

U.S. DEPARTMENT OF ENERGY 1 OFFICE OF FOSSIL ENERGY AND CARBON MANAGEMENT | NATIONAL ENERGY TECHNOLOGY LABOARATORY

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

IN THIS ISSUE

Water-Energy Project Highlights

Researcher Spotlight

Conferences and Events

Water-Related Publications and Presentations

JULY 2021

NETL's Water Management R&D Review Sessions Discuss Technologies to Lower Water Use in Energy Production



NETL's 2021 Water Management Research and Development (R&D) Review Meeting was held virtually on May 10 and 17, 2021. Along with NETL researchers, industry and university engineers and scientists working on NETL-supported projects discussed research-driving technologies to lower water use in energy production projects. Sotirios (Sam) Thomas, division director for Advanced Energy & Hydrogen Systems, acting program manager for Sensors & Controls and Novel Concepts, and acting program manager for Water Management R&D of the U.S. Department of Energy (DOE), provided welcome and opening remarks, and Briggs White, technology manager for Crosscutting Research, provided an overview on NETL's water program.

Some of the presented projects highlighted at the meeting include:

- Impact of Water Use of Power Systems. Presented by Tim Skone and Erik Shuster, NETL.
- Applying Anodic Stripping Voltammetry to Complex Wastewater Streams for Rapid Metal Detection. Presented by David Jassby, University of California Los Angeles.
- Water Recovery from Cooling Tower Plumes. Presented by Karim Khalil, Infinite Cooling, Inc.
- Enhanced Cooling Tower Technology for Power Plant Efficiency Increase and Operating Flexibility. Presented by Yaroslav Chudnovsky, Gas Technology Institute.
- Produced Water and Waste Heat-Aided Blowdown Water Treatment: Using Chemical and Energy Synergisms for Value Creation Presented by Lian-Shin Lin, West Virginia University Research Corporation.

NETL develops advanced technologies that provide clean energy while safeguarding the environment. NETL's water-energy research supports DOE's mission to ensure America's security and prosperity by addressing its energy and environmental challenges through transformative science and technology solutions.

To learn more about the Water Management R&D Review Meeting, visit https://netl.doe.gov/21water-proceedings.

Highlights: NETL's ProteusLib Goes Live in September 2021

As part of the efforts within the National Alliance for Water Innovation (NAWI) in seeking to advance early-stage water treatment technologies, NETL has continued to lead the development of ProteusLib. ProteusLib is an open-source library of water treatment models built on NETL's Institute for the Design of Advanced Energy Systems (IDAES) Integrated Platform, which is an advanced process systems engineering tool for flowsheet-based analysis.



IDAES includes an extensible, hierarchical model library that covers units and physicochemical properties typically associated with chemical and energy processes, including advanced units incorporating process intensification concepts. The new capabilities of ProteusLib will support the design and optimization of integrated water treatment systems to improve existing systems and enable the analysis of innovative new designs that incorporate emerging technologies.

Recent modeling additions to ProteusLib include: 1) unit models for reverse osmosis and energy recovery; 2) property models for concentrating sodium chloride solutions and seawater; and 3) property and reaction models for multiple chemistry processes based on detailed electrolyte systems. The initial use of these models has focused on assessing the technoeconomic viability of a low salt rejection reverse osmosis process, a novel multistage membrane process for high salinity brine desalination and the energy consumption of a commercial desalination facility using actual plant operating and design data.



Example flowsheet of a water treatment train including pretreatment, desalination, and posttreatment that ProteusLib will be able to simulate and optimize.

This work will enable the simulation and optimization of established and emerging water treatment technologies within the context of an entire treatment train. The model will be maintained throughout the NAWI program. The model library is scheduled to be publicly released on Sept. 30, 2021.

For an overview presentation on ProteusLib, click here.

For more information on IDAES, visit https://idaes.org.

