NATIONAL ENERGY TECHNOLOGY LABORATORY

WINTER 2023

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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Highlights: DOE Partners with Universities to Address Critical Produced Water Management Issues

U.S. DEPARTMENT OF ENERGY | Fossil Energy and Carbon Management

The United States Department of Energy (DOE) Office of Fossil Energy and Carbon Management (FECM) Advanced Remediation Technologies Division-Water Management (ART-WM) has reviewed and selected proposals from universities as part of a DOE-led effort to address critical produced-water issues. This effort supports a directive of Executive Order 14008 (Tackling the Climate Crisis at Home and Abroad), which seeks to address the issue of environmental justice, chiefly the remediation and reduction of legacy pollution and the development of critical clean water infrastructure. Produced water, part of the water infrastructure that requires remediation for reuse, is the focus of the partnership between DOE and the selected universities.

The partnership serves as a unique platform that allows universities to work directly with ART-WM on the Nation's most pressing water-energy issues. Through the partnership, the Water Management Program is able to leverage the capabilities and expertise of the Nation's leading institutions, especially in the areas of machine learning and artificial intelligence, water characterization and treatment, and critical minerals (CM) recovery. The partnership will also provide the opportunity for universities to tap into the program's state-of-the-art, multi-million-dollar research and development (R&D) infrastructure.

Universities selected for the partnership include:

- Carnegie Mellon University
- The University of Texas at El Paso
- The University of Texas at Austin
- The Colorado School of Mines
- The University of Pittsburgh
- The University of North Dakota Energy and Environmental Research Center

Produced Water Research Partnership

In the autumn of 2022, DOE-university partnership began work to support produced water research efforts under three specific tasks:

- Lowering the Cost of Zero Liquid Discharge and Resource Recovery (ZLD+RR)
- Compiling Full Detailed Aqueous Speciation and Mineral Saturation Indexes of Produced Waters Across the United States
- Leveraging DOE's Produced Water Optimization Framework PARETO for Rare Earth Element and/or Critical Minerals Recovery from Produced Water

Additionally, the universities will collaborate with each other across the tasks to enhance coordination and leverage technical synergies, including data sharing.

Highlights: NETL Welcomes New Technology Manager

NETL is excited to welcome back John D. Rogers in a new role as Technology Manager of Environmentally Prudent Stewardship (EPS) and Hydrates programs in the Science & Technology Strategic Plans & Programs Division at the Laboratory's Houston, Texas, office. Rogers previously worked at NETL in the Laboratory's Strategic Center for Natural Gas and Oil in Morgantown, W.Va., as a project manager. He holds a Ph.D. and B.S. in Chemical Engineering from New Mexico State University, as well as an M.S. in Petroleum Engineering from Texas Tech University Lubbock. Rogers also holds a Professional Engineer (PE) license.

During Rogers' career, he has held diverse roles in federal and local government, university R&D, and non-profit and industrial private sectors where he primarily focused on environmentally responsible resource recovery. Rogers has held positions such as a Senior Production Operations Engineer, Reservoir Engineer, Industrial Wastewater Control Supervisor, Project/Program Manager, and Vice President of Operations. These roles enabled him to provide innovative technical direction as he worked on engineering and budgetary economic evaluations/studies; production and reservoir asset optimization and management in oil and gas recovery; technical and economic project evaluation; water and wastewater management; and various R&D projects of subsurface fluid flow analysis including enhanced oil recovery (EOR); carbon capture, utilization, and storage (CCUS) investigations; and improving geothermal and unconventional oil and gas extraction.

