NATIONAL ENERGY TECHNOLOGY LABORATORY

SUMMER 2022

WATER-ENERGY NEXUS NEWS

U.S. DEPARTMENT OF ENERGY | OFFICE OF FOSSIL ENERGY AND CARBON MANAGEMENT | NATIONAL ENERGY TECHNOLOGY LABORATORY

An Update on the National Energy Technology Laboratory's Water-Energy Research and Related Activities

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FECM's Advanced Remediation Technologies Division Integrates Water Programs

The Department of Energy (DOE) Office of Fossil Energy and Carbon Management (FECM) is celebrating the integration of the produced water (PW) management research and development (R&D) activities (originally housed within NETL Oil & Gas upstream research) with the Water Management for Power Systems program (operated under NETL's Crosscutting Research Program). These joined programs will be based in the Advanced Remediation Technologies Division (ART). The water-related R&D within FECM will be executed by ART-Water Management (ART-WM), representing one of the first combined programs of its type within DOE.

ART-WM's mission is to deliver societal benefits and market impacts through technical and non-technical solutions that advance the affordability, reliability, sustainability, and resilience of water in the energy sector. In support of this mission, the projected program outcomes are to develop, scale, and deploy technologies; inform decision-makers; and to engage regional stakeholders. The program outcomes are realized by the research conducted under the advanced water technology R&D portfolio. Currently, ART-WM covers research in the remediation of wastewaters associated with coal power generation; the characterization, treatment, and management of PW during oil and gas operations; and the recovery of critical minerals and rare earths, and other beneficial resources from fossil energy-associated waste streams and effluent waters.

ART-WM is coordinated across three R&D areas: advanced treatment processes, biological and chemical characterization, and advanced computing systems and big data. These areas encompass several technical focuses, including water quality characterization, water-energy data acquisition and analysis, systems and process optimization, and technology testing and validation. To support research in these areas, ART-WM is actively developing advanced machine-learning platforms to automate time-intensive tasks and perform high-computational analysis on water effluent and water-energy infrastructure data.

ART-WM currently funds projects in 11 states (Arizona, California, Colorado, Illinois, Massachusetts, North Carolina, North Dakota, Ohio, Pennsylvania, Washington, and Wyoming). An example of an initiative that falls under ART-WM's scope of technology testing and validation is the Brine Extraction and Storage Test (BEST) site in North Dakota. The BEST site is unique in that it can accommodate performance evaluations of a broad range of innovative treatment technology approaches for application to a wide range of PWs, simulating PW chemistry and salinity from diverse geologic basins across the United States (U.S.). Since 2019, four different innovative technology approaches have been tested under different flow-rates and PW salinities with additional technology evaluation testing planned for late 2022.

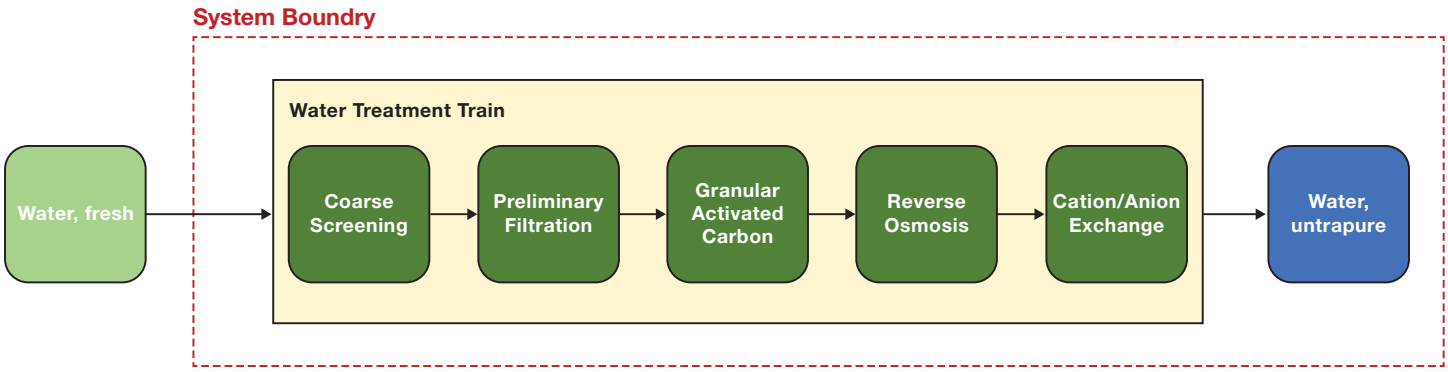
Mr. Hichem Hadjeres will serve as the program manager for ART-WM. Previously, Mr. Hadjeres was the project coordinator for the Water Management for Power Systems program and served as the project lead for various water-energy management projects at DOE. Prior to joining DOE, Hichem Hadjeres was active in the clean-tech innovation ecosystem in the Boston area, where he played a leadership role in several start-ups and mentorship initiatives. He holds an M.S. in Hydrology from the University of Rhode Island, a B.S. in Geosciences from Wesleyan University, and a certificate in Machine Learning from Cornell University.

