NATIONAL ENERGY TECHNOLOGY LABORATORY

SPRING 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

IN THIS ISSUE

NETL Welcomes the New Director at the Office of Resource Sustainability

Vanessa Núñez-López is the new director of the Advanced Remediation Technologies division in the Office of Fossil Energy and Carbon Management's (FECM) Office of Resource Sustainability's Office of Research & Development. In support of the new mission, Núñez-López is focused on restructuring the division's research and development (R&D) portfolio to showcase the best advanced technologies and processes that minimize the environmental impacts associated with the extraction of oil and gas resources.

Prior to joining the U.S. Department of Energy (DOE) in 2021, Núñez-López was a Research Scientist Associate and Principal Investigator at the University of Texas at Austin, Bureau of Economic Geology. Over the course of ten years, she conducted research on developing economically viable approaches to advance the large-scale deployment of geologic carbon sequestration technologies. A significant percentage of her research was funded by DOE-NETL Funding Opportunity Announcement (FOA) grants. Before joining the Bureau of Economic Geology, Núñez-López was a Senior Reservoir Engineer at Chevron Energy Technology's Carbon Storage group, where she served as the company representative for several carbon capture, utilization, and storage (CCUS) joint industry projects, such as the renowned Weyburn-Midale International Energy Agency (IEA) project.

Núñez-López's research has been published in numerous academic journals, conference proceedings, and contract reports, as well as mentioned in different media outlets. She earned an M.S. in Petroleum Engineering and an M.A. in Energy and Mineral Resources, both from the University of Texas at Austin.

FECM's Office of Resource Sustainability administers DOE's technological development and approaches for reducing the environmental impacts of the nation's historical and continued use of fossil fuels. The Office of Resource Sustainability has two major offices: the Office of Research & Development and the Office of Regulation, Analysis, and Engagement.

The Office of Research & Development advances technologies and solutions to reduce the environmental impacts and emissions associated with fossil energy development, use, transportation, and storage. This includes reducing emissions in the production, transportation, and storage of oil and natural gas; developing advanced remediation technologies for produced water, abandoned mines, abandoned wells, and the conversion of methane to useful products; and improving the economics and environmental performance of critical minerals extraction, processing, use, and disposal.

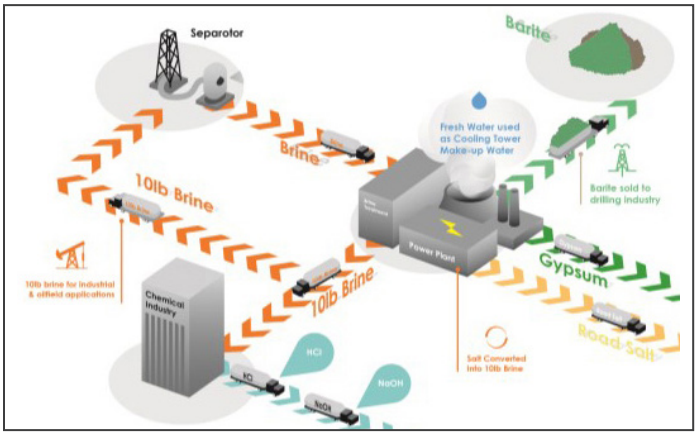
The Office of Regulation, Analysis, and Engagement regulates the import and export of natural gas, conducts analysis of fossil fuel and carbon markets, assesses policy and regulatory proposals, leads outreach for domestic and international engagements, and addresses environmental and energy justice impacts for communities most impacted by fossil fuel development and use.

Highlights: Co-treating FGD Effluent from Longview Power Plant and Produced Water from Oil and Gas Wells

Through NETL's Water Management Portfolio, Dr. Nicholas Siefert is leading a project on the co-treatment of flue gas desulfurization (FGD) effluent from Longview Power Plant in Maidsville, West Virginia (WV), and produced water from oil and gas wells near Morgantown, WV. West Virginia University's (WVU's) Innovation Hub and a WVU research team led by Dr. Lance Lin and Dr. Harry Finklea are supporting this effort. This work builds off a DOE/FECM-funded project at WVU managed by NETL's Dr. Heather Hunter and Dr. Jessica Mullen to co-treat cooling tower blowdown water with produced water.