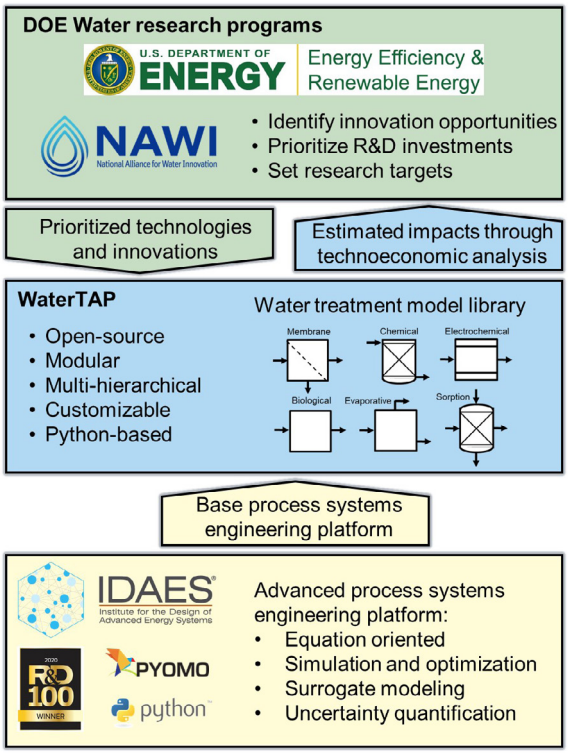
With his focus on transitioning to clean sustainable energy resources, Rogers will help execute the Laboratory's mission in the areas of strategic planning, technical leadership, collaborative team efforts with various stakeholders and R&D efforts. Rogers is dedicated to fostering team success in creating and utilizing cutting-edge technology to develop technically sustainable energy from the subsurface. In his new role as the Technology Manager for the EPS and Hydrates programs, Rogers has the opportunity to lead a cross-functional, interdisciplinary technical team within NETL to execute FECM's Advanced Remediation Technologies research efforts.

As Technology Manager, Rogers oversees the strategic and technical direction and implementation of the R&D in the EPS and Hydrates programs at NETL and ensures government funding is obligated in a timely and fiscally responsible manner. The current focus of the EPS program is coordinating research and advising technical direction to maximize the benefits and minimize the environmental impacts of U.S. unconventional natural gas liquids production. A current concentrated research area is advanced technologies related to reduced water usage and efficient produced water management as well as increased resource recovery efficiency and production operations. The Hydrates Program research is focused on the technical understanding of naturally occurring hydrates in Alaska and in moderately deep areas of the Gulf of Mexico.

Highlights: DOE's WaterTAP: Advancements Toward a Circular Water Economy

NAWI National Alliance for Water Innovation

Water supply and wastewater management face significant stressors in the 21st century including climate change, aging infrastructure, growing wastewater production and rising awareness of human health and environmental impacts from current water management practices. These stressors have exposed vulnerabilities in securing resilient, low-cost water supplies and managing wastewater. Since incremental technological advancements in the preceding decades have not overcome these mounting challenges, there has been growing interest in transforming the 20th century paradigm of a linear water economy to a circular water economy.[1] This radical transformation would shift the water economy from one in which water is extracted from the environment (primarily freshwater), treated and distributed for use with the resulting wastewater treated and discharged to the environment, to an economy where water is repeatably reused with fit-for-purpose treatment locally and its contaminants are recovered as valuable products. However, a circular water economy is not economically viable with current water treatment technologies. To advance water treatment technologies, DOE funded the development of the Water Treatment Technoeconomic Assessment Platform (WaterTAP). The Office of Energy Efficiency & Renewable Energy (EERE) research program that conceptualized WaterTAP and initiated its development is the National Alliance for Water Innovation (NAWI), which also serves as DOE's desalination hub.



Within the past two years, WaterTAP has developed numerous water treatment modeling capabilities. The WaterTAP development team primarily consists of members from four national labs including NETL, Lawrence Berkeley National Laboratory (LBNL), National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory. This team added water treatment models spanning broad categories including membrane, evaporative, physical, chemical, biological, ad/absorption and electrochemical-based technologies that range in detail from simple to complex. The team demonstrated the use of these models by completing detailed technoeconomic assessments of emerging water treatment trains, such as multi-stage high-pressure reverse osmosis and low salt-rejection reverse osmosis. The team also successfully integrated detailed water chemistry predictions for mineral precipitation from OLI Systems commercial software.

WaterTAP development is funded for at least two more years across three EERE programs. In the short term, WaterTAP developers will focus on supporting more water treatment technologies, refining current models, and creating publications that demonstrate the novel capabilities of the tool. In the long term, WaterTAP developers will assess opportunities for supporting advanced computational capabilities, which could include dynamic modeling, mixed-integer programming, conceptual design, uncertainty quantification, stochastic programming and robust optimization. WaterTAP funding is expected to extend beyond fiscal year 2024 through new DOE research programs and funding opportunities that seek to accelerate the transition to a circular water economy.

To access WaterTAP, please click here. To learn more about NAWI, please click here.

