BUREAU OF RECLAMATION

R&D Office Research Updates

Power and Energy

U.S. Department of the Interior

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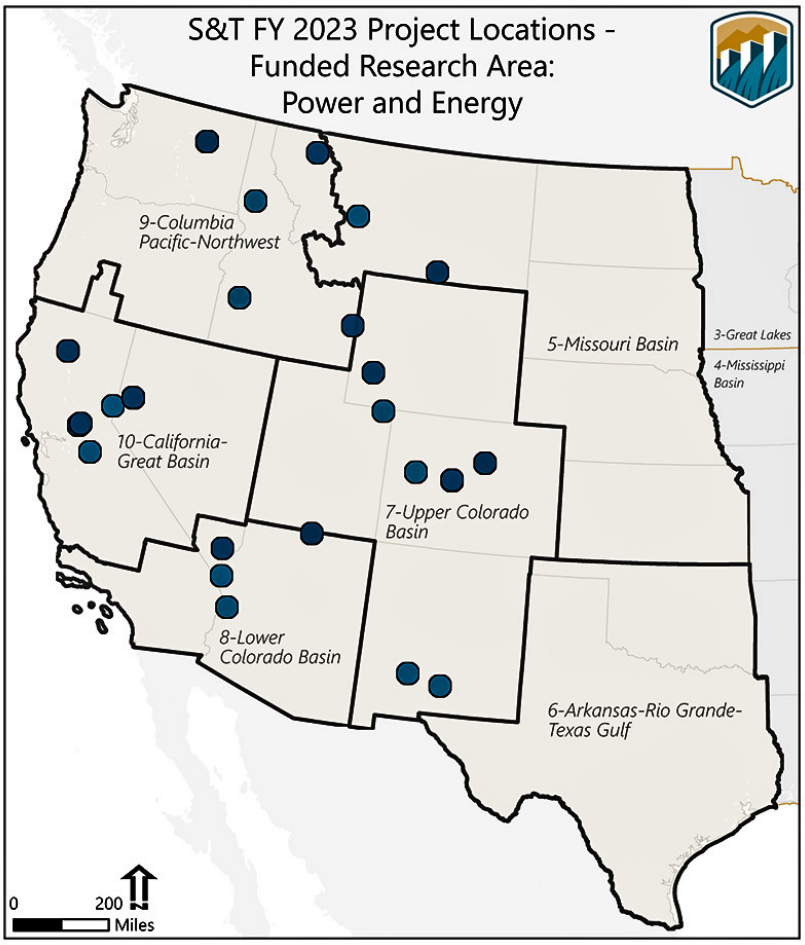
Executive Summary

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 FY23, S&T funded 23 Power and Energy projects for a total of $0.9M: there was 1 new project totaling $0.1M and 22 were continuing totaling $0.8M. PE research is extremely valuable to Reclamation, as demonstrated by development of new operation and maintenance methods and investigation of new technologies.



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: 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

FY22 Completed Projects

300: Performance Testing Multiple Units of Similar Hydraulic Design – Shanna Durham

This research investigated hydropower performance characteristics of hydraulically similar hydroelectric units, performance tests, archival unit data, and turbine manufacturer's predicted performance to identify opportunities to optimize operations at multiple unit powerplants. Reclamation, Oak Ridge National Lab, and Hydro Performance Processes, Inc. investigated two multi-unit powerplants to test each unit, gather historical data, analyze the data, and provide optimization improvements. The research estimated the increased value and reliability for multi-unit optimization, informed by regular performance testing under historical dispatch and water availability scenarios. Optimization scheduling at the two powerplants also outlined the optimized generating efficiencies. Additional Reclamation powerplants could benefit from an optimization study for water conservation and generation schedule analysis for increased revenue and optimized water usage, such as those with existing units that have not had recent turbine runner replacements.

Palisades Powerplant Units 1, 2, 3, and 4.

Engineers inspect instrumentation.

20009: Power System Instrumentation – Patrick Council

This research developed test equipment for acquiring high value data to indicate the condition of power plant equipment and improve Reclamation's ability to keep its power plants running reliably. The equipment includes new wireless instrumentation that enabled Mt. Elbert Power Plant to monitor a crack on their rotor to minimize outage requirements by integrating wireless instrumentation with their Machine Condition Monitor. Significant progress was also made on the flexible air gap probe and the direct current (DC) Arc Flash Mitigation Breaker. Future collaboration with a commercial company could bring solid state DC breakers into the marketplace, which would not only benefit Reclamation, but also many industries where DC arc flash is an issue. Facilitated adoption of this research is essential to ensure that the investment will yield returns for years to come in the form of reduced O&M costs.

