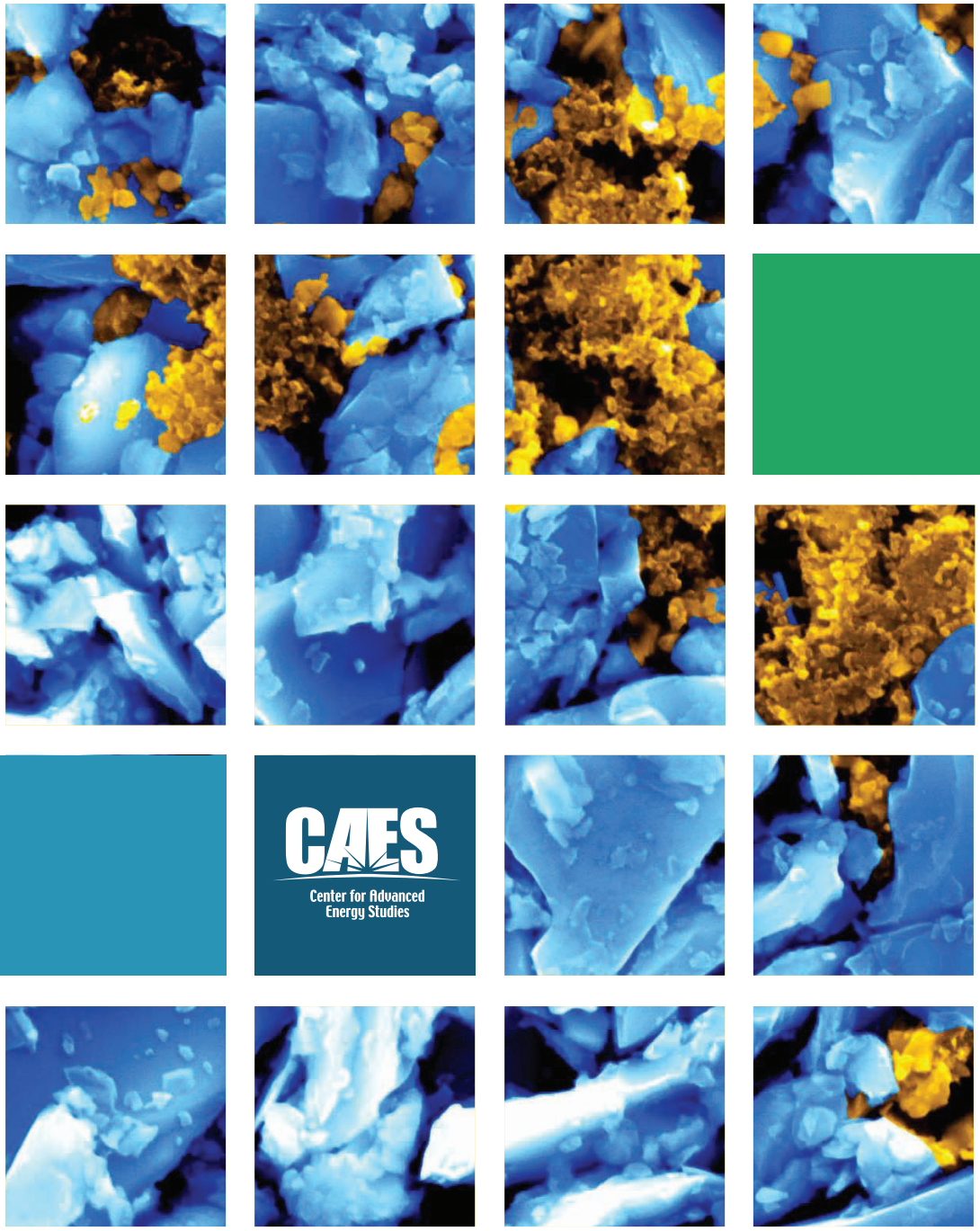
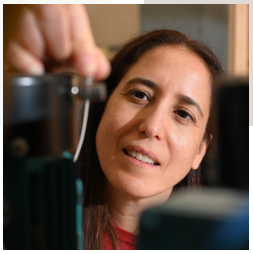


CENTER FOR ADVANCED ENERGY STUDIES

2022 ANNUAL REPORT

This report provides an overview of the main accomplishments of the CAES community in FY22.



On the cover, the photo is a microscopic view of batteries from research conducted by an Idaho National Laboratory researcher—one of the four entities collaborating with CAES.

DIRECTOR'S LETTER

IT HAS BECOME CLEAR IN MY RELATIVELY SHORT TIME AT THE CENTER FOR ADVANCED ENERGY STUDIES that the integrity and professionalism of those involved with CAES, from the students to the maintenance crew, are admirable. A second revelation has been the receptiveness to collaboration. This is the key to CAES' success and the reason for its existence; the willingness to work together is exciting and important to the continued success of CAES. In the coming months, I will work with the associate directors, the universities and the national laboratory to explore how we can harness this willingness to collaborate. The focus of this effort will be twofold: to bring more students and researchers into the building and to refine the CAES Strategy into areas where our collaborative efforts can have the most impact.

As you will see in this report, our impact in 2022 was extensive. We saw the introduction of the Research Experience for Undergraduates program and the 10 REU fellows who participated over the summer. We also saw the resumption of the in-person Center for Space Nuclear Research Summer Fellowship Program after the program went virtual for two years due to the pandemic. These are examples of experiential learning that we look to replicate and expand in the years ahead.

We're also working to develop a sense of community at CAES. The goal is to not only make CAES a great place to conduct research, with state-of-the-art tools and equipment, but also to create a welcoming environment that makes it a great place to work. On that front, we are working with Idaho State University to open the parking lot to food trucks. This will facilitate networking among the CAES community. And we're working on an in-house newsletter to ensure CAES residents are better informed about upcoming events and research news.

There are many exciting developments on the horizon and many to celebrate in this year's annual report. CAES researchers are receiving financial support, as well as recognition at the state and national levels. We installed new state-of-the-art equipment that will increase the opportunities for collaboration in the years to come and initiated new programs while building on others. Those are just a few of the accomplishments outlined in this report – accomplishments that make me proud to be part of this consortium.

I look forward to working with all of you as we transform the culture at CAES, to improve and expand our collaborative opportunities while fulfilling our mission and vision.

In the meantime, I welcome your ideas for improving the way things are done around here. My door is always open.

Philip Reppert
Center for Advanced Energy Studies director

CONTENTS

NEW FACES

New CAES director announced

Philip Reppert was named director of Idaho University Collaborations and CAES in April. Reppert was previously the associate director of Geological and Environmental Systems at the National Energy Technology Laboratory. There, he provided technical leadership and capability stewardship for a complex organization with three teams/branches who conduct research in the earth sciences. Prior to that, Reppert spent seven years at the National Geospatial-Intelligence Agency as a senior project scientist and supervisor of the geophysics subsurface research branch.

