The Mount Elbert Powerplant is a pumped storage hydropower facility near Leadville, Colorado, that provides power to the Rocky Mountain region. *Photo by Bryan Bechtold and Josh Bauer, NREL*

Highlights From the Hydropower Investment and Public-Private Ecosystem Assessment

This document summarizes findings from the report on opportunities to increase investment and deployment of medium-sized[1] hydropower and pumped storage hydropower.

Hydropower

Hydropower plays an important role in the U.S. energy generation portfolio and the clean energy transition, representing almost 30% of U.S. renewable energy generation and about 6% of all U.S. electricity generation today.[2] Going forward, while the renewable energy that hydropower provides will still be important, its greatest contribution may be its ability to provide a clean, low-cost source of firm capacity—a key service that is necessary for grid stability and that helps reduce the costs and environmental impact of integrating wind and solar generation.

Pumped storage hydropower[3] (PSH) represents 96% of utility-scale energy storage capacity and 70% of grid storage capacity and supports grid stability and reliability across the country.[4] PSH facilities enhance grid stability by providing long-duration energy storage, which will become even more important as more variable renewables are added to the grid.

The hydropower incentives in the Infrastructure Investment and Jobs Act and the Inflation Reduction Act, along with the financial market's growing interest in meeting environmental, social, and governance standards, present a unique opportunity to accelerate investment in future medium-sized hydropower and PSH upgrades, retrofits, and new developments.

Photo from Adobe Stock 641455830

Gathering Market Intelligence

To better understand market sentiment, the authors conducted 33 interviews; distributed an investment survey to 148 recipients that received 36 responses; and analyzed transaction data from 43 medium-sized hydropower acquisitions, infrastructure investments, and corporate investments from the last 10 years.

[1] Medium-sized is defined in the report as 5–30 megawatts of installed capacity.
[2] Uría-Martínez, Rocío, and Megan Johnson. 2023. U.S. Hydropower Market Report. Oak Ridge, TN: Oak Ridge National Laboratory. DOE/EE-2271. https://www.energy.gov/sites/default/files/2023-09/U.S.%20Hydropower%20Market%20Report%202023%20Edition.pdf
[3] Pumped storage hydropower is a type of hydropower project where energy can be stored and generated by moving water between two reservoirs of differing elevations. https://www.energy.gov/eere/water/glossary-hydropower-terms
[4] Uría-Martínez and Johnson 2023

The Investment Landscape Today

Medium-sized projects currently represent a pipeline of more than 1 gigawatt (GW) in added capacity.[5] Projects that make up this pipeline include capacity additions, non-powered dams, conduits, PSH, new stream-reach development, and hybrid projects that combine multiple renewable technologies.

