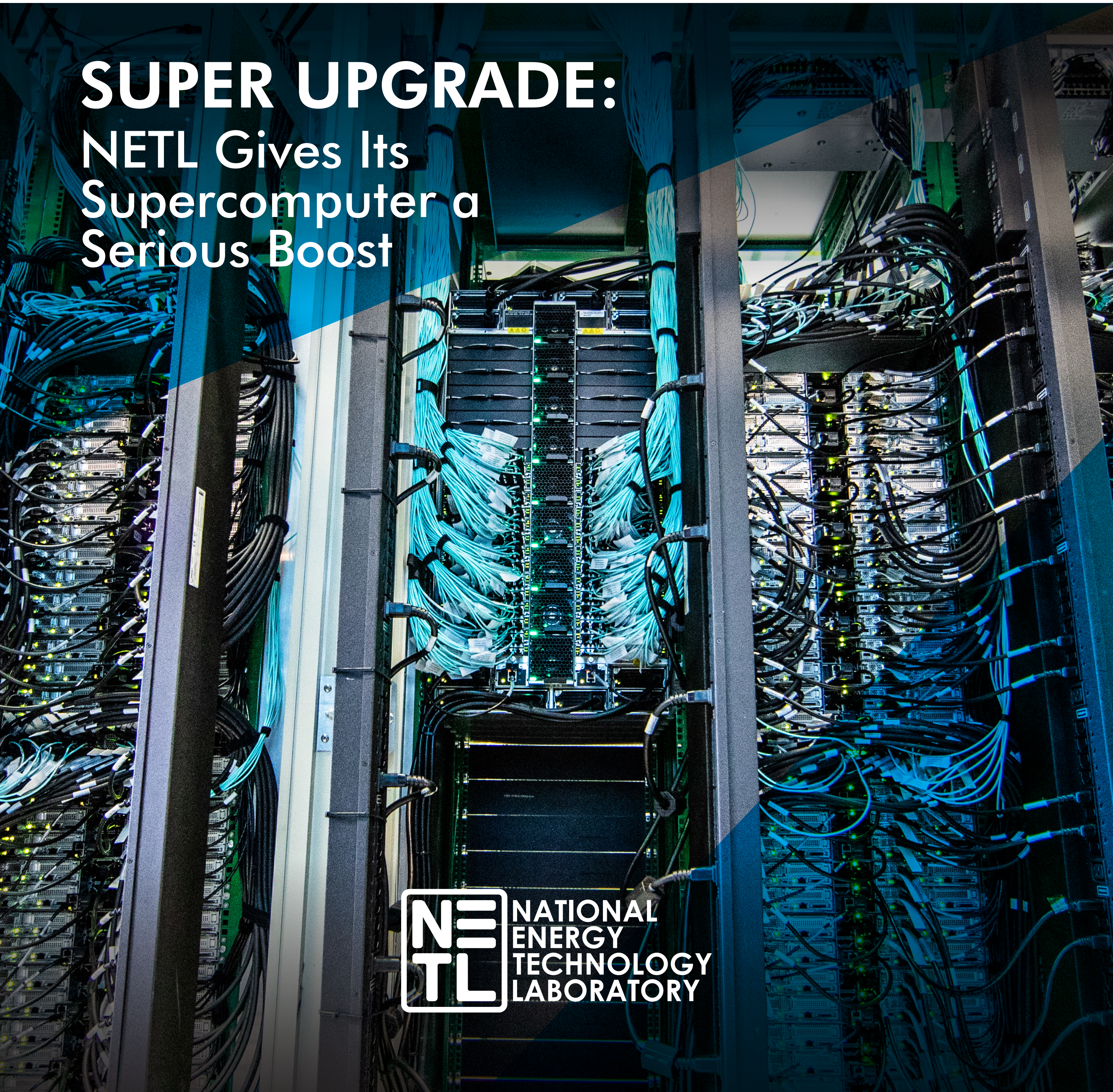
Vol. 01 / Winter 2018

NETL EDGE

A Publication of the U.S. Department of Energy's National Energy Technology Laboratory

SUPER UPGRADE:

NETL Gives Its Supercomputer a Serious Boost



NATIONAL ENERGY TECHNOLOGY LABORATORY

NETL EDGE

Vol. 01/ Winter 2018

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NATIONAL ENERGY TECHNOLOGY LABORATORY

MESSAGE FROM THE BOARD

Dear Reader:

Periodically, we take stock of our Laboratory's most recent significant research and assemble a publication rich with stories designed to describe the work and make clear its potential for positively impacting the nation's energy future. These stories explain how a dedicated collection of talented researchers pursue scientific curiosity in support of our mission to discover, integrate, and mature technology solutions that enhance the nation's energy foundation and protect the environment for future generations.

We are pleased to present the first edition of *NETL Edge* for your consideration. The following pages will enlighten readers with information about NETL's work on the important assignment of recharging the nation's coal plants for 21st century performance; our progress with industry and academic partners on new ways to recover rare earth elements from coal and coal byproducts; our collaboration with key research universities; how we are upgrading the Laboratory's supercomputer capabilities; and much more.

We appreciate your interest in our work for America's energy future, and we welcome your continuing involvement in the drive to attain and sustain global energy dominance.

Sincerely,

The NETL Editorial Board

ON THE COVER

Network and power cables are accessible behind the server racks of the newly upgraded Joule supercomputer at NETL's Morgantown, West Virginia, site. The update is providing an eight-fold increase in computational speed and power over the previous supercomputer, enabling NETL scientists and engineers to greatly expand their research capabilities. Joule is on its way to again becoming one of the fastest computers in the country. **Read more on page 16.**

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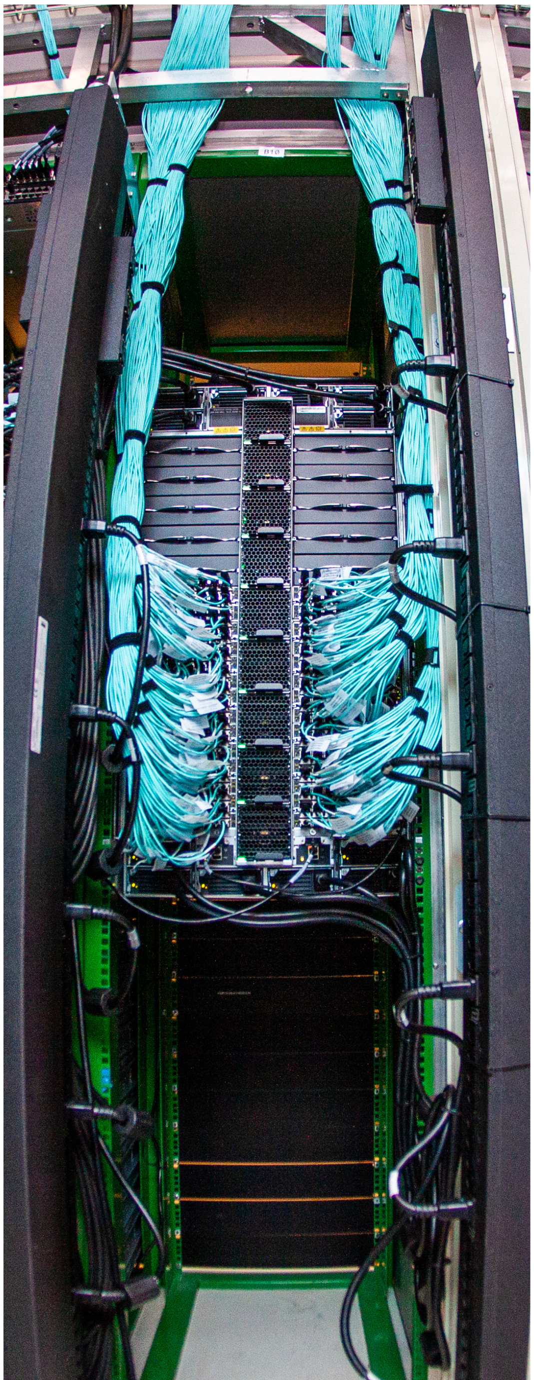