[1] Mauter, M. S. & Fiske, P. S. Desalination for a circular water economy. Energy Environ. Sci. 13, 3180–3184 (2020). DOI: 10.1039/D0EE01653E

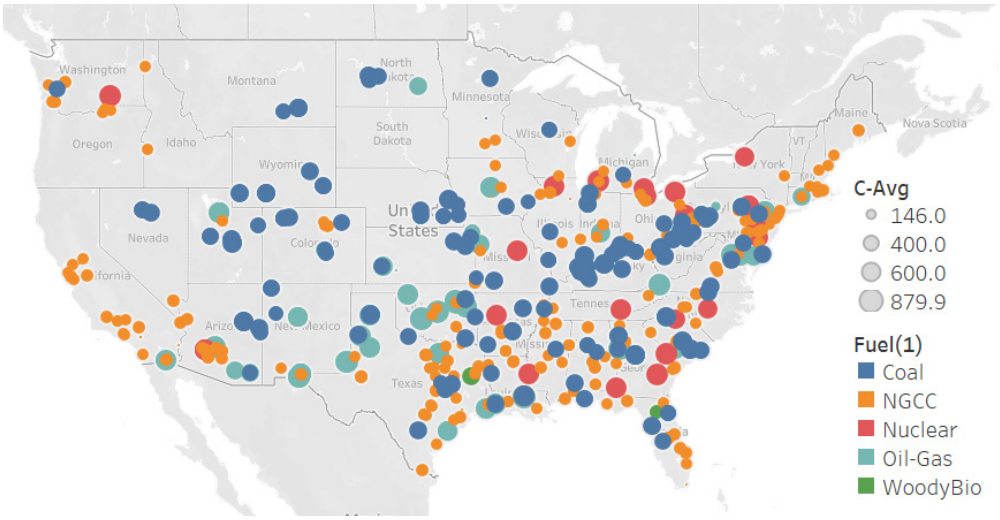
Highlights: NETL and the GMLC – Water Risk for the Bulk Power System

NETL participates in the Grid Modernization Laboratory Consortium (GMLC), a joint venture of multiple national laboratories and non-government organizations. One project focuses on Water Risk for the Bulk Power System: Asset to Grid Impacts. The goal of this effort is to develop an analysis platform that can provide environmental and economic benefits by aiding short-term operational and long-term investment decisions. NETL's role, led by Erik Shuster and Tim Skone, is to provide accurate, up-to-date water withdrawal and consumption factors for thermoelectric power plants. These power plants include nuclear, natural gas combined cycle (NGCC), natural gas steam, oil steam, coal-fired and biomass combustion electricity generating power plants. Accurate water-use factors are necessary in modeling water stress. The water-use factors developed by NETL will be used in NREL's Regional Energy Deployment System (ReEDS) Model and other models that support the GMLC project.

Unique contributions of the NETL study include a five-year study period (2016–2020) with monthly as well as annualized data to enable identification of seasonal trends and the public release of individual power plant water-use factors data. The overall focus of the study was to increase the granularity of the data, accounting for variations in water-use factors with local climate and operational practices, as well as fuel and cooling technology.

Water use is a general term covering both withdrawal and consumption. Water withdrawal is the water removed from a body of water, and water consumption is the water that is not returned. Water-use factors are further categorized by the fuel used to generate the electricity and by cooling technology. Cooling technologies can be broken down into wet once-through, wet recirculating and dry cooling. Recirculating systems can be broken down into induced (RI), forced (RF) and natural draft (RN) units. Once-through systems withdraw huge amounts of water and return most or all of it, resulting in zero to near-zero water consumption. Recirculating systems use cooling towers and withdraw much less water than once-through systems; however, recirculating systems consume water through evaporation. Water-use factors are reported as the volume of water used to generate 1 MWh of electricity. This study reports these factors in gal/MWh. The map shows water consumption by fuel type for power plants that use recirculating cooling technologies.

For more information about the GMLC, please click here.



Water consumption for U.S. recirculating cooling plants (size units are in gal/MWh)