NETL looks forward to sharing more news about the integration of the water programs in the coming months. For more information about ART-WM, please contact Mr. Hichem Hadjeres at Hichem.Hadjeres@hq.doe.gov.

Highlights: NETL Presents Hydrogen Water and Greenhouse Gas LCA Research at ISSST

In June 2022, representatives from NETL's Life Cycle Assessment (LCA) Team presented at the Pittsburgh-located International Symposium on Sustainable Systems and Technology (ISSST) on the life-cycle global warming potential (GWP) and water consumption impacts of hydrogen production. The presentation titled, "Life Cycle Greenhouse Gas Emissions and Water Consumption From Existing and Emerging Hydrogen Pathways" was given by NETL support contractor Megan S. Henriksen and co-authored by John White, Jadon Grove, Liam Walsh, H. Scott Matthews, Matthew Jamieson, Eric Grol, and Timothy J. Skone. This effort builds on the GWP-focused Hydrogen Baseline study released in April 2022 by adding additional pathways and also considering water consumption. More information about NETL's "Comparison of Commercial, State-of-the-Art, Fossil-Based Hydrogen Production Technologies" study can be found here.

Henriksen discussed the team's research on hydrogen production from a detailed cradle-to-gate life cycle analysis, emphasizing the importance of water consumption when considering decarbonization strategies. Life cycle impacts of hydrogen production, especially global warming potential, are well established in literature, but water impacts have been underexplored. This novel research models a full water treatment train (e.g., including reverse osmosis) for water to reach the purity standard required for hydrogen production. This generalized water treatment train can be adapted for use in future LCA studies.



The research demonstrates the significant trade-offs that exist in pursuing both low-carbon and low-water consumption technologies. For example, hydrogen production via biomass gasification results in a low to negative GWP, but the life cycle water consumption of these technologies is several orders of magnitude higher than other production pathways. Overall, electrolysis-based hydrogen production technologies powered by 100% renewable electricity resulted in the lowest GWP and water consumption impacts.

This landmark study highlights a key gap in current hydrogen decision-making. As research on the hydrogen economy is increasingly prioritized (supported in part by DOE's Hydrogen Shot initiative that strives to reduce the cost of hydrogen to $1 per 1 kg of clean hydrogen in 1 decade) life cycle environmental impacts beyond GWP must be prioritized.

For more information on ISSST, please visit https://issst.net/about/

Highlights: WaterTAP Adds More Water Treatment Modeling Capabilities

The Water treatment Technoeconomic Assessment Platform (WaterTAP) is an open-source Python-based software tool for assessing the performance and economic viability of water treatment trains. The tool development began in July 2020 and is led by researchers at NETL in collaboration with other national laboratories including Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, and Oak Ridge National Laboratory. The work is funded under two sources: 1) DOE's desalination hub – the National Alliance for Water Innovation (NAWI), and 2) DOE FOA-0002336 – Research and Development for Advanced Water Resource Recovery Systems.