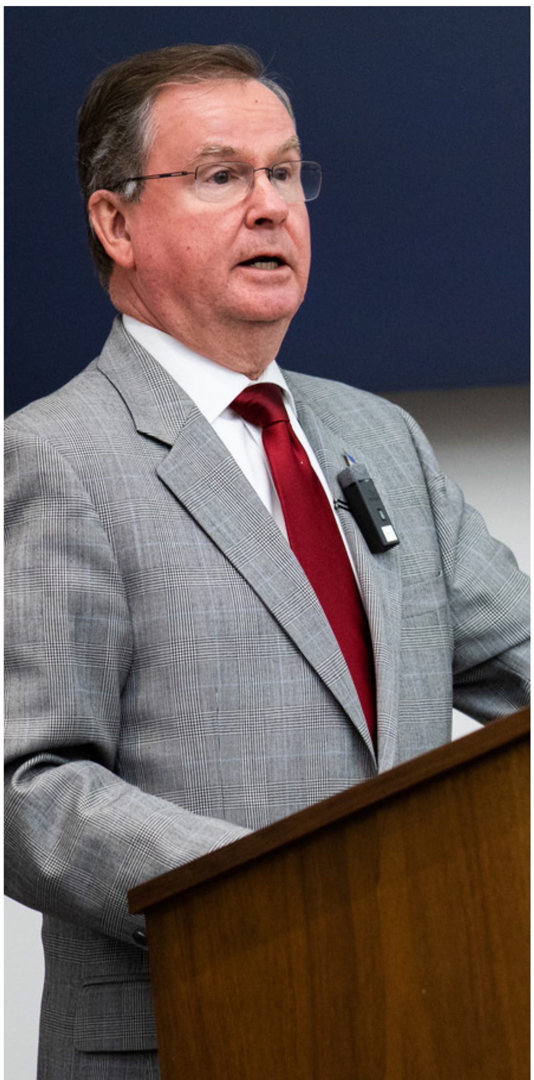

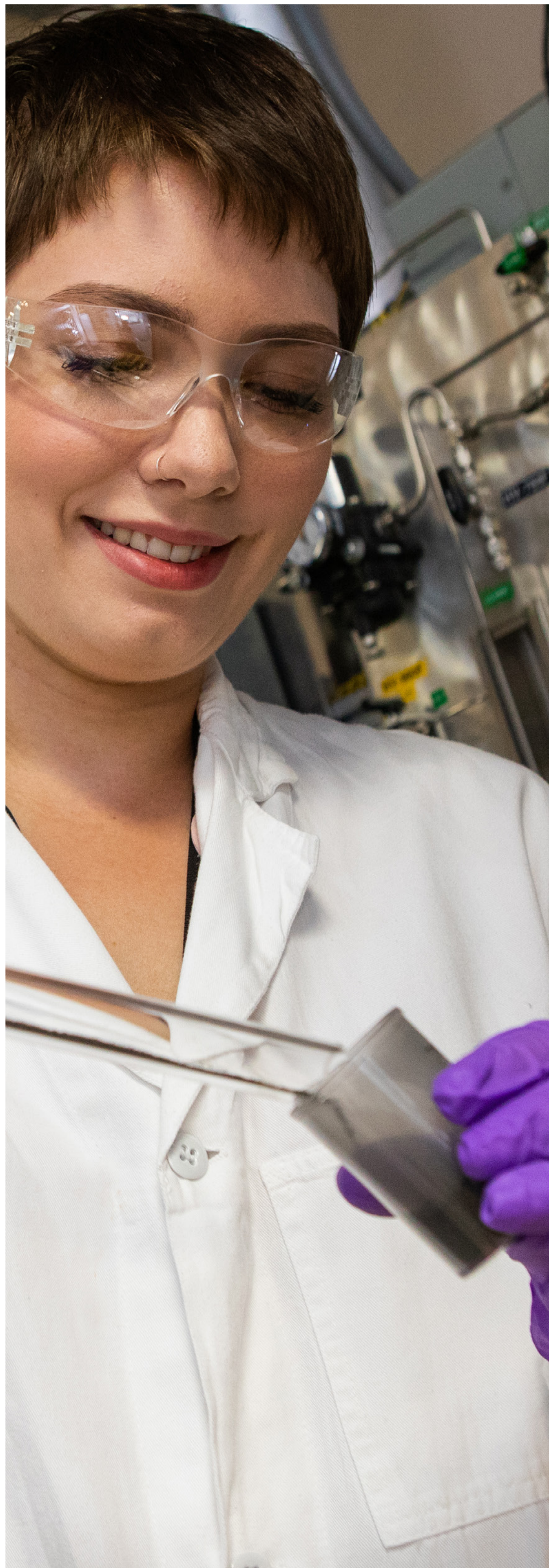

TRANSFORMATIONAL TECHNOLOGIES

America's existing coal-fired power plants need transformative technologies like those being developed at NETL, the nation's only national laboratory dedicated to fossil fuel research.

By Gerrill Griffith

America's fleet of coal-based electric power generation facilities has experienced negative impacts from business, regulatory, and technical changes – changes that eroded the viability and slowed the use of coal to produce the electricity that has powered the nation's growth for generations. The changes caused the closure of many plants, creating hardships for many local communities that lost jobs and tax revenue, and threatening the reliability of America's electricity supply.

Geo Richards, a veteran researcher who works on NETL's science and technology strategic plans and programs, explained that, when faced with the challenge of developing new ways to revamp, renew and recharge coal-burning plants to meet the challenges of the 21st century, researchers embarked on a scientific quest to help the nation develop and engage transformational technologies that are designed to adapt existing plants to address economic and environmental concerns. It was an assignment that comes from the heart of NETL's mission to discover and mature technology solutions that enhance the nation's energy foundation and protect the environment for future generations.

"For decades, coal was the fuel of choice for low-cost power generation," Richards explained. "That all changed because of a variety of factors, including the availability of sustained low-cost natural gas; decreasing capital costs of competing electricity generating technology options; and more frequent dispatch load-following units."

Coal once represented a stable, low-cost fuel option compared to more volatile, higher priced natural gas. However, the advent of hydraulic fracturing for production of shale gas and the projection that natural gas will remain low cost for the foreseeable future have significantly impacted the fuel cost advantage of coal. In addition, trends in capital costs of competing electricity-generating technologies, both natural gas-fueled and renewable options, represented additional pressure on capital intensive coal projects that might have improved the economics of existing coal-fueled electricity generating units. Societal preferences for more reliance on renewable energy sources are causing non-renewable electricity generators to curtail output to accommodate the intermittency of wind and solar power.

These factors combined to discourage new coal-based plants from being brought online. In addition to fewer coal-fired plants contributing to the nation's power supply, existing plants are now required to operate in ways that are suboptimal from the perspective of efficiency and capacity. There are options for improving the economic competitiveness of existing plants, but they often require substantial investments at a time of stringent environmental regulations and greater attention to life cycle aspects of coal use, such as water intensity and byproduct management. As a result, non-coal alternatives often have an advantage, and a pattern of substantial coal-fueled plant retirements has developed. If these important energy infrastructure assets continue to retire, the security of America's baseload coal-powered electricity supply may be significantly undermined.

As DOE's only national laboratory dedicated to fossil energy research, NETL is suggesting an approach to develop transformational technologies for existing plants that will focus on providing innovative options for relieving the pressures of the new paradigm shifts for electricity generation while protecting the environment.

"The intent is to address identified challenges by developing technologies that increase coal-fired power plant efficiency, improve unit reliability and availability, and enhance unit capabilities for flexible operations known as cycling," Richards said "The goal is to identify technologies that can be promptly deployed at existing coal-fueled electricity-generating units across the United States, enabling the nation to build upon a century's worth of infrastructure investments for clean, affordable and reliable electricity supplies while providing sufficiently rapid return on investment to justify implementation."

The fundamental technical challenge facing the development of relevant technologies is a lack of detailed, comprehensive data and information that allows for the identification and prioritization of low-cost and high-impact technology options. The following section describes the five research steps involved with NETL's pursuit of technical solutions.

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NETL'S APPROACH HAS FIVE DISTINCT RESEARCH STEPS:

1 ENERGY TECHNOLOGY SYSTEMS & MARKET ANALYSIS

The work is designed to identify and estimate the benefits of technology options that can improve the economic viability of existing coal-fueled electricity-generating units. It is an urgent task that calculates emerging technical, market and other barriers to the continued use of existing assets. The outcome of the work will identify high-priority opportunities with the greatest potential for near-term impacts and help support development of a useful knowledge base of data and information that can be used to guide research efforts and help technical and policy decision-makers.

2 OPTIMIZING DYNAMICS FOR PERFORMANCE & RELIABILITY

NETL experts believe that improving the flexible operation of existing plants by developing and applying high-fidelity dynamic process models and controls to optimize plant performance and reliability is critical. Because of the urgency of the task, efforts are needed to address opportunities for achieving optimal plant efficiency during flexible operations, including load-following and minimum-load conditions. The result will produce high-fidelity dynamic process performance and fault models, sensor network designs, and advanced process controls for baseline existing plants and industry partner plants.