Highlights: NETL Develops Water Model and Technologies for Thermoelectric Power Plants

Water is an operationally critical resource for thermoelectric power plants, used most often as a coolant. Water shortages, potentially one of the greatest challenges facing all sectors of the U.S. in the 21st century, will be an especially difficult issue for thermoelectric generators due to the large amount of cooling water required for power generation. In addition, water availability issues are intensified by the fact that population is increasing in water-stressed areas.

NETL researchers have developed a water use model to estimate future thermoelectric power plants' water withdrawal and consumption in the



NETL's water-saving technologies to reduce water use.

U.S. Future freshwater withdrawal and consumption requirements for the U.S. thermoelectric generation sector are estimated using the latest Energy Information Administration Annual Energy Outlook data to identify regions where water issues could become acute. The water use model also quantifies water saving benefits of funded NETL water management R&D.

There are five types of technology categories supported by NETL to reduce freshwater use: external alternative water sources, internal water sources, plume abatement, condenser coatings, and enhanced cooling towers. These reductions have been empirically calculated through studies, and are applied to both new and existing power plants. These water-saving technologies can be combined to increase efficiency. The use of external alternative water sources and dry cooling can also provide the most significant total water savings. Of the five technology categories evaluated, condenser coatings are the only NETL funded technology that can be applied to both once-through and

wet recirculating cooling systems.

To learn more about NETL's Water Management R&D, visit https://netl.doe.gov/coal/water-management.

Highlights: NETL Participates in Southwestern Pennsylvania Water Network Virtual Engagement Series

A representative from Research Partnerships & Technology Transfer participated in a series of virtual engagement meetings that were held on April 20, May 4, and May 18, 2021. The purpose of the engagement series was to take steps to strengthen a regional network of private and public sector organizations to collaborate on water quality, quantity, access, and affordability issues in Southwestern Pennsylvania. The virtual meetings were organized and coordinated by the Water Center at the University of Pennsylvania.

Participants in the meeting included more than 100 representatives from federal and state agencies, regional and local watershed associations, and

concerned citizens groups. Several topics were covered over the three days of meetings with direct relevance to NETL's water-energy mission, including the impacts of abandoned mine drainage (AMD) and climate change on water availability and quality. Information was presented to the group on the Laboratory's efforts to treat and recover rare earths and critical minerals from AMD as an approach to addressing national security concerns and of more relevance to the network of remediating legacy environmental problems.

To learn more about the Water Center at the University of Pennsylvania, visit https://watercenter.sas.upenn.edu.



Highlights: NETL Files a Patent on Fiber Optic pH Sensor for High-Temperature and High-Pressure Environments

Recently, NETL researchers filed a patent and published a paper on pH sensors comprised of optical fibers coated with metal oxide-based pH sensing materials for use in high-temperature and high-pressure environments. pH is an important parameter to be measured in water for many applications such as environmental science, geochemistry, biotechnology, clinical chemistry, and marine science. pH also affects the structural health of infrastructures (e.g. pipelines and wellbore casing), as reduced pH can promote corrosion.



Experimental setup for a fiber optic pH sensor.

Researchers at NETL have been working on functionalized optical fiber pH sensors for real-time distributed pH monitoring of energy infrastructures. Compared to traditional sensing methods, fiber optic pH sensors offer several advantages. They are chemically and thermally stable, lightweight, feasible, and small in size. In addition, they do not need a separate reference electrode as required in potentiometric sensing methods. Fiber optic pH sensors can be used for remote, distributed, and continuous pH sensing in harsh environments. They have been deployed for distributed temperature and pressure sensing in the subsurface.

The potential applications of optical fiber pH sensors include real-time pH monitoring in subsurface environmental, long-distance pipelines, and water treatment.

For more information on NETL's available technologies, visit https://netl.doe.gov/business/tech-transfer/available-technologies.

Water-Energy Project Highlights

Earlier this year, NETL's Cross-cutting R&D Program announced the availability of \$3.3 million in federal funding for cost-shared R&D projects under a Funding Opportunity Announcement (FOA) entitled, "Water Management for Thermal Power Generation" (DE-FOA-002399). The FOA is focused on the identification and treatment of alternative sources of water for power generation, and is directly supporting DOE's Water Security Grand Challenge Goal 3: "Achieve near-zero water impact for new thermoelectric power plants, and significantly lower freshwater use intensity within the existing fleet."

