BUREAU OF RECLAMATION

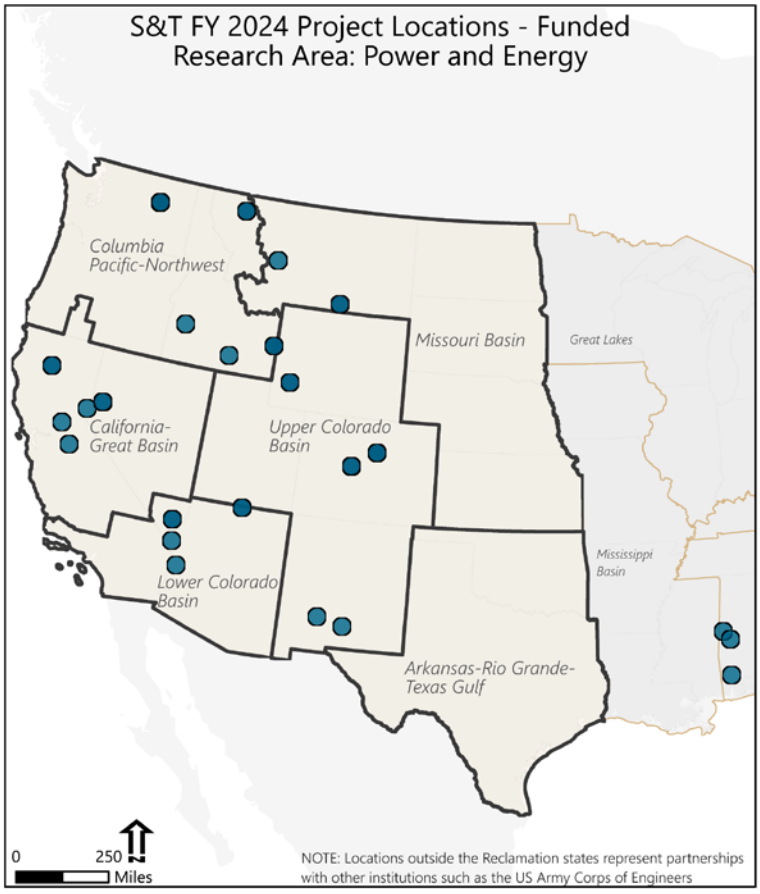
Research Updates
R&D Office

Power and Energy

U.S. Department of the Interior

January 2024

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 FY24, S&T funded 31 PE Projects approximately totaling $1.7M: five were new totaling $0.5M and 26 were continuing totaling $1.2M. Additionally, the new Facilitated Adoption program funded three projects as part of its inaugural funding cycle ($1.0M). Benefit Cost Ratio calculations (BCR) are estimated for two PE projects each year to demonstrate the value of this research. Power System Instrumentation had a BCR of 52.8. This project developed wireless instrumentation to monitor rotor rim float but is also being applied to monitor strain for a rotor crack. The BCR is primarily due to costs savings based on decreased labor hours to perform inspections compared to traditional, wired instrumentation and decreased outages because the monitoring is allowing the facility to stay online. Using Strain-Sensing Technology had a BCR of 44.3. This project evaluated a sensor that allows for determination of load on bolts without removing or loosening. The BCR is primarily based on increased efficiency of plant monitoring. Other benefits not quantified include risk reduction due to increased safety by applying this new technology. As demonstrated, PE research is extremely valuable to Reclamation, both by developing new instrumentation solutions and by demonstrating commercially available ones.

Science and Technology Program: Research Areas

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 research projects led by 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/needs_priorities/index. html)

S&T Research Areas and Categories

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

Power and Energy (PE)
Hydro Powerplants, Energy Efficiency, Pumping Plants, and Non-Hydropower Renewable

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

Environmental Issues in 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 Climate Change and Variability

