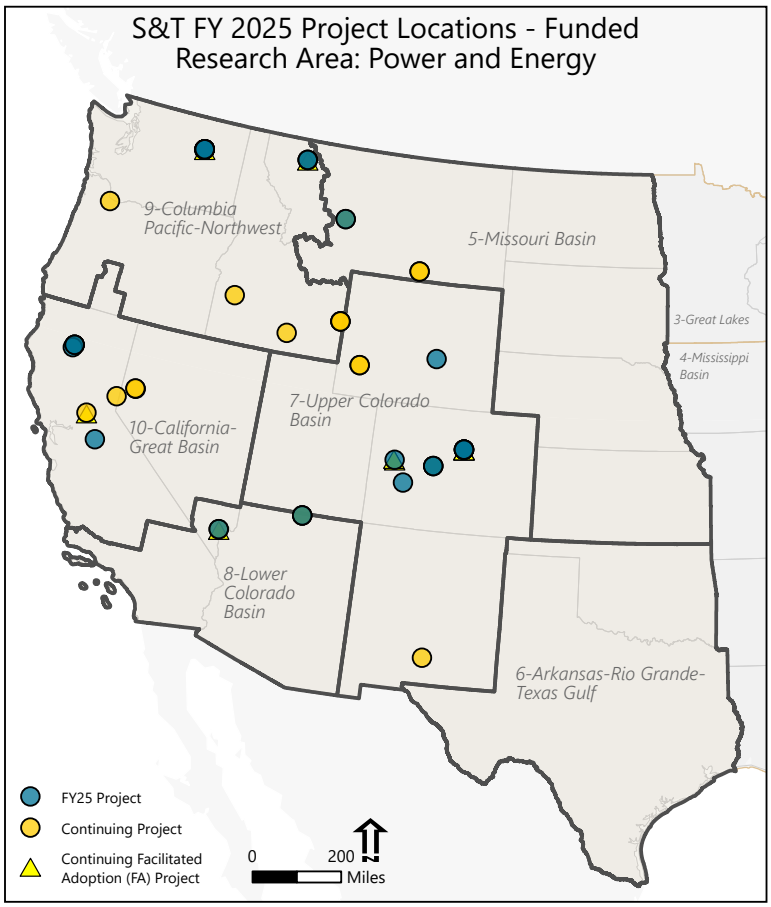
BUREAU OF RECLAMATION

Research Area Summary
Power & Energy
Research and Development Office

U.S. Department of the Interior

June 2025

Executive Summary



The Power and Energy (PE) Research Area of the Science and Technology Program (S&T) examines research in the following categories: Hydro Powerplants, Energy Efficiency, Pumping Plants, and Non Hydropower Renewable. In FY25, the S&T Research Program funded 16 PE projects approximately totaling $1.6 M. Six new projects received $0.8 M in FY25, and 10 continuing projects received $0.8 M in FY25. Additionally, the S&T Facilitated Adoption Program continued to fund eight projects ($1.8 M) in FY25. S&T estimates a benefit-cost ratio (BCR) for PE projects each year to demonstrate the value of this research. A BCR of 597 was calculated for Optimizing Hydraulic Turbine Operation and Maintenance Through Reducing Cavitation. This project focused on improving techniques for detecting and mapping turbine cavitation erosion and its intensity. The BCR is primarily due to new monitoring equipment that gives facility staff the ability to detect when cavitation is occurring in real time and shift unit loading to avoid cavitation damage to the extent possible, as well as remote-operated vehicle cavitation inspections which allow for reductions in the labor required for an inspection and enhance personnel safety. As demonstrated, PE research is extremely valuable to Reclamation.

Reclamation's Research and Development Office (R&D) manages the Science and Technology Program (S&T) and is focused on providing innovative solutions for Reclamation water and power facility managers and its western customers and stakeholders, primarily through competitive funding opportunities to Reclamation employees.