WVU researchers Payton Seats, Karen Buzby, and Mohammad Ahmed

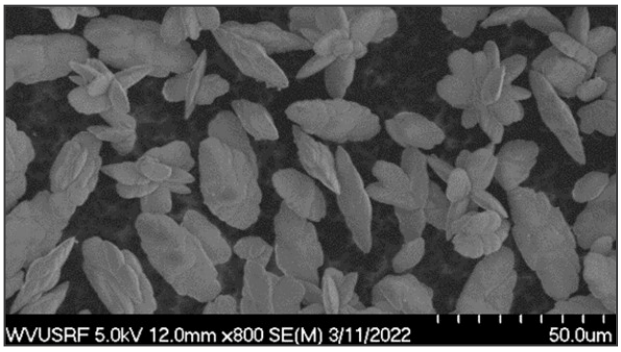
The overarching goal of the current project is to demonstrate a novel and cost-effective process to recover freshwater, limestone, barite, and 10-lb brine from FGD effluent. This project is a demonstration of a zero liquid discharge with resource recovery process. Its near-term objective is to produce a novel pilot process demonstrating high water and resource recovery from effluent streams at fossil power plants, and to publish data on both the design and operation of the pilot process.



WVU's potential future scenario for co-treating power plant effluent with produced water to generate valuable products, such as barite, gypsum, road-salt, 10-lb brine, and make-up freshwater

Given the complementary chemistry of produced water from unconventional oil and gas development and its proximity to power plants in the north-central Appalachian region, opportunities exist to manage FGD effluent and produced water in a novel co-treatment approach. In particular, the introduction of produced water into FGD water treatment could offer a unique opportunity to generate barite, one of 35 critical minerals identified by the United States Geological Survey (USGS). During 2017–2019, barite's annual U.S. market was approximately $0.5 billion/year, with 87% of domestic consumption of barite imported. While the mineral barite has many applications, about 90% of barite consumed in the United States is used as a weighting agent to drill new wells.

The co-treatment of sulfate-rich effluent streams with barium-rich produced water can reduce the chemical and energy footprints for managing the wastewaters because the complementary chemistries offer "free" chemicals commonly used for removing scale-forming constituents. Such an approach can also generate 10-lb brine as a saleable product with lower energy requirements due to the high salt content of produced water. The co-treatment pilot process consists of chemical treatment, membrane filtration (nanofiltration and reverse osmosis), and thermal evaporation. Technical feasibility of a similar co-treatment process was demonstrated by WVU researchers with cooling blowdown and produced waters, showing recovery of barite and more than 90% water with approximately 50% chemical and 20% energy savings compared to treating the two waters separately.



Barite mineral generated from the co-treatment process. Barite's high density makes it an ideal weighting additive to drilling fluids and concrete

Highlights: NETL Adds Capabilities to WaterTAP

NETL researchers continue to lead the development of a process-scale water treatment modeling tool, Water Technoeconomic Assessment Platform (WaterTAP, previously called ProteusLib). WaterTAP is a technoeconomic assessment tool for existing and emerging water treatment technologies and trains and is based on NETL's Institute for Design of Advanced Energy Systems (IDAES) platform, an advanced process systems engineering tool.

The development of WaterTAP is funded by two sources: 1) the National Alliance for Water Innovation (NAWI), DOE's desalination hub; and 2) DOE FOA 0002336 - Research and Development for Advanced Water Resource Recovery Systems. While both funding sources seek to develop water treatment models, each focuses on different technology readiness levels (TRLs) and application areas. NAWI focuses on early-stage technologies (TRL 2–4) for desalination, while DOE FOA 0002336 focuses on more mature technologies up to pilot demonstration (TRL 4–7) for wastewater treatment and resource recovery.

New versions of WaterTAP that incorporate additional models and capabilities are publicly released each quarter. Previous releases in September and December 2021 focused on simulation and optimization capabilities for reverse osmosis treatment trains, including physical and chemical pre- and post-treatment and mineral scaling prediction. The most recent release in March 2022 included initial models for evaporative desalination technologies (mechanical vapor compression and forced circulation crystallization) and integrated more than 40 simple water treatment models that are useful to screen technologies from another previous NAWI modeling effort called WaterTAP3.