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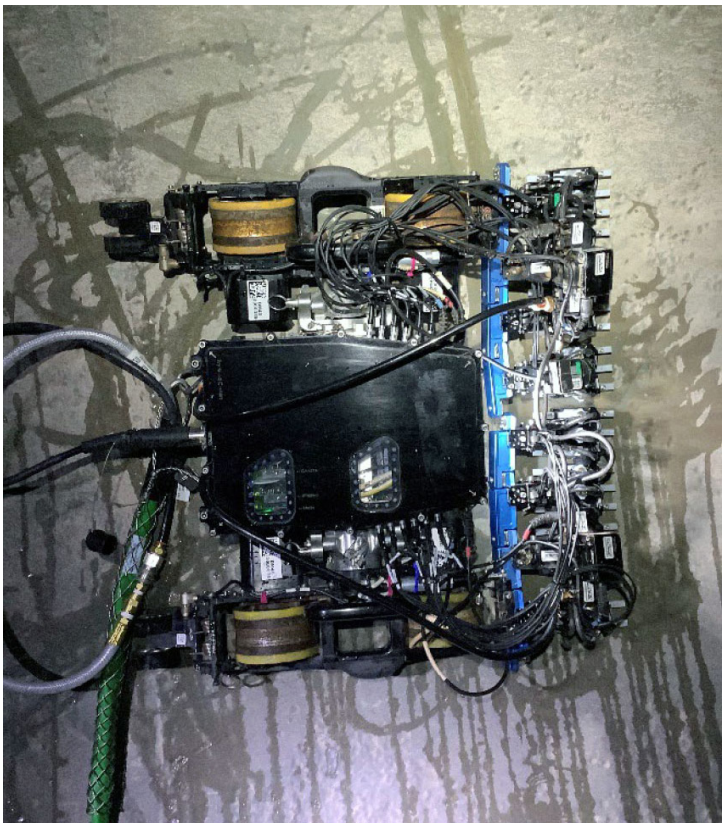
Power and Energy

FY23 Completed Projects

22064: Robotic Non-Destructive Inspection of Hydraulic Streel Structures – David Tordonato

Reclamation performs non-destructive testing of structures to survey for metal loss and corrosion. The current standard of practice is to collect data manually. New technology allows for remote inspection vehicles (RIVs) to collect a large sampling of data at a rate much faster than a human. RIVs could decrease risk to personnel and provide access to presently unreachable areas. Market research was performed to investigate commercially available technologies, and then several RIVs were demonstrated at Reclamation facilities. While the RIV technology demonstrated has some practical limitations related to pipe diameter and length, it may be possible to supplement Reclamation's current approach to condition assessment with robotics to yield more useful information on the structure's overall condition. Development of RIV technology is continually improving and these methods are expected to become more practical for a broader set of use cases in the future.



Robotic magnetic crawler equipped with an array of 24 UT transducers.

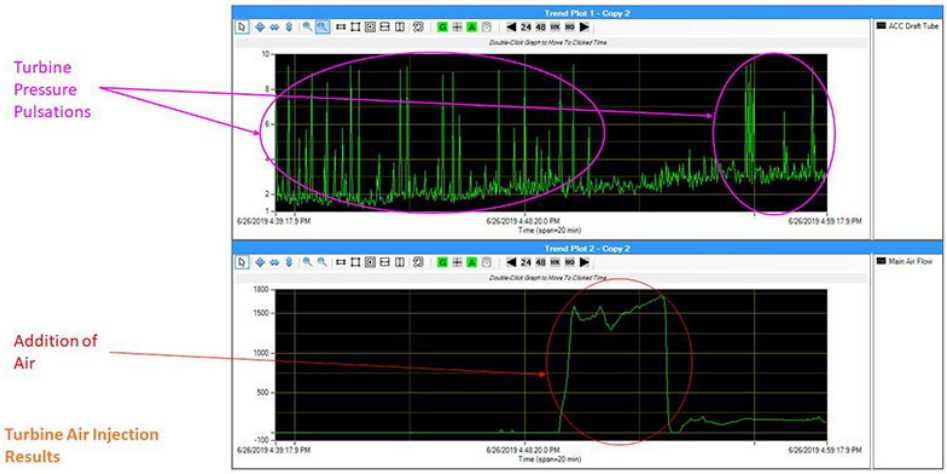
Researcher at Grand Coulee Dam.

