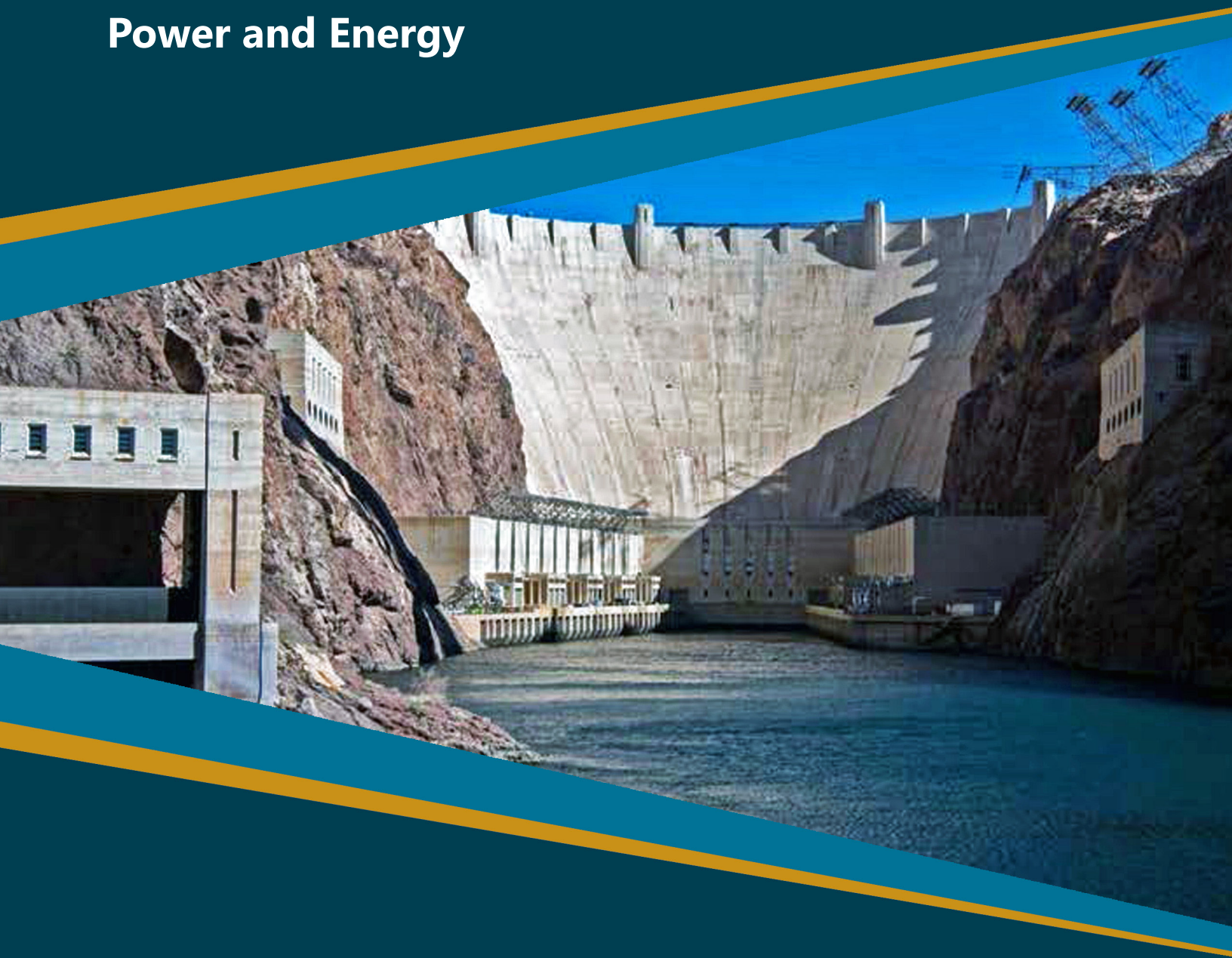
BUREAU OF RECLAMATION

R&D Office Research Updates

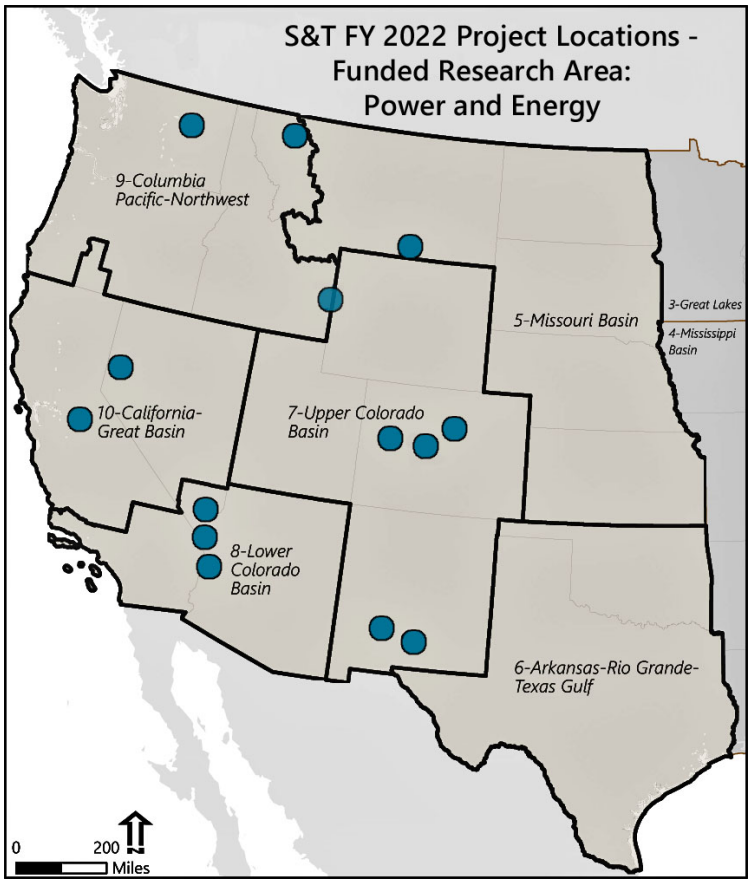
Power and Energy



U.S. Department of the Interior

January 2022

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 FY22,S&T funded 33 PE Projects approximately totaling $1.3M: 9 were new totaling $0.6M and 24 were continuing totaling $0.7M. Benefit-cost ratio (BCR) calculations are estimated for two PE projects each year to demonstrate the value of this research. A BCR of 9.6 was calculated for the Rotor Installed Corona Mapping of Stator Windings within Large Diameter Hydro Generators primarily due to diagnosing generator insulation condition using the Rotating Corona Probe, which eliminates the need for an extended outage to disassemble generator and remove the stator in order to perform traditional corona probe testing. A BCR of 2.8 was calculated for Effects of Water Absorption on Epoxy-Mica Based Stator Winding Insulation Systems. This project improved understanding of how and when winding insulation systems absorb water, examined impacts to the service life of stator windings due to water exposures, and provided guidance for preventing water exposure and ameliorating the impacts of water exposure when it happens. The economic benefits are based on improved winding service lives and prevented unplanned outages by following the recommendations from the project. As demonstrated, PE research is extremely valuable to Reclamation, both by development of new O&M inspection methods and techniques, as well as by providing better O&M guidance.

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

Front cover: Hoover Dam and Powerplant.

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

Power and Energy

FY21 Completed Projects

19078: Rotor Installed Corona Mapping of Stator Windings within Large Diameter Hydro Generators - Jacob Lapenna

Researcher demonstrating the prototype system on the rotor of a hydro generator.