3 SENSORS, DIAGNOSTICS & CONTROL FOR PERFORMANCE & RELIABILITY

A range of specific technologies and activities encompass NETL's work in this area that helps improve performance evaluations and detect equipment deterioration – just two factors leading to enhanced operations of coal-fired power plants. For example, one specific area, system identification, builds mathematical models of dynamic systems using measurements of a system's input and output signals – a critical component of finding innovative ways to upgrade the nation's fleet of coal-fired power plants. System identification requires model structures and estimation and evaluation methods to be effective. The process yields needed information on stability, heat rates, and emissions during cycling and part-load operations. However, applying the approach to active power plants often requires disruptive step changes. Research is focused on implementing online system identification that avoids disruptions. If successful, the research will produce an effective, low-cost way to continuously optimize existing plant control systems that can be used to optimize load-following and -cycling plant performance, and augment advanced condition-based monitoring systems.

4 MATERIALS FOR PERFORMANCE & RELIABILITY

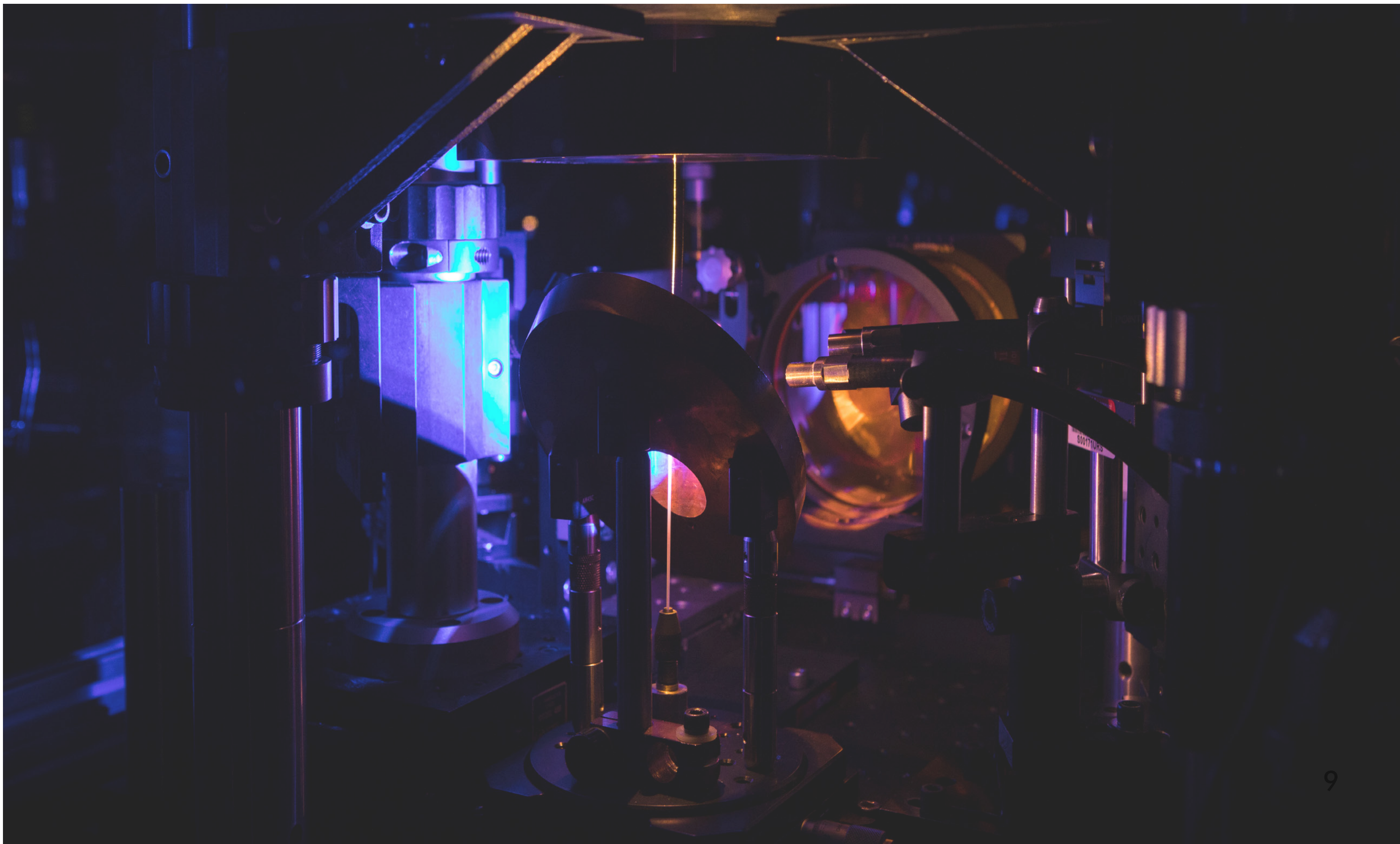
Scientists and engineers around the country are engaged in investigations that cut across many scientific and technological disciplines to address materials requirements for all fossil energy systems, including innovative advanced power systems. The goal is to develop materials with unique thermal, chemical, and mechanical capabilities with a focus on the severe operating environments typical of fossil energy production. For example, ongoing NETL research focuses on increasing the knowledge base of materials performance in several key areas: materials development for high-temperature, erosive and corrosive environments; real-time materials performance monitoring; corrosion, wear and failure mechanisms in severe environments; materials protection strategies; and lifetime predictions.

NETL works closely with industry, academia, and government agencies to monitor and ensure that research is relevant and effective in addressing materials performance needs that can assure reliability for both current and next-generation energy systems. When appropriate, identified materials-related research results can be pursued for application to the existing fleet of coal-fueled electricity generating units.

5 POWER PLANT COMPONENT IMPROVEMENT

Plant operators and managers rely on detailed computational fluid dynamics (CFD) modeling to make practical decisions about how to operate coal plants at part-load. Work in this category can help address current challenges through development of a CFD model based on an industrial-scale boiler to allow model sensitivity, validation, and uncertainty quantification. The effort will produce an industrial-scale CFD model and result in a modeling framework that allows generation of reduced order models – computationally inexpensive mathematical representations that offer the potential for near real-time analysis.

NETL's Bo Liu operating the laser heated pedestal growth system at NETL Morgantown. The system is used to grow crystalline sapphire optical fiber for very high-temperature sensors that can be used to take multipoint temperature measurements along the fiber in the hottest parts of combustion systems.



PROMISING POTENTIAL

NETL, WVU Establish Rare Earth Extraction Facility

By Cassie Shaner

Rare earth elements (REEs) are essential in today's technology-dominant world. They make vibrating cell phones, crisp LED screens and other in-demand technologies possible. Once thought to be rare, REEs are abundant in Earth's crust but also challenging to extract. For decades, the United States and other nations have relied primarily on imports from China, which supplies more than 90 percent of REEs worldwide.

An innovative new facility established in collaboration with NETL has the potential to yield a valuable domestic supply of REEs from a nontraditional source – acid mine drainage (AMD), a waste byproduct of coal mining operations. If successful, the bench-scale Rare Earth Extraction Facility (REEF) at West Virginia University (WVU) will ultimately enhance national security, stimulate economic growth, reinvigorate coal country and promote responsible stewardship of the environment.

“This is a milestone moment in our Lab’s efforts to develop a domestic supply of rare earth elements.”

The REEF is a key component of two DOE projects managed by NETL. DOE Assistant Secretary for Fossil Energy Steven Winberg joined officials from NETL and WVU to celebrate the facility’s launch in July 2018.

“This is a milestone moment in our Lab’s efforts to develop a domestic supply of rare earth elements, which are essential for modern technologies,” NETL (Acting) Director Sean I. Plasynski said. “Innovation is central to our work at NETL, and this cutting-edge research supports DOE’s core mission to keep America safe and secure. This facility will explore the feasibility of meeting the growing demand for REEs by taking advantage of our abundant natural resources. If successful, we will create business opportunities that stimulate the economy and boost jobs, help the coal industry and ensure national security by reducing our reliance on imports.”

UNDERSTANDING RARE EARTHS

The 17 elements typically described as rare earths include the lanthanide series within the periodic table – elements 57-71, the first of two rows often pulled out below the rest of the elements – along with transition elements scandium and yttrium.

These important elements are used in high-technology devices that support a broad range of industries, including transportation, health care and defense. For instance, samarium is used to make studio lights and optical lasers. The U.S. defense industry alone requires about 800 tons of REEs per year.

REEs are divided into two categories – light and heavy, with heavier REEs less plentiful and generally worth more money. However, the value of individual REEs varies based on market conditions. Refined scandium, which is more scarce than other REEs, can command as much as $15,000 per kilogram.