The S&T Program has five research areas (listed below) directly related to Reclamation's mission.
For more information, visit: https://www.usbr.gov/research/st/index.html

S&T Research Areas and Categories

Water Infrastructure (WI)
Dams, Canals, Pipelines, and Miscellaneous Water Infrastructure

Power and Energy (PE)
Hydro Powerplants and Pumping Plants

Developing Water Supplies (WS)
Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System Water Losses

Environmental Issues for Water Delivery and Management (EN)
Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration

Water Operations (WP)
Water Supply and Streamflow Forecasting, Water Operations Models and Decision Support Systems, Open Data, and Hydrologic Variability

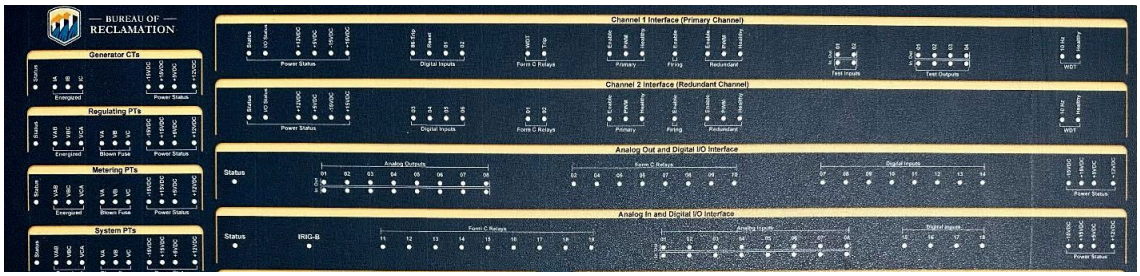
Power and Energy Coordinator:
Erin Foraker eforaker@usbr.gov

Power and Energy

FY24 Completed Projects

19004: Excitation and Governor Control Systems – Kyle Clair

Reclamation operates hydroelectric generators connected to the Western U.S. power system. Currently, Reclamation is in the process of upgrading many excitation/governor systems. Typically, Reclamation uses a variety of manufacturers, making it difficult to maintain and support several different manufacturers' maintenance procedures. This project aims to provide a low-cost, simpler alternative with a "Reclamation made" controller that could be easily retrofitted and installed. This is critical, as the obsolete controllers that are in place can cause supportability/reliability issues in the near future if not replaced soon. Designs have been completed for the new digital prototype exciter and speed governor controllers. Pilot exciter and speed governor controllers were installed and commissioned in Fiscal Year 2024.



Portable controller field interface to perform specialized testing as an excitation or speed governor digital controller.

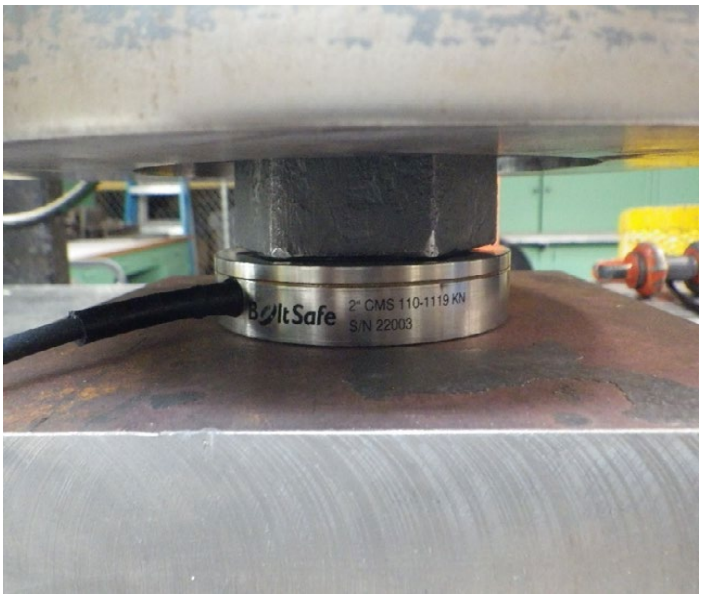
20048: Utilizing Winter-Kennedy Method for Hydropower Flow Measurement – Josh Mortensen