In addition to supporting the R&D portfolios of the two funding sources, WaterTAP seeks to provide a unified, flexible, and powerful platform to the broader water research for modeling and simulating conventional and emerging water treatment technologies. WaterTAP is composed of a modular model library that is based on NETL's Institute for the Design of Advanced Energy Systems (IDAES) platform. WaterTAP is updated and released quarterly; the most recent release in June 2022 included new modeling capabilities for electrodialysis, mechanical vapor compression, crystallization, granular activated carbon, and ultraviolet processes. Previous releases have included detailed models for reverse osmosis treatment trains spanning pretreatment, primary, and post-treatment, as well as simple models spanning a broad range of water treatment technologies.

To access WaterTAP, please visit https://github.com/watertap-org/watertap

To learn more about NAWI, please visit https://www.nawihub.org

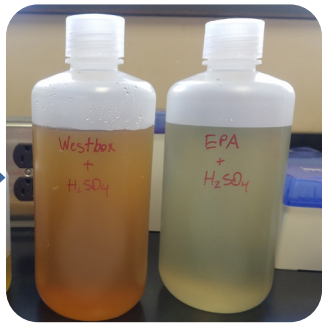
Highlights: NETL Presents Targeted Rare Earth Extraction (TREE) Process

On June 17, 2022, NETL support contractor Mengling Stuckman presented "Rare Earth Element/Critical Mineral (REE/CM) Recovery from Coal Byproducts and Acid Mine Drainage (AMD)" to the Brazilian Coal Association at a meeting in Pittsburgh, Pennsylvania. During the presentation, Stuckman explained that one potential domestic source of REE is coal waste by-products, such as acid mine drainage and combustion coal ash, due to their abundances and fast availability as waste products with enriched REE contents. The fly ash "reserve" in the United States could satisfy 94% of the domestic REE demand. Stuckman also discussed how researchers at NETL performed advanced characterization that identified REE/CM hosting phases in different coal wastes and developed the TREE process, which has a U.S. patent pending.

The TREE process has the potential to offset the cost of coal waste treatments, and significantly cut the processing cost while reducing the environmental footprint of critical mineral extraction. This method uses mild inorganic acids at ambient temperatures via a three-step mild acid extraction process that results in high levels of extraction (ranging 80–100%) from a low-cost waste stream. This process is applicable to AMD solids, other ash products (such as those derived from biomass or waste combustion), or coal ashes produced from industries outside the electric utility sector. This process can be amended to the material being extracted, creating a value stream that can be tailored to each coal stream. The clean leachate created through TREE requires much less purification processing and provides leachate with minimized radioactive material extraction under mild acidic conditions. This process could end U.S. dependence on imported REEs, mitigate pollution, and create more jobs as the United States transitions to a clean energy economy. NETL is currently in a three-year partnership with the University of Wyoming to scale out the laboratory's patent-pending technology. The project intends to show the economic viability of this process.

For more information, please click here.