In May 2021, the DOE's Office of Fossil Energy and Carbon Management announced the selection of two projects to receive nearly \$2 million under the FOA. The selected projects will support the design, construction, and operation of engineering-scale prototypes of water treatment technologies for the existing and future fleet of thermoelectric power plants. Power plant owners, operators, and technology developers will collaborate and advance near-term water treatment solutions for commercial deployment.

The two projects are described below:

Clean Water Production in Cooling Towers — Infinite Cooling Inc. (Somerville, Massachusetts)

This project plans to use novel technology to produce clean water from cooling tower recirculating water by leveraging the evaporation/condensation cycle within cooling towers. The technology uses electric fields to ionize the plumes coming out of cooling towers, charge the escaping water and direct it toward mesh collectors, where it collects and flows down. The project team will build a full-scale prototype on the cooling tower at the Fox Energy Center, a large natural gas fired power plant in KauKauna, WI. Testing will quantify system performance for water production rates and water quality and assess system durability.

Electrodialysis Reversal (EDR) Pilot Test — ION Clean Energy Inc. (Boulder, Colorado)

This project plans to complete an EDR pilot conceptual study and commercial cost estimate, needed to evaluate the retrofit of an EDR system at the Nebraska Public Power District's Gerald Gentleman Station (GGS). EDR can be used to remove or concentrate salts in water or other industrial streams without adding or consuming chemicals and generating little or no additional waste. The project will result in the development, testing, and evaluation of an application to treat difficult and highly varying "gray" water streams generated from power plant operations.

To learn more about NETL's Crosscutting Water Research, visit https://netl.doe.gov/coal/water-management.

For more information on the FOAs, visit https://www.energy.gov/fe or click here.

Conferences and Events

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

The Water Expo

Description: The Water Expo is a bilingual tradeshow and conference that presents equipment, technologies, products & know-how for the wastewater, sewer infrastructure, environmental services, portable sanitation, water quality, and high-pressure industries. The virtual conference was held in May 2021 and the in-person conference will be held in August 2021 in Miami, FL.

Date: Aug. 25–26, 2021 Locale: Virtual + In-Person (Miami, FL) Website: https://www.thewaterexpo.com

The Ground Water Protection Council (GWPC) 2021 Annual Forum

Description: GWPC is a nonprofit 501(c)6 organization whose members consist of state ground water regulatory agencies which come together within the GWPC organization to mutually work toward the protection of the nation's ground water supplies. The purpose of the GWPC is to promote and ensure the use of best management practices and fair but effective laws regarding comprehensive ground water protection.

Date: Sept. 26–29, 2021

Locale: Salt Lake City, UT

Website: https://www.gwpc.org

Water Environment Federation Technical Exhibition and Conference (WEFTEC)

Description: WEFTEC is the world's most comprehensive gathering of water quality professionals and thought leaders, featuring the sector's leading conference program, an extensive exhibition showcasing the field's most cutting-edge solutions, and a variety of valuable networking opportunities. The virtual conference will take place in November 2021.

Date: Oct. 16–20, 2021 and Nov. 16–18, 2021 Locale: In-Person (Chicago, IL) + Virtual Website: https://www.weftec.org

37th Annual International Conference on Soils, Sediments, Water, and Energy

Description: Association for the Environmental Health and Sciences (AEHS) Foundation is a non-profit, membersupported 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. 18–21, 2021 Locale: Virtual Website: https://www.aehsfoundation.org

Researcher Spotlight



Erik Shuster Environmental Engineering Researcher Erik.Shuster@netl.doe.gov

Erik Shuster is an environmental engineering researcher on the Energy Markets Analysis Team where he performs systems and benefits studies on fossil energy-related technologies. He earns his master's degree in chemical engineering from the University of Pittsburgh. Shuster has been with NETL for more than 19 years.