20012: Machine Condition Monitoring-Enhance and expand Reclamation developed Machine Condition Monitoring (MCM) System – Jim DeHaan

Machine Condition Monitoring (MCM) is the process of monitoring machine parameters and associated systems to identify the condition of a machine by recording changes that are indicative of an issue. Trends in the data provide information about the machine and can help predict when to schedule maintenance or other intervention activities to prevent machine damage and unplanned outages. The Hydropower Diagnostics and SCADA Group has developed an MCM system utilizing commercial data acquisition hardware and in-house written code, which was funded under previous research projects starting in 2009. This research has helped to evolve Reclamation's MCM system, making it more robust. More significantly, it has added new tools and means of analysis as afforded by the evolution in MCM techniques, technology, and analysis tools.

8121: Cavitation Detection Techniques for Optimizing Hydraulic Turbine Operation and Maintenance – John Germann

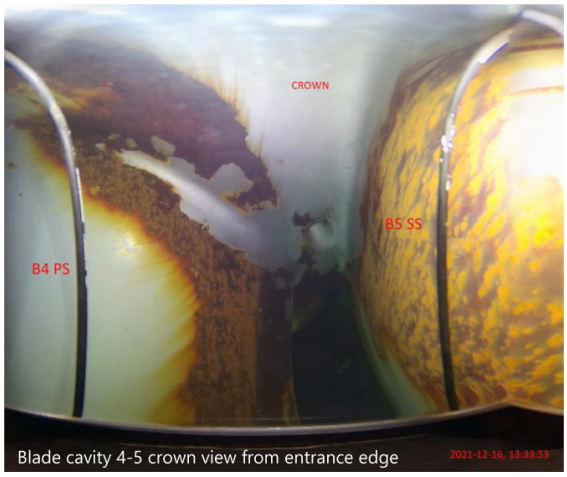
Cavitation induced phenomena in hydroelectric turbines continues to be an important research driver due to the high cost of repair of associated damage. Reclamation has been conducting research that takes high frequency vibratory and acoustic measurements to measure and quantify the damaging effects of hydraulic induced cavitation. The effect of air injection on cavitation and pressure pulsations during operation was also studied. The main technological areas investigated with this study are instrumentation technology, signal processing, air injection and hydraulic turbine and generator assessment and monitoring. The study culminated with the installation of cavitation monitors on a hydroelectric generator unit.



Air injection sensor output showing effective mitigation of pressure pulsations.

21104: Optimizing Hydraulic Turbine Operation and Maintenance Through Reducing Cavitation – John Germann

Water levels at Reclamation reservoirs affected by ongoing drought are near historic lows. As reservoir water levels begin to drop to near and below the operational power pool, operating under these extreme off-design conditions may result in dynamic hydraulic phenomena that can produce undesired damage to the turbine runner such as cavitation induced erosion, excessive pressure pulsations, and high vibration. This research improved cavitation testing and monitoring and air injection testing on hydraulic turbines. This research is also exploring other new technologies such as the use of Remotely Operated Vehicle (ROV) inspections, testing better cavitation damage assessment tools and techniques, and development of a robotic welder for repair.



ROV turbine runner blade inspection.

20203: New Reclamation-wide Maintenance Management Toolset – Jim DeHaan

To maximize the value of the Reclamation's power production assets, the implementation of a condition-based predictive maintenance program that can be deployed Reclamation wide is necessary to help optimize plant maintenance. To support this implementation, this research pursued the following two objectives: 1) evaluate the business case for implementing several hydro plant condition monitoring systems at a Reclamation powerplant and 2) deploy a pilot network infrastructure that supports the transfer and storage of condition monitoring data. The project results found that condition monitoring reduces labor requirements, reduces equipment downtime, increases equipment life expectance, and has a payback period varying from 10 months to over 10 years. The network pilot was successfully implemented, used Reclamation's existing IT infrastructure, and complies with Reclamation's security requirements.

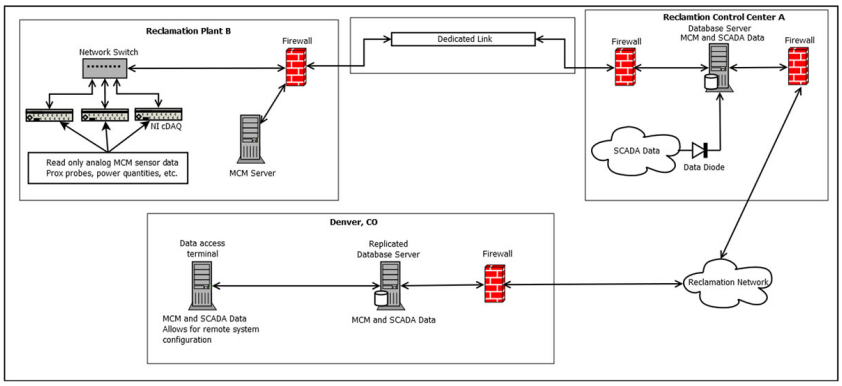


Diagram showing successful data transmission pilot. MCM data is transmitted from Plant B to Control Center A, where it is merged with SCADA data. The database at Control Center A is replicated in Denver for analysis access.