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

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

For more information on the Water Resource Recovery FOA, visit https://eere-exchange.energy.gov/ or here.

Highlights: DOE Funds the Development of a Novel Membrane Technology to Remove Key Constituents from Produced Water

Funded by DOE through a cooperative agreement, ZwitterCo, Inc., an early-stage membrane company headquartered in Cambridge, Massachusetts, is the awardee of the "Fouling-Resistant, Chlorine-Tolerant Zwitterionic Membranes for Treatment of Produced Water in the Permian Basin" (DE-FE0031851) project. Started in 2020, the goal of the project is to advance the development of the membrane technology that can reject key constituents from produced water while maintaining immunity to detrimental and irreversible membrane fouling. The project will optimize ZwitterCo's membrane technology for the demanding operational parameters of produced water treatment and verify performance with actual samples in the Permian Basin.

ZwitterCo's membrane module

The patented membrane technology uses zwitterions (also known as an "inner salt"), which are molecules that have both a positively and a negatively charged group in close proximity. These charges pull water to the zwitterion while repelling organic components such as proteins, fats, and oils that stick to traditional membranes and impede their filtration capacity, making filtration of highly saline waste streams more practical and cost-effective.

In early 2022, ZwitterCo completed modification of its skid-mounted pilot system and deployed the equipment to the Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, New Mexico. In cooperation with the New Mexico Produced Water Research Consortium (NMPWRC), BGNDRF, and several other research groups, produced water was delivered to BGNDRF for testing.

Samples of produced water feed, permeate, and concentrate from the ZwitterCo superfiltration pilot test

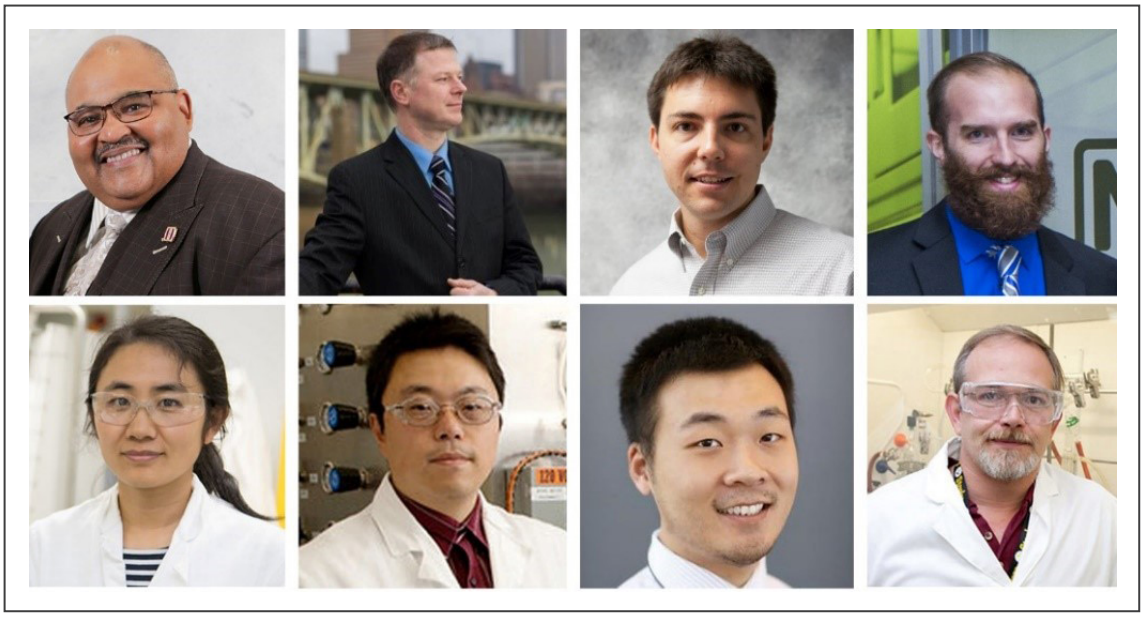
Over six weeks of testing at BGNDRF, ZwitterCo and its partners accumulated more than 500 hours of cumulative runtime with the same membrane module, including two separate 168-hour runs with less than 3% downtime. Target water quality objectives, including removal of oil and grease, were achieved at a variety of operating conditions. Notably, significant portions of runtime were carried out at extreme freshwater recovery rates of over 99%. ZwitterCo's superfiltration membrane maintained high performance at extreme conditions, responding well to cleaning and maintaining factory permeability despite severe loading of iron, oil, and grease. After modification to increase pre-oxidation of the dissolved iron, the permeate was measured with a Silt Density Index (SDI) of less than 1.0. The ability to transform severely distressed produced water waste into a clean water source with SDI <1.0 opens the door to many reuse and desalination cases that are currently not economically feasible.