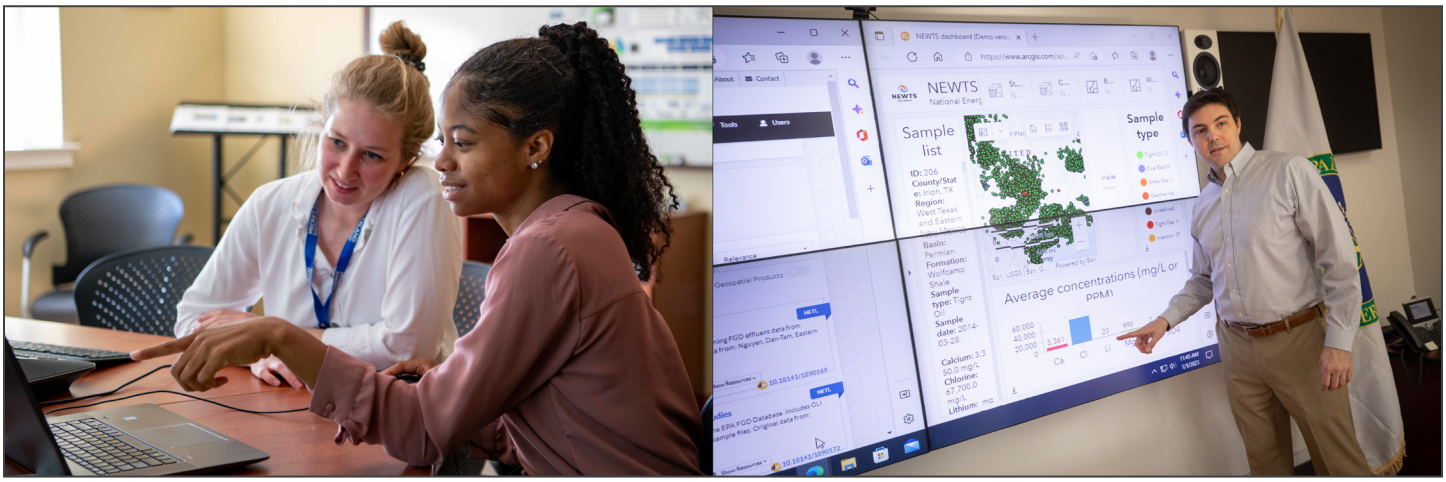
Highlights: NETL's NEWTS Tool Adds New Data Sets

In September 2022, NETL launched a free online tool, the **National Energy Water Treatment and Speciation (NEWTS) Database**, which can be utilized by community leaders and water researchers to better understand the composition of energy-related wastewater streams. The data provided by the tool will help mitigate environmental risks and identify possible sources of valuable CM.

NEWTS provides information about the levels of toxins, concentrations of metals and other hazardous materials found in energy-related wastewater streams, which include power plant leachate, acid mine drainage (AMD), brackish water and oil and gas produced water. Researchers can input the data into software to develop appropriate remediation steps.

This winter, NEWTS released new ash pond effluent and ash pond leachate data sets, which follow the 2022 release of three large datasets with flue gas desulfurization (FGD) power plant effluent, brackish water and produced water compositions. All the available data sets are in spreadsheet formats (.xlsx/.csv) that are easy to enter into commercial software such as OLI Studio and Geochemist Workbench.

For the latest information about the NEWTS Database, please click **here**.



NETL's Nicholas Siefert (far right) discusses the recently developed NEWTS database as well as the NEWTS dashboard being developed by the Lab. Other contributors to this online tool include NETL's Madison Wenzlick (far left) and Alexis Hammond, a Mickey Leland Energy Fellowship research associate. (Not shown are PI: Burt Thomas and Dashboard Developer: Devin Justman).

Water-Energy Project Highlights

NETL Oversees REE and CMM Recovery Projects

In 2021, NETL selected six projects to receive a total of nearly $1.2 million through Funding Opportunity Announcement (FOA) 2404, *Advanced Processing of Rare Earth Elements and Critical Minerals for Industrial and Manufacturing Applications,* to create a sustainable supply chain of critical minerals and materials (CMM), including rare earth elements (REE), which are crucial to the development of clean energy and national defense technologies.

The six projects with funding from FOA 2404 are overseen by the DOE-NETL Critical Minerals Sustainability Program, which focuses on extracting, separating, and recovering CMM from unconventional resources, such as coal and coal-based resources. One of the FOA 2404 projects is conducting a value analysis to determine the recoverable value of REE from AMD. West Virginia University Research Corporation has teamed up with several industry partners, including Rivian Automotive Inc., an American electric vehicle (EV) automaker and automotive technology company. Under this partnership, they worked to analyze AMD preconcentrate from an REE/CMM recovery pilot plant near Mount Storm, W.Va.

The overall objective of this project is to design, develop, and deploy innovative process technologies to produce salable rare earth metals and CMM from AMD to provide critically needed materials to assist in meeting the Nation's demand. A few CMM of interest are Nd, Pr, Co, and Li, which have various applications, including EV battery technology.

NETL's Michael Fasouletos, who is the federal project manager, explains that the project team examined the value of CMM coming from the AMD source and a milestone was achieved when "the results showed that the overall contained value is nearly $2,000 per metric ton, which would make this environmentally benign process also economically attractive."