REEs do not occur naturally in elemental form, but the vast coal resources throughout the United States contain quantities sufficient to meet the country’s needs for years to come.

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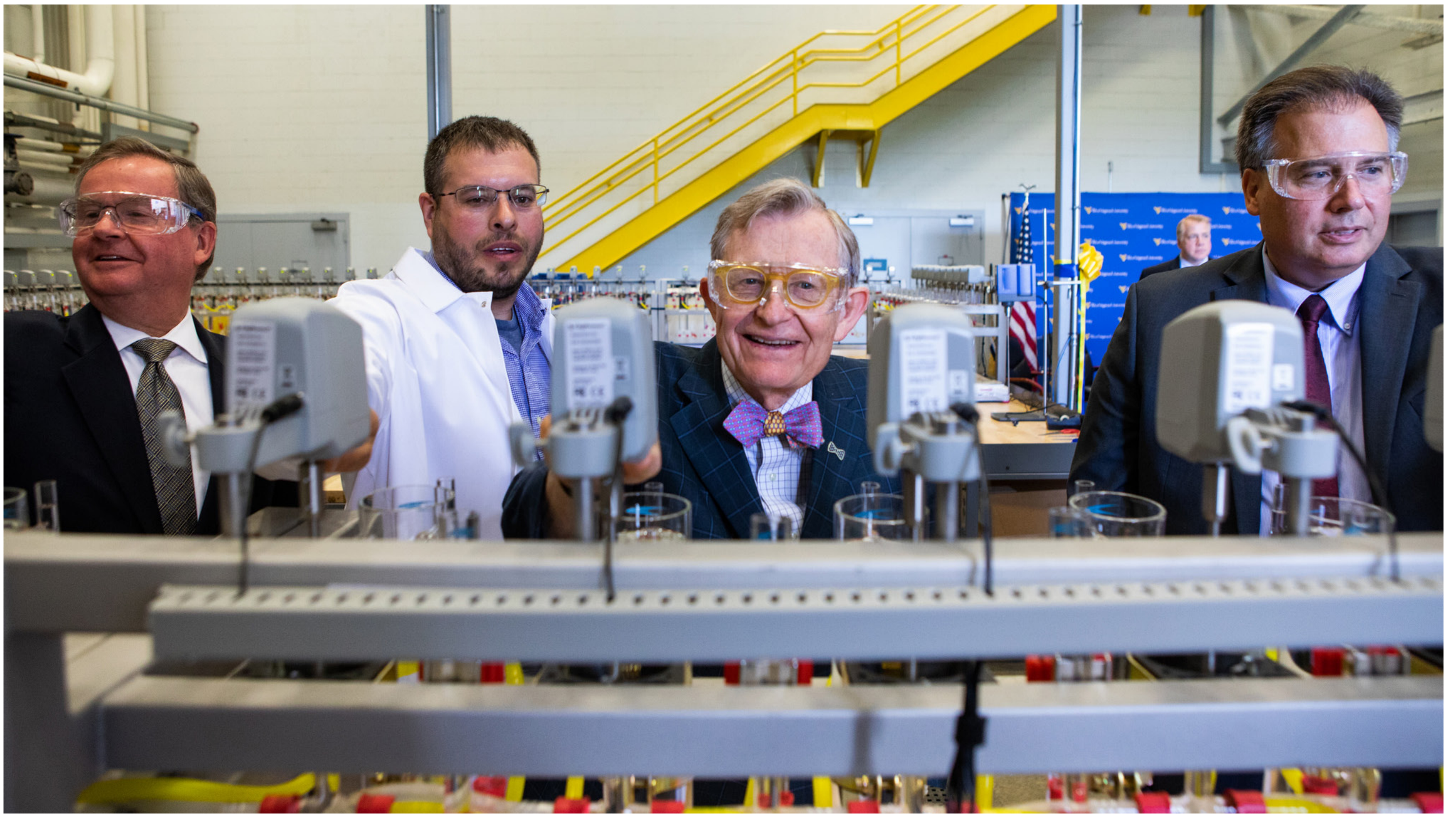


Assistant Secretary for Fossil Energy Steven Winberg, Rare Earth Extraction Facility Operator Chris Vass, WVU President E. Gordon Gee and NETL Director (Acting) Sean I. Plasynski check out mixer-settlers used to extract rare earth elements from acid mine drainage at the facility’s commissioning celebration on July 18, 2018.

The Rare Earth Extraction Facility aims to produce about 3 grams of rare earth concentrates per hour with a purity of at least 2 percent – or 20,000 parts per million – from acid mine drainage sludge. The continuously operating Rare Earth Extraction Facility features 100 mixer-settler units used to extract valuable rare earths through a two-stage chemical separation process.

HOW IT WORKS

The REEF's origins date back to the late 1990s, when the U.S. Geological Survey was tasked with looking at AMD treatment sources to determine whether anything of value could be extracted. Government officials were primarily interested in precious metals, but scientists at the USGS conducted analysis for much of the periodic table. The data was later shared with Paul Ziemkiewicz, director of the West Virginia Water Research Institute at WVU, who referred to it when DOE issued a 2015 funding opportunity announcement seeking to identify sources of REEs and ways to extract them. Ziemkiewicz recognized that REEs were found in the raw AMD water but not in the treated effluent, which meant that REEs were being extracted with solid residues, or sludge, generated during AMD treatment.

WVU received $3.4 million from DOE as part of a $4.3 million project, led by Ziemkiewicz and managed by NETL, aimed at recovering REEs from AMD. The REEF is a key component of the project's second phase, which investigates the technical feasibility of extracting REE concentrates with a purity of at least 2 percent – or 20,000 parts per million – from AMD sludge. During phase 1, WVU and its partners confirmed AMD as a viable source of REEs and developed an extraction and separation process. The REEF, a continuously operating facility commissioned in phase 2, employs a two-stage chemical separation process that includes acid leaching and solvent extraction to produce about 3 grams of REE concentrate per hour.

Raw AMD contains acid and dissolved metals. Because some of these metals are regulated for public safety, AMD must be treated by raising the pH to a neutral level, oxidizing the metals and removing regulated metals such as iron, aluminum and manganese. The resulting orange sludge is primarily composed of metal hydroxides.

The REEF process involves bringing in sludge from existing AMD treatment facilities and acidifying it to remove a portion of the gangue – waste consisting of iron, aluminum, manganese and gypsum. This produces an REE-enriched pregnant leach solution that goes to the solvent extraction circuit, where it is emulsified with a mixture of kerosene and

“It could be a potential economic windfall with benefits to the environment and local job market.”

an extractant that grabs REEs while leaving the gangue in the aqueous phase. This takes place in mixer-settlers and can then be repeated as many times as necessary. REEF has 100 mixer-settlers that successively raise the concentration of REEs by rejecting the remaining gangue while classifying the REEs on an elemental basis. Once the desired concentration of REEs is achieved, the extractant is treated to release a nearly pure REE product.

Rockwell Automation, another partner in the REEF project, is investing about $700,000 in in-kind services, equipment and expertise to make the processing system fully automated – a move that will enable easier scale-up as the technology advances.

A second project awarded to WVU will make use of the same facility and process as it seeks to extract REEs from AMD prior to treatment, while it is still naturally acidic and before it is contaminated with gangue. Ziemkiewicz also serves as principal investigator for that project, which he said offers even greater potential benefits. The $864,000 project could extract enriched REE concentrates of higher purity and be more economical by eliminating steps within the sludge-based extraction process.

‘NO DOWNSIDE’

A native of Kansas City, Jessica Mullen has always enjoyed the outdoors – particularly hiking and biking. When she came to the Appalachian region for postdoctoral work at NETL’s Morgantown, West Virginia, site, she fell in love with the area’s natural beauty. She also understood people’s concerns about the impact of energy operations on the environment.

Mullen’s scientific curiosity and passion for the Earth drive her work at NETL, where she is proud to serve as the federal project manager for both WVU projects aimed at extracting REEs from AMD. She noted that while AMD is a pollutant that must be treated per federal regulations, it’s also abundant in Appalachia.

“Customarily, it has been considered a liability, but it could be a potential economic windfall with benefits to the environment and local job market, all while meeting the security needs of the nation,” Mullen said. “We’re all hopeful that this research is going to be a win-win-win. There’s really no apparent downside to this.”

According to WVU’s research, estimates based on the volume of AMD generated in Pennsylvania and West Virginia alone suggest that their sludges could generate up to 2,700 tons of REEs per year. A survey of 154 AMD treatment facilities found enough sludge in surface storage to generate additional REEs worth $122 million.

