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U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Water Power Technology Office

Subject: Request for Information: DE-FOA-0002713: Data and Research Needs for Climate Change-Informed Hydropower Operation and Resource Planning

Submitted via electronic mail to: WPTORFI@ee.doe.gov

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The National Hydropower Association (NHA)[1] appreciates the opportunity to respond to the Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), Water Power Technology Office's (WPTO) recent request for information (RFI), and to provide the industry's perspectives and insights on data and research needs for climate change-informed hydropower operation and resource planning. Research to date shows that water patterns are changing, whether they may be related to extreme rainfall, variations in snow melt, drought, or wildfires. The development of new or upgraded forecasting tools to predict meteorological patterns will prove helpful to the industry. NHA commends DOE's consideration of data collection, research, and tools that will make a definitive contribution in the operations, planning and safety of hydropower assets.

NHA offers the following recommendations.

[1] National Hydropower Association (NHA) is a national non-profit trade association dedicated exclusively to representing the U.S. hydropower industry. NHA's membership consists of over 250 organizations, including consumer-owned utilities, investor-owned utilities, independent power producers, equipment manufacturers, environmental and engineering firms, and attorneys.

Topic 1: Facilities and assets of concern (Questions 1, and 2)

NHA Response:

NHA is a trade association that represents the U.S. hydropower industry, with a membership spanning across the entire country. NHA's membership includes, generator owners, manufacturers, engineering and consulting firms, contractors, law firms and other service businesses that support the hydropower industry. The association represents a diverse footprint of the industry with varying size and types of hydropower assets. Hydropower producers supply energy to a multitude of industries.

Hydropower facilities also provide crucial ancillary services that allow the electric grid to remain stable, as well as the ability to provide the flexibility our future grid will require with increased onboarding of variable resources.

Topic 2: Risks of Concern (Questions 3, 4, and 5)

NHA Response:

As a national trade association, NHA is not in a position to describe all of the risks of concern for each individual member. However, the association is able to generalize member issues. Due to the geographic diversity of NHA members, individual members or additional outreach may be warranted by DOE to characterize each type of operational challenge presented by climate change and develop appropriate research and tools to address these varying types of hydrological systems.

Over the past several years, different regions of the country have experienced a complex combination of more severe storms, other regions have experienced more drought related issues, and still others have experienced wildfires as a concern. Each region has different hydrological characteristics and the impacts of climate change create different concerns. Examples of this include more intense storms in the southeastern US where associated increase in storm precipitation must be assessed to better understand the evolving risk of flooding and other operational issues such as spillway adequacy and coordination between cascading dams. In the Pacific Northwest changing snow patterns from historical snowpack trends is a cause for concern in terms of the availability of reservoir inflow for generation, the snow melt timing, as well as for concerns around increased flooding risk. California itself has a different hydrological characteristic as well that largely follows the weather that impacts water produced by snow and other moisture in the Sierra Nevada mountains. The change in weather patterns also presents a challenge for the repair and construction of facilities operating in a river environment, requiring clear prediction of suitable construction periods and novel approaches.

Aside from precipitation patterns, regions within the country have also experienced severe cold or severe heat, creating a necessity to serve customers with electricity at times of extreme temperature excursions. As some hydropower assets rely on real time river flows, assessing flows within the scope of extreme weather events and ways they may be best managed can create challenges for operators. Similarly, changing snow patterns and levels can present generation challenges for seasonal energy supplies.

Analysis of climate is of great importance to the operation, construction, and power production of facilities. The ability to predict river conditions is required to also anticipate construction risk, select power turbines, and ultimately forecast revenue generation necessary to justify asset repair or construction funding.

In addition to climate change issues, the electric generation industry within the nation is changing significantly as a greater number of variable renewables are connected to the grid. These renewable sources, dominated by wind and solar, create much more intermittent supply and require other power sources to balance the grid. As electricity markets continue to evolve, different "compensation products" are being developed to help manage and improve resiliency of the grid, provide adequate energy reserves to cover contingencies, and balance the loads. Hydropower is well positioned to provide these products and services within required system response times as well as clean generation. NHA recognizes the work that DOE has undertaken to better understand these issues and to develop tools to address markets, such as the HydroWIRES Initiative.

Topic 3: Variables of Interest (Questions 6, 7 and 8)

NHA Response:

As previously mentioned, NHA represents a diverse industry of hydropower owners and operators from all points of the country. Each region, company, and river system may use a variety of currently available systems and tools to assist in their management of the rivers and power production. Many companies utilize federally established sources such as USGS Gage station data, NWS forecasts, NOAA information and other available sources. Sensors and instrumentation on dam facilities themselves can generate invaluable data as to predict the performance and health of the facility. In some instances, companies have adopted their own sensor systems to assist them in managing their respective systems, ranging from rain gauge systems to level transmitters in different reservoirs or rivers. Many have also implemented extensive river flow models to help operations predict how fast water may collect in rivers from widespread storms to assess the time water will reach downstream projects. While NHA cannot speak for individual companies and their specific needs, collectively an extensive amount of energy is invested by numerous users and organizations, such as USGS and NWS, to create information used to inform watershed management. Standardizing meteorological data and making it available to users is critical.