1+ GW

capacity of proposed medium-sized projects in the current pipeline

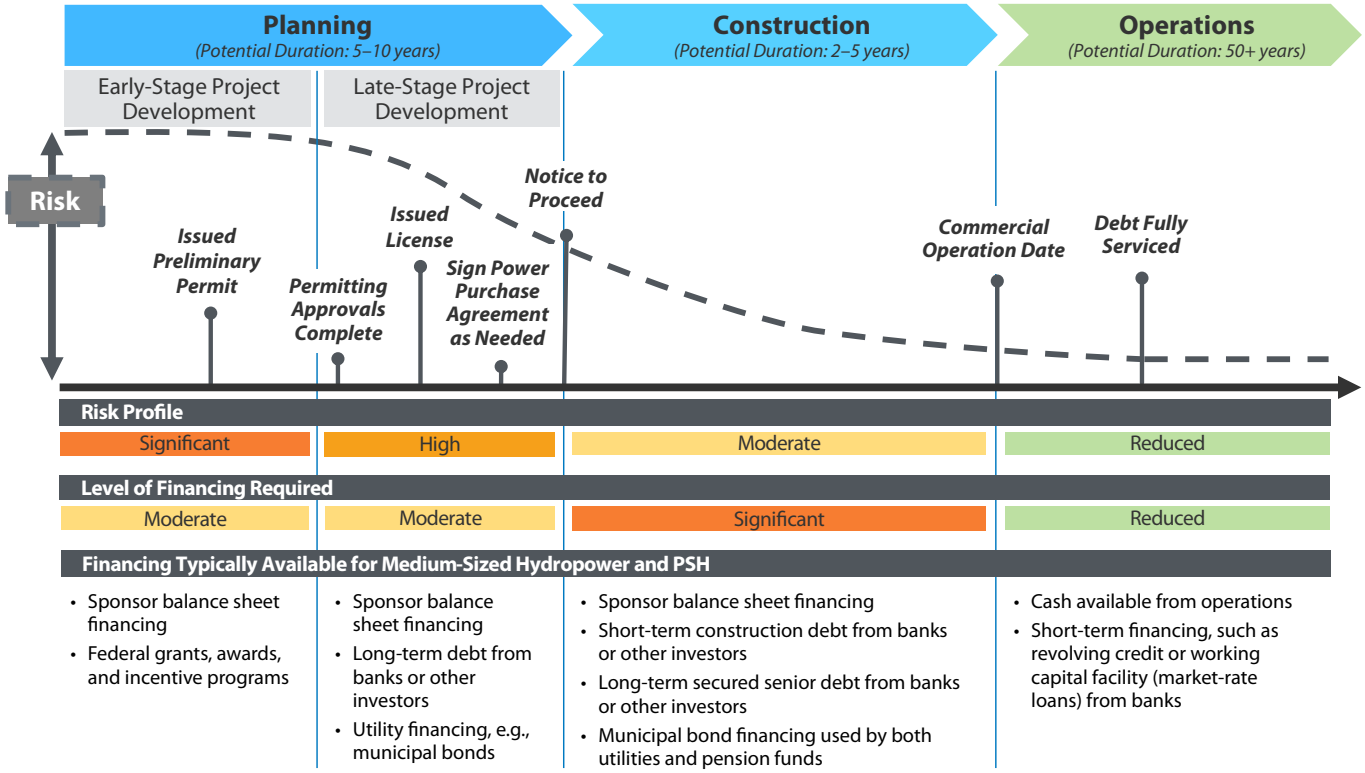

Figure 1. The general phases of hydropower project development, including planning, construction, and operations, each with unique risks, challenges, and capital requirements. It also demonstrates how the risk profile of a project typically decreases as it progresses through each phase. This risk profile plays an important role in determining the type and availability of investment capital.

Hydropower Project Development Stages and the Interplay of Risk and Financing Needed

In general, investors typically seek to minimize investment risks and achieve or exceed target rates of return within a reasonable time frame. To incentivize increased private financing of hydropower projects, addressing long project development timelines and high capital costs could help reduce barriers to investment. Raising equity or debt is difficult for developers until they have obtained a license because of the characteristically long and complex development timelines. In addition, as discussed in further detail in the report, pathways to achieve adequate compensation during operations vary depending on the regional market structure. The report identifies several risks throughout the project life cycle, along with associated impacts to investment and mitigation options.

In the investment survey, 72% of 14 surveyed investors and 78% of 14 surveyed developers indicated that they would potentially be interested (answering "yes" or "maybe") in continuing their involvement in the medium-sized hydropower and PSH market over the next 5 years. Market interest may continue to grow if the investment risks outlined in the report are adequately addressed.

Shazreen Meor Danial and Ismael Mendoza Carrillo evaluate the RivGen Power System at NREL's Energy Systems Integration Facility.
Photo by Dennis Schroeder, NREL

[5] Data from Johnson, Megan, Shih-Chieh Kao, and Rocío Uría-Martínez. 2023. Existing Hydropower Assets (EHA) Plant Database, 2023. Oak Ridge, TN: Oak Ridge National Laboratory. https://doi.org/10.21951/EHA_FY2023/1972057

Opportunity Highlights

New technology innovations present potential opportunities for future investment in medium-sized hydropower and PSH projects. The report details a few of these opportunities, summarized below, although it is important to note that their applicability may vary by region.

Modular Conduit Hydropower

In the last decade, developers have begun designing and deploying small modular conduit systems that may decrease construction costs, reduce project timelines, and increase flexibility.

Non-Powered Dam Resources

About 97% of U.S. dams are non-powered, representing an attractive development opportunity with a potential capacity of 2 GW or more for medium-sized hydropower and PSH.[6]

Hybrid Plant Configuration

Utilizing hydropower in a hybrid configuration with other renewables and battery storage can unlock new revenue streams by providing peaking power or ancillary services.

Closed-Loop PSH Innovation

Closed-loop PSH projects, which can offer siting flexibility, account for the majority of PSH projects in the pipeline. These pipeline projects would be the first closed-loop facilities in the United States.

Investor Overview, Profiles, and Motivations

Most current or future potential hydropower and PSH investors are technology-agnostic and consider hydropower in the context of a multi-asset allocation strategy in search of the best return. Table 1 summarizes the types of investors by their activity and investment drivers, which is detailed further in the report. This characterization was developed through market research and the review of 43 medium-sized hydropower and PSH transactions over the past 10 years.