To learn more about the membrane technology, visit https://zwitterco.com/technology or click here.

Highlights: NETL's MUST Team Receives the U.S. Secretary of Energy's Achievement Award

In October 2021, the NETL research team behind the development of multi-functional sorbent technology (MUST) was awarded a prestigious 2021 R&D 100 Award in the Mechanical/Materials category. In December 2021, the team was once again recognized by DOE's Secretary of Energy, Dr. Jennifer M. Granholm, and received the Secretary of Energy's Achievement Award.

Each year, the Secretary recognizes select individuals and group project members who have shown exceptional creativity, drive, and commitment that have had a lasting impact on DOE's mission. This award is part of the Secretary's Honor Awards, which presents the Excellence Award for individuals and the Achievement Award for groups.



Members of the team (from top-left corner) are McMahan Gray, Thomas Tarka, Nicholas Siefert, Walter Wilfong, Qiuming Wang, Fan Shi, Tuo Ji, and Brian Kail

MUST is a low-cost revolutionary sorbent innovation that can successfully remove difficult-to-extract heavy metals and critical minerals (CM) from wastewater, contaminated waterways, and electronic and pharmaceutical production processes. Unlike other technologies, MUST does not require water or other solvents to remove metals. MUST is regenerable and reusable, providing a recycling advantage that reduces waste, lowers costs, and makes the product accessible to a wide range of consumers and industries. NETL researchers have partnered with Somerset International Inc., which will use MUST to treat acid mine drainage (AMD), and Dow Chemical, whose plans call for using MUST in pharmaceutical and electronic production processes.

Congratulations, team!

For more information on NETL's recipients of the Secretary's Honor Awards, visit https://netl.doe.gov/node/11461/.

Water-Energy Project Highlights

Following the winter issue's project highlight on DOE's "Fit-for-Purpose Field Project: Developing and Validating Pressure Management and Plume Control Strategies through a Brine Extraction Storage Test (BEST)," this article looks at one of the Phase II field projects with the University of North Dakota (UND) Energy and Environmental Research Center (EERC).

Inside the BEST facility

EERC validated the efficacy of active reservoir management (ARM) applications to industrial CO_2 storage projects (through a field test) and demonstrated the steps necessary to design and implement ARM for industrial carbon capture and storage projects. In addition, the project developed a water treatment test bed to test various technologies with the application of treating high-total dissolved solids brines associated with geologic CO_2 storage targets. The treated brines could serve as a source of water for agricultural, industrial, or domestic use.

EERC completed the construction of its brine treatment technology test bed in July 2019 and has conducted three technology evaluations to date that included a mechanical vapor recompression (MVR) unit provided by NETL, an air gap membrane distillation system developed by the University of Pittsburgh, and a supercritical water desalination reactor developed by Ohio University.

A brine salinity of approximately 180,000 mg/L of total dissolved solids (TDS) was selected as an inlet target to represent the anticipated salinity range of deep saline aquifers targeted for CO_2 storage injection. Varying water recovery rates were evaluated to determine the steady-state energy consumption of targeted salinities for each technology, and the concentrate and permeate effluents were subjected to routine analytical chemistry determinations. The MVR technology, provided by NETL, demonstrated that the concentrated brine effluent exhibited a 30% to 80% increase in salinity when compared to the inlet brine, and the outlet permeate salinity ranged from approximately 550 mg/L TDS to 1050 mg/L TDS (99.4% to 99.7% salt rejection).