In addition to serving as CAES director, Reppert oversees collaboration between Idaho National Laboratory and the CAES universities.

Reppert earned a bachelor's degree in Electrical Engineering from Pennsylvania State University and a doctorate in Geophysics from the Massachusetts Institute of Technology. Reppert has a distinguished research background in near-surface geophysics and ground-penetrating radar, as well as rock physics.

Reppert took over for Terry Brog, who had served as interim CAES director since fall 2020. We thank Brog for his work as interim director, particularly his effort to streamline operations at CAES during the pandemic. His leadership has helped us get researchers into the laboratories.

CAES steering committee gains new member as ISU names VPR

Idaho State University named **Martin Blair** as vice president for research (VPR) in June. As VPR, Blair joins INL Deputy Laboratory Director for Science and Technology and Chief Research Officer Marianne Walck, CAES Director Philip Reppert, Boise State Vice President of Research and Economic Development Nancy Glenn and University of Idaho Vice President for Research and Economic Development Christopher Nomura on the CAES steering committee.

Prior to his arrival at ISU, Blair served as executive director at the University of Montana's Rural Institute for Inclusive Communities, responsible for developing

community-focused interdisciplinary research partnerships, overseeing strategic planning and managing a multi-million dollar budget across more than 50 programs.

Blair earned a bachelor's degree in Special Education, a master's degree in Secondary Education and a doctorate in Education and Disability Policy from Utah State University. He also earned certifications from the National Leadership Institute at the University of Delaware and CITI: Social and Behavioral Research.

Kiyo Fujimoto named lab lead

INL researcher **Kiyo Fujimoto** was named lab lead for the Advanced Manufacturing Suite this fall. Fujimoto received her PhD in Materials Science and Engineering from Boise State University in the spring. She has been involved with INL since 2017, when she was an INL Graduate Fellow, and is now a staff scientist leading research focused on additive manufacturing methods for the development of advanced sensors and instrumentation for extreme environments.

Fujimoto earned a bachelor's degree in Chemistry from Boise State. In addition to receiving an INL Graduate Fellowship, she is the recipient of the Idaho Space Grant Consortium Fellowship and the Department of Energy Nuclear Energy University Partnerships Fellowship. At INL, her work is focused on materials development or feedstock synthesis relevant to harsh environments for a wide range of additive manufacturing techniques.

BSU names Glenn VPR after serving as interim

Nancy Glenn was named vice president for research and economic development (VPR) for Boise State University in September. Glenn, a professor in the Department of Geosciences, had served as interim VPR since June 2021.

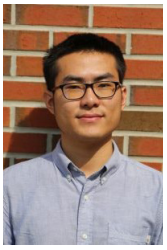
Glenn earned a bachelor's degree in Geological Engineering from University of Nevada, Reno; a master's degree in Civil Engineering from University of California, Berkeley; and a PhD in Geo-Engineering from University of Nevada, Reno.

New professors at UI

Krishnan Raja, a Chemical and Materials Engineering Department faculty member, joined UI, Idaho Falls as a visiting faculty member.

Ming-Hsun Cheng joined UI, Idaho Falls as an assistant professor for Energy & Environment.

Microscopy & Characterization Suite adds to staff



Yu Lu (top left) is a senior research associate and instrument lead. **Sidharth (Sid) Sukumaran Nair** (top right) is a research associate and sample preparation lead. Ching-Heng Shiau is a postdoctoral researcher.

Interns

Nahuel Guaita was CAES' Programmatic graduate intern over the summer and fall, as he was completing his master's degree in Public Policy, with a concentration in Energy and Environmental Policy, from Oregon State University.

Undergraduates

Mia Rudin is a student at University of Texas at Dallas, where she is majoring in Geological and Earth Sciences/Geosciences.

Leah Alboucq is a student at Boise State University, where she is majoring in Health Studies.

NEWS

CAES universities sign MOU for full access to Falcon supercomputer

Researchers at the CAES universities have exclusive access to the Falcon supercomputer, one of the nation's fastest academic computers, thanks to an agreement signed in mid-January. The memorandum of understanding between the universities and Battelle Energy Alliance provides students and researchers from the universities unfettered access to the computer, which is located at Idaho National Laboratory's Collaborative Computing Center in Idaho Falls. The arrangement has also increased opportunities for collaboration between INL researchers and those at the universities. This investment in INL's future fulfills a CAES mission of training and educating the future energy workforce.

BSU's Nuclear Energy Student Club formally recognized by American Nuclear Society

The American Nuclear Society board approved the creation of a new student section at Boise State University in May. Assistant professor Brian Jaques, a CAES fellow, serves as the group's faculty adviser.

"This is a great opportunity for students to engage and network with other sections in the state of Idaho, as well as nationally and internationally," said Jaques, who holds a joint appointment with INL. "The section brings awareness and excitement of Idaho's rich nuclear energy history to the community, in addition to introducing our future nuclear energy workforce to the vast opportunity and promise of the field."

CAES hosts NSF Research Experience for Undergraduate (REU) program

Ten students took part in the inaugural REU program, "Advanced Manufacturing for a Sustainable Energy Future," at CAES over the summer. A $365,000 grant from the National Science Foundation led to the creation of the program, which will run 10 weeks each summer through 2024. The program is designed to give students hands-on research experiences and networking opportunities to develop their science, technology, engineering and math identity and literacy, while providing professional development opportunities for careers in the energy sector.

Five students from Idaho's two- and four-year higher-education institutions were in the inaugural cohort this year, along with five students selected from a pool of applicants from across the nation. The students worked alongside faculty from the CAES universities and Idaho National Laboratory researchers to assist on projects related to advanced manufacturing.