20036: Evaluating Kevlar Rope for Use in Gate Hoist and Crane Applications for Improved Service Life – Zach Cepak

The typical materials for wire ropes are galvanized steel or stainless steel wires. Stainless steel is expensive, and corrosion is a serious issue for galvanized steel that can lead to a catastrophic failure. This research evaluated alternative materials like Kevlar and other synthetic rope for crane and hoist applications. The benefit of Kevlar rope is that it does not corrode as quickly as steel. This would increase the service life of ropes at Reclamation facilities, saving money through less frequent rope replacement. Kevlar ropes are also greaseless, which is a desired environmental outcome for this work. The research also found rope strength to be a potential benefit because the rope diameter determines the size for the drum that it spools on and the corresponding in-line equipment. If Kevlar is a stronger material than steel, this decreases rope diameter and the size and ratings of the remaining equipment, reducing the overall footprint.

Example of a catastrophic wire rope break.

20076: Using Strain-Sensing Technology to Increase Safety and Reliability of Inaccessible Critical Connections in Hydropower Equipment – John Germann

'Smart' washers installed on this turbine head cover bolt allow for continual real time monitoring of bolt tightness and load.

Hydroelectric facilities have critical bolted joint connects that can fail with catastrophic consequences. The 2009 accident at the Sayano-Shushenskaya Powerplant in Russia initiated when headcover bolts on a generator turbine failed, killing 75 people and heavily damaging the powerplant. Many connections are inaccessible, making it difficult to confirm the threaded assemblies are tight and at the required bolt load. This research investigated two modern load sensors, a load indicating washer and a load indicating fastener, to directly measure and monitor bolt tightness and health. Sensors were tested in Reclamation's Hydraulic Investigations Laboratory prior to installation on the turbine headcover bolts of a large generating unit at a powerplant. The research found the sensors to successfully monitor the bolt tightness or load and to provide up to a ten-fold increase in bolt-tightening accuracy compared to current installation practices. The technology will help alleviate scheduled and unscheduled maintenance needed in finding loose or broken bolts and reduce the risk of catastrophic failure of these critical connections.

21087: Quantifying the Flexibility and Economic Potential of Reclamation's Hydropower Assets – Jordan Lanini

RiverWare is a flexible decision support system Reclamation frequently uses to inform decisions in river basins across the western United States. Reclamation developed HydrOS, a flexible, stand-alone hydropower optimization system that determines optimal unit loading levels and commitment solutions to meet power output or flow rate targets in real time. This project explored the potential for linking the two models, informing reservoir operators with better estimates of potential hydropower generation. To date, the Technical Service Center (TSC) developed HydrOS models of Buffalo Bill Reservoir and Yellowtail Dam, two facilities with existing RiverWare models. Future efforts will select promising methods for linking the methods and explore improvements in hydropower representation over existing RiverWare models. The project will also investigate the economic benefits accruing from our projects and potential economic gains resulting from better-informed operations.