In addition, a conservative techno-economic analysis performed as part of the project found that REE extraction from AMD sludge is economically attractive with a refining facility projected to generate positive cash flow within five years. The REEF work is focused on demonstrating the feasibility of the extraction process as well as the economics.

“One of the biggest issues that we’ve always faced in acid mine drainage treatment is how do you pay for this over the long haul,” Ziemkiewicz said. “This provides an additional revenue stream not only for communities but also for the industry itself. Now they have two products. They’ve diversified their revenue stream, and it’s paying them to keep treating their AMD and keep it out of streams.”

Ziemkiewicz said the continuous process created at the REEF is ambitious compared to a traditional laboratory bench-scale project, because everything must work perfectly to ensure success. But the fully automated process should also make the near-turnkey technology more economically attractive for potential investors.

DOMESTIC SUPPLY BY 2020

WVU’s REEF-related projects are among 22 projects across the country managed by NETL’s REE program. Since the program launched in 2014, it has expanded exponentially to tackle a variety of REE projects tied to three key technology areas: enabling technologies, separations technologies and process systems. All are focused on producing a domestic supply of high-purity, salable rare earth oxides from coal and coal byproducts, which NETL aims to achieve by 2020.

“We have an aggressive portfolio of projects with innovative partners across the country. Our success hinges on co-production of materials, demonstration of environmentally benign processing and competitive economics,” said Mary Anne Alvin, Technology Manager for NETL’s REE program. “Facilities like WVU’s Rare Earth Extraction Facility are critical in achieving our objectives as we work to provide significant value to our national security, energy independence, environmental future and economic growth.”

MEET NETL'S NEW CHIEF INFORMATION OFFICER

Antonio Ferreira

By Krista Baker

From space-based applications to cancer research, NETL's new chief information officer (CIO) and chief information security officer (CISO) joins NETL with 20 years of experience in research computing.

Ferreira boasts a wide resume, from an early career studying electronic and optical materials for space-based applications for the U.S. Department of Defense to working on cancer research at St. Jude Children's Research Hospital.

“It is my sincere hope that information technology and research computing will help shape the future of NETL and its partners.”

Antonio Ferreira was born in Norman Rockwell’s hometown, Stockbridge, Massachusetts, and grew up in a small town in the heart of dairy country in central New York. He earned a bachelor’s degree in mathematics from Syracuse University followed by a doctorate in theoretical chemistry from the University of Memphis. He has an extensive background in high-performance computing and storage systems for big data applications.

“Family circumstances brought me back to Memphis, Tennessee, where I switched my scientific focus and began working on novel therapeutics for glioblastoma and joined St. Jude Children’s Research Hospital,” Ferreira said. “While at St. Jude, I continued my work in cancer research and designed and built the scientific computing environment necessary for the Pediatric Cancer Genome Project, which at the time was the largest human genomics project in the world.”

Because of Ferreira’s research, he is listed as a co-inventor on three patents for chemotherapeutics and antibiotics.

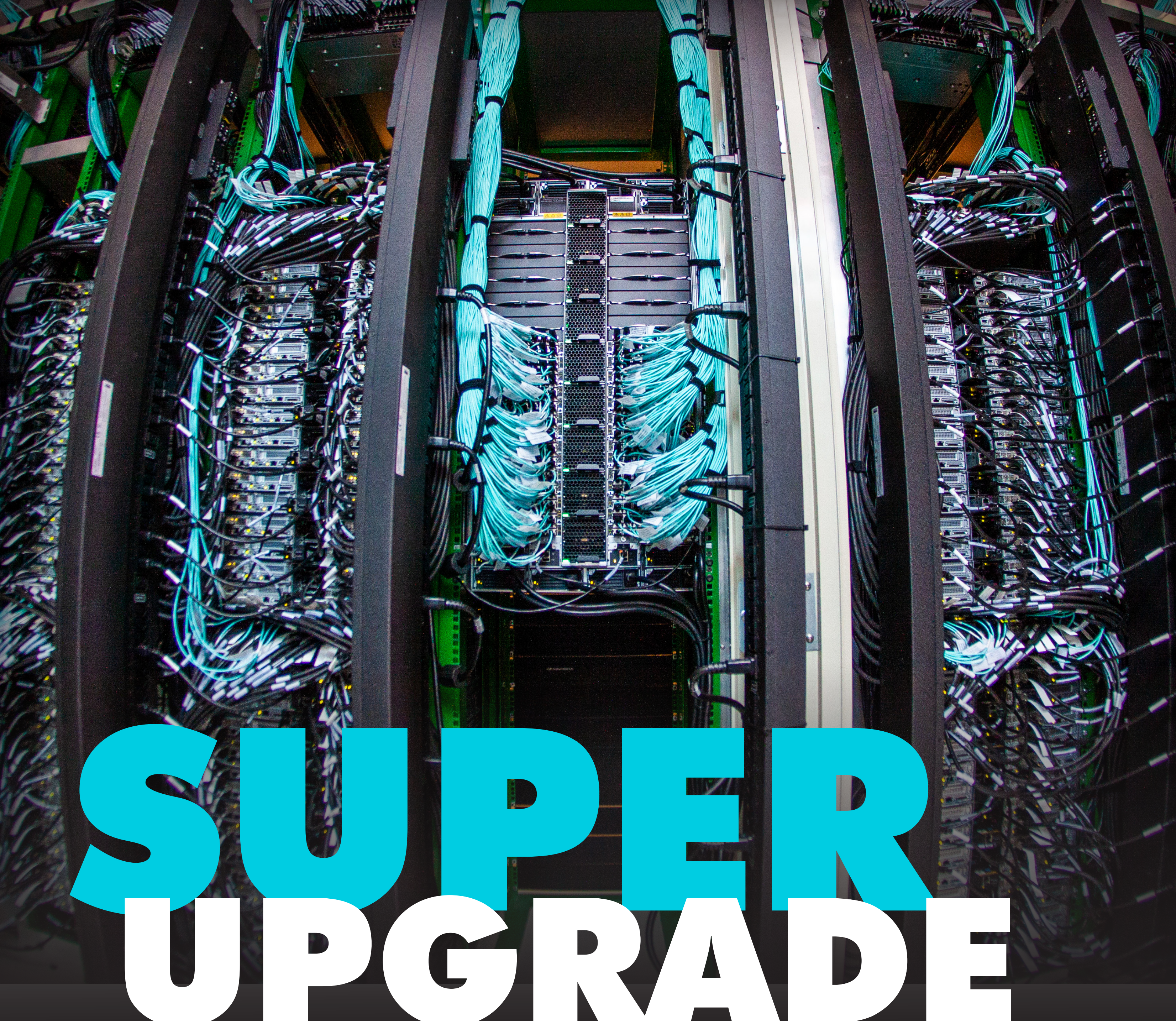
His most recent previous position was at the University of Pittsburgh, where he joined a then newly formed Institute for Personalized Medicine. He served as a research associate professor and became the executive director of the Center for Simulation and Modeling.

As the first person to serve as NETL’s CIO/CISO in a dual role, Ferreira is responsible for guiding and overseeing all the Lab’s information technology efforts. This includes everything from cell phones to supercomputers. In his work, he is developing an IT strategy for the long term that enables the NETL mission and supports the Lab’s research collaborations across the country. He says he sees tremendous potential for transforming the way NETL delivers that mission.

“I firmly believe that computing is an enabling technology that will continue to change the way we understand and manage the world around us. Employees are becoming more mobile, cybersecurity threats are increasing, cloud computing is being widely adopted in government, and nearly every area of science and engineering is being reshaped by computing,” said Ferreira. “NETL is uniquely positioned to bring value to the fossil energy community by embracing these new technologies and ways of doing business. It is my sincere hope that information technology and research computing will help shape the future of NETL and its partners.”

Ferreira calls himself a “true scientist at heart” and is a scholar in residence in the Department of Chemistry at Duquesne University.

“Being around bright young minds reminds me of how exciting science is and how much it will challenge your preconceptions about the world,” said Ferreira. “In my free time, I coach baseball and sometimes soccer. Teaching kids about teamwork, hard work, perseverance, and how to demand the best of themselves is one of the most rewarding things I get to do.”



SUPER UPGRADE

NETL Enhances Computation Capabilities

By Krista Baker

NETL's computational science and engineering competency impacts all research that happens throughout the Lab. To keep pace with a growing energy demand, NETL scientists increasingly depend on shared simulations and data, analysis tools, and research collaborations, all of which require high-speed information access and high-performance computational infrastructure. That's why NETL is enhancing its computation capabilities with a refresh of its Joule supercomputer and created a new capability to move massive amounts of data between the Lab's three campuses in Oregon, Pennsylvania, and West Virginia with the Energy Sciences Network (ESnet).