Here are the REU fellows along with their project titles and mentors:

Lydia Beardsley
University of Idaho

PROJECT: Development of High-Temperature Resistant Permanent Magnets Using Advanced Manufacturing

MENTORS: Dan LaBrier, Idaho State University (faculty) and Bryce Kelly (INL)

Miranda Cardenas
University of Utah

PROJECT: Multiphysics Modeling and Experimental Characterization of Printed Magnetostrictive Acoustic Sensors

MENTORS: Dan Deng, Boise State University (faculty) and Josh Daw (INL)

Dylan Cox
Oregon State University
and Katelyn Shadley
University of Idaho

PROJECT: 3D Li-ion Batteries through Advanced Manufacturing

MENTORS: Claire Xiong, Boise State University (faculty) and Bin Li (INL)

Stratton Jenks
University of Idaho
and Josh Peck
Idaho State University

PROJECT: Advanced Manufacturing for Bulk Storage of Hydrogen

MENTORS: Mustafa Mashal & Bruce Savage, Idaho State University (faculty) and Kunal Mondal (INL)

Minh Nguyen
Idaho State University

PROJECT: Novel Alloy Development for Nuclear Applications

MENTORS: Brian Jaques, Boise State University (faculty) and Boone Beausoleil (INL)

Hayden Pritchard
University of Montana

PROJECT: Corrosion Performance of Additively Manufactured Structured Materials

MENTORS: Mike Hurley, Boise State University (faculty) and Donna Guillen (INL)

Avery Rambur
College of Idaho

PROJECT: Classical Molecular Dynamics Simulations of Nuclear Materials

MENTORS: John Russell, University of Idaho (faculty) and TBD (INL)

Hannah Smith
University of Utah

PROJECT: Modeling and Optimization of Advanced Manufacturing Processes

MENTORS: Lan Li, Boise State University (faculty) and Michael McMurtrey (INL)

New 3D metal printer installed at CAES as Advanced Manufacturing Laboratory takes shape

A new 3D metal printer for nuclear-grade materials was installed at CAES over the summer, one of several pieces of equipment that complement Idaho National Laboratory's advanced manufacturing strategy, accelerating and supporting INL's research and development capabilities as well as its partnerships with academia, industry, federal agencies and national laboratories through the Nuclear Science User Facilities network. The printer, part of approximately $1.5 million in equipment installed in the new Advanced Manufacturing Laboratory at CAES, was made possible by a 2020 award through the Nuclear Energy University Program for a project led by Boise State University faculty member Mike Hurley. The project stems from Hurley's participation in the 2019 CAES Summer Visiting Faculty Program and includes his faculty program partner Donna Guillen from INL and Boise State faculty members and fellow 2019 faculty program alumni Dave Estrada, who is the CAES associate director for Boise State, and CAES Fellow Brian Jaques, the CAES Advanced Manufacturing lead at Boise State.

The printer is an Open Additive PANDA with a 6x6x4-inch build volume, 300 W laser and production print speeds that is capable of printing stainless steels, super alloys and tool steels.

The equipment in the new Advanced Manufacturing Laboratory supports materials development, printed sensors and structural additive manufacturing from INL and the CAES universities, while supporting existing programs and opening new areas in printed and flexible electronics and trusted artificial intelligence for advanced manufacturing. The Advanced Manufacturing Laboratory is managed as a shared resource benefitting the CAES universities, multiple INL mission areas and several directorates at INL, including Nuclear Science & Technology, Energy & Environment Science & Technology, National and Homeland Security, Advanced Test Reactor and Materials and Fuels Complex.

The laboratory is complemented by a new ThermoFisher Spectra 300 scanning transmission electron microscope in CAES's Atomic-Scale Imaging Laboratory, part of the Material and Characterization Suite, that is capable of doing post irradiation examination of printed structural materials and sensors.

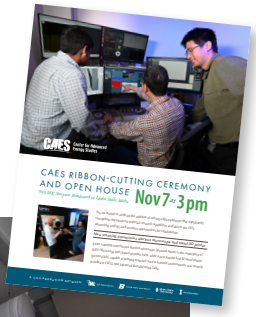
Equipment in the new Advanced Manufacturing Laboratory includes a Superinkjet printer and Nanojet aerosol jet printer capable of printing sensors as well as:

- Mills for powder production, including a Torrey Hills three-roll mill, Retsch Emax high energy ball mill, Retsch mortar and pestle mill, Retsch cronymil
- High precision scales
- Zeiss Axio imager KMAT (an upright, fully motorized, PC controlled, high performance research microscope)
- Particle size analyzer w/zeta potential measurement
- Rotary evaporators
- Planetary centrifuge
- Anton Paar dynamic mechanical analyzer and rheometer

CAES debuts new scanning transmission electron microscope

CAES officially debuted a new scanning transmission electron microscope (S-TEM) in late July. The ThermoFisher FEI Spectra 300 kV S-TEM is Idaho National Laboratory's latest investment in CAES, designed to create opportunities for collaborative materials research for the CAES universities, INL and industry in several of the national laboratory's mission areas. The new microscope is part of the Microscopy and Characterization Suite, a Nuclear Science User Facilities laboratory, and is more technologically advanced than any of the current TEM resources across the CAES complex. Among its capabilities:

- The new S-TEM offers an energy resolution of less than 0.2 eV compared to 0.8 eV with current TEMs at INL
- It enables the study of stoichiometry changes in oxide fuels, chemistry of fission products in nuclear fuels, and oxidation/corrosion behavior of metals and ceramics
- It is equipped with a next-generation Cs S-CORR probe corrector
- It provides improved spatial resolution at low accelerating voltages, enabling analysis of light elements (carbon, nitrogen and oxygen for example)
- It enables research on a wider range of materials, from those that are sensitive to high-energy electron beams to high atomic number materials such as uranium
- It is equipped with an EMPAD detector, which can obtain more than 1,000 diffraction patterns per second
- It captures dynamic material behavior such as phase changes and crystallization in harsh environments
- It has a broader electron energy range (30kV-300kV) for characterization than current TEMs in the CAES complex (80kV – 200kV)
- It is equipped with a double-corrector (probe and image) configuration
- It is capable of achieving point-resolution close in value to the information limit of the system



CAES celebrated the S-TEM and 3D Metal Printer at a ribbon-cutting ceremony.

Center for Space Nuclear Research Summer Fellowship Program returns to CAES

CAES welcomed the summer fellows for the Center for Space Nuclear Research in June – the first year the fellowship has been held in person since 2019. Stephen Herring, the center's director, led the program virtually in 2020 and 2021.

Each summer, the center, which is housed at CAES, invites a group of undergraduate and graduate students from across the country to learn about cutting-edge research in nuclear power and propulsion technologies through its Summer Fellowship Program. The program runs for 10 weeks and allows the fellows to work as a team, in partnership with Idaho National Laboratory researchers, to complete a research project of interest to NASA in potential nuclear technology performance. The Summer Fellowship Program allows participants to experience a real research environment, to learn from nuclear scientists and to preview careers in research. This year, those accepted as fellows had the option of participating in person or virtually. Nine students attended in person while two participated online.

Here are the fellows and the schools they attend:

Zyed Ansary
University of Denver

Daniel John Black
Brigham Young University-Idaho

Aanchal Gupta
University of Illinois Urbana-Champaign

Kaasturi Khatun
University of Southern California

Kean Martinic
Idaho State University

Arnold Pradhan
University of Idaho

Berenice Sosa Aispuro
Idaho State University

Daniel Watson
Texas A&M

Teyen Widdicombe
University of Idaho

Participating online

Manikandan Pandiyan
University of Michigan

Bikash Parajuli
University of Akron

Did you know?