Reliable discharge measurements in hydropower penstocks are important to measure unit efficiency and quantify water passed through the powerplant. The Winter-Kennedy (WK) method of flow measurement correlates a difference in pressure at a cross-section of the scroll case to the discharge through the hydropower unit. Many of Reclamation's hydropower units include pressure taps configured for WK measurements but few are being used. The intent of this study was to determine the value of existing WK systems by comparing flow estimates from original WK calibrations to an absolute flow rate measurement. Field tests were done on six different WK pressure tap systems at three Reclamation hydropower plants. Equipment and original calibrations were at least 40 years old for each unit tested. Test results showed that the original calibrations drifted significantly and for each case the pressure taps would require recalibration to produce accurate measurements. However, provided they are properly maintained, WK measurements are of great value by providing a reference flow measurement that can be used to track changes to operations and efficiencies for a low cost and should be taken advantage of wherever they are available.

Winter-Kennedy flow meter during field testing.

20076: Using Strain Sensing Technology to Increase Safety and Reliability in Critical Connections – Chad Paulson

This research project investigated improved techniques and instrumentation to monitor critical bolt connections on hydroelectric infrastructure. As part of the research, two different types of load sensing fasteners were investigated, tested, and subsequently installed on a hydroelectric generator turbine with this research project. One type uses a real-time online monitoring system and the other requires routine, manual checking. Results show that this new technology could greatly enhance the safety and reliability of suspect bolt connections. This technology is especially advantageous for monitoring connections that are inaccessible for inspection. It was also discovered that the real-time load washers could be used to accurately set load for hydraulic and pneumatic torque wrenches, taking out much of the error that occurs when converting actual load to torque.



Laboratory testing of load-sensing washer in Denver, Colorado.

21006: Development and Refinement of Rotor Turning Device for Safer and More Efficient Maintenance and Diagnostic Tasks – Jacob Lapenna

The Bureau of Reclamation has many large rotating machines within its hydropower fleet. For various maintenance and diagnostic tasks, there is a need to turn these machines in a slow, controlled, and precise manner. In practice, this has required manual turning by a person or complex crane maneuvers. In all cases, manually turning the rotor is dangerous, inefficient, and imprecise. This research developed a system, the Rotor Turning Test Suite (RTTS), to remotely perform this turning while monitoring the rotor's rotational position with very high precision and accuracy. RTTS is a cyber-physical system that uses a secure, local browser application that controls the rotor and displays data to the user in real-time. This research developed the RTTS system architecture through systems analysis and user research via surveys, with compromises made between user preferences and what was required for system functionality and future enhancements.

Encoder driven by rotor slip ring at bottom and revolution sensor and target at top.

21027: Online Monitoring of Protection Systems: Pilot Project – Stephen Agee

This research aimed to improve the reliability and regulatory compliance of protection systems at Reclamation facilities. Proper operation of protection systems is critical to ensure the safety of Reclamation employees and power generation equipment, and compliance with regulatory standards is essential to maintain power system reliability. In this study, researchers piloted several online monitoring solutions. The results demonstrated that continuous monitoring of system components is possible and offers numerous benefits, including early detection of issues, reduced testing outage time, lower risk of equipment misconfiguration, and more consistent documentation. Reclamation should continue to explore opportunities for innovation and improvement for protection system monitoring, such as further research into emerging technologies and long-term monitoring of additional pilot deployments. Reclamation should also consider integrating online monitoring solutions into long-term asset management strategies to maximize the value of these investments.

Human machine interface (HMI) for online monitoring of protection systems.