Shuster supports the NETL Crosscutting Technologies division through water management, materials, energy storage, and advanced sensors and controls work. He is the key contact for NETL's Water-Energy National Energy Modeling Systems (NEMS), Systems Analysis, and Modeling. Shuster is also involved in the NAWI support.

⁶⁶My interest is in thermoelectric water use at the plant and national fleet levels, regional, and national power plant water modeling and benefits from novel water reducing technologies...⁹⁹

Shuster has co-authored four scientific publications. His publications include: Water-Energy Prototype Model for the NEMS Modeling Platform: Thermoelectric Water Demand and Its Implications on Regional Electricity Market, Potential Impacts of Electric Power Production Utilizing Natural Gas, Renewables and Carbon Capture and Sequestration on US Freshwater Resources, and Carbon Capture and Sequestration: Potential Impacts on U.S. Water Resources. His water-related effort includes the systems level analysis of water use under FWP task Impact of Water Use of Power Systems (FWP-1022428 Task 5).

Recent Water-Related Publications and Presentations

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

Biogeochemistry of the Antrim Shale Natural Gas Reservoir

Brooke Stemple, University of Notre Dame; Kara Tinker, Leidos/NETL; Preom Sarkar, ORISE/NETL; Josh Miller, ORISE/NETL; Diuna Gulliver, NETL; Kyle Bibby, University of Notre Dame (JUNE 2021)

https://pubs.acs.org/doi/abs/10.1021/acsearthspacechem.1c00087

Cost Optimization of Multi-Stage Gap Membrane Distillation

Alexander V. Dudchenko, SLAC National Accelerator Laboratory; Timothy V. Bartholomew, KeyLogic/NETL; Meagan S. Mauter, Stanford University (JUNE 2021)

▶ https://www.sciencedirect.com/science/article/abs/pii/S0376738821001782

NRAP-Open-IAM: A Flexible Open-Source Integrated-Assessment-Model for Geologic Carbon Storage Risk Assessment and Management

Veronika Vasylkivska, Battelle/NETL; Robert Dilmore, NETL; Greg Lackey, Battelle/NETL; Yingqi Zhang, Lawrence Berkeley National Laboratory; Seth King, Leidos/NETL; Diana Bacon, Pacific Northwest National Laboratory; Bailian Chen, Los Alamos National Laboratory (LANL); Kayyum Mansoor, Lawrence Livermore National Laboratory; Dylan Harp, LANL (JUNE 2021)

▶ https://www.sciencedirect.com/science/article/abs/pii/S1364815221001572

Technoeconomic Analysis for Hydrogen and Carbon Co-Production via Catalytic Pyrolysis of Methane

Jarrett Riley, ORISE/NETL; Chris Atallah, Leidos/NETL; Ranjani Siriwardane, NETL; Robert Stevens, NETL (JUNE 2021) https://www.sciencedirect.com/science/article/abs/pii/S0360319921010806

Experimental Validation of a Multiphase Flow Model of a Lab-Scale Fluidized-Bed Gasification Unit

Andrea Porcu, Grande Miniera di Serbariu; Yupeng Xu, Leidos/NETL; Mauro Mureddu, Grande Miniera di Serbariu; Federica Dessì, Grande Miniera di Serbariu; Mehrdad Shahnam, NETL; William A. Rogers, NETL; Bhima S. Sastri, U.S. DOE; Alberto Pettinau, Grande Miniera di Serbariu (JULY 2021)

▶ https://www.sciencedirect.com/science/article/abs/pii/S030626192100413X

Understanding Controls on the Geochemistry of Hydrocarbon Produced Waters from Different Basins Across the US

Shikha Sharma, West Virginia University (WVU); Vikas Agrawal, WVU; Rawlings N. Akondi, WVU; Yifeng Wang, Sandia National Laboratory; Alexandra Hakala, NETL (DECEMBER 2020)

► https://pubs.rsc.org/en/content/articlelanding/2021/EM/D0EM00388C#!divAbstract

Contact Us

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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:

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



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