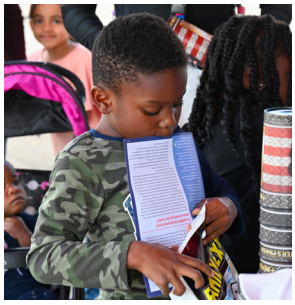
Idaho National Laboratory and the Universities Space Research Association created the Center for Space Nuclear Research in 2005 to foster collaboration between the lab and university scientists. The center's scientists and engineers research and develop advanced space nuclear systems, including power systems, nuclear thermal propulsion and radioisotopic generators.

State legislature approves funding for Nuclear Engineering program

The Idaho Legislature approved $1.1 million to support the joint Nuclear Engineering program offered by Idaho State University and University of Idaho, a move that will allow for expansion of the program's faculty. The partnership between the two CAES universities demonstrates the state Board of Education's push for collaboration between Idaho's public universities and colleges. Students enrolled at either of the universities can take classes at the other university, either at physical campuses or online, and collaborate with Idaho National Laboratory researchers. As of spring 2022, more than 200 students from UI were enrolled at the Idaho Falls campus, and 974 ISU students were enrolled both online and on campus.

CAES hosts open house

Approximately 100 affiliates of CAES – students, faculty and INL researchers – attended an open house at CAES in mid-September. The event featured tours of the facility, a poster session and demonstrations in the Applied Visualization Laboratory and the Small Modular Reactor Simulator Laboratory, which features a simulator of the control room for a NuScale small modular reactor. The open house offered a chance for the affiliates to bring their families and network with other members of the CAES community.



ACCOLADES

Notable awards at a glance

National Science Foundation Scholarships in STEM program award

National Science Foundation Scholarships in STEM program award of $5 million went to Boise State University to help students from historically underserved backgrounds.

CAES' involvement focuses on designing a Scholars Seminar to help establish networks, provide skills-based training and highlight career opportunities. *Read more on this page.*

Higher Education Research Council-Idaho Global Entrepreneurial Mission

The Higher Education Research Council-Idaho Global Entrepreneurial Mission awarded $2.1 million over three years to a team led by University of Idaho's Michael Haney for a project that calls for creating an immersive training environment for students across Idaho.

The award will lead to a project at CAES called Secure Cyberspace and Resilient Industrial Systems Workforce Development, a physical lab that ties into an existing simulator at the Applied Visualization Laboratory that focuses on cybersecurity for the nuclear industry and infrastructure. *Read more on page 11.*

Nuclear Regulatory Commission grant

The Nuclear Regulatory Commission (NRC) awarded a $450,000 Faculty Development Grant to Idaho State University faculty member Amir Ali.

Ali, the lab lead for CAES' Innovation Laboratory, plans to use the award to create a program enabling thermal hydraulic research at ISU. *Read more on page 9.*

Idaho Global Entrepreneurial Mission award

Idaho Global Entrepreneurial Mission awarded $348,000 to University of Idaho assistant professor Amin Mirkouei and industry partner Idaho Strategic Resources to research and develop a new technique for drilling and extracting rare earth elements. The project includes researchers from INL, CAES and the state of Idaho. *Read more on page 13.*

Boise State receives NSF award to establish CAES Scholars Consortium

A $5 million award from the National Science Foundation's Scholarships in STEM program will enable Boise State University to create a statewide academic consortium with the College of Southern Idaho and the College of Western Idaho. Boise State's award will fund scholarships for more than 150 students pursuing degrees in electrical and computer engineering. The goal is to address the nation's need for scientists, mathematicians, engineers and researchers. CAES' role will be to create a Scholars Consortium to assist first-year students at the colleges prepare for careers in science, technology, engineering and math fields with targeted mentorship, self-discovery, and development of their career aptitude and professional identity.

UI, ISU team gets grant to create immersive cybersecurity training

A team led by University of Idaho faculty member **Michael Haney** received a $2.1 million award from the Higher Education Research Council-Idaho Global Entrepreneurial Mission (HERC-IGEM) for a project that calls for creating an immersive training environment for cybersecurity students statewide.

The project, Reconfigurable Attack-Defend Instructional Computing Laboratory (RADICL) at the University of Idaho's Idaho Falls Center for Higher Education, will be available to students at any Idaho university. The project will provide access to what will eventually be a hybrid physical/virtual environment through the Idaho Regional Optical Network, a high-speed optical network that connects higher education institutions, health care organizations, government agencies and not-for-profit organizations throughout the state. It expands on the RADICL facility on University of Idaho's main campus in Moscow, which provides hands-on teaching and research in the areas of information assurance, cyber defense, and modern computing platforms and networks. The new effort will include cyber-physical systems and operations technology for critical infrastructure. The immersive environment created by the project will mimic real-world activity on the internet – "Things you couldn't do in a classroom," said Haney, associate professor of computer science for the University of Idaho and a cybersecurity researcher at Idaho National Laboratory.

Led by Haney, the project includes UI researchers R.A. Borrelli, Dakota Roberson and Constantinos Kolias, and Idaho State University researchers Benjamin Lampe, Sean McBride and Ryan Lind.

The HERC-IGEM program, which is designed to stimulate competitive research at Idaho's higher education institutions, will fund the project for three years at $693,000 annually.

Projects selected for funding must align with the statewide higher education research strategic plan. Haney's project aligns with the plan to boost cybersecurity education at the state's universities and colleges through a private fiber-optic network that connects classrooms and research laboratories on all of Idaho's public higher education institutions. The goal is to eventually incorporate CAES and INL's Collaborative Computing Center and Cybercore into the plan. At CAES, Haney plans a project called Secure Cyberspace and Resilient Industrial Systems Workforce Development, a physical lab that ties into an existing simulator at the Applied Visualization Laboratory and focuses on cybersecurity for the nuclear industry and infrastructure.

ISU's Nuclear Engineering Program receives NRC grant

Idaho State University's Nuclear Engineering Program received a $450,000 grant from the Nuclear Regulatory Commission through the Faculty Development Grant program to support assistant professor **Amir Ali's** research program.

The NRC program provides support for education in nuclear science, engineering and related trades to develop a workforce capable of designing, constructing, operating and regulating nuclear facilities and safely handling nuclear materials. The grant is for faculty members in the first four years of their career and is intended to support faculty development under supervision by a mentor.

Ali, who leads the Innovation Laboratory at CAES, plans to use the award to create a program enabling thermal hydraulic research in ISU's Nuclear Engineering Department.

