Background

A critical roadblock to achieving a fully renewable and clean electricity grid in the US is replacing fossil-based generation with alternative technologies. While utility-scale battery technologies are being developed and their lifecycle emissions and sourcing challenges are being addressed, pumped storage hydropower (PSH) is a proven large-scale, long-duration storage option that is being considered anew across the US.

The existing fleet of PSH projects consist of open-loop projects that are continuously connected to a natural waterway, typically with the lower reservoir created by damming a river. Conversely, the majority of currently proposed PSH projects use a closed-loop (off-river) design. The environmental effects of closed-loop pumped storage projects, or the addition of pumped storage to an already constructed and impounded lower reservoir (or to two existing reservoirs), may be lower than the effects of new open-loop pumped storage that involves the construction and impoundment of new reservoirs.[1] However, no low impact definition for any type of pumped storage hydropower exists. PSH may have significant impacts on surface and ground water, terrestrial and aquatic resources, land use, cultural and tribal resources, and recreational opportunities.

LIHI's certification program has explicitly excluded PSH primarily because fossil fuels supplied by regional electric grids were (and still are) the most common source of power for the PSH pumping cycle. Yet, recognizing the increasing penetration of wind and solar power since LIHI's founding in 1999, the idea of expanding the certification program to potentially include existing PSH projects was first considered as part of LIHI's Strategic Plan in 2018. Based on staff research, the limited number of existing PSH projects at that time[2], and the lack of meaningful incentives in many energy markets that could create value for LIHI certification, this avenue of inquiry was not pursued at that time.

Over the next several years, the penetration of wind and solar, along with PSH development activity in the US, increased dramatically (Table 1) and in 2022 LIHI reactivated the idea of evaluating the potential for a low impact PSH definition that could include both existing and new PSH projects. Unlike conventional hydropower and the first wave of PSH that were built prior to modern environmental laws[3], the current wave of proposed PSH projects in the development pipeline presents a unique, limited-time opportunity to influence pumped storage design and operation to minimize its impacts.

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[1] United States Department of Energy. (2020). A Comparison of the Environmental Effects of Open-Loop and Closed-Loop Pumped Storage Hydropower. https://www.energy.gov/sites/prod/files/2020/04/f73/comparison-of-environmental-effects-open-loop-closed-loop-psh-1.pdf

[2] 43 projects, all open-loop. United States Department of Energy. (2021). U.S. hydropower market report 2021 edition. p. 3, p. 99. https://www.energy.gov/sites/default/files/2021/01/f82/us-hydropower-market-report-full-2021.pdf

[3] e.g., Endangered Species Act, Clean Water Act, and the National Environmental Policy Act

Table 1. Proposed Pumped Storage Hydropower Projects in the Federal Energy Regulatory Commission (FERC) development pipeline.

Year	Number of PSH Projects in FERC Development Pipeline
2017	48[4]
2019	67[5]
2022	96[3]
2023	80[6]
2024	63[7]

While many PSH projects are proposed each year, many never advance beyond initial application to FERC (the "pending preliminary permit" stage), or beyond the FERC approval to study project feasibility (the "active preliminary permit" stage), or beyond FERC's approval of the design, construction, and operation of the project (licensing stage). Even with a FERC license, it can take years to get to the point of construction. FERC may grant multiple time extensions to begin construction, yet some projects are still ultimately not built, and the license is surrendered by the developer or revoked by FERC. Similar surrender or revocation proceedings can occur at the pending or active preliminary permit stages.

Add-on type PSH proposals at existing conventional hydropower projects may be authorized by FERC under amendments to the existing project licenses. The number of those projects is difficult to quantify, and they are not included in Table 1.

Initiating the Low Impact PSH Definition Project

LIHI's 2023 Strategic Plan directed LIHI staff to conduct additional research into PSH and its potential environmental and social impacts in order to begin to define low impact PSH. LIHI staff researched PSH project types, synthesized the science on their impacts from existing literature published in the US and globally, and documented the major impacts and benefits of PSH. LIHI staff developed a project budget, a process plan, and two-year implementation schedule. An internal Task Force comprised of LIHI board members and staff was formed and a professional facilitator (Kearns & West) was retained to support the project. The Hewlett Foundation awarded a $100,000 grant to support the project, largely underwriting expenses related to facilitation and travel.