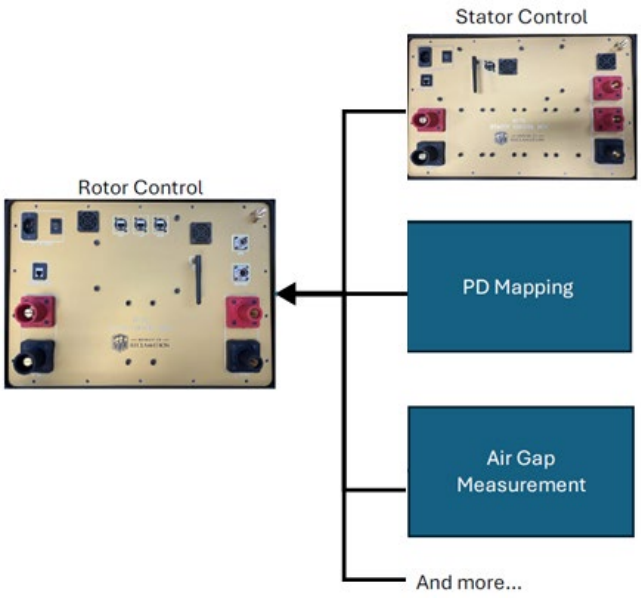
21091: Evaluation and Validation of Fatigue on Aging Hydro Mechanical Components using Finite Element Analysis – Marcel Sorel

Reclamation's powerplants face increasing signs of fatigue failure such as cracking and broken weld joints. Advanced engineering modeling tools are now available, and as aging units undergo upgrades it is crucial to ensure mechanical components can withstand changing dynamic forces. This research assessed fatigue impacts on components using finite element analysis (FEA), which breaks down complex components into smaller, solvable parts to predict system response to real-world forces. Five finite element models were created: two (2) thrust brackets, a single turbine shaft, a mechanical seal, and a piping wye branch. The findings will enhance Reclamation's ability to prevent catastrophic failures and minimize downtime through targeted inspections and advanced computational analyses, leading to more accurate predictions, optimized designs, and cost savings. The program aims to include a variety of components, ultimately improving operational safety and increasing unit availability.term asset management strategies to maximize the value of these investments.

Finite element analysis equivalent stress results overlayed for a hydroelectric generator mechanical seal.

22012: Rotor Installed Corona Probe with Near Field Communication Antennas: Further Refinement Toward a Final Product – Jacob Lapenna

This project continues previous work on the feasibility of remotely sensing partial discharge with near field communication antennas, with a goal to develop a path forward for deploying this technology across Reclamation and possibly industry wide. Economic analysis indicates that widespread adoption of this technology across Reclamation will yield around a 10x return on investment, with benefits including reduced outages, better O&M decision support, and an increase in hydropower fleet reliability. However, there are many technological hurdles to overcome before this technology can be widely adopted. In collaboration with S&T 21006, these research efforts led to the development of the Rotor Turning Test Suite (RTTS) System. This project covers: 1) acquisition of dedicated hardware to incorporate into the RTTS for partial discharge mapping, and 2) development of systems within the RTTS to accept this and other diagnostic testing techniques. Future work will include incorporation of the hardware into the extensible RTTS systems.



Rotor turner testing suite computing architecture and modular hardware.

22014: Improved Adhesion of Polyurethane Coatings with Phosphating – Meredith Heilig

The Bureau of Reclamation has replaced some degraded, historical linings on its infrastructure with polyurethane-based systems. However, some field-installed polyurethane lining systems have shown serious adhesion issues and delamination well before the estimated service life. Improving the adhesion of these materials is necessary for Reclamation to consider their use as linings in the future. This study continues previous work to investigate the effects of phosphating and expanded testing to include corrosion protection, simulated field conditions, and an additional sample group. The study found that pretreatment with phosphoric acid improved performance of a polyurethane-polyurea hybrid compared to pre-treatment with derivatives. Additionally, using a urethane primer improved performance of the polyurethane-polyurea hybrid to a greater extent compared to all phosphating pretreatments applied in the study. All samples pretreated with phosphoric acid or primed with a urethane surface conditioner showed potential performance improvements. Potential future work includes a larger, more focused study, including field-applicable methods and more rigorous laboratory testing.