The months-long ESnet project provided a high-performance network built specifically to support scientific research and the sharing of that information. It is owned by DOE and managed by Lawrence Berkeley National Laboratory.

"The new connection is rated at 10 gigabits per second (Gbps), over an order of magnitude larger and faster than NETL's previous connections, and it is upgradable to 100 Gbps should that become necessary," said Jeff Cotton, the program manager for IT Support Services at NETL. "Through this new connection, NETL's three campuses are now capable of moving large amounts of data among sites that simply could

Joule is a critical tool supporting NETL's research portfolio in its mission to discover, integrate and mature technology solutions to enhance the nation's energy foundation and protect the environment for future generations.

not be done previously. This new connection rate allows the sharing of information, experimental results, establishment of disaster recovery protocols via storage at geographically isolated locations, and the expansion of capabilities of the Energy Data Exchange (EDX), a premier research collaboration tool."

ESnet also links researchers from NETL locations in Albany, Morgantown, and Pittsburgh with more than 40 DOE science laboratories and 140 research and commercial networks, allowing collaboration with scientists located all around the world.

ESnet isn't the only upgrade moving NETL into the future of advanced computational capacities.

NETL's Joule supercomputer, located at the site in Morgantown, West Virginia, is on its way to again becoming one of the fastest computers in the country. The refresh, which kicked off in August, is providing an eight-fold increase in computational speed and power over the current supercomputer, enabling NETL scientists and engineers to greatly expand their research capabilities.

The supercomputer has become a critical capability for NETL research and development activities. When developing new concepts, materials or devices, researchers use this valuable tool to quickly evaluate options or variables that will allow researchers to focus their efforts on more promising technologies.

Examples of how researchers are using Joule in the NETL research portfolio include:

- **Developing optimal reactor designs based on computational fluid dynamics simulations** – This approach will revolutionize how gasifiers and other chemical reactors are designed, enabling the design of low-cost, high-efficiency reactors. The approach requires the use of many multiphase computational fluid dynamics simulations, each simulation being computationally intensive.
- **Using new models for the development of fuel cells** – This approach helps scientists and industry optimize fuel cell configuration and thereby increase power output and lifespan while reducing material costs and waste from production.
- **Enabling advanced technologies through computational materials research** – This approach leads to the discovery, development and demonstration of cost-effective advanced structural materials for use in extreme environments.
- **Investigating computational chemistry** – This approach provides computational and experimental insight into the atomic-level processes used for energy applications. Research includes molecular optimization and material design.
- **Using configuration and process modeling for reactors and separations** – This approach is an important tool in the hunt for more efficient means to separate rare earth elements from coal, mine tailings and fly ash.
- **Using uncertainty quantification for all predictive simulations** – This approach requires hundreds of simulations of complex models to be completed in a timely manner, which necessitates the use of a supercomputer. As this capability matures at NETL, the need for even greater computing capability becomes critical.

As one of the world's fastest, most energy-efficient supercomputers, Joule allows energy researchers to discover new materials, optimize designs, and better predict operational characteristics. In addition, Joule allows research to be conducted that experimentation alone cannot achieve. Joule is a critical tool supporting NETL's research portfolio in its mission to discover, integrate and mature technology solutions to enhance the nation's energy foundation and protect the environment for future generations.

These state-of-the-art computing facilities enable the advanced computational capacities and collaborative workspaces used at NETL to create cutting-edge modeling tools that facilitate rapid technology development and understanding. From helping energy researchers across the country discover new materials, to optimizing designs and better predicting operational characteristics, NETL's computing capabilities are helping to ensure that the Lab remains on the forefront of energy research.

NETL Collaborates with 16 Universities to Tackle Fossil Energy Research Challenges

> "The University Coalition has developed a well-advanced infrastructure for us to work with NETL to continue the development of fossil energy technologies."

Fossil fuels are the dominant sources of energy in the United States, supplying more than 80 percent of the nation's power. Energy forecasts by the U.S. Energy Information Administration, BP and numerous other entities indicate that coal, oil and natural gas will continue to meet the bulk of the nation's energy needs for decades to come.

As DOE strives to reduce the cost of electricity and promote responsible stewardship of the environment, fundamental research challenges that impede the advancement of fossil energy-based technologies must be addressed to enable effective use of the nation's vast domestic energy resources. NETL is aggressively addressing these challenges in partnership with 16 universities across the country that comprise the University Coalition for Fossil Energy Research (UCFER). UCFER recently awarded 11 additional projects for a total of $2.69 million.

UCFER is led by Pennsylvania State University, which hosted the coalition's inaugural meeting in May 2016. NETL hosted the coalition's first annual meeting in May 2017, followed by its first annual technical review meeting in April 2018 at the Lab's Morgantown, West Virginia, site. Participants from partner schools were invited to join NETL leaders and researchers to conduct coalition business, review ongoing projects, and discuss future possibilities for collaboration to tackle critical challenges in important fossil energy research areas.

"The university coalition has developed a well-advanced infrastructure for us to work with NETL to continue the development of fossil energy technologies," UCFER Director Chunshan Song of Penn State, said. "This meeting has been wonderful in the exchange and two-way dialogue between NETL leaders and technology managers, NETL researchers, and the university faculty members for all the 16 universities. That's a great accomplishment."

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UNIVERSITY COALITION FOR FOSSIL ENERGY RESEARCH

GAINING MOMENTUM

UCFER was created in fall 2015, starting with nine founding member institutions: Penn State, the Massachusetts Institute of Technology, Princeton University, Texas A&M University, the University of Kentucky, the University of Southern California, the University of Tulsa, the University of Wyoming, and Virginia Tech.

The DOE project period runs from October 2015 through September 2021. Song said it was important for the coalition to begin by establishing a solid infrastructure. In collaboration with NETL, UCFER's leaders outlined a vision, goals and objectives, by-laws and an organizational structure to guide the coalition's work. NETL representatives serve on the Executive Council, Technical Advisory Council, and Core Competency Advisory Board.

UCFER's contract with DOE was finalized in April 2016, at which time a request for proposals (RFP) was issued for the first round of funding. The six projects resulting from that RFP address carbon use and reuse, carbon storage, and crosscutting research. For instance: Two projects, both led by the University of Southern California, aim to develop models that inform carbon storage efforts. One looks at microseismic events to develop a tool for predicting the risk of induced seismicity during CO_2 injection, while the other uses geophysical and geomechanical data to monitor the injected CO_2.

In 2017, a second round of funding was awarded to another six projects, valued at about $2 million. Those projects focus on carbon capture, advanced combustion, and oil and natural gas infrastructure. The coalition also expanded by adding seven new schools: Carnegie Mellon University, Louisiana State University, Ohio State University, the University of North Dakota, the University of Pittsburgh, the University of Utah, and West Virginia University.

A third RFP was issued in November 2017. UCFER's Technical Advisory Council met in closed session during the April 2018 technical review meeting to discuss 81 submitted proposals. Nearly $4.1 will be eventually awarded to projects in seven areas: advanced combustion, carbon capture, carbon storage, carbon use and reuse, fuel cell technologies, gasification, and recovery of rare earth elements.

Addressing UCFER members at April's technical review meeting, NETL Director (Acting) Sean I. Plasynski praised the coalition's "excellent work" thus far. "I'm confident the coalition can keep that momentum going. Together we can solve critical problems for the Department of Energy and our nation," he said.

Assistant Secretary for Fossil Energy Steven Winberg speaks at The University Coalition for Fossil Energy Research (UCFER) meeting at NETL in Morgantown, W. Va.

FUTURE WORK

NETL leaders also shared research and development areas in which the Lab would be interested in pursuing future projects through UCFER. Randall Gentry, NETL's deputy director and chief research officer, noted that valuable opportunities are tied to the Lab's core competencies.

"We can do a lot in terms of impact and relevance, and in terms of improving fossil energy systems," Gentry said. "This is where our collaboration with UCFER is so important, making sure we're doing the most innovative research that we can to address the most important areas in fossil energy." John Wimer, associate director of Science and Technology Strategic Planning at NETL, identified a dozen potential topics for UCFER, including:

- Solid oxide fuel cell modeling and degradation.
- Coal conversion using microwave technology.
- Creation of an American coal database.
- Development of high-value products from domestic coal.
- Development and testing of improved sensors and controls within existing coal-fired power facilities.