"We've never had that at ISU," Ali said, adding that the new program will meet a "strong need" from Idaho National Laboratory.

The program Ali is developing under the mentorship of Chad Pope – a professor, Nuclear Engineering program director at ISU, and principal investigator on the grant – will feature two to three courses, one on computational thermal hydraulics and another on fire protection systems for nuclear applications.

Ali's award will most immediately impact CAES through the introduction of research on the fission gas release phenomenon in advanced reactors.

Researchers from ISU, BSU receive DOE grants for projects involving INL

Two projects involving Idaho National Laboratory and CAES universities were among 29 projects that received a total of $21 million through the Department of Energy's Established Program to Stimulate Competitive Research (EPSCoR) program in September.

Idaho State University's Cori Jenkins, an assistant professor of chemistry, and ISU colleague Josh Pak were recipients of an EPSCoR award in collaboration with INL researcher Simon Pimblott, in the Nuclear Science and Technology directorate. The project, "Mechanistic and Kinetic Analysis of Polymer Deconstruction and Modification by Irradiation for Polymer Upcycling," developed in part from an ISU-CAES seed grant also involving INL researchers. ISU awards seed grants to collaborative research projects involving partners from INL and the other CAES universities, with funding from the portion of ISU's annual state funding allocated for CAES activities.

Boise State University's Kurtis Cantley, an associate professor of electrical and computer engineering, received EPSCoR funding for a project called "Neuromorphic Systems for Power Grid Cyber-Resilience," on which he is collaborating with researcher Craig Rieger in INL's National and Homeland Security directorate.

DOE's EPSCOR program is designed to enhance the capabilities of states and territories to conduct sustainable and nationally competitive energy-related research. Twenty-five states, including Idaho, plus Puerto Rico, Guam and the U.S. Virgin Islands are eligible to participate in the program, which pairs innovative ideas from EPSCoR-eligible institutions with leading-edge capabilities at national laboratories. The goal is to enhance research while building expertise and capabilities that will enable the institutions to better compete for other federal research and development funding, while advancing the geographic diversity of researchers conducting competitive energy-related research.

"The EPSCoR program is a long-standing and critical pillar in the Department of Energy's efforts to ensure that all regions and institutions, particularly those that have been historically underrepresented in federal research funding programs, are engaged in competitive, impactful, clean-energy-relevant research," Asmeret Asefaw Berhe, director of the DOE Office of Science, said in a news release announcing the awards. "The projects selected for awards will help to build expertise and capabilities at the EPSCoR institutions and will strengthen their connections to the wealth of capabilities at the DOE national laboratories."

CAES Fellow Mustafa Mashal receives two fellowships

Mustafa Mashal, a CAES fellow and associate professor in the Department of Civil and Environmental Engineering at ISU, received the Fulbright U.S. Scholar Award and the University of Canterbury's Visiting Erskine Fellowship this year.

For his Fulbright award, Mashal is spending 10 months at Qatar University in Doha, Qatar, conducting research on the use of titanium alloy bars to retrofit structurally deficient concrete buildings, teaching a graduate-level class on precast concrete and providing seminars and training sessions.

Prior to his Fulbright program, Mashal spent four months at the University of Canterbury for the Visiting Erskine Fellowship, teaching a class on designing and retrofitting reinforced concrete bridges to withstand earthquakes, and he collaborated with the faculty on research projects.

Mashal, a member of the initial cohort of CAES Fellows, received a $1.1 million award through the Idaho Global Entrepreneurial Mission in 2019 for a project that led to the construction of the Disaster Response Complex on ISU's campus in Pocatello. Mashal collaborated with INL researcher Bryon Marsh on the project. Their collaboration dates to a CAES Collaboration meeting in 2018.

Boise State faculty member on team awarded NEUP grant

CAES Fellow **Brian Jaques** of Boise State University is among the researchers involved in a project that received a $300K grant via the Nuclear Energy University Program. Led by a researcher from the University of Texas at San Antonio, the project supports the fabrication and testing of advanced nuclear fuels and materials, specifically the development of uranium-bearing compounds, alloys and composites. Jaques, an assistant professor of Materials Science and Engineering, is a frequent collaborator

with Idaho National Laboratory researchers in the High Temperature Test Laboratory, Transient Reactor Test Facility and the Advanced Test Reactor on the In-Pile Instrumentation Program. He is also the Boise State representative in CAES' effort to collaborate with ATR for student engagement.

ISU faculty member, CAES resident, awarded NASA fellowship

Dan LaBrier, an assistant professor of nuclear engineering at Idaho State University and a CAES resident, was recently awarded an Idaho NASA Established Program to Stimulate Competitive Research (EPSCoR) Summer Faculty Fellowship.

The fellowship program supports Idaho-based faculty in their efforts to better align their research programs with topical areas and missions that NASA leads, offering participating faculty members time and resources to analyze and understand NASA's needs and examine how their research and expertise might meet those needs.

Fellows are introduced to resources such as the NASA Solicitation and Proposal Integrated Review and Evaluation System, the 2020 NASA Technology Taxonomy, the NASA Human Research Roadmap and TechPort, and the opportunity to meet with the Idaho NASA EPSCoR team to better understand processes.

CAES fellow part of team that lands NSF grant

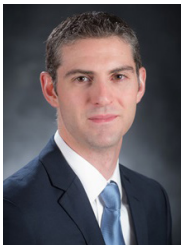
CAES Fellow **Claire Xiong** from Boise State University is a member of a research team that received a grant of nearly $2 million from the National Science Foundation to engage prospective elementary teachers' mathematical learning through science, technology, engineering and math (STEM) inquiry and experiential learning. The goal of the research is to improve prospective elementary teachers' engagement through innovative, interdisciplinary and inquiry-based approaches to address the pressing needs for integration of multiple disciplines in

STEM education. The grant will empower interdisciplinary collaboration across STEM fields, including mathematics, computer science, and materials science and engineering, across four universities: Boise State, Augusta University, the University of Texas at San Antonio, and Kapi'olani Community College. Xiong is an associate professor of materials science and engineering at Boise State.

INL researcher, ISU faculty member, named to statewide Accomplished Under 40 list

Idaho National Laboratory researcher **Kunal Mondal**, an affiliate faculty member in Idaho State University's Department of Civil and Environmental Engineering, was recognized by Idaho Business Review's Accomplished Under 40. The publication awards the title each year to 40 people selected by a panel for their "exceptional work ethic and leadership in both government and private sector organizations." Mondal, in INL's Energy and Environment Science and Technology directorate, has collaborated often with CAES Fellow Mustafa Mashal, an ISU associate professor, to advance the field of materials science. Mondal's research focus is micro/nano fabrication of functional materials, soft and stretchable electronics, and carbon nanomaterials.