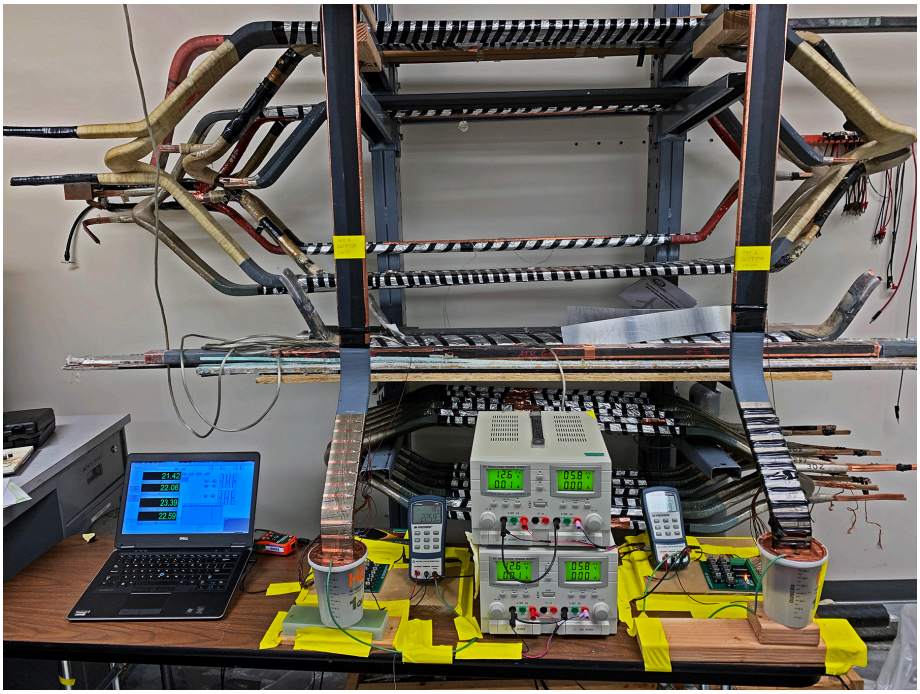
Partial discharge in stator windings can lead to damage and forced outages if not addressed. However, the previously available techniques to perform corona probe testing were either time-intensive or did not accurately identify the discharge location due to poor resolution. This research utilized near field communication antennas to map partial discharge activity, with slot level resolution and throughout a stator winding. The demonstration occurred on a service aged hydro generator with minimal disassembly of the asset and without the need to remove the rotor. Results suggest that, with further research and development, this method may be a viable replacement for conventional corona probe testing. As a replacement, this method would allow for trending of partial discharge activity in each slot of large stator windings while significantly reducing costs, hazards, and risks associated with obtaining this data, which would be a substantial leap in diagnostic capabilities within the industry.

Acoustic absorption panels installed in the opening between two galleries at Hoover Powerplant.

8141: Noise Induced Hearing Loss - Lisa Duncan

When Hoover Dam was built in the 1930s, noise regulations were not yet written, and noise control methods were not yet developed. Due to the number of workers affected by permanent hearing loss from noisy work environments, this study was performed to assess current noise levels, to install controls to reduce noise in areas of the powerplant most populated by employees and assess the reduction in noise achieved by the installation of controls. A complete noise survey was performed on the Arizona side of the Hoover Dam powerplant in Boulder City, NV in July of 2016. Based on this survey, a series of engineering controls to reduce noise levels was recommended. The suggested controls were then prioritized, and in a first phase, a subset of the controls was installed on both the Arizona and the Nevada sides of the Powerplant. A post-installation noise survey was performed in April 2021, and a comparison of noise levels before and after the installation of the controls was made for the Arizona wing, resulting in significant decrease of noise levels.