DOE Assistant Secretary for Fossil Energy Steven Winberg also addressed the technical review meeting. He shared robust goals for the Office of Fossil Energy to help inform future research by UCFER. Those goals include improving reliability of the existing fleet of coal-fired power plants and developing advanced technologies necessary for the next generation. He also hopes to improve productivity of natural gas operations through advanced computing, data mining, and analytics.

"We're focused on early-stage research, and you are the beginning of that early-stage research," Winberg said. "I want to take this opportunity to thank you for everything that you do. It's clearly a high-value proposition – not only for fossil energy, but for the Department of Energy and for the country at large. I think it's pretty impressive that there are 16 premier universities in this coalition. … It speaks to an ability for universities to collaborate. I know you also compete, but you can and you do collaborate. And that's powerful. I encourage it, and I think you need to keep that up."

Penn State Vice President of Research Neil Sharkey also praised UCFER's work and stressed the value of collaboration.

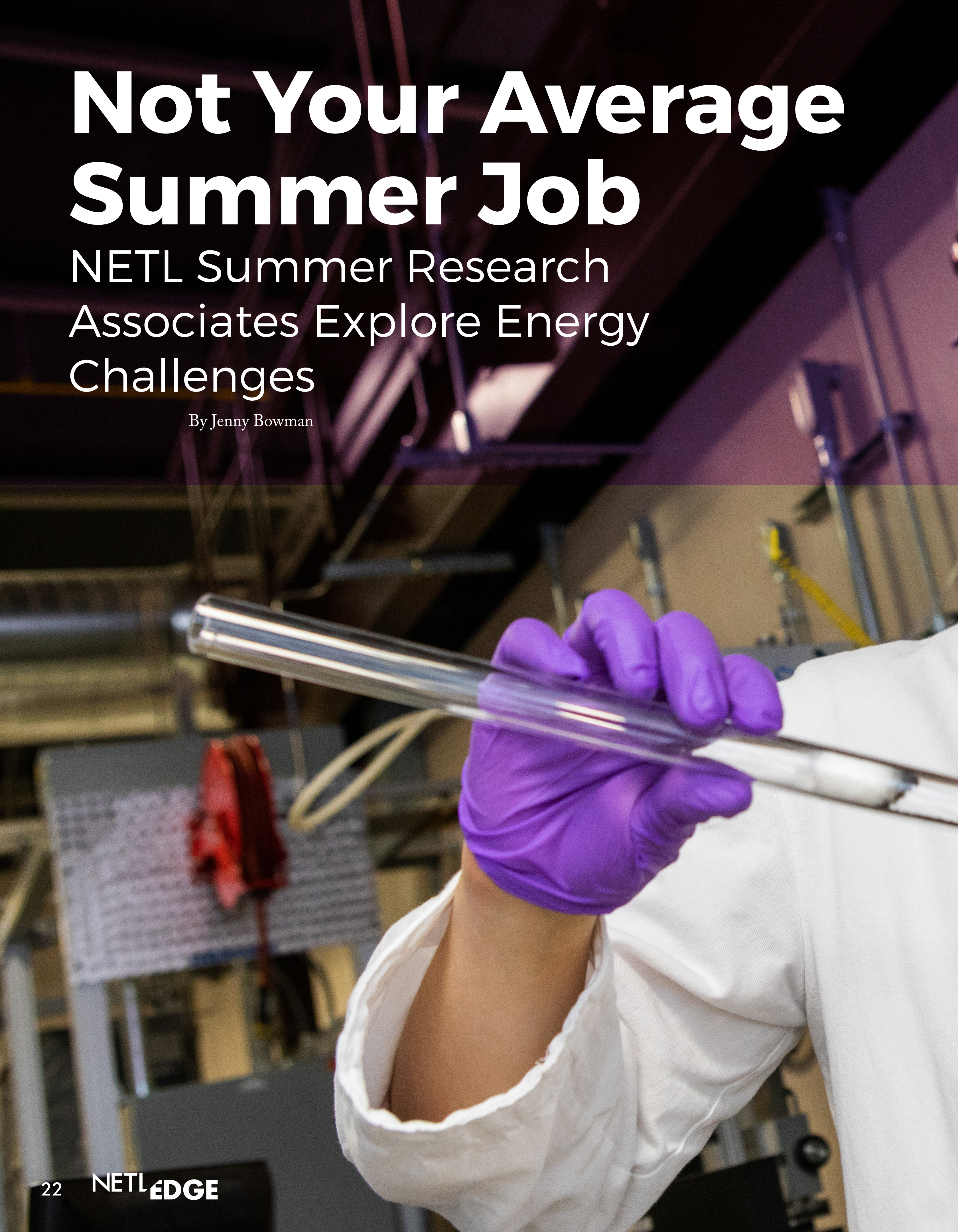
"The program is very much on track," Sharkey said, referring to UCFER. "I think that our combined efforts are really doing an excellent job. We've got incredible firepower that can really make a difference. Putting this many universities together with a major energy laboratory, only good things can happen."

Partnerships like UCFER help NETL leverage its connections, resources and expertise to develop reliable and affordable solutions to the nation's energy challenges. By finding ways to cut costs and boost efficiency, NETL and its partners advance home-grown energy initiatives, revitalize key manufacturing industries and associated jobs, stimulate a growing economy, and improve the health, safety, and security of all Americans.

Not Your Average Summer Job

NETL Summer Research Associates Explore Energy Challenges

By Jenny Bowman



Each summer, NETL researchers proudly serve as mentors in the Mickey Leland Energy Fellowship (MLEF) and Consortium for Integrating Energy Systems in Engineering and Science Education (CIESESE) programs. Both programs support the Energy Department's goal to build a sustainable professional and academic pipeline ready to take on the challenges of current and future energy systems.

For nearly 20 years, the MLEF program has been improving opportunities for under-represented students in science, technology, engineering, and math (STEM), while building a diverse foundation of future STEM professionals. The DOE-sponsored CIESESE program is building a sustainable professional and academic pipeline, particularly of professionals from the Hispanic community, ready to take on the challenges of current and future energy systems.

All three NETL research sites – Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania – hosted summer research associates in 2018. The students came from all over the nation, representing more than 25 institutions across 17 states and Puerto Rico.

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Mickey Leland intern Yuniba Yagues in the ReACT Lab at NETL in Morgantown, W. Va.

Mickey Leland mentor David Tucker collaborating with CIESESE intern Michelle Soto in the Hyper Facility at NETL in Morgantown, W. Va.

NETL researcher David Tucker, who served as a mentor to 10 of the research associates, said the students' enthusiasm created a rewarding experience for mentors and interns alike. "Mentoring people with the drive to explore new ideas and concepts with a goal of improving the nation's energy future is a particularly enriching experience. I feel an urgency and responsibility to engage students because, if they are not engaged in energy research at the beginning of their careers, the future will be bleak indeed."

Tucker's research takes place in NETL's Hybrid Performance (Hyper) facility, a one-of-a-kind facility that provides a unique opportunity for energy researchers to explore dynamic control and performance issues related to coupling fuel cell and gas turbine technologies. MLEF and CIESESE research associates contributed to several projects in the Hyper facility, from improving power infrastructure, to increasing the conversion of energy from intense thermal resources, to developing control strategies for the reliable operation of these highly efficient systems.

Michelle Soto, a chemical engineering student at the University of Puerto Rico at Mayaguez, was one of several collaborators in the Hyper facility investigating how hybrid systems can help reduce emissions and increase the efficiency of current power production processes. Soto said she hopes to pursue a career with DOE and believes her summer experience will help her accomplish this goal. "My goal is to work on a project with DOE to develop a new technology that can produce energy in a sustainable, secure, efficient and reliable way," Soto said. "As an engineer, I want to focus on the development of technologies for energy production that takes into consideration the welfare of the environment and society while helping solve current problems in our power grid."

Tianna Coburn, who studies chemical engineering at Oregon State University, heard about the MLEF program at a career fair and decided to apply to gain experience in a professional lab and collaborate with other STEM professionals. She said many of NETL's research areas aligned with her own interests, such as materials engineering. "I would like to work toward sustainable solutions for society's energy usage so that we can continue to enjoy technology advancements while preserving the environment," Coburn said. Coburn's research with mentor Peter Hsieh in NETL's Albany lab was focused on water permeation through seams in composite liners for natural gas pipelines.

