Hydropower Testing Network Voucher Opportunity Capability Category Definitions

The following tables provide descriptive context for the testing capability categories and sub-categories, inclusive of both computer modeling and physical testing. These categories are used primarily for filtering projects and enable Voucher Recipients to find relevant capabilities more easily. These categories are not exhaustive and are subject to change.

Voucher Providers (Test Facilities) may select only one primary category and should select the most relevant if more than one is applicable.

Primary Test & Evaluation Category	Description
Hydraulic Testing	Laboratories equipped to analyze hydraulic flows at specified flow rates, velocities, and/or pressures, such as through flumes, conduits, or pumps. Activities may include (but are not limited to) performance validation of hydraulic machinery, design optimization of hydraulic engineering structures, sediment transport and river engineering studies, validation of measurement instrumentation, hydrodynamic modeling, and modeling of environmental indices.
Mechanical, Material, & Structural Testing	Laboratories equipped to measure, test, and analyze the mechanical and material properties of a system or component and performance of mechanical components and structures. Activities depend largely on the technology but may include extended duration or accelerated testing and evaluation (for properties like cavitation, corrosion, erosion, and biofouling resistance), destructive testing to identify failure points and modes, non-destructive testing and imaging, and response characterization. Testing may occur at multiple scales (e.g., full-scale and/or partial scale), different levels of system completeness (full system to component) and may include both testing of the end product as well as the manufacturing or repair processes.
Electrical and Electronic Testing	Laboratories with specialized testing capabilities dedicated to power systems, controls, power conversion, transmission and distribution, interconnection, monitoring, and grid simulations. These capabilities often test for component performance, efficiency, reliability, and safety within a representative electrical system. Testing methodologies may include the integration of physical hardware with simulated or virtual components to create a comprehensive testing environment (i.e., control- and power-hardware-in-the-loop). Laboratories experienced in performing modeling and analysis of electrical system/component modeling. Laboratories capable of modeling and simulating electrical power derived from single or multiple technologies and energy storage systems. Laboratories with experience in grid level impact analysis and/or system level analysis (hybrid generation/storage, co-location/reliability). This can include capabilities that utilize AI/ML tools and techniques for faster, more effective, or innovative approaches to a given analysis or modeling system.

Aquatic Environment and Biological Testing	Laboratories capable of studying complex interactions between environmental stressors triggered by hydropower operations and aquatic organisms and their habitats. Facilities may be equipped with advanced laboratory equipment and analytical tools for conducting water quality analysis (e.g., oxygen, temperature, nutrients, contaminants, etc). In addition, the testing facilities may feature specialized capabilities for studying fish passage and responses to hydraulic structures, survival through hydropower machinery, and behavior around attraction/deterrent strategies. Additionally, facilities capable of modeling fish behavior, flow/pressure effects on fish, and possible environmental or ecological impacts of hydropower technologies. This can include capabilities that utilize AI/ML tools and techniques for faster, more effective, or innovative approaches to a given analysis or modeling system.
Techno-Economic Analysis	Laboratories with experience in techno-economic plant- and site-level analysis of either individual or multi-system hydropower technologies. Laboratories experienced with providing TEA of individual and/or multi-technology systems to provide comprehensive feasibility analysis, energy production simulation, and financial modeling. Laboratories capable of providing assistance for site design, analysis for hybrid systems, operating strategies, and/or co-location opportunity assessment. This can include capabilities that utilize AI/ML tools and techniques for faster, more effective, or innovative approaches to a given analysis or modeling system.

Voucher providers may select multiple sub-categories if directly applicable to the capability.

Test & Evaluation Subcategory	Description
Artificial Intelligence	Laboratories specializing in the development and validation of advanced data-driven or computer science technologies (e.g., machine learning, computer vision, or natural language processing). Relevant testing may include, but not limited to, forecasting hydrodynamic and environmental conditions, early detection of system failures, automated identification and classification of aquatic species and their passage through hydropower or pumped hydropower storage, and automatic digitization of key information from legacy or unstructured documentation.
Advanced Manufacturing	Laboratories capable of testing advanced manufacturing (e.g., 3D printing) or advanced material (e.g., composite) production processes related to hydropower components at model and full scales.
Advanced Operational Modeling	Analysis and modeling capabilities capable of high-fidelity simulation and optimization of power and water operations at the single plant, multi-plant, grid, river, or basin scale. Capabilities could include a combination of independent, connected, or integrated power and water analysis tools.
Biofouling	Laboratories capable of testing the fouling performance of innovative hydropower components and materials using relevant riverine species.
Computational Fluid Dynamics (CFD)	Laboratories equipped with software and expertise capable of conducting CFD analysis to evaluate the performance of conventional hydropower designs. This may include but is not limited to appropriate fidelity, resolution, and dimensionality approaches for conducting unsteady simulations of complex transitional turbulent flows to investigate flow behavior, surface stresses, cavitation, temperature and other environmental constituents, particle tracking, fluid-structure interaction, etc. This may be applied at the component, system, or site level as in reservoir and tailrace vicinity as necessary. These models are generally fully three-dimensional and used for modeling near-field phenomena.
Cybersecurity	Laboratories capable of penetration testing of communication systems, intelligent electronic devices, industrial control systems, distributed control systems (DCS), and/or Supervisory Control and Data Acquisition (SCADA) system components associated with dam and hydropower operations.
Environmental Monitoring	Laboratories with capabilities for environmental monitoring capabilities (oxygen level, temperature, sediment contamination, pollutant, species presence, etc.) beneficial to the analysis of water impoundment, diversion, power generation, conveyance, and release to natural waterways.
Finite Element Analysis/Modeling (FEA/FEM)	Laboratories equipped with software and expertise capable of performing FEA/FEM analysis to evaluate the durability, safety, and performance of the materials and structural elements associated with hydropower designs subjected to various loading and operating conditions (e.g., hydrodynamic, thermal, magnetic, environmental, etc.). This may include but not limited to appropriate fidelity, resolution, and dimensionality approaches for