Table 1. Current Investors in Medium-Sized Hydropower and PSH and Future Opportunities

Investor Type	Current Activity	Drivers to Attract Investment*
Project Developers/ Independent Power Producers	• Active in providing on-balance-sheet financing for projects (not included in transaction analysis) • Active in acquiring existing facilities to add to their fleets of hydropower and PSH assets	• Access to early-stage grants • Reduced permitting and licensing timelines • Ability to secure power purchase agreements
Utilities and Community Choice Aggregators	• Active in acquiring facilities and financing various projects using rates paid into their system, municipal bonds, debt, and tax credits	• Opportunities to expand current portfolios through capacity additions
Private Equity and Venture Capital Funds	• Active in making corporate investments into hydropower companies, including developers, equipment manufacturers, and product suppliers	• Projects with stable cash flow • Scalable technologies that can monetize rapid market growth
Institutional Investors	• Moderately active in providing patient capital to already-developed projects	• Stable long-term projects with limited risk to steady cash flows
Commercial Banks	• Limited investment in the last decade	• Signed power purchase agreements to reduce potential revenue risk • Larger-size deals
Tax Equity Investors	• Limited investment in the last decade	• Shorter lead times that better align with forward commitments for tax liabilities, e.g., solar projects • Tax incentives to promote investment

* *These examples are indicative but not exhaustive.*

Very Active Moderately Active Less Active

[6] Menser, Paul. 2023. "Non-Powered Dams Offer Opportunity for Clean Energy." Idaho National Laboratory. October 25, 2023. https://inl.gov/feature-story/non-powered-dams-offer-opportunity-for-clean-energy

Summary of Opportunities

Today, the U.S. Department of Energy and other federal agencies play a critical role in championing the development of the hydropower industry through the Water Power Technologies Office (WPTO) and other offices. There has been a fundamental transformation of federal funding with the Infrastructure Investment and Jobs Act passed in November 2021 and the Inflation Reduction Act passed in August 2022, which include billions of dollars in appropriated funding for which hydropower and PSH development qualify. These initiatives represent an unprecedented opportunity for hydropower technologies. WPTO has produced an extensive set of resources[7] aimed at supporting hydropower and PSH market growth, including resource analysis reports, technical guidance documents, and interactive toolkits. WPTO has also offered funding opportunities focused on low-impact hydropower,[8] cybersecurity, fish passage, and other topics.

The Mount Elbert Powerplant in Leadville, Colorado.
Photo by Bryan Bechtold and Josh Bauer, NREL

Recommended Opportunities

As detailed in the report, the following opportunities to increase investment in hydropower and PSH were identified in interviews, the investment survey, and market research:

Provide Financing, Funding, and Support for Early-Stage Development

Government assistance in the form of financing, grant funding, and technical assistance could continue to support early-stage project development and expand the pipeline of projects.

Support Improved Market-Based Incentive Signals for Hydropower and PSH

Market intelligence may help to diversify potential revenue sources for hydropower and PSH as well as support revenue stability and reduce the risk profile of hydropower and PSH projects.

Support Transparent and Efficient Permitting and Licensing Processes

Identifying additional opportunities within relevant federal and state government agencies to reduce time required for permitting, licensing, and relicensing is key to decreasing development timelines and costs.

Support New, Innovative Research on Reducing Deployment Time and Costs

Continuing to fund research, including demonstration projects, is vital to decreasing deployment time and costs, modernizing existing infrastructure, and commercializing new technologies.

Clarify New Legislation and Regulations and Conduct Outreach With Developers and Industry

To fully realize the potential of federal incentives to unlock investment, agencies should clarify changes to tax credit eligibility and domestic content requirements.

Increase Awareness of New Opportunities in Hydropower and PSH

Providing educational resources for targeted audiences, like hydropower industry investors and developers, can help facilitate their consideration of hydropower for their portfolios moving forward.

Download the full report at:
https://www.nrel.gov/docs/fy24osti/87470.pdf

[7] Find WPTO hydropower resources here: https://www.energy.gov/eere/water/hydropower-program
[8] Some medium-sized projects qualify as low impact per Federal Energy Regulatory Commission regulations https://www.ferc.gov/licensing/smalllow-impact-hydropower-projects/smalllow-impact-hydropower-projects-types-projects and Low Impact Hydropower Institute criteria: https://www.hydro.org/powerhouse/article/certifying-hydropower-as-low-impact/

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