James Egbu, a chemistry student at Texas State University in San Marcos, said NETL gave him an opportunity to gain and develop research skills to become a better scientist. "I was

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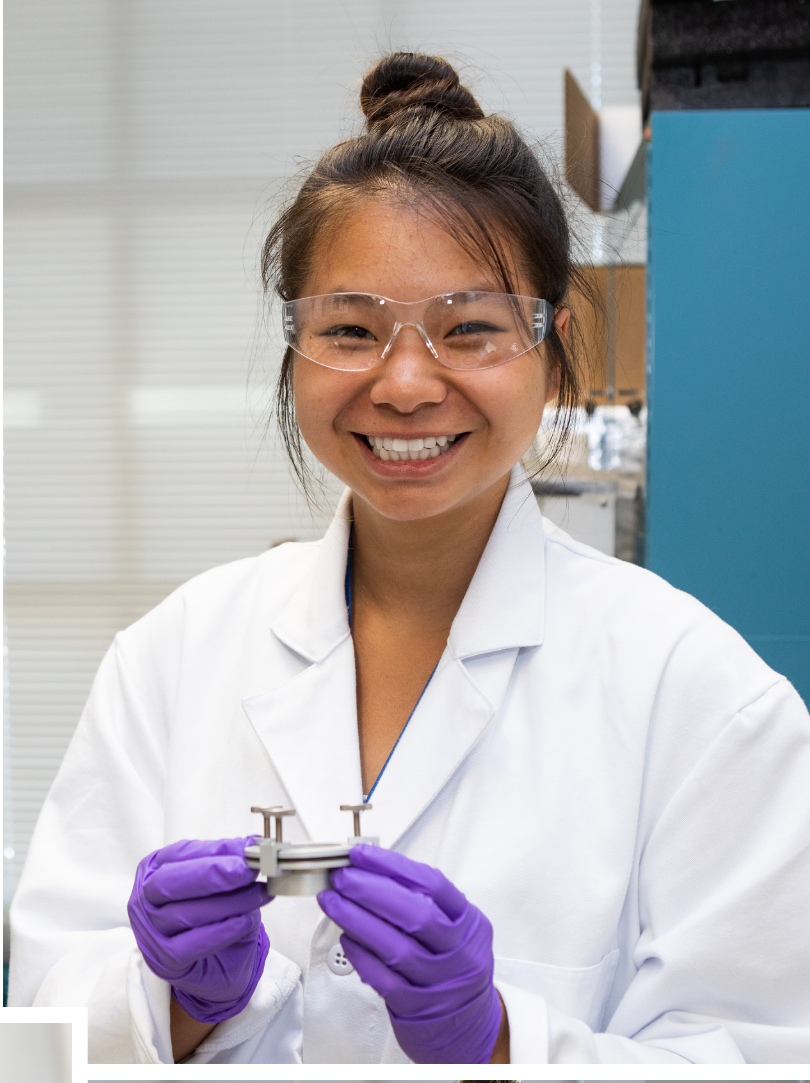
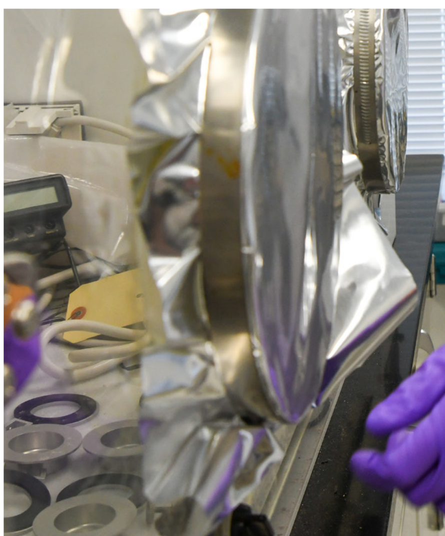
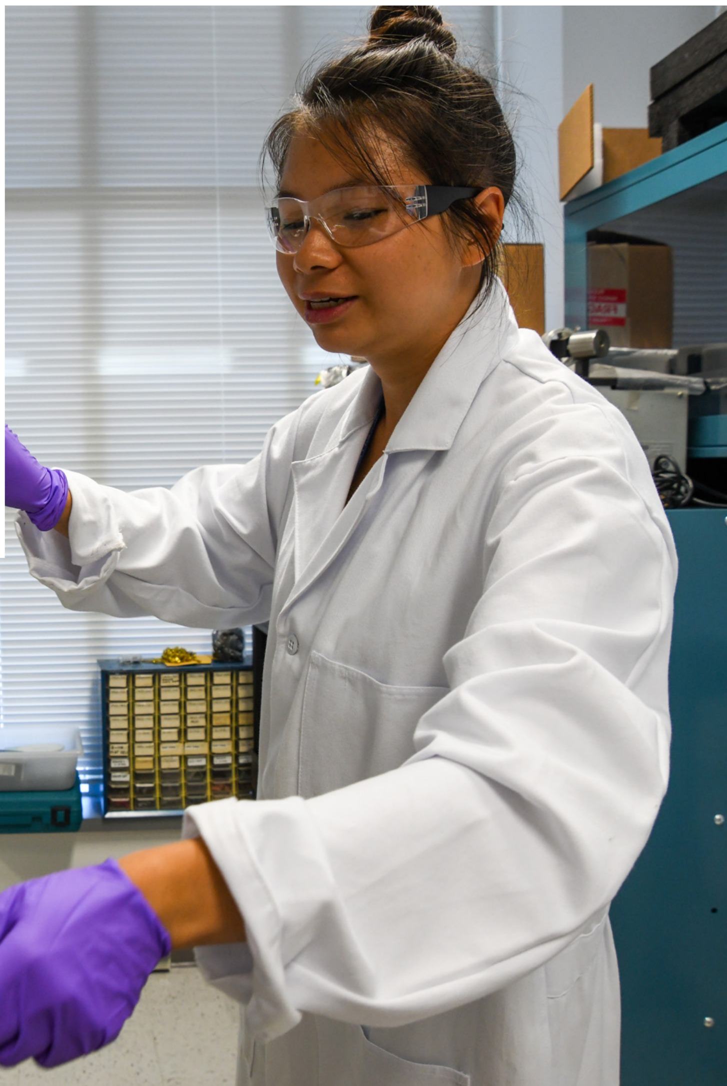
"The fellows get valuable experience working in the lab, and NETL helps ensure we have a highly skilled, well-trained workforce to continue its important work."



Mickey Leland Fellow Tianna Coburn in the lab at NETL in Albany, Oregon, taking out samples from the environmentally controlled chamber.





Mickey Leland Fellow James Egbu researches electroless plating of optical fiber in the Advanced Sensor Development Lab.

looking for an opportunity to participate in energy-related research," Egbu said. His research with mentor Jeff Culp at NETL's Pittsburgh lab was focused on electroless plating as a potentially cost-effective method to improve materials in the oil and gas industry. Egbu plans to continue to pursue his passion for research. "I am almost finished with an M.S. in chemistry. I plan to become a research scientist after I complete my Ph.D. I hope to participate in meaningful research and present my work to the scientific community. In doing so, I hope to contribute not only to materials research but also to improving the world around us," Egbu said.

The efforts of NETL's 2018 summer research associates spanned a wide range of research areas. For example, MLEF and CIESESE participants investigated the extraction of rare earth elements from coal and coal byproducts, and developed oxygen carriers for chemical looping combustion of fossil fuels. They used the image analysis and microscopy capabilities in NETL's CT Scanning Laboratory to study flow and permeability in porous geomaterials to help further understanding of the subsurface. With NETL sensor experts, summer research associates studied disposable temperature sensors and corrosion behavior to advance corrosion sensing and mitigation in natural gas pipelines – efforts that will help preserve the safety and integrity of oil and gas operations.

These are just a few examples of the valuable research MLEF and CIESESE summer research associates contributed toward NETL's mission to discover, integrate and mature technology solutions to enhance the nation's energy foundation and protect the environment for future generations.

The summer programs culminated with technical forums for each program. NETL hosted a technical forum July 23-24 at its Morgantown site, featuring eight CIESESE participants from NETL and eight from other DOE sites who presented on their research during the program. The 2018 MLEF Technical Forum was held in downtown Pittsburgh Aug. 6-9, with 59 student presentations and remarks from Office of Fossil Energy and NETL representatives and MLEF co-founders.

Patricia Adkins-Coliane, who coordinates NETL's Graduate Education Programs, said the summer research programs hosted by the Lab are an essential part of inspiring and training the next generation of energy researchers who will continue leading the United States to an energy dominant future. "As a U.S. Department of Energy national laboratory and a driver of innovation, NETL has a responsibility to encourage excellence in the disciplines that enable reliable, affordable energy for our nation's prosperity. We demonstrate this commitment to education through our Graduate Education Programs' research opportunities like the MLEF and CIESESE, community outreach, and K-12 education outreach activities. The fellows get valuable experience working in the lab, and NETL helps ensure we have a highly skilled, well-trained workforce to continue its important work."

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