Similarly, planning thresholds used by NHA members are widely variable. In regions where severe rainstorms are of concern, sub-daily models and predictors are critical. On the other extreme, data is necessary to project 20 to 30 years into the future for resource planning purposes. In short, NHA members utilize a wide the range of information thresholds in operating hydropower facilities. While DOE may receive responses that will help to prioritize temporal and spatial needs, ultimately both sides of the spectrum will necessitate addressing to in some degree due to the complexity of resource operation and resource planning.

Topic 4: Data and research needs

Question 9: Have you ever used climate data to inform your operation and to evaluate potential future risks? Climate data is broadly defined in this RFI as any relevant historic or future hydro-meteorologic information based on observations, model simulations, or paleo-hydrologic information.

NHA Response:

Meteorologic data is applied by operators in varying degrees and for various purposes across the industry to address needs including, generation predictions, project valuation, near-term and long-term resource planning, relicensing, as well as risk analysis.

A smaller operator may only utilize simple weather services to aid them due to costs of more sophisticated information and predictors.

A larger operator may utilize climate data to inform operations, resource planning, plant refurbishments, capital investment decision-making, relicensing with the Federal Energy Regulatory Commission (FERC), operational risk analysis, climate adaptation planning, and hazard mitigation and planning, such as Probable Maximum Flood predictions for dam safety purposes. One industry member is currently conducting an enterprise-wide Climate Vulnerability and Adaptation Study across multiple climate hazards to inform potential future risks to other infrastructure.

The hydropower industry utilizes climate data and current water data that measure and record streamflows to predict and schedule the short-term, weekly or 10-days hydropower operation. NHA recommends that WPTO engage with the hydropower industry and research institutions to use these data and conduct research in models and tools development that will analyze future hydroclimatic events, inform long-term valuation of hydropower projects and dam safety.

In addition to assessing the economics of new developments or refurbishment of existing plants, consultants also utilize climate data to analyze future hydroclimatic events such as probable precipitations events in dam safety, modeling inflow rates and volumes, as well as in the long-term valuation of hydro projects.

Question 10: If your organization has invested or plans to invest in developing climate change-informed data and decision-making capabilities, what is the preferred method of investment? Examples may include but are not limited to developing direct research contracts with a consultant or research institute, hiring in-house expertise, utilizing government supported technical assistance, joining a community-based consortium, etc.

NHA Response:

The industry utilizes varied approaches in developing climate change-informed and decision-making data. If necessary, hiring of in-house expertise and contracting with consultants are the most prevalent avenues. A consultant may be utilized for larger, more intensive projects to support climate modeling and scenario development. Collaborative development with research institutions and local universities is also applied, as well as government supported technical assistance. Engagement in industry trade groups to understand leading practices and lessons learned is also utilized.

Question 11: If WPTO provided baseline climate data across a set of potential future scenarios, would that be helpful for supporting your long-term planning and risk assessment?

NHA Response:

NHA sees benefit in WPTO providing baseline climate data across future scenarios to support industry's long-term planning and risk assessment. Access to baseline data will aid assessments in future operations and market management, trends, and timing of impacts for informed decision-making on long-lead investments, prediction of varying water patterns in the form of precipitation, the duration or lack thereof of precipitation events, flood events, and watershed or regional patterns. The supply of such data has value as it will enable organizations to focus on the analysis of data relevant to their uses. This is particularly relevant as some organizations may lack the capacity to gather such data on their own.

From a geographic perspective, localized data sets specific to a watershed or basin will yield the greatest value. Baseline climate data sets of a generic or regional perspective may provide some benefit with respect to long-term planning, though their use relative to particular projects may be limited. Local baseline climate data across a set of potential future scenarios would be more credible and of greater benefit.

In terms of the data sets, NHA suggests the development of baseline data at the scale and level of refinement necessary for resource scale planning versus screening level data sets. Capturing the range of local variability versus the average of future scenarios will provide the most benefit. For example, data providing the range of future streamflow from multiple global climate models will be of greater value than the average of an ensemble data.

The dataset providing most value will facilitate the capability to import underlying data into a GIS system or equivalent mapping system for internal consumption and tag climate data with geolocation metadata, to correlate climate projections to discrete infrastructure locations. Access to meteorological data and forecasting tools would also improve dam safety in terms of understanding the magnitude of oncoming storms or precipitation events and emergency or contingency planning to ensure the dam is capable of safely passing the forecast flows.

Additionally, NHA suggests the baseline climate data be downscaled at a sufficient level of granularity to understand discrete climate hazards and associated risks to infrastructure.

Question 12: If WPTO provided baseline climate data across a set of potential future scenarios, what are time horizons of greatest concern (e.g., seasonal-to-subseasonal, annual, decadal, multi-decadal, and/or till the end of 21st century)?