University of Idaho faculty member leads team that received NSF EPSCoR award



University of Idaho faculty member **Michael Maughan** leads a research team that received a $3.9 million Research Infrastructure Improvement Track-2 Focused Established Program to Stimulate Competitive Research (EPSCoR) Collaboration award from the National Science Foundation's Office of Integrative Activities. The project calls for teams from UI and Auburn University to create a framework to utilize renewable and waste feedstocks to develop 100% bio-based materials for the Advanced Housing Manufacturing Industry of the Future. The project includes outreach to high school chemistry students, undergraduate and graduate student education, and mentoring postdoctoral scholars and early-career faculty members. The two NSF EPSCoR states involved in the project, Idaho and Alabama, are expected to benefit economically from industry partnerships and technology developments that emerge from it. Maughan is an assistant professor in the Advanced Manufacturing and Material Properties Group at UI and a member of the 2021 cohort of the CAES Summer Visiting Faculty Program.

BSU faculty receives multimillion-dollar research grant from US Air Force

The Boise State University Advanced Nanomaterials and Manufacturing Laboratory and NextFlex, a Department of Defense-sponsored Manufacturing USA institute, received a $4.3 million grant from the Air Force Research Laboratory at Wright-Patterson Air Force Base to enable advanced manufacturing of flexible hybrid electronics using mixed dimensional materials.

Dave Estrada, the CAES associate director for BSU and associate professor in the Micron School of Materials Science and Engineering, leads the effort to enable the fundamental science necessary to expedite the manufacturing, maintenance and repair of sensors and systems critical to ensuring global persistent awareness, resilient information sharing, and the speed and reach of U.S. Air Force missions.

"This award will position our team to advance semiconductor manufacturing techniques that may currently not be well suited for processing atomically thin films," said Estrada.

UI faculty member tours French nuclear plants

CAES Fellow Haiyan Zhao visited several nuclear sites in France during a visit arranged through the French section of the American Nuclear Society. Zhao is an associate professor in the Chemical and Biological Engineering Department and affiliated faculty in the Nuclear Engineering and Environmental Science program at University of Idaho, Idaho Falls.

Over seven days in July, she crisscrossed France to tour nuclear facilities such as Cadarache, the largest technological research and development center for energy in Europe that hosts several research reactors; La Hague, a nuclear fuel reprocessing plant; Andrea LLW waste storage site; and Marcoule Nuclear Site.

"It was really eye-opening to see how the French government, industry and the public respond to challenges and work together," Zhao said. She came away from the trip with valuable information about how the country handles the nuclear fuel cycle, from the front-end of preparing material for reactors to the back end of safely preparing, managing and disposing of the radioactive spent nuclear fuel.

Zhao was joined on the trip by eight professors from across the U.S. She applied for and was selected to participate in the journey in 2020. The event was delayed until this year due to the COVID-19 pandemic.

CAES students receive accolades

Two of the students who participated in the CAES Research Experience for Undergraduates (REU): Advanced Manufacturing for a Sustainable Energy Future program this summer received awards for their work. Hannah Smith was one of 10 REU students in the nation selected to present at the Engineering Education Conference, held in Washington, D.C., in September. Miranda Cardenas was awarded the University of Utah's Virginia Lee Beecraft Scholarship for a personal statement she wrote on her REU experience that discussed her background and the impact she hopes to make through her work in advanced manufacturing. The scholarship is awarded to a student who demonstrates creativity, resilience and a desire to positively impact the world. In addition, REU Program Coordinator Hillary Fishler, who is CAES' programmatic lead, was selected to present professional development tools and strategies developed for the program at the Engineering Education Conference.

CAES fellows' team wins INL competition

Several members of the inaugural cohort of CAES's Research Experience for Undergraduates: Advanced Manufacturing for a Sustainable Energy Future program are also members of a team that won Idaho National Laboratory's Innovation Week 2022 Net-Zero Collaboration Challenge. Lydia Beardsley, Miranda Cardenas, Dylan Cox, Hayden Pritchard, Avery Rambur, Katelyn Shadley and Hannah Smith joined INL intern Kari Perry to win the challenge for their proposal, "Bike Commuter Resource Center." The team received 160 hours of time to develop the project, which addresses the lack of bike accessibility in Idaho Falls and offers an innovative solution that includes education, information availability and community development to encourage INL employees to reduce their carbon emissions by biking to work. Contest organizers said the team's proposal has the potential to significantly reduce emissions related to employee commuting, which makes up 12% of INL's total carbon emissions, while improving biker safety and enhancing employee health and well-being.

University of Idaho projects win IGEM awards

Several projects with CAES connections won awards through the Idaho Global Entrepreneurial Mission, a grant program that funds research projects in which faculty members from CAES universities collaborate with industry to bring viable technologies to market.

HempWool project

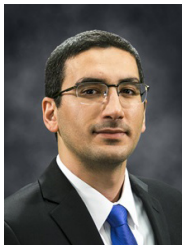
University of Idaho received a $206,000 grant from IGEM to collaborate with industry partner Hempitecture Inc. to research and develop a natural fiber insulation product. The goal is to develop the product, called HempWool, into a pioneering sustainable product in the building industry.

"This innovation means exciting changes to the building industry in Idaho and beyond," said Tom Kealey, director of the Idaho Department of Commerce, which awards IGEM grants. "We are excited to see this public-private partnership between Hempitecture Inc. and the University of Idaho."

The UI team is composed of several researchers in the university's College of Natural Resources and includes **Damon Woods**, interim director of the university's Integrated Design Lab and a leader of the Innovative Energy Systems working group at CAES.

Hempitecture is a building materials supplier based in Ketchum, Idaho. HempWool is expected be created with the fiber from industrial hemp grown sustainably in rural communities across the U.S.

Development of Idaho Sourced Rare Earth Elements project



A collaborative project led by University of Idaho assistant professor **Amin Mirkouei** received a $348,000 IGEM award. Mirkouei's project, "Development of Idaho Sourced Rare Earth Elements Drilling and Extraction," involves a team from UI, researchers from Idaho National Laboratory and the Idaho Geological Survey, and industry partner Idaho Strategic Resources.

It calls for research and development on a new technique for drilling and extracting rare earth elements.

"This project capitalizes on the university's research strengths in mining, as well as utilizing key partnerships and expertise around the state," Idaho Commerce Director Tom Kealey said in a news release. "The outcome of this IGEM public-private research project could have a profound economic impact on Idaho's mining industry."