This effort not only supports the mission to secure a national CM supply, but also utilizes a common legacy mining waste by-product, AMD discharge, which requires treatment under the Clean Water Act. Extracting CMM from AMD has the potential to create a revenue stream that could offset AMD treatment costs, which is a long-term goal for the Mount Storm, W.Va., pilot plant.

In addition to the national and local economic benefits, each of the six projects with funding under FOA 2404 could help insulate manufacturers from international supply disruptions by forming a domestic supply chain providing raw feedstock and producing market-ready metals. To learn more about all six projects, please click here and here. For more information about DOE-NETL's Critical Minerals Sustainability Program, please click here.

In addition to the discussed cooperative agreements, learn about NETL'S Small Business Innovation Research projects for CMM recovery related to the water-energy nexus by visiting the following project landing pages: Low-Cost Environment-Friendly Critical Materials Recovery from Produced Water, Critical Minerals and Materials Recovery from Oil and Gas Produced Water, and Extraction of Values-Added Minerals from Produced Water Through Novel Multistage Nanofiltration.

Conferences and Events

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

World Water-Tech Innovation Summit

Description: Now in its 12th year, the World Water-Tech Innovation Summit in London has become the annual meeting place and catalyst for innovation. The summit will bring together the most forward-thinking water companies, regulators, engineering firms, technology giants, investors and innovators to tackle the critical issues of the decade ahead.
Date: Feb. 21–22, 2023
Location: London, United Kingdom
Website: https://worldwatertechinnovation.com/

The Permian Basin Water in Energy Conference

Description: The Permian Basin Water in Energy Conference (PBWIEC) facilitates collaboration and innovative strategy development for the improved use, recovery and recycling of water in the oil industry. The PBWIEC is a program of The University of Texas Permian Basin and housed at the university's Shepperd Leadership Institute.
Date: Feb. 28–Mar. 2, 2023
Location: Midland, Texas
Website: https://waterinenergy.com/

32nd Annual International Conference on Soil, Water, Energy and Air

Description: The 32nd International Conference on Soil, Water, Energy, and Air and Association for Environmental Health and Sciences Foundation Semi-Annual Meeting offers attendees an opportunity to exchange findings, ideas, and recommendations in a professional setting. For the past 31 years, this annual conference has helped bring the environmental science community closer together by providing a forum to facilitate the exchange of information of technological advances, new scientific achievements and the effectiveness of standing environmental regulation programs.
Date: Mar. 20–23, 2023
Location: San Diego, California
Website: https://www.aehsfoundation.org/west-coast-conference.aspx

WEF/AWWA Utility Management Conference

Description: The American Water Works Association (AWWA) and the Water Environment Federation (WEF) are again partnering to offer this gathering of utility executives and managers. Over the past three decades, members of AWWA and WEF have established The Utility Management Conference™ as one of the leading, most informative and prestigious management conferences.
Date: Mar. 28–21, 2023
Location: Sacramento, California
Website: https://www.wef.org/UtilityManagement

Sustainable Water Management Conference

Description: The Sustainable Water Management Conference brings together water sector organizations and professionals to discuss all aspects of resilient and efficient water management. Attendees will gain insights into best practices for managing water resources, source water protection, sustainable utility planning, analyzing the costs and benefits of water conservation and exploring alternative water sources including stormwater and reuse.
Date: Apr. 16–19, 2023
Location: Minneapolis, Minnesota
Website: https://www.awwa.org/Events-Education/Sustainable-Water-Management

Researcher Spotlight

Joseph Renk

Senior Program Manager
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Joseph Renk is a Senior Program Manager at NETL. He works within the Office of Resource Sustainability's Advanced Remediation and Methane Mitigation Technologies programs on the Unconventional Oil & Gas Team. He holds an M.S. in Earth Science with an emphasis in Geology, and a B.S. in Petroleum Technology from California University of Pennsylvania. Renk joined NETL as a Federal Project Manager in 1991 after working at NETL in the Oak Ridge Institute for Science and Education (ORISE) Program where he supported the former Clean Coal Technology Program reviewing environmental issues and completing National Environmental Policy Act determinations for Environmental Assessments and Environmental Impact Statements. Before joining the ORISE Program, Renk worked as a staff geologist at an engineering firm.

