 2017. See Figure 6: Generator Reliability Attribute Mix. http://www.pjm.com/-/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx?la=en

strategies for the identified materials of interest that are the subject of this request. The Office will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that WPTO is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind WPTO to any further actions related to this topic.

PROPRIETARY INFORMATION: Because information received in response to this RFI may be used to structure future programs and FOAs or NOTAs and/or otherwise be made available to the public, *respondents are strongly advised NOT to include any information in their responses that might be considered business sensitive, proprietary, or otherwise confidential.* If, however, a respondent chooses to submit business sensitive, proprietary, or otherwise confidential information, it must be clearly and conspicuously marked as such in the response.

Responses containing confidential, proprietary, or privileged information must be conspicuously marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Federal Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

If your response contains confidential, proprietary, or privileged information, you must include a cover sheet marked as follows identifying the specific pages containing confidential, proprietary, or privileged information:

> **Notice of Restriction on Disclosure and Use of Data:**
> Pages [*list applicable pages*] of this response may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for the purposes described in this RFI [DE-FOA-0001886]. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

In addition, (1) the header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure" and (2) every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with [[double brackets]] or highlighting.

EVALUATION AND ADMINISTRATION BY FEDERAL AND NON-FEDERAL PERSONNEL: Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to WPTO providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

REQUEST FOR INFORMATION RESPONSE GUIDELINES:
Responses to this RFI must be submitted electronically to WPTORFI@ee.doe.gov no later than 5:00pm (ET) on April 6, 2018. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Only electronic responses will be accepted. Please identify your answers by responding to a specific question or topic if possible. Respondents may answer as many or as few questions as they wish.

WPTO will not respond to individual submissions or publicly publish a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.