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[4] United States Department of Energy. (2017). U.S. hydropower market report 2017 edition, p. 3. https://www.energy.gov/sites/default/files/2018/04/f51/Hydropower%20Market%20Report.pdf

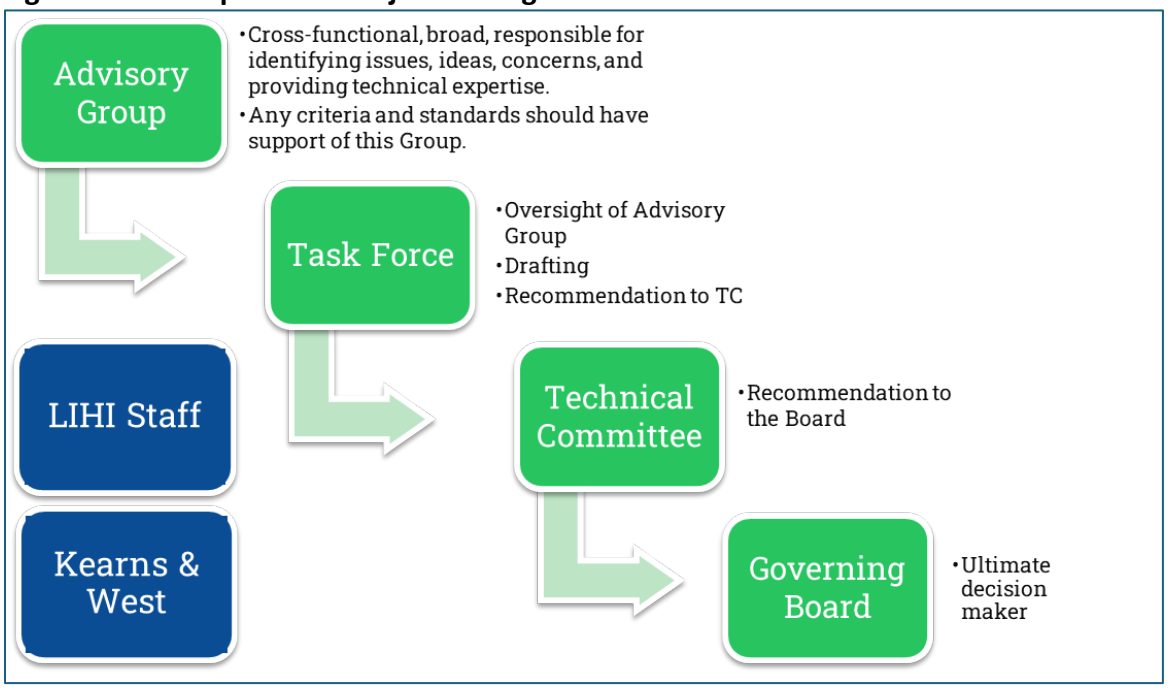
[5] United States Department of Energy. (2023). U.S. hydropower market report 2023 edition. p. 36. https://www.energy.gov/sites/default/files/2023-09/U.S.%20Hydropower%20Market%20Report%202023%20Edition.pdf

[6] Megan M. Johnson and Rocio Uría-Martínez. 2024. U.S. Hydropower Development Pipeline Data, 2024. HydroSource, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA. DOI: https://doi.org/10.21951/HMR_PipelineFY24/2338143 https://hydrosource.ornl.gov/data/datasets/us-hydropower-development-pipeline-data-2024/

[7] Active and pending FERC preliminary permit lists (12/10/2024 revision) from https://ferc.gov/licensing, plus those in pre-licensing phase (6) from FERC and LIHI data, and those licensed but not yet constructed (3) from footnote 6.

LIHI built on its existing organization, board members, advisors, community of interested parties, and history of collaboration to initiate an inclusive process to work to develop a definition of low impact PSH. Figure 1 illustrates the management framework that was developed:

Figure 1. Low Impact PSH Project Management Framework



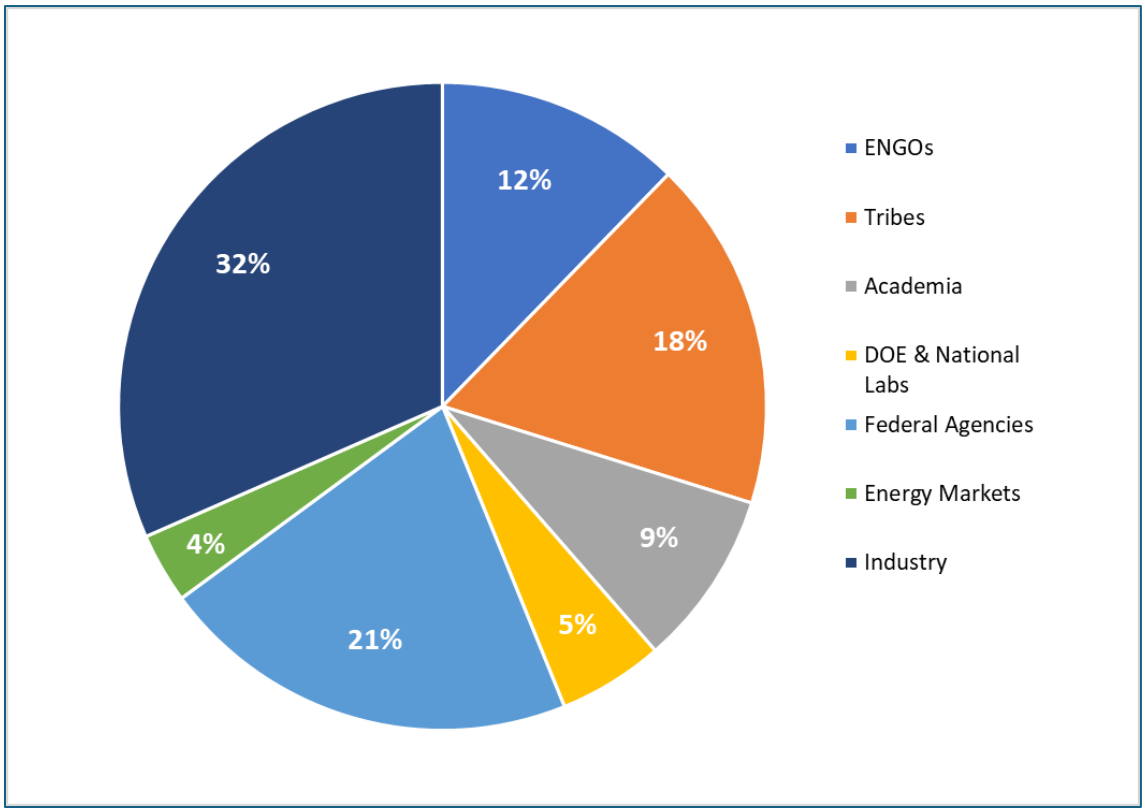
Collaborative Process

Through a combination of direct invitation and public solicitation for volunteers, LIHI assembled an external Advisory Group representing a cross-section of subject matter and technical expertise in the following areas:

- Water, land, and river science and conservation
- Tribal knowledge and experience
- Environmental justice and socioeconomics
- Environmental and ecological impacts of energy generation and construction
- Natural resource agency regulations
- Pumped storage operations
- Pumped storage development
- Energy grid and markets

The Advisory Group was comprised of about 60 individuals with broad representation from across the hydropower and PSH landscape (Figure 2).

Figure 2. Advisory Group Participation



An initial Advisory Group kickoff meeting was held in December 2023 where the project goals and objectives were discussed. The goal of the collaborative process was to explore whether a low impact definition could be developed that is acceptable to all parties, how it would be used, and whether LIHI could create a separate certification program for PSH based on the definition. The following objectives guided the process of defining low impact PSH.

- Determine what aspects of natural, social, cultural resources could be impacted by the construction and operations of new and existing pumped storage projects in the US.
- Clearly articulate stringent but achievable goals that would lead to the optimal outcome for each resource type.
- Define science- and knowledge-based standards for demonstrating goals have been met.
- Publish results with sufficient details such that projects can evaluate impacts and inform design of future projects.

Subsequent meetings were held on a bi-weekly basis from February 2024 – November 2024. Each resource area impacted by PSH projects that had been identified by LIHI staff through their research and literature review was introduced and the potential PSH impacts were discussed by the group focusing on issues, concerns, and what aspects could be considered low impact. For some resource areas, subject matter experts shared additional insights.

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The following eleven impact areas were identified and explored at the Advisory Group meetings:

- Community and Tribal Engagement
- Socio-Economics
- Cultural and Historic Aspects
- Aquatic Ecology
- Terrestrial Ecology
- Water Quality
- Water Quantity and Availability
- Geology and Soils
- Air Quality and Noise
- Land Use and Aesthetics
- Recreational, Public, and Traditional Cultural Access

An iterative approach was used to develop the low impact definition for each impact area. First, LIHI staff drafted language. Then the Task Force provided its input, and then the Advisory Group reviewed, commented, and provided additional input. The definition language was revised in response to all input and the review process was repeated. Once the definition was fully developed, the Technical Committee of the LIHI Governing Board made a recommendation to the full Governing Board to allow the definition to be published for broader public comment.

The resulting definition provided below, has been structured purposely to be similar to the existing LIHI certification program with an outcome-oriented goal statement for each impact area, alternative standards by which a PSH project could achieve the goal, and a set of defined terms. In addition, the definition attempts to be as stringent as possible while also being achievable. An important consideration for the definition was that it be broad enough apply to different facility types - open-loop, closed-loop, underground, add-ons to existing hydro, etc.; and applicable to the different phases of PSH development - site selection, design, construction, and operation.