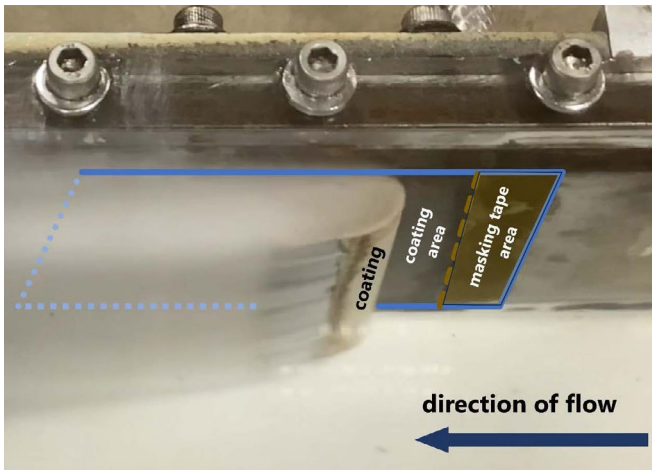


Image of flow test panel in high velocity water as coating delaminates.

Researcher performing field electrochemical impedance spectroscopy testing on a vinyl-coated miter gate compartment at a U.S. Army Corps of Engineers facility.

Protection Systems Combined with Vinyl Coatings – Grace Weber

Corrosion protection of water infrastructure is crucial to maintain water delivery and improve structure service life. The most effective corrosion protection is a combination of protective coatings and cathodic protection (CP). However, some coatings such as vinyl can be susceptible to CP and have been observed to blister in some circumstances. The goal of this research was to better understand the susceptibility of zinc-rich vinyl coatings to CP through laboratory and field work. The results did not provide conclusive information on the complex blistering mechanisms, and the final report includes several recommendations to Reclamation designers on the use of CP with zinc-rich vinyl coatings for both new and existing structures.

FY25 New S&T Research Projects

25017: Integration of Renewable Energy Sources – Implementation of a Hydro Generation Start/Stop and Cycling Costs Methodology – James DeHaan

In today's power market, many hydro facilities are struggling financially. Often, facilities are providing more and more load balancing services, as the amount of wind and solar energy on the power system increases. Revenue streams based solely on hydro energy production are not sufficient to cover these additional services. Without a method to identify, evaluate, and determine the cost of the ancillary services, it is impossible to determine the financial impact. There is an urgent need to identify these costs so that hydro facilities can either minimize these costs or be sufficiently compensated for supplying these needed power system services.

25019: Accelerating Breakthroughs in Cavitation Resistant Materials Performance – Allen Skaja

The development of improved cavitation resistant materials is significantly reducing the cost of cavitation repairs. A 2024 S&T Return-on-Investment analysis found a potential return of 127,000% if a 5% outage reduction could be achieved. However, Reclamation laboratories are limited in the scale of this research by the current facilities. This research will upgrade Reclamation's cavitation testing facility and standardize testing procedures across Reclamation, its research partners, and other water infrastructure entities.

25020: Demonstration of Remoted Inspection for Inaccessible Metallic Pipe – David Tordonato

Traditionally, Reclamation's interior inspections of buried or encased metallic pipe, such as penstocks and outlet works, have been completed by humans, typically using rope access techniques where necessary. Robotic crawlers and submersibles may offer the ability to physically collect information without putting humans at risk. This project seeks to identify and demonstrate solutions for inspection of inaccessible features, such as penstocks with small diameters (less than 42-inches), as well as restricted or challenging access points.