19085: Additive Manufacturing Investigation and Demonstration for Hydropower Applications – David Tordonato

This project sought to examine the current state-of-the-art in additive manufacturing (AM) technology and to determine how this technology can be applied within Reclamation and the hydropower industry. The project focused on identifying where Reclamation should leverage the inherent advantages of AM to solve challenges that are unique to maintaining aging infrastructure. The results suggest that 3D metal printing is viable and, in very specific situations, may be appropriate for producing small parts for use at Reclamation facilities. Part selection is a significant determinant of a successful and economically sound project. The ultimate, long-term vision for use of AM at Reclamation is to develop a streamlined, AM-based approach for repair or replacement of legacy components on existing equipment and structures in lieu of the traditional process that includes design, procurement of materials, custom fabrication, and assembly.

A photograph showing additively manufactured aluminum log boom anchor parts and wall (Photo credit: Oak Ridge National Laboratory).

FY24 New Research Projects

Science and Technology Program

24005: Monitoring Field Trials and Optimizing Cavitation-resistant Coating Systems – Allen Skaja

This research is a continuation of completed work that included laboratory testing of cavitation-resistant coatings and two field trials. In this continued research, the team will monitor the existing field trials and begin two new field trials, one at a Reclamation facility and one at a Denver Water facility. The research team will also partner with the U.S. Army Corps of Engineers to develop a Military Specification for a cavitation-resistant coating system. The goal of the project is to provide practical protective coating solutions for severe cavitation and erosion service conditions.

24023: Install, Commission, and Finalize Evaluation of Cost Effective, Flexible Excitation and Governor Control System Platform Speed Governor & Voltage Regulator Prototypes – Kyle Clair

Reclamation is facing challenges regarding employee training and retention, equipment obsolescence, and budget shortfalls. Specifically, maintaining and replacing digital excitation and speed governor controllers in Reclamation powerplants is prohibitively expensive. Training fragmentation issues occur when trying to maintain multiple vendor systems. Proprietary vendor computer code cannot be modified and maintained by Reclamation. This research will investigate if these issues can be addressed by developing a reasonably cost-effective, flexible Excitation and Governor Control System Platform using commercial off-the-shelf hardware and open-source programming tools.

24024: Develop Filtering Technology to Improve Data Acquisition and Subsequent Regulatory Modeling of Simulated Power Grid – Matthew Burgamy

Modeling of power grid systems is becoming more complex as generation needs grow. As the manipulation of voltage and power becomes more important to maintain a strong and flexible grid of varying loads, so then does the precision of the tools we use to predict the response of the generators responsible for those changes. This research will investigate the improvement of testing equipment to provide more precise and accurate data that can be used for better model validation of generators connected to the power grid.

24032: Explore Option to Implement Better Overcurrent Protection Practices of the Generator Field Winding for More Accurate Coordination and Cost Effective for Units to Implement – Yuriy Komlev

Many generators across Reclamation are unprotected from generator field winding overcurrent. These units are at risk of catastrophic failure, which would cost Reclamation millions of dollars. This research will determine options for implementing inverse time overcurrent protection that does not require significant labor and equipment cost. Specifically, researchers will identify a protection device that can measure the direct current of the generator, test the equipment in the laboratory for accuracy and repeatability, and then commission and coordinate with limiters in powerplant installations.

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24059: Creation and Consumption of Machine Condition Monitoring Data Using Mobile Devices – Lyle Brouwer

Mobile devices are ubiquitous and are being adapted in process control to deliver process data and analytics to operators, supervisors, and managers throughout the electrical power industry. However, their use within Reclamation is very limited. This project seeks to improve Reclamation's Machine Condition Monitor (MCM) data acquisition application by researching options for connecting mobile devices to MCM systems for both creation and consumption of process information. The goal is to allow supervisors and management to view condition-based maintenance indicators of all the plant's generators centrally in real time through improvements to data collection and remote viewing using mobile devices.