Others involved with the project include:

- Indrajit Charit, professor, UI department chair and CAES resident
- Lee Ostrom, UI, Idaho Falls Center executive officer and professor
- John Russell, UI research professor and CAES associate director for the university
- Claudio Berti, director and state geologist, Idaho Geological Survey
- Virginia Gillerman, economic and mining geologist, Idaho Geological Survey
- Daniel Ginosar, INL
- John Swallow and Robert Morgan, Idaho Strategic Resources

HIGHLIGHTS

Summer Visiting Faculty Program's fifth year

Five faculty members from the CAES universities participated in the fifth annual CAES Summer Visiting Faculty Program. The primary objective of the 12-week program is to support and guide faculty from the CAES universities as they develop a submission-ready research proposal in collaboration with an Idaho National Laboratory researcher who will support their proposal. Members of the cohort participated in professional development, seminars and informational sessions aimed at building the faculty members' understanding of DOE and its core capabilities, INL's strategic initiatives and areas of interest, and best practices in cross-institutional collaboration. The program's long-term objectives include continued partnerships between the faculty member, INL and the CAES consortium; strengthening the consortium's inclusive research community; and supporting science, technology, engineering and math (STEM) research and education across Idaho through collaborative university and laboratory networks.

Here are this year's participants:

- Dahzi Yang, Boise State University, collaborated with Hillary Fishler, CAES, and John Koudelka, Nuclear Science and Technology directorate
- Rajib Mahamud, Idaho State University, collaborated with Ahmed Hamed, Energy and Environment Science and Technology directorate
- Hasan Jamil, University of Idaho, collaborated with Shad Staples, NS&T
- Matthew Swenson, UI, collaborated with Kaustubh Bawane, Materials and Fuels Complex
- Alex Vakanski, UI, collaborated with Fei Xu, MFC, and Yachun Wang, NS&T

CAES Summer Visiting Faculty Program, at a glance:

48 faculty members from the CAES universities have participated since the program's inception in FY-18.

Past projects that have received funding include:

- *An offshoot of a project led by Boise State University's Mike Hurley led to the installation of a 3D metal printer for nuclear-grade materials at CAES.*
- *A project led by Idaho State University's Irene van Woerden and former INL Communications Director Rae Mos called for an in-depth analysis of the public perceptions of nuclear energy.*
- *A project led by Boise State's Edoardo Serra used Lego Mindstorms to help teachers inspire middle-school students pursue careers in cybersecurity.*

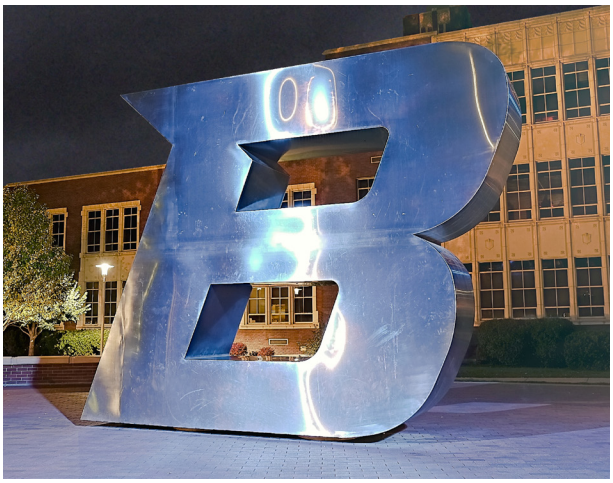
CAES Collaboration Funds celebrates fifth year with record number of submissions

Thirteen projects were selected to receive CAES Collaboration Program Development Funds for 2022, out of a record number of 23 submissions. This marks the fifth year in which these funds have been awarded to projects led by Idaho National Laboratory researchers in partnership with faculty members/researchers from the CAES universities. The goal is to establish and foster relationships between the CAES entities in research, education and innovation. This year, CAES leadership selected 13 proposals best suited to enhance collaborative relationships among the CAES entities.

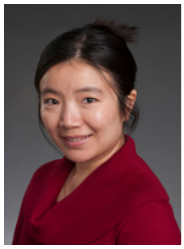
- *This year, the program's fifth year, 13 proposals were awarded out of a record number of submissions (23).*
- *Since the program's inception, 42 projects have been awarded for a total of $1,018,862 in CAES funding.*
- *Eight white papers produced, new course material developed at each university, several seminars held, one award through INL's Laboratory Directed Research and Development program.*
- *The largest awards to emerge are a $1.1 million award through the Idaho Global Entrepreneurial Mission for an ISU/INL project and a $430,000 award from the Office of Nuclear Safety, also for an INL/ISU project.*
- *Since FY-20, 25 graduate students, a Ph.D. student and three interns have supported these projects.*
- *Since the program began, 26 proposals have been submitted, including five pending from FY-22.*

Principal Investigator	INL Researcher(s)	INL Directorate(s)	CAES Focus Area
Boise State University			
Lan Li (with Amir Ali)	Joshua Fishler	NS&T	Nuclear Energy
Brian Jaques	Junhua Jiang	NS&T	Nuclear Energy and Advanced Manufacturing
Sing Ming Loo	Eleanor Taylor	N&HS	Cybersecurity and Innovative Energy Systems
Idaho State University			
Amir Ali (with Lan Li)	Joshua Fishler	NS&T	Nuclear Energy
Mostafa Fouda	Md Riaz Kayser Ahmed Hamed	NS&T EES&T	Nuclear Energy
Mustafa Mashal	Vaibhav Yadav	NS&T	Nuclear Energy
Mustafa Mashal	Kunal Mondal	EES&T	Nuclear Energy
Mustafa Mashal	Xingyue Yang, Rajiv Khadka John Koudelka	NS&T	Computing, Data and Visualization
Anirban Chakraborty	Asef Redwan	EES&T	Energy-Water Nexus
Leslie Kerby	Ryan Stewart	NS&T	Nuclear Energy and Computing, Data and Visualization
University of Idaho			
Min Xian	Mukesh Bachhav	MFC	Advanced Manufacturing
Haiyan Zhao	Hanping Ding	EES&T	Innovative Energy Systems
Ahmed Ibrahim	Elmar Eidelpes Gabriel Ilevbare	NS&T EES&T	Nuclear Energy
Indrajit Charit	Cheng Sun	MFC	Advanced Manufacturing

NS&T = Nuclear Science and Technology, EES&T= Energy & Enviornment Science & Technology, N&HS=National & Homeland Security, MFC=Materials & Fuels Complex



Paper on collaborative research effort published



Researchers from Idaho National Laboratory, Boise State University and University of Idaho who are working on a project studying the long-term performance and safety of lithium-ion batteries had their work published in the journal Small. The project, which is funded by INL's Laboratory Directed Research and Development program, focuses on the least understood areas of the batteries, the solid electrolyte interphase (SEI). The SEI is the region at the interface between the battery electrodes and the electrolyte and enables the transport of charge. The research team includes Boise State professors **Claire Xiong** and **Lan Li**, who are both CAES fellows; UI's I. Frank Cheng; and INL's Eric Dufek. The work utilized nondestructive electrochemical-atomic force microscopy to systematically monitor and compare the dynamic SEI formation and evolution on a pair of representative graphitic materials with and without defects. The outcome is a comprehensive understanding of the formation and evolution of SEI on graphitic electrodes.