25026: Hydropower Runner In-Situ Polymer Extensions for Improved Operations – Kelly Kepler

Drought and fluctuating reservoir conditions are changing the way Reclamation powerplants operate. Powerplants are being asked to be more flexible in their operations than before by operating in off-design or high and part load regions, which can result in cavitation damage or excessive vibration. This project evaluates a novel low cost, in-situ polymer extension option to alter runner performance with respect to cavitation and overall operating range. The project will select a powerplant to test leading and trailing edge polymer extensions and their effect on unit performance, with the goals of reduced cavitation damage, increased operating ranges, and climateresilience in hydropower operation.

25027: Hydropower Runner Alternative Manufacturing Methods – Kelly Kepler

Improving the value of hydropower has been a Reclamation and Federal government goal in recent years, as operation, maintenance, and replacement costs have steadily increased. In this project, Reclamation will partner with General Electric Vernova, the Department of Energy, and Hoover Powerplant to investigate and demonstrate a runner manufactured through a novel automated process developed by GE, using additive manufacturing and robotic welding. The final runner will be installed at Hoover Powerplant. The project will make recommendations on use and inspection of the new manufacturing method.

25029: Investigating Adhesion and Internal Stress of Coatings – Allen Skaja

This project will investigate the internal stress and loss of adhesion developed in coatings during fluctuating immersion exposure conditions for gates, bulkheads, and stop logs. The strains from changes in temperature and hydration levels, combined with the difference in thermal properties of the coatings and steel, impart significant stresses to the coatings and can result in coating failure. A better understanding of coating adhesion and internal stress is needed to find longer service life coatings.

FY25 Continuing Facilitated Adoption Project

ProgramFA25051: Development and Refinement of Rotor Turning Device for Safer and More Efficient Maintenance and Diagnostic Tasks – Jacob Lapenna

This project demonstrates the commercial grade device for turning rotors developed through internal Reclamation research projects for use within Reclamation facilities. This project will expand the number of Rotor Turning Test Suites (RTTS) devices to additional facilities or regions, train facility personnel, and include an internal Operations & Maintenance workshop. Implementation will improve bearing alignment and signal mapping and reduce the need for human intervention to manually turn rotors.

FA25055: Turbine Air Injection Testing and Implementation – Michael Rauh

Turbine air injection has proven successful in reducing rough zone range and vibration magnitude on units in Grand Coulee's Washington Powerhouse under prior Reclamation research projects. This Facilitated Adoption Project aims to expand turbine air injection to additional Reclamation facilities through testing and data analysis to assess turbine air injection benefits at up to three Reclamation facilities in separate regions. Once testing is completed, one air injection system will go through design, control system supply, and commissioning for one facility.

FA25056: Evaluation and Validation of Fatigue on Aging Hydro Mechanical Components Using Finite Element Analysis – Marcel Sorel

The objective of this project is to better predict equipment failures, identify high stress concentrations, and extend equipment fatigue life by expanding Finite Element Analysis capability for assessing hydropower mechanical components. Prior Reclamation internal research resulted in the creation and analyses of models spanning thrust brackets, shafts, and mechanical seals. This project continues to develop Reclamation core technical capability in modeling, analyzing, and predicting fatigue life in hydropower mechanical components across Reclamation assets.