FY23 Facilitated Adoption Projects

FA24067: Wireless Battery Cell Voltage Monitor for Routing NERC Required Battery Testing – Dan McElroy

Each Reclamation powerplant has at least one battery that needs to be tested routinely due to regulatory requirements. BATMON2 is a wireless battery cell voltage monitor that empowers Reclamation facilities to perform their own battery capacity testing safely and quickly, a much cheaper option than having the TSC perform the battery tests. This project will build 10 sets of BATMON2 and install them at selected facilities across Reclamation.

FA24070: Machine Condition Monitoring (MCM) Deployment – James DeHaan

Machine Conditioning Monitoring (MCM) is the process of monitoring machine parameters to identify the condition or health of the machine. This project would expand the deployment of MCM systems that include cavitation detection to additional Regions and Area Offices. The data will help to predict when to schedule maintenance or other intervention activities to prevent damage and consequential outages. Current installations are at the Eastern Colorado Area Office and Grand Coulee Dam. Potential new sites include Hoover, Flaming Gorge, New Melones, Folsom, Freemont Canyon and Hungry Horse Dams.

FA24069: Predictive Maintenance Deployment – James DeHaan

Predictive Maintenance (PdM) involves collecting data to determine exactly when equipment needs maintenance, reducing O&M costs and increasing operational flexibility. Since the expertise needed to analyze these data are distributed throughout Reclamation, they must be available on a secure network, requiring close coordination with Reclamation's information technology personnel. A pilot PdM project was successfully completed in cooperation with the Power Resources Office at the Palisades power plant. This project will pursue additional pilot installations in other facilities including Hoover, Glen Canyon and Grand Coulee Dams.

FY24 New and Continuing Research Projects

ID	Final Year	Title	Lead
19004	2024	Excitation and Governer Control System	Kyle Clair
19223	2024	Reduction of Damaging Stator Core and Winding Vibrations in Large-Diameter Salient-Pole Synchronous Machines	Eric Eastment
20014	2024	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	2024	Evaluating Kevlar Rope for Use in Gate Hoist and Crane Applications for Improved Service Life	Zach Cepak
20048	2024	Utilizing the Winter-Kennedy Method for Hydropower Flow Measurement	Josh Mortensen
20100	2025	Evaluation of Alternative Fire Suppression Methods for Generators for Improved Safety, Effectiveness and Reliability	Sean Kyer
21006	2024	Development and Refinement of Rotor Turning Device for Safer and More Efficient Maintenance and Diagnostic Tasks	Jacob Lapenna

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ID	Final Year	Title	Lead
21022	2024	Develop Integrated Tools for Digital Excitation and Speed Governor Control Systems	Kyle Clair
21027	2024	Online Monitoring of Protection Systems: Pilot Project	Stephen Agee
21091	2024	Evaluation and Validation of Fatigue on Aging Hydro Mechanical Components using Finite Element Analysis	Marcel Sorel
22012	2024	Rotor Installed Corona Probe with Near Field Communication Antennas: Further Refinement Toward a Final Product	Jacob Lapenna
22014	2024	Improved Adhesion of Polyurethane Coatings with Phosphating	Meredith Heilig
22021	2024	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	2024	Integration of Renewable Energy Sources - Determining Hydro Generation Start/Stop and Cycling Costs	Jim DeHaan
22037	2024	Engineering and Maintenance for Cathodic Protection Systems Combined with Vinyl Coatings	Grace Weber
22044	2024	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	John Germann
23033	2025	Reclamation Maintenance Improvement Initiative (MII) Toolset – Appling Analytical Methods to Powerplant Data to Help Optimize the Use of Hydro Generator Maintenance Resources	Jim DeHaan
23063	2025	Online Transformer Oil Monitoring	Ben Few
23064	2025	Improved Performance During Drought at Glen Canyon	Patrick Council
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
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Front cover photo: Powerplant at Glen Canyon Dam in Arizona.
Back cover photo: Horizontal shaft Kaplan units at Allen E. Inman Powerplant at Minidoka Dam in Idaho.