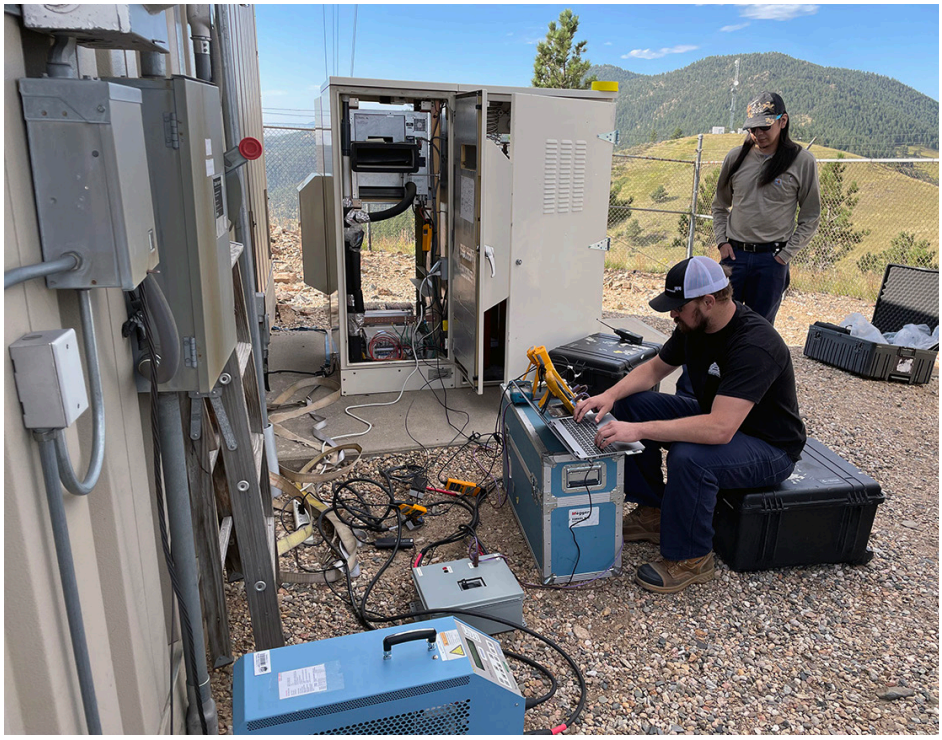
19251: Effects of Water Absorption on Epoxy-Mica Based Stator Winding Insulation Systems - Eric Eastment



Two generator stator winding bars being exposed to water and instrumented to detect water absorption.

Stator windings of large motors and generators are a substantial investment representing millions of dollars in capital cost per unit. The electrical insulation of large generator and motor stator windings are comprised of mica-based tapes which are held together with an epoxy binder. This research is to determine the impacts of water exposure on the potential life of a stator winding insulation system. Windings are exposed to water for varying reason, for example if an air-to-water heat exchanger or water-cooled bearing system leaks inside the generator, powerplant roof leaks, natural disasters such as floods, or actuation of water-based fire suppression systems also present potential water exposures. In each of these cases the potential water ingress paths, exposure time, and amount of water are different and likely have different impacts to winding life. The research results will analyze the effects and produce guidance should water exposures occur. The guidance is aimed at providing working-level direction to powerplant personnel about how to handle water exposures to avoid further damaging the winding and attempt to obtain expected service life.

20013: Fuel Cell Evaluation – Report on the long-term performance of fuel cells installed to provide extended backup power at several ECAO communication sites - Jim DeHaan



Load Test of Hydrogen Fuel Cell.

Hydrogen fuel cells have been in operation at Bureau of Reclamation facilities for over 15 years. Starting in 2003, the Eastern Colorado Area Office and Technical Service Center collaborated to install hydrogen fuel cells to provide 48-Volts Direct Current backup power at seven microwave communication sites. The purpose of this study is to evaluate the fuel cells over the approximate 15-year period since their installation and report on their long-term viability, reliability, maintenance cost and overall cost effectiveness. The study shows fuel cells continue to be cost-effective option for providing backup power at these communication sites and should be considered at other locations that require long-term lower-power backup power.

FY22 New Projects

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

This project advances the field-tested prototype system to detect and map partial discharge throughout a service-aged generator with minimal disassembly of the asset. The research will refine the prototype for internal use to provide the greatest impact as fast as possible within Reclamation's fleet.

22014: Improved Adhesion of Polyurethane Coatings with Phosphating - Stephanie Prochaska

This project scales-up the research testing on the effects of phosphating on polyurethane adhesion. This expected outcome is a comprehensive analysis of the effects of phosphating on polyurethane including evaluation of undercutting resistance, electrochemical impedance spectroscopy, and a new test method that evaluates adhesion strength under "real-life" hydraulic conditions in the high-velocity tunnel.

22021: Determining compatibility of Zinc Anodes for Cathodic Protection in Various Waters Specific to Reclamation and US Army Corps of Engineers Facilities: Phase II - Christine Henderson

This research will identify facilities that can use zinc anodes and provide a model for future implementation of zinc anodes based on water chemistry. The ability to use more anode options for CP system design on immersed steel structures will allow for greater flexibility and capability to meet facility needs for corrosion mitigation.