AMD Solids Fly Ash TREE Process



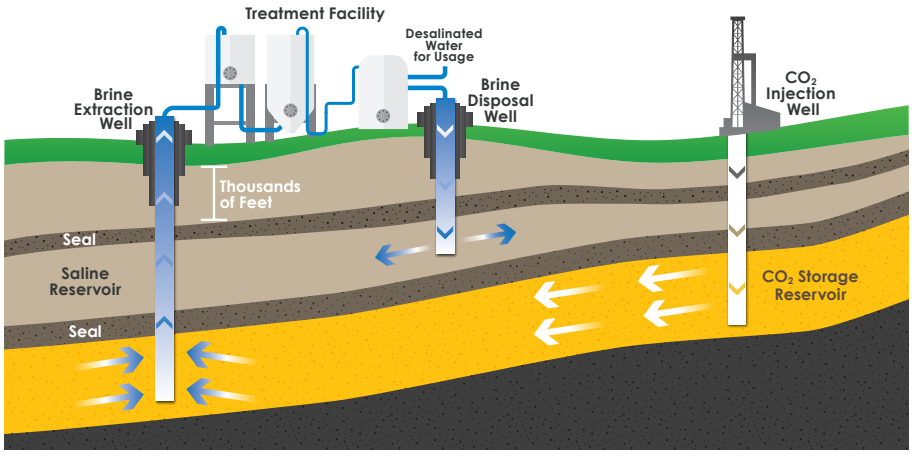
Clean REE Leachate

Highlights: NETL Presents at I-WEST Water & Energy Workshop

The Intermountain West Energy Sustainability & Transitions (I-WEST) project is focused on delivering a regionally relevant technology roadmap to transition six U.S. states to a carbon-neutral energy economy. I-WEST encompasses Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming. The I-WEST initiative is sponsored by DOE and leverages decades of R&D funded by DOE energy programs. Los Alamos National Laboratory (LANL) leads the effort on I-WEST, joined by partners NETL, universities (Arizona State University, Colorado School of Mines, Montana State University, New Mexico Institute of Mining and Technology, San Juan College School of Energy, University of New Mexico, University of Utah's Energy Geoscience Institute, University of Wyoming's School of Energy Resources), and non-profit research (Resources for the Future).

NETL participated in the "Water & Energy: How Do They Mix?" workshop hosted virtually on June 14, 2022. As part of the workshop's Tour of Low-Carbon Technology Water, a series of lightning talks on Water Needs for Transition Pathways were given. NETL support contractor Derek Vikara presented on "Carbon Storage and Utilization: Perspective on Water Usage and Opportunities." Vikara discussed carbon capture and storage (CCS), which involves injecting captured carbon dioxide (CO_2) into suitable subsurface geologic reservoirs for long-term storage, and how water factors into the technology's implementation—this includes the protection of underground sources of drinking water and through potentially producing and managing water as part of reservoir pressure management.

For example, CO_2 storage site field operators can choose to employ water production strategies from storage formations, as depicted in the schematic, as a means to manage and reduce pressure in the subsurface as well as improve storage capacity.



Vikara also discussed two DOE-supported CarbonSAFE initiatives under development in the I-WEST region, including those at Dry Fork Station, Wyoming, and at the San Juan Generating Station, New Mexico. These projects are planning and developing storage sites capable of handling injection and storage of several million tons of CO_2 per year; each are considering producing and managing water as part of their reservoir management strategies. Produced waters, however, must be managed, either through treatment for reuse or via re-disposal back into the subsurface. Treatment and reuse of PWs as part of large-scale CCS operations may provide an opportunity for the I-WEST region to augment their existing water resource base as part of achieving its low-carbon transition. Additionally, certain treatment approaches can offer other benefits related to resource recovery from the water itself, including potential low-grade geothermal energy and potential REE extraction.

To watch the June 14 presentations and to view the workshop slides, please click here.

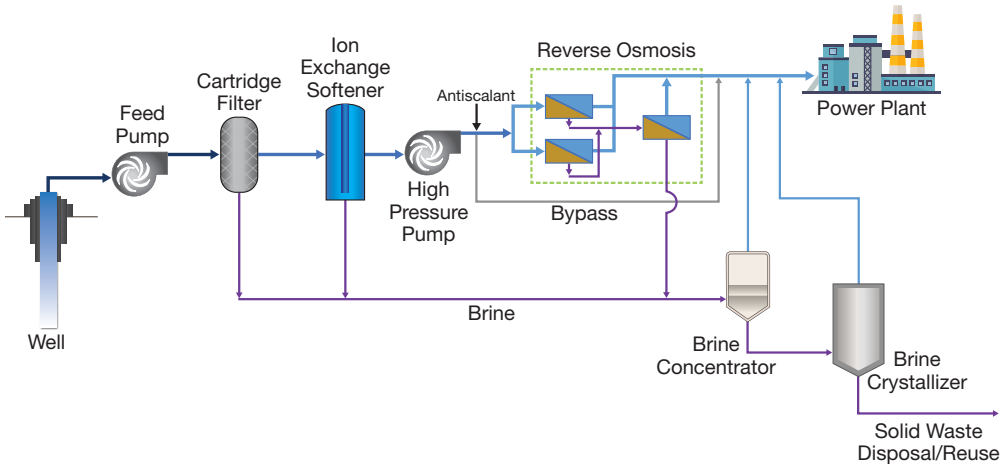
For more information about the I-WEST initiative, please click here.