NHA Response:

NHA's Waterpower Innovation Council (WIC) conducted a survey of council members, results returned showed that all time horizons listed prove useful for varying assessments conducted by operators. For operators, seasonal-to-sub seasonal, decadal, and multi-decadal are of the most importance to operators and planners. Similarly, results showed decadal and multi-decadal showed of most importance to consultants, including in the area of dam safety.

NHA offers an additional breakdown of the survey results and decision making that takes place within specific time horizons.

Short Term
Sub-daily:

- Assist in optimizing hydropower operation (peak load vs baseload) to manage energy resources and maximize revenues.

1 - 10 Day:

- Assist in daily load and resource forecast requirements.
- Assist in the Lease Cost Planning. Specifically, weekly load projections.

Seasonal-to-sub seasonal:

- Assist in operations and market management.
- Seasonal-to-sub seasonal changes are often driven by weather patterns which, while non-stationary due to climate change, are modeled differently (e.g., using signals like ENSO, identifying atmospheric rivers and ridges earlier) than climate resiliency / risk models. The Center for Western Weather and Water Extremes is conducting especially promising research on S2S forecasting.

Annual:

- Assist in load allocation across water users, water quality and water management.

Mid Term (decadal to 50 years)
Decadal:

- Assist in understanding trends and timing of impacts for informed decision-making on long-lead investments.

Multi-decadal:

- Assist in conducting economic analyses. Specifically, a 50-year time horizon for project valuation.
- Assess long-term valuations of hydro projects, important in considering hydro asset terminal values. 40 and 50 years are common terminal asset valuation time horizons.
- From a dam safety perspective, muti-decadal and longer will provide great benefit as such infrastructure has an exceedingly long life.

Long Term (50 years and beyond)
End of 21st century:

- A 100-year time horizon will assist in major infrastructure decision making.
- From a dam safety perspective, muti-decadal and longer will provide great benefit, again from the long-life of such assets.
- Climate change impact analysis.

Question 13: If WPTO expanded climate change research with respect to hydropower operation and resource planning, what research areas would you like to see explored?

NHA Response:

NHA believes that research and tools are needed to predict the water quantity and varying water patterns in the form of precipitation, rainfall/runoff as well as snowmelt, the duration of precipitation events from watershed to regional scales. Future potential flooding and drought forecasting should be a priority to manage and operate reservoirs. Research in climate change impacts on future hydropower generation and dam safety will provide a major benefit to the industry.

NHA offers the following recommendations for operation and resource planning, as well as risk assessment:

General:

- Modeling of various climate change scenarios to understand how precipitation and rapid snow melt, among other impacts, potentially affect the risk of dam failures.
- Extreme flood probability.
- Snowpack contribution and coincidence with extreme rain events.
- Water availability for hydropower storage and generation.
- Extreme rainfall and frequency.
- Research in climate change effects on global precipitation patterns.
- Rainfall, streamflow, and drought forecast.
- Comparing small and modular pumped storage with battery storage from a performance, reliability, and cost perspective.
- River-basin flow based on climate models with existing dams operational, new dams and with existing dams removed.

- A dataset version similar to the LOCA data, a gridded dataset providing downscaled meteorological projections suitable for the hydrologic models operators utilize. The data could provide different scenarios based on the range of climate projections identified by the IPCC/CMIP6 or similar.

Northwest:

- Models yielding high confidence, quarterly predictions of temperatures, winds, and moderate to severe weather.
- Multi-year drought risk.
- Multi-hazard risk, such as wildfire, flooding, and landslides.
- Heat and freezing impacts on equipment.
- Snowpack melting and associated impact on hydropower generation.

West:

- Precipitation patterns, snowmelt trends and rain patterns, pertaining to specific watersheds.
- Changes in distribution patterns and increases in extreme patterns, leading to increased magnitude and frequency of floods and droughts.
- Drought analysis.

East:

- Modeling seasonal water temperature changes (increase, decrease, variability) in Eastern North America, particularly, Mid-Atlantic and Northeastern regions of United States. Comparing these results to a compilation of water temperature restrictions on hydro operations will assist in identifying locations where changes to restrictions can be explored and/or implemented.
- Speed to onset and level of impact for changes in precipitation, inland or coastal flooding, stream flows, and ice accumulation.
- From an operational perspective, tie climate projections to FERC Dam Safety standards, including potential impact of climate change on discrete hydro facility infrastructure (e.g., spillways, embankments, construction standards, ice booms, design standards, etc.).
- In terms of rate recovery processes, cost recovery for forward-looking climate mitigation investments.
- Extreme rainfall events such as hurricane and tropical cyclones impacts on hydropower and dam safety.

Once again, NHA appreciates the opportunity to respond to this RFI. DOE has been invaluable in helping the industry better understand and address its challenges, while being a steward for natural resources and facilitating access to affordable and reliable energy. NHA hopes the feedback provided within this response is valuable as the department considers next steps in identifying research and tools aimed at informing climate change impacts on operations and resource planning for the hydropower industry. We look forward to future discussions.