Moving forward, EERC is anticipating a fourth technology demonstration with the University of Kentucky (UK) in the spring of 2022. UK has developed a novel zeolite-derived membrane dewatering system, which will be evaluated similarly to the previous technologies. Upon completion of the UK technology evaluation, EERC will thoroughly evaluate all technology results, including energy consumption, and plans to compare technical and economic characteristics as a whole. It is anticipated that the UND BEST testbed facility will remain open and operational through 2022 and additional technologies may be evaluated.

For more information on the BEST project, visit https://netl.doe.gov/node/2476 or click here.

Conferences and Events

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

AWRA 2022 Geospatial Water Technology Conference

Description: The American Water Resources Association (AWRA) Geospatial Water Technology Conference is designed around sharing geospatial solutions to water resources-related problems. Innovative water resources scientists, engineers, modelers, and software designers from public/government agencies, academic, and private sectors convene to exchange ideas, compare challenges, and identify solutions.
Date: May 9–12, 2022
Locale: Austin, Texas
Website: https://www.awra.org/Members/Events_and_Education/Events/2022_GIS_Conference/2022_GIS_Conference.aspx

EPRI Water-Energy Transformation Forum

Description: This collaborative forum will discuss the role of water as the Energy sector changes rapidly and starts to achieve decarbonization targets. The forum will be facilitated by the Electric Power Research Institute (EPRI) staff with expertise in a broad range of technical areas, including water management and treatment technologies, instrumentation and controls, cycle chemistry, materials, cooling and heat transfer, carbon capture and sequestration, and the low carbon resources initiative.
Date: May 18–19, 2022
Locale: Charlotte, North Carolina | Hybrid Virtual Content
Website: https://www.epri.com/research/programs/073222/events/67066159-F42E-47DA-A6DF-F610161171C9

2022 World Environmental & Water Resources Congress

Description: The event will feature eight concurrent technical tracks over a period of three days. Approximately 900 leading engineers and scientists from around the world attend the Environmental & Water Resources Institute Congress each year to discuss the latest research, case studies, and evolving best practices in water resources and the environment.
Date: June 5–8, 2022
Locale: Atlanta, Georgia
Website: https://www.ewricongress.org/about

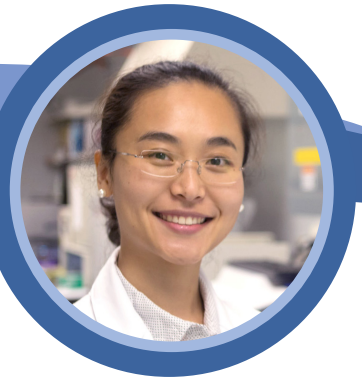
AWWA ACE22

Description: Organized by the American Water Works Association (AWWA), the Annual Conference & Exhibition (ACE22) provides an opportunity to connect with global water experts in every segment of the water sector. ACE22 will showcase smart technologies and new programs that address critical issues to protect the world's most important resource.
Date: June 12–15, 2022
Locale: San Antonio, Texas | Hybrid Virtual Content
Website: https://www.awwa.org/ace

2022 PA Abandoned Mine Reclamation Conference

Description: With a theme of "New Opportunities on the Horizon," the conference will highlight initiatives underway to ensure the continuation and improvement of reclamation programs and policies related to topics such as new AMD treatment system technologies, tools, and products; water quality monitoring; operations, maintenance, and rehabilitation of treatment systems; mapping, drones, equipment, and other helpful new technologies; legislative updates and concerns at all levels of government; and climate change, energy, and AMD.
Date: June 22–23, 2022
Locale: State College, Pennsylvania | Hybrid Virtual Content
Website: https://2022.treatminewater.com/

Researcher Spotlight



Ruishu Wright

Research Physical Scientist
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Ruishu F. Wright, Ph.D. is a Research Physical Scientist on NETL's Functional Materials Team. Wright holds a Ph.D. in Energy and Mineral Engineering and Electrochemical Science and Engineering from the Pennsylvania State University (PSU). She obtained her M.S. in Chemical Engineering and Technology from Tsinghua University and her B.S. in Metallurgical Science and Engineering from Central South University.