Throughout his career at NETL, Renk has managed a variety of technical projects for DOE, which includes work outside of FECM at EERE's Advanced Manufacturing Office, the Building Technologies Office, and the Vehicle Technologies Office. He previously supported DOE's Office of Legacy Management as well. His current work includes managing the recently nominated **Produced Water Management Through Geologic Homogenization, Conditioning and Reuse project** carried out by the University of North Dakota's Energy & Environmental Research Center's. The project, which is funded by NETL and developed in partnership with the North Dakota Industrial Commission Oil and Gas Research Program and Nuverra Environmental Solutions, was a finalist in the Oil and Gas category of the 2022 Institution of Chemical Engineers Global Awards.

Renk's research interests include both upstream and midstream oil and gas development and mitigation measures for environmental prudent development. Renk was previously involved in induced seismicity projects in Oklahoma where state geological agencies from varying states worked on developing a measure for controlling induced seismicity, which was mainly from the reinjection of produced waters in geologic formations. Renk also has an interest in the mitigation of methane emissions from midstream operations where he supported a project that reliably, accurately, and autonomously identified methane leaks at critical midstream sectors. Additionally, Renk is currently involved in the Carbon Ore Rare Earths – Critical Minerals (CORE-CM) Program as a coordinator working closely with the NETL technology manager and FECM HQ Program Office and managing two projects in Wyoming in the Powder River, Green River and Wind River basins. The CORE-CM Program will help secure a domestic supply of REE and CM, which are crucial to the manufacture of clean energy technologies that will help decarbonize the energy sector.

Renk has authored and co-authored various publications, including **Establishing Tertiary EOR Operations in Unconventional Plays**; **Connecting Geomechanical Properties with Potential for Proppant Embedment and Production Decline for the Emerging Caney Shale, Oklahoma**; and **Computed Tomography Scanning and Geophysical Measurements of the Caney Shale Formation from the Tomaney #1-35-34-27 Well**.

Publications and Presentations

Below are several water-related journal articles, reports, and presentations authored or co-authored by NETL staff.

PARETO: An open-source produced water optimization framework

Markus G. Drouven, NETL; Andrés J. Caldéron, NETL; Miguel A. Zamarripa, NETL; Keith Beattie, LBNL (NOVEMBER 2022)

▸ https://link.springer.com/article/10.1007/s11081-022-09773-w

Dynamic Modeling, Parameter Estimation, and Data Reconciliation of a Supercritical Pulverized Coal-Fired Boiler

Katherine Hedrick, West Virginia University (WVU); Elijah Hedrick, WVU; Benjamin Omell, NETL; Stephen E. Zitney, NETL; Debangsu Bhattacharyya, WVU (NOVEMBER 2022)

▸ https://pubs.acs.org/doi/10.1021/acs.iecr.2c01977

A Technical-Economic Assessment of Brackish Water Treatment for Fossil Power Plant Cooling with Reduced Environmental Impact

Zitao Wu, NETL; Haibo Zhai, NETL; Eric Grol, NETL; Chad Able, NETL; Nicholas Siefert, NETL (MAY 2022)

▸ https://www.netl.doe.gov/energy-analysis/details?id=f22b4ace-dfbe-469a-877a-7c37a99a16eb

Impact of Non-Steady State Operation on Cooling Water Consumption at Coal- And Natural Gas-Fired Power Plants

Meagan Mauter, ORISE; Anjali Mulchandani, ORISE; Alison Fritz, NETL; Eric Grol, NETL (JANUARY 2021)

▸ https://netl.doe.gov/energy-analysis/details?id=9c2a7f69-d641-4df5-921c-5731d70e22ad

2022 Resource Sustainability Annual Project Review Meeting

A selection of water-related presentations given by FECM and NETL staff at the review meeting that took place from Oct. 25–27, 2022 in Pittsburgh, Pa. For complete proceedings, please click here.

- Advanced Remediation Technologies – Water Management Program Overview
  Hichem Hadjeres, FECM
- Water Management for Power Systems RIC FWP: Experimental Tasks
  Nicholas Siefert, NETL
- Water Management for Power Systems: Systems Analysis Tasks
  Alison Fritz, NETL
- The National Energy Water Treatment and Speciation (NEWTS) Database
  Burt Thomas, NETL
- Ocean & Geohazard Analysis
  MacKenzie Mark-Moser, NETL
- Characterization-Informed Recovery of Critical Minerals from Acid Mine Drainage Treatment Solids
  Mengling Stuckman, NETL
- Project PARETO – DOE's Produced Water Optimization Initiative
  Markus Drouven and Miguel Zamarripa-Perez, NETL
- Predicting Pollutant Generation in the Subsurface to Inform Produced Wastewater Remediation and Reuse
  Lauren Burrows, NETL

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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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