For more information about DOE's CarbonSAFE initiative, please click here.

Water-Energy Project Highlights

Reducing Freshwater Consumption at Fossil Fuel-Fired Power Plants with Treated Brackish Water for Cooling

In the United States, the thermoelectric power sector accounts for about 40% of the total freshwater withdrawals, mainly for wet cooling systems. More than 61% of U.S. thermoelectric generating capacity uses wet recirculating cooling systems, which are the largest water consumers at fossil fuel power plants. Freshwater availability affects thermoelectric power generation but distributes unevenly across the United States. Increasing droughts and climate change can reduce freshwater availability, exacerbate water scarcity, and then pose high water risks for thermoelectric power plants in the western United States. Without a sufficient supply of desired water, electric power generators will likely suffer from power production curtailment or even complete shutdown. To alleviate such adverse impacts from freshwater shortages, the thermoelectric power industry needs to explore alternative freshwater-saving options. Among these options are advanced cooling systems (including dry cooling systems), or use of nontraditional water sources (such as reclaimed water, brackish groundwater, PW from oil and gas extraction, and extracted formation water from CO_2 storage in saline reservoirs) in wet cooling towers.



Brackish Water Treatment System with Zero Liquid Discharge for Brine Disposal

NETL's Strategic Systems Analysis and Engineering (SSAE) directorate recently completed an analysis ("Treatment of brackish water for fossil power plant cooling: Tradeoffs in freshwater savings, cost, and capacity shortfalls") that evaluates the technical, economic, and environmental impacts from using treated brackish groundwater in wet cooling towers to reduce or eliminate freshwater consumption at 13 existing coal- and gas-fired thermoelectric power plants in Arizona and New Mexico (a water-constrained region of the United States). Based on fleet averages, retrofitting brackish water treatment systems decreases freshwater consumption at coal- and gas-fired electric generating units by 94% and 100%, respectively, while increasing the levelized cost of electricity generation by approximately 9% and 11%, respectively.

However, trade-offs in freshwater savings and cost are highly affected by the method of disposal of the brine generated as a byproduct of brackish water treatment. Due to permitting, local regulation, or public pressure, it could become necessary (in some cases) to eliminate all byproduct waste streams entirely, a concept known as zero liquid discharge. The addition of thermal zero liquid discharge for brine disposal can roughly double the average cost of freshwater consumption savings for existing electric generating units, as shown in the figure. Therefore, while significantly reducing consumptive plant freshwater use, the cost-effectiveness of brackish water treatment relative to dry cooling deployment also highly depends on the management of concentrated brines.

Conferences and Events

Listed below are upcoming conferences and events that align with NETL's water-energy research efforts.

2nd International Conference on Water, Energy, and Environment for Sustainability (IC-WEES) 2022

Description: The National University of Sciences and Technology is organizing the second IC-WEES. The conference aims to bring together expert individuals and diverse research groups to exchange and share R&D updates and discuss sustainable solutions to challenges in climate change, disaster risk reduction, environment and water resources management, and respective nexuses between these fields.
Date: Aug. 17–18, 2022
Locale: Islamabad, Pakistan
Website: https://icweecs.mce.nust.edu.pk/

12th International Conference on Acid Rock Drainage (ICARD) 2022

Description: For more than three decades, ICARD has been the major international forum for sharing technical solutions for the prediction and prevention of acid rock drainage, and for communicating the evolution of leading practice management strategies. ICARD provides the platform for the mining industry, consultants, researchers, technology developers and suppliers, regulators, and community and non-government organizations (NGOs) to share their perspectives on this important topic.
Date: Sept. 18–24, 2022
Locale: Virtual
Website: https://www.icard2022.com.au/