	modeling and assessing component and facility level forces, stresses, forces, hydroelastic response, surface degradation, translation, deformation, etc.
Fish Behavior and Entrainment	Laboratories capable of testing fish exclusion devices, fish bypasses, fish ladders, and other conveyance systems for fish behavior, attraction, entrainment, and passage efficiency.
Fish Passage Survival	Laboratories capable of testing turbines, spillways, conduits, and other water conveyance systems/structures in to assess mortality, injury, and other impacts on species.
Friction Testing and Tribology	Laboratories capable of testing common wear assemblies, sliding interfaces, or lubricated systems associated with hydropower facilities (bushings, bearings, seals, seats, etc.) in freshwater environments for friction, wear, and lubrication performance.
Generator Performance	Laboratories capable of conducting power testing of hydropower generators and related rotary equipment for applications of 100kW and above typically using equipment, like a dynamometer, in dry conditions.
Geotechnical Applications	Laboratories capable of testing geotechnical sensing methods or geotechnical solutions in conditions related to dams, impoundments, and water conveyance.
Grid Integration and Interconnection Analysis	Laboratories with software and experience to assess performance of hydropower with respect to grid reliability and dynamic system response.
Grid Integration (Hardware-in-the-loop)	Laboratories with capabilities for energized grid interactive testing of power generation, transformation, protection, instrumentation, and/or control equipment related to hydropower facilities. Testing may often include hardware-in-the-loop configurations i.e., using a closed loop circuit of hardware and software to physically simulate in-service conditions and system operations.
Hydraulics Modeling	Laboratories with software and expertise specialized in modeling hydrodynamics (e.g., water elevation and flow velocity) or relevant environmental indices (e.g., stream temperature, concentration of nutrients, gas, or sediment, as well as particle tracking) for reservoirs, or upstream and downstream of river reaches near hydropower facilities. These models are generally 1D, 2D or 3D (with either width or depth averaging) and used for modeling far field and larger scale phenomena as compared to CFD.
Loading Testing	Laboratories capable of testing novel material properties, bearings, and mechanical assemblies with forces commonly experienced during operation and extreme events (rough zone operation, load rejection, flood regulation) to identify component fatigue and failure characteristics.
Material Characterization	Laboratories capable of providing material characterization of samples of existing in-service materials (destructive testing) and of new materials, composites, and alloys for future application in hydropower applications.

Repair Methods	Laboratories with suitable space, equipment, and conditions to test and evaluate novel repair methods for practicality, safety, efficiency, and/or endurance.
Sediment Passage	Laboratories capable of conducting sediment passage modeling associated with various hydroelectric equipment and impoundment structures.
Sensors and Controls	Laboratories capable of testing novel sensor, control, and actuation systems under conditions found in hydropower facilities, power conduits, penstocks, dams, and reservoirs.
Structural Integrity and Dam Safety	Laboratories capable of model and scale testing of concrete and embankment structures, spillways, and interfaces to gates, drains, penstocks and other dam and powerhouse structures, such as through material testing of core samples.
Surface Resistance	Laboratories capable of providing surface resistance (erosion, corrosion, cavitation, etc.) testing of components, coatings and assemblies commonly associated with water diversion, impoundment, conveyance, power generation and release to natural waterways.
Techno-Economic Analysis – Individual Technologies	Laboratories experienced with providing TEA of individual and/or multi-technology systems to provide comprehensive feasibility analysis, energy production simulation, and financial modeling.
Techno-Economic Analysis – Site Design and Assessment	Laboratories with software and experience to assess site characteristics and co-location potential.
Toxicology, Biodegradability, and Bioaccumulation	Laboratories with capabilities for testing the toxicity, biodegradability, or bioaccumulation of relevant hydropower environmental constituents (e.g., environmentally acceptable lubricants or contaminated sediments) and their impacts on the environment.
Turbine Performance	Laboratories capable of conducting hydraulic testing of hydropower turbine designs and novel material constructions at full or partial scales to assess efficiency, hydrodynamic conditions, aeration, cavitation, or other hydraulic performance parameters.
Water Passage	Laboratories capable of providing performance and/or accelerated wear testing of water passage and control apparatus (outlets, gates, spillways, chutes, boat passage, etc.).