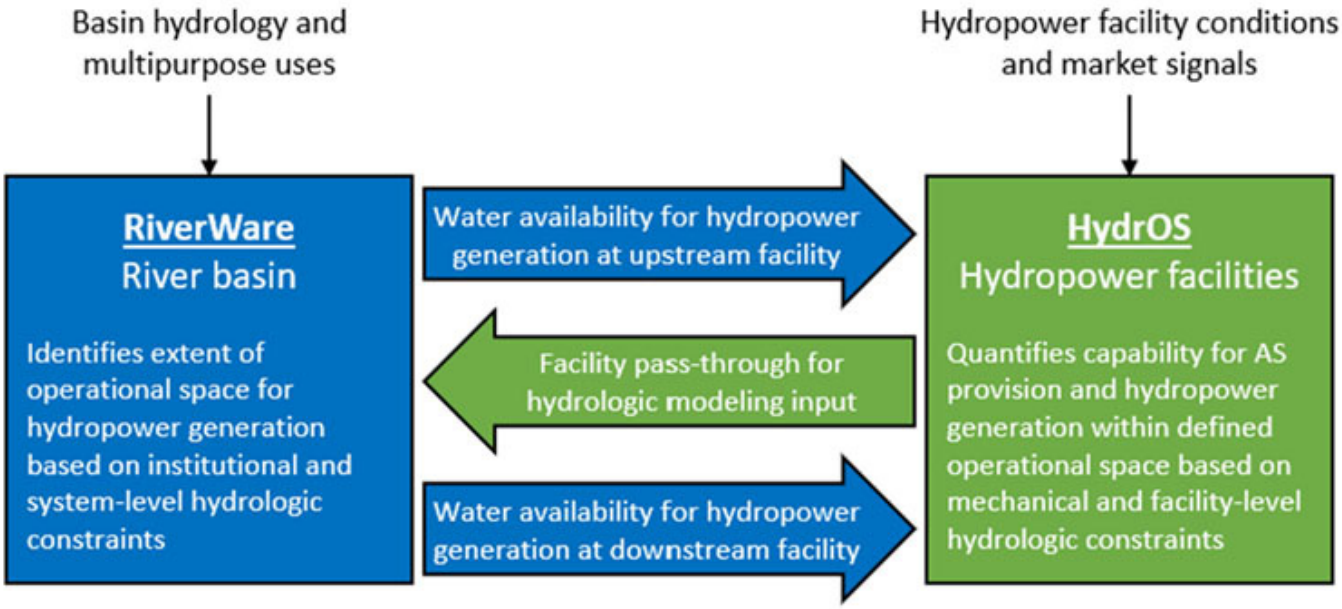

Diagram of a conceptual linkage of the HydrOS and RiverWare models.

FY23 New Projects

23030: Automated In Situ Repairs of Damaged and Aging Infrastructure – John Germann

The need for in situ or 'in place' repair of Reclamation's aging infrastructure has been repeatedly identified by field personnel as a critical area of need and development. This research investigates the use of 3D scanning and automated welding for two proposed applications: 1) robotic cavitation repair of turbine runners, and 2) a proof of concept to utilize three-dimensional scanning to map a repair area geometry and print the repair directly onto the native part. The research advances potential additive manufacturing applications at Reclamation and may provide faster, easier, and safer methods for cavitation damage repair on turbine draft tubes and runners.

FY23 Active Projects

ID	Final Year	Title	Lead
1707	2023	Hydrokinetic Devices Subject to Supercritical Flow: Impacts on Canals and Considerations	Josh Mortensen
19004	2023	Excitation and Governer Control System	Kyle Clair
19085	2023	Additive Manufacturing Investigation and Demonstration for Hydropower Applications	David Tordonato
19223	2024	Reduction of Damaging Stator Core and Winding Vibrations in Large-Diameter Salient-Pole Synchronous Machines	Eric Eastment
19251	2023	Effects of Water Absorption on Epoxy-Mica Based Stator Winding Insulation Systems	Eric Eastment
20012	2023	Machine Condition Monitoring	Jim DeHaan
20048	2023	Utilizing the Winter-Kennedy method for Hydropower Flow Measurement	Josh Mortensen
20203	2023	New Reclamation-wide Maintenance Management Toolset	Jim DeHaan
21006	2023	Development and Refinement of Rotor Turning Device for Safer and More Efficient Maintenance and Diagnostic Tasks	Jacob Lapenna
21022	2023	Develop Integrated Tools for Digital Excitation and Speed Governor Control Systems	Kyle Clair
21027	2023	Online Monitoring of Protection Systems: Pilot Project	Stephen Agee
21091	2023	Evaluation and Validation of Fatigue on Aging Hydro Mechanical Components using Finite Element Analysis	Marcel Sorel
21104	2023	Optimizing Hydraulic Turbine Operation and Maintenance Through Reducing Cavitation	John Germann
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	Stephanie Prochaska
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.	Chrissy Henderson
22024	2025	Learning from the Past, Inspection of Historic Penstock Lining Field Trials; Shasta Penstocks and Collbran Siphon	Allen Skaja
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	2024	Modular Anode Sled Development and Testing for Cathodic Protection of Immersed Steel Structures	Matthew Jermyn
22064	2025	Robotic Non-Destructive Inspection of Hydraulic Streel Structures	David Tordonato
23030	2025	Automated In Situ Repairs of Damaged and Aging Infrastructure	John Germann

Front cover photo: Engineers inspecting switchyard equipment.

Back cover photo: Engineer performing wheel pit inspection at powerplant.