22024: Learning from the Past, Inspection of Historic Penstock Lining Field Trials; Shasta Penstocks and Collbran Siphon - Allen Skaja

Researchers will inspect the historic field trials of 26 different linings applied at Shasta Dam in 1949 and at Collbran Siphon in 1959 to evaluate the linings for corrosion protection and erosion due to sediment loading. The expected outcome is a better understanding of how these lining provide long-term corrosion protection via actual field data.

22026: Integration of Renewable Energy Sources - Determining Hydro Generation Start/Stop and Cycling Costs - Jim DeHaan

This research will evaluate the impact of renewable energy sources on hydropower equipment. The expected outcome is a defendable cost calculation methodology to support the growing industry consensus that there are significant costs being incurred due to hydropower generator starts/stops and cycling operations.

22037: Engineering and Maintenance for Cathodic Protection Systems Combined with Vinyl Coatings - Grace Weber

The proposed research will investigate interactions between the vinyl coating and cathodic protection (CP) at typical field polarization levels. Immediate benefits of the research will be greater understanding of interaction between CP and vinyl coatings, which will improve design, best practices, and maintenance recommendations to Reclamation facilities.

22044: Improved Processing and Analysis of Test and Operating Data from Rotating Machines - Stephen Agee

This research strives to aid in the development of condition-based maintenance (CBM) and predictive maintenance (PdM) tools for hydroelectric facilities, both generators and pumps. The research will explore, test, and develop software tools to process data collected from rotating machines.

22060: Modular Anode Sled Development and Testing for Cathodic Protection of Immersed Steel Structures - Matthew Jermyn

This project aims to design and install anode sleds with multiple anode configurations at a Reclamation facility. The research will study the effectiveness of the systems relative to more traditional approaches.

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

The project evaluates new robotic technology for its feasibility to supplement the current approach to condition assessment in penstocks, outlet works, steel lined siphons, and other steel structures. The research will determine if the large sampling of data provided by robotics yields more useful information on the structure's overall condition.

FY22 Active Projects

ID	Final Year	Title	Lead
300	2022	Performance Testing Multiple Units of Similar Hydraulic Design	Shanna Durham
1707	2022	Hydrokinetic Devices Subject to Supercritical Flow: Impacts on Canals and Considerations	Josh Mortensen
8101	2022	Cavitation Detection Techniques for Optimizing Hydraulic Turbine Operation and Maintenance	John Germann
19004	2022	Excitation and Governer Control System	Kyle Clair
19085	2022	Additive Manufacturing Investigation and Demonstration for Hydropower Applications	David Tordanato
19146	2022	Demonstration and Use of Advanced 3D Measuring Techniques using Portable Laser and Arm Technology	Chad Paulson
19251	2022	Effects of Water Absorption on Epoxy-Mica Based Stator Winding Insulation Systems	Eric Eastment
20009	2022	Power System Instrumentation	Stephen Agee
20012	2022	Machine Condition Monitoring - Enhance and expand Reclamation developed Machine Condition Monitoring (MCM) system. System utilizes in-house developed software and commercial data acquisition hardware.	Jim DeHaan
20014	2022	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	2022	Evaluating Kevlar Rope for Use in Gate Hoist and Crane Applications for Improved Service Life	Zach Cepak
20048	2022	Utilizing the Winter-Kennedy method for Hydropower Flow Measurement	Josh Mortensen
20076	2022	Using Strain-Sensing Technology to Increase Safety and Reliability of Inaccessible Critical Connections in Hydropower Equipment	John Germann
20100	2022	Evaluation of Alternative Fire Suppression Methods for Generators For Improved Safety, Effectiveness and Reliability	Sean Kyer
20203	2023	New Reclamation-wide Maintenance Management Toolset	Jim DeHaan
21087	2021	Quantifying the Flexibility and Economic Potential of Reclamation's Hydropower Assets	Melissa Estep
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
22024	2023	Learning from the Past, Inspection of Historic Penstock Lining Field Trials; Shasta Penstocks and Collbran Siphon	Allen Skaja
22064	2023	Robotic Non-Destructive Inspection of Hydraulic Streel Structures	David Tordonato
19223	2024	Reduction of Damaging Stator Core and Winding Vibrations in Large-Diameter Salient-Pole Synchronous Machines	Eric Eastment
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.	Christine Henderson
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