New and Continuing Projects*

ID	Final Year	Title	Lead
1707	2025	Hydrokinetic Devices Subject to Supercritical Flow: Impacts on Canals and Considerations	Josh Mortensen
19223	2025	Reduction of Damaging Stator Core and Winding Vibrations in Large-Diameter Salient-Pole	Eric Eastment
19251	2025	Effects of Water Absorption on Epoxy-Mica Based Stator Winding Insulation	Eric Eastment
20014	2025	Rotor-Mounted Scanner – Participate in the development and deployment of a new and improved version of the Rotor-Mounted Scanner hydro condition monitoring system, designated StatorScan.™	Jim DeHaan
20036	2025	Evaluating Kevlar Rope for Use in Gate Hoist and Crane Applications for Improved Service Life	Zach Cepak
20100	2025	Evaluation of Alternative Fire Suppression Methods for Generators For Improved Safety, Effectiveness and Reliability	Sean Kyer
21022	2025	Develop Integrated Tools for Digital Excitation and Speed Governor Control Systems	Kyle Clair
22021	2025	Determining compatibility of Zinc Anodes for Cathodic Protection in Various Waters Specific to Reclamation and US Army Corps of Engineers Facilities: Phase II.	Meredith Heilig
22026	2025	Integration of Renewable Energy Sources - Determining Hydro Generation Start/Stop and Cycling Costs	Jim DeHaan
22044	2025	Improved Processing and Analysis of Test and Operating Data from Rotating Machines	Stephen Agee
22060	2025	Modular Anode Sled Development and Testing for Cathodic Protection of Immersed Steel Structures	Matthew Jermyn
23005	2025	A Conducting Study: Determining Mechanisms to Attain Energy Self-Sufficiency and Reliability at Two Reclamation Field Offices	Bonnie Van Pelt
23023	2025	Intake Vortex Formation Effect on Turbine Performance	Kelly Kepler
23030	2025	Automated In Situ Repairs of Damaged and Aging Infrastructure	Kelly Kepler
23033	2025	Reclamation Maintenance Improvement Initiative (MII) Toolset – Appling analytical methods to powerplant data to help optimize the use of hydro generator	James DeHaan
23063	2025	Online Transformer Oil Monitoring	Ben Few
23064	2025	Improved Performance During Drought at Glen Canyon	Patrick Council and Lyle Brouwer
23068	2026	Advancing O&M using State-of-the-Art Instrumentation	Jim DeHaan
23069	2026	Renewable Energy Assessment at Glen Canyon	Shane Mower
24005	2026	Monitoring Field Trials and Optimizing Cavitation-Resistant Coating Systems	Allen Skaja
24023	2026	Install, Commission, and Finalize Evaluation of Cost Effective, Flexible Excitation and Governor Control System Platform Speed Governor & Voltage Regulator Prototypes	Kyle Clair
24024	2025	Develop Filtering Technology to Improve Data Acquisition and Subsequent Regulatory Modeling of Simulated Power Grid	Matthew Burgamy

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ID	Final Year	Title	Lead
24032	2025	Explore options to implement better overcurrent protection practices of the generator field winding for more accurate coordination and cost effective for units to implement.	Yuriy Komlev
24059	2026	Creation and Consumption of Machine Condition Monitoring Data Using Mobile Devices	Lyle Brouwer
25017	2027	Integration of Renewable Energy Sources – Implementation of a Hydro Generation Start/Stop and Cycling Costs Methodology	James Dehaan
25019	2027	Accelerating Breakthroughs in Cavitation Resistant Materials Performance	Allen Skaja
25020	2027	Demonstration of Remoted Inspection for Inaccessible Metallic Pipe	David Tordonato
25026	2027	Hydropower Runner In-Situ Polymer Extensions for Improved Operations	Kelly Kepler
25027	2027	Hydropower Runner Alternative Manufacturing Methods	Kelly Kepler
25029	2027	Investigating Adhesion and Internal Stress of Coatings	Allen Skaja
FA25051	2027	Development and Refinement of Rotor Turning Device for Safer and More Efficient Maintenance and Diagnostic Tasks	Jacob Lapenna
FA25055	2026	Turbine Air Injection Testing and Implementation	Michael Rauh
FA25056	2026	Evaluation and Validation of Fatigue on Aging Hydro Mechanical Components Using Finite Element Analysis	Marcel Sorel

**Continuing projects include those that received no-cost extensions.*

Front cover photo: Nathaniel “Nat” Washington Powerplant Unit G24 inner/ outer head cover bolts where load sensing washers were tested.

Back cover photo: Hydropower generating units at Glen Canyon Dam, Arizona.