National Clean Energy Week

Description: Join the annual week-long celebration of clean energy innovation and help solve the world's most pressing challenges in nuclear, solar, wind, wave, hydropower, geothermal, natural gas, biomass, carbon capture and storage, and waste-to-energy technologies.
Date: Sept. 26–30, 2022
Locale: Virtual programs/in-person events, Washington, D.C.
Website: https://nationalcleanenergyweek.org/

38th Annual International Conference on Soils, Sediments, Water, and Energy

Description: The Association for the Environmental Health and Sciences (AEHS) Foundation is a non-profit, member-supported organization that facilitates conferences, seminars, publications, and collaborative partnership around soil, sediment, and water assessment, cleanup, and protection. The event gives participants the opportunity to exchange information and advance awareness on environmental issues.
Date: Oct. 17–20, 2022
Locale: Amherst, Massachusetts
Website: https://www.aehsfoundation.org/

ghgt–16

Description: The International Energy Agency Greenhouse Gas R&D Programme (IEAGHG) is the guardian of the Greenhouse Gas Control Technologies (GHGT) conference series. The GHGT conferences are held every two years in IEAGHG's member countries. The conference series rotates between North America, Europe, and Asia. The GHGT conference series is established as the principal international conference on greenhouse gas mitigation technologies, focusing on carbon capture, utilization, and storage. Each conference is a forum for technical discussions related to the field of greenhouse gas control technology.
Date: Oct. 23–27, 2022
Locale: Lyon, France
Website: https://ghgt.info/

Researcher Spotlight

Eric Grol

Senior Energy Systems Analyst

Eric.Grol@netl.doe.gov

Eric Grol is a Senior Energy Systems Analyst on NETL's Energy Process Analysis Team. Grol earned his B.S. and M.S. degrees in Chemical Engineering from the University of Pittsburgh. He joined NETL in 2007. Since 2010, he has been the lead regulatory analyst at NETL and has assumed technical responsibility for all air, water, and solid waste regulations pertaining to the use of fossil energy for power generation. He is frequently called upon as a subject matter expert during technical discussions in interagency reviews, and many of his studies have been used by the Environmental Protection Agency and cited in the official rulemaking docket for such regulations.

Throughout his career, Grol has performed techno-economic evaluations of fossil-based energy systems including coal gasification, fuel cells, and advanced combustion. He currently leads the analysis efforts in support of NETL water R&D, which in recent years has focused on wastewater treatment processes for fossil energy systems. As part of this effort, his work includes the recently completed analysis "Treatment of brackish water for fossil power plant cooling: Tradeoffs in freshwater savings, cost, and capacity shortfalls," as overviewed in the Water-Energy Project Highlights section above.

On July 19, 2022, Grol presented at the American Society of Mechanical Engineers (ASME) POWER 2022 conference in Pittsburgh, Pennsylvania. The presentation was titled "Perspectives on an Engineering Career in the Office of Fossil Energy and Carbon Management at the U.S. Department of Energy." During the talk, Grol summarized his professional experiences working at a government R&D laboratory, including an overview of the support engineering analysis provides to in-house research and program direction, typical assignments and work products, and the challenges and opportunities related to a government engineering career.

Grol is passionate about his research at NETL, and explains that,

> *"My engineering career in government has afforded me the opportunity to not only research some of the grand challenges of our time, but to also contribute to innovative solutions to manage our fossil energy resources."*

Grol has authored and co-authored multiple publications, including Fundamental challenges and engineering opportunities in flue gas desulfurization wastewater treatment at coal fired power plants; Dry cooling retrofits at existing fossil fuel-fired power plants in a water-stressed region: Tradeoffs in water savings, cost, and capacity shortfalls; Technical assessment of an integrated gasification fuel cell combined cycle with carbon capture; and the Impact of Load Following on the Economics of Existing Coal-Fired Power Plant Operations.