Her research interests include R&D of advanced sensors for real-time measurements, characterization, and monitoring of geochemical parameters in subsurface wellbores and sensor technologies for real-time structural health monitoring of water pipeline infrastructures. Her expertise lies in developing advanced sensors and functional materials to enable various sensor platforms such as optical fiber sensors and passive wireless sensors. She also has strong knowledge of corrosion and materials degradation in pipelines and deep wells with extreme conditions such as high temperature high pressure (HTHP) environments.

Wright serves as the Principal Investigator for multiple projects and coordinates R&D efforts of an interdisciplinary team to develop real-time sensors and functional sensitive materials to enable subsurface geochemical monitoring in support of the Subsurface Hydrogen-Natural Gas Storage field work proposal (FWP) and Onshore Unconventional Resources FWP. She also coordinates the Embedded Sensor Technology Suite for the Wellbore Integrity Monitoring project under the Subsurface Technology and Engineering Research, Development, and Demonstration (SubTER) Initiative. Currently, Wright is the Technical Portfolio Lead for the Natural Gas Infrastructure FWP, where sensor and materials technologies are being developed to monitor and mitigate corrosion and gas leaks in natural gas pipelines. These technologies can be translated to water pipelines to improve the resilience of water infrastructure. Wright explains,

> *"Subsurface geochemical monitoring is important for understanding geochemical processes, wellbore integrity monitoring, underground aquifer contamination detection, and abandoned well-plugging integrity, and has impacts on mitigation of risks leading to leakage and water contamination and reduction of greenhouse gas emissions to meet the objectives of infrastructure resilience, environmental justice, and mitigating climate change."*

Wright holds five pending and awarded U.S. patents on sensor technologies and has co-authored more than 40 articles, including Corrosion Sensors for Structural Health Monitoring of Oil and Natural Gas Infrastructure: A Review, Distributed fiber optic pH sensors using sol-gel silica based sensitive materials, Fully distributed optical fiber sensor for water and humidity monitoring, Electrochemical Corrosion of Ultra-high Strength Carbon Steel in Alkaline Brines Containing Hydrogen Sulfide, and Low-cost fiber optic sensor array for simultaneous detection of multiple parameters.

Water-Energy Publications

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

Determination of transition metal ions in fossil fuel associated wastewaters using chelation ion chromatography

Joshua D. Miller, NETL, Oak Ridge Institute for Science and Education; Mengling Y. Stuckman, NETL; Nicholas Means, NETL; Christina Lopano, NETL; J. Alexandra Hakala, NETL (APRIL 2022)

▸ https://www.sciencedirect.com/science/article/abs/pii/S0021967322001224

Prediction of Barium Sulfate Deposition in Petroleum and Hydrothermal Systems

Derek M. Hall, PSU; Serguei N. Lvov, PSU; Isaac K. Gamwo, NETL (APRIL 2022)

▸ https://www.taylorfrancis.com/chapters/edit/10.1201/9781003091011-5/prediction-barium-sulfate-deposition-petroleum-hydrothermal-systems-derek-hall-serguei-lvov-isaac-gamwo

Evaluating the Impact of Proprietary Oil & Gas Data on Machine Learning Model Performance Using a Quasi-Experimental Analytical Approach

Derek Vikara, NETL; Kolawole Bello, NETL; Nur Wijaya, NETL; Travis Warner, NETL; Alana Sheriff, NETL; Donald Remson, NETL (MARCH 2022)

▸ https://www.osti.gov/biblio/1855950

Sorption and transformation of biocides from hydraulic fracturing in the Marcellus Shale: a review

Nizette Consolazio, Carnegie Mellon University (CMU); J. Alexandra Hakala, NETL; Gregory V. Lowry, CMU; Athanasios K. Karamalidis, PSU (FEBRUARY 2022)

▸ https://link.springer.com/article/10.1007/s10311-021-01352-2

Dry cooling retrofits at existing fossil fuel-fired power plants in a water-stressed region: Trade-offs in water savings, cost, and capacity shortfalls

Haibo Zhai, University of Wyoming (UW), CMU; Edward S. Rubin, CMU; Eric J. Grol, NETL; Andrew C. O'Connell, NETL; Zitao Wu, UW; Eric G. Lewis, NETL (JANUARY 2022)

▸ https://www.sciencedirect.com/science/article/abs/pii/S030626192101299X

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.

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Program staff are also located in
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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:

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

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