Water-Energy Publications and Presentations

Below are several water-related publications and presentations authored or co-authored by NETL staff.

Effects of Short-Term Water Constraints on Electricity Dispatch: A Case Study of ERCOT and SPP Regions

Yash Kumar, NETL; Rachel Hoesly, NETL; Aranya Venkatesh, NETL; Erik Shuster, NETL; Arun Iyengar, NETL (APRIL 2022)

- https://pubs.acs.org/doi/10.1021/acsestwater.1c00450

Scientific Results of the Hydrate-01 Stratigraphic Test Well Program, Western Prudhoe Bay Unit, Alaska North Slope

Ray Boswell, NETL; Timothy S. Collett, United States Geological Survey (USGS); Koji Yamamoto, Japan Oil, Gas and Metals National Corporation (JOGMEC); Norihiro Okinaka, JOGMEC; Robert Hunter, Petrotechnical Resources of Alaska; Kiyofumi Suzuki, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba; Machiko Tamaki, Japan Oil Engineering Company, Limited; Jun Yoneda, AIST, Sapporo; David Itter, Hilcorp Alaska, LLC; Seth S. Haines, USGS; Evgeniy Myshakin, NETL; and George Moridis, Lawrence Berkeley National Laboratory (APRIL 2022)

- https://pubs.acs.org/doi/10.1021/acs.energyfuels.2c00327

Estimating Fresh Water Needs to Meet Future Thermoelectric Generation Requirements and Program Water Saving Benefits – 2022 Update

Erik Shuster, NETL; Rachel Hoesly, NETL; Abbey Pizel, NETL (MAY 2022)

- https://www.osti.gov/biblio/1871666-estimating-fresh-water-needs-meet-future-thermoelectric-generation-requirements-program-water-saving-benefits-update

Project PARETO – DOE's Produced Water Optimization Initiative

Miguel Zamarripa, NETL. Presented at ExxonMobil Research and Engineering (EMRE) Optimization and Data Science Community Meeting (MAY 2022)

- https://www.project-pareto.org/

A multi-criteria CCUS screening evaluation of the Gulf of Mexico, USA

Anna Wendt, NETL; Alana Sheriff, NETL; Chung Yan Shih, NETL; Derek Vikara, NETL; Tim Grant, NETL (JULY 2022)

- https://www.sciencedirect.com/science/article/pii/S1750583622001062

Treating and Co-Treating Fossil Energy Effluent Streams

Nicholas Siefert, NETL. Presented at ASME POWER 2022 (JULY 2022)

- https://event.asme.org/POWER

Treatment Technology Assessment of Landfill Leachate

Chad Able, NETL; Eric Grol, NETL; Danny Rellergert, NETL; Vincent Mazzoni, NETL. Presented at ASME POWER 2022 (JULY 2022)

- https://event.asme.org/POWER

Contact Us

NETL is part of DOE's national laboratory system. NETL is a government-owned, government-operated (GOGO) laboratory supporting DOE's mission to advance the national, economic, and energy security of the United States.

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochran Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

Program staff are also located in
Houston, Texas, and **Anchorage, Alaska.**

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Get Social with Us

There are several ways to join the conversation and connect with NETL's Water-Energy Research Program:

Partnering with NETL

NETL's partnership activities are central to DOE's core mission. NETL utilizes a complete suite of contractual vehicles, as well as its inherent authority as a GOGO laboratory, to pursue technology development and eventual transfer of technology to the marketplace. NETL's success in developing technology solutions that can be applied to the intersection of water and energy depends upon strong relationships with both public and private entities. From targeted competitive announcements to cooperative research and development agreements, NETL offers a variety of cost-shared funding and partnership arrangements to help move technology and intellectual property through the maturation cycle into the marketplace.

For more information on partnering with NETL in the water-energy space, contact:

Thomas J. Feeley, III
Research Partnerships & Tech Transfer
Thomas.Feeley@netl.doe.gov
412-386-6134

https://netl.doe.gov/water-energy-research

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