"Through this collaboration, we discovered that defects in the graphite structure induce the formation of a thinner, denser and more uniform SEI, which leads to improved battery performance," said Xiong, the principal investigator. "We now have a new design strategy to overcome the Achilles's heel of lithium-ion batteries — limited charge cycling capacity."

Boise State University professor teams with INL on materials science research effort

Boise State University associate professor Paul Simmonds is collaborating with Idaho National Laboratory on research that calls for using a process called molecular beam epitaxy to enable the study of the elements that form the foundation of nuclear energy production. The process will enable Simmonds and his colleagues to "grow" materials with few defects, allowing them to observe the movement of electrons and phonons with unparalleled accuracy. Current studies of the movement of the electrons and phonons found in these elements (uranium, plutonium and other actinides) are limited in part because of defects and impurities. Molecular beam epitaxy will allow the researchers to create a structure with the desired elements arranged in a predetermined arrangement, enabling the electronic and thermal properties of the materials and the observation of quantum mechanical effects. It also could lead to additional research on actinide materials at INL.

ISU awards seed grants for collaborative research efforts

TEN researchers at Idaho State University received $243,000 in ISU-CAES seed grants in December for collaborative research projects involving partners from Idaho National Laboratory and the other CAES universities. The projects range from microreactor design to pumped hydropower to high performance computing. The funding for the projects comes from the portion of ISU's annual state funding allocated for CAES activities.

1. **Amir Ali,** a Nuclear Engineering Department faculty member, is collaborating with INL researcher Yasir Arafat on a project called "*Performance Optimization of MARVEL Microreactor Power Conversion System*"
2. **Paul Bodily,** a faculty member in the Computer Science Department, is collaborating with INL researcher Rajiv Khadka on "*Application of Advanced Computational Theory to Facilitate Efficient Solutions to Real-World Combinatorial Problems*"
3. **Tony Forest,** a Physics Department faculty member, is collaborating with Chutiing Tan (INL) on "*A Neutron Generator for Materials Testing*"
4. **Mostafa Fouda,** a faculty member in the Electrical and Computer Engineering Department, is collaborating with Ahmed Hamed (INL) on "*Smart Analytics of Biomass Images*"
5. **Jon Kalivas,** a faculty member in the Chemistry Department, is collaborating with John Koudelka (INL) on "*Virtual Reality for Dynamic Data Visualization of Analytical Chemical Data*"
6. **Mustafa Mashal,** a Civil Engineering Department faculty member, is collaborating with fellow ISU researchers Dan LaBrier and Jared Cantrell, and INL researchers Som Duhlipala and Amit Jain on "*Machine Learning-Aided Validation of a Sustainable and Highly Durable Construction Technology for the Containment Facility of Advanced Reactors*"
7. **Srinath Pashikanti,** a faculty member in the Biomedical and Pharmaceutical Sciences Department, is collaborating with fellow ISU researcher Rene Rodriguez and INL researchers Robert Fox and Donna Baek on "*Incorporation of Sterics in Novel Phosphonium Ionic Liquid (PIL) and Their Effect on Ligand Intermolecular Interactions and Chelation Properties*"
8. **Bruce Savage,** a Civil Engineering Department faculty member, is collaborating with fellow ISU researchers Chikashi Sato, Jim Mahar and Mustafa Mashal, and University of Idaho researchers Karen Humes and Dakota Roberson on "*Water Storage Infrastructure Viability Using Repurposed Tires for Pumped Hydro*"
9. **Keith Weber,** Geographic Information Systems Training and Research Center director, is collaborating with Boise State University's Kathleen Araújo and Cassandra Koerner, and INL researchers Kelly Wilson, Ryan Hruska, Shiloh Elliot and Chris Forsgren on "*The Power Grid/Wildfire Nexus: Using GIS and Satellite Remote Sensing to Identify Vulnerabilities*"
10. **Danny Xu,** a faculty member in the Biomedical and Pharmaceutical Sciences Department, is collaborating with Boise State researcher Kenneth Cornell and INL's Eric Whiting on "*Hearing Loss Prevention Through Integrative High-Performance Computing, Data Science and Experimental Biology*"

Collaborative project on wastewater involves INL, Boise State University

A collaborative research effort involving Boise State University, Drexel University and Idaho National Laboratory has demonstrated an energy-efficient, conceptually simple technique to remove ammonia from agricultural wastewater. The research team — co-led by **David Estrada**, associate professor of Materials Science and Engineering at Boise State University and the CAES associate director for Boise State, and Tedd Lister, a chemical separations researcher in INL's Energy and Environment Science and Technology directorate — has published an article in the Nature Partner Journal Clean Water on their work. The project demonstrates a technique for removing dissolved ionic impurities from wastewater without the use of filters or high pressure that uses a fraction of the energy of traditional methods. The technique utilized by the research team, capacitive deionization (CDI), is an emerging water treatment technique in which water flows between two oppositely charged electrodes. The ionic impurities in wastewater are polarized, which causes the anions to be attracted and stored in the positive electrode while the cations are attracted and stored in the negative electrode.

"The neat advantage with CDI is that you can reverse the charges on the electrodes and repel the stored ions into a concentrated stream", said Luis Diaz-Aldana, a member of the research team who is an electrochemical engineer in INL's Energy and Environment Science and Technology directorate. "So not only can you clean water, but you can also recover any precious resources that were discharged into the wastewater."

Previous studies have explored carbon-based materials as electrodes in the CDI system. However, these materials can be limited in chemical diversity, surface chemistries and surface-area-to-volume ratio, which all combine to limit performance in CDI systems. This prompted the team to partner with Chris Schuck and Yury Gogotsi at Drexel University to investigate the efficacy of MXenes in a flowing electrode CDI system.

Naqsh Mansoor, a Boise State graduate student in materials science and engineering, was first author on the article, which explained that using MXenes in a flow electrode style CDI architecture results in 100 times improvement in the deionization capacity of the system when compared to activated carbon based electrode systems. This essentially means that a higher number of pollutant ions can be pulled out from the wastewater stream while using less of the electrode material and a fraction of the energy.

CAES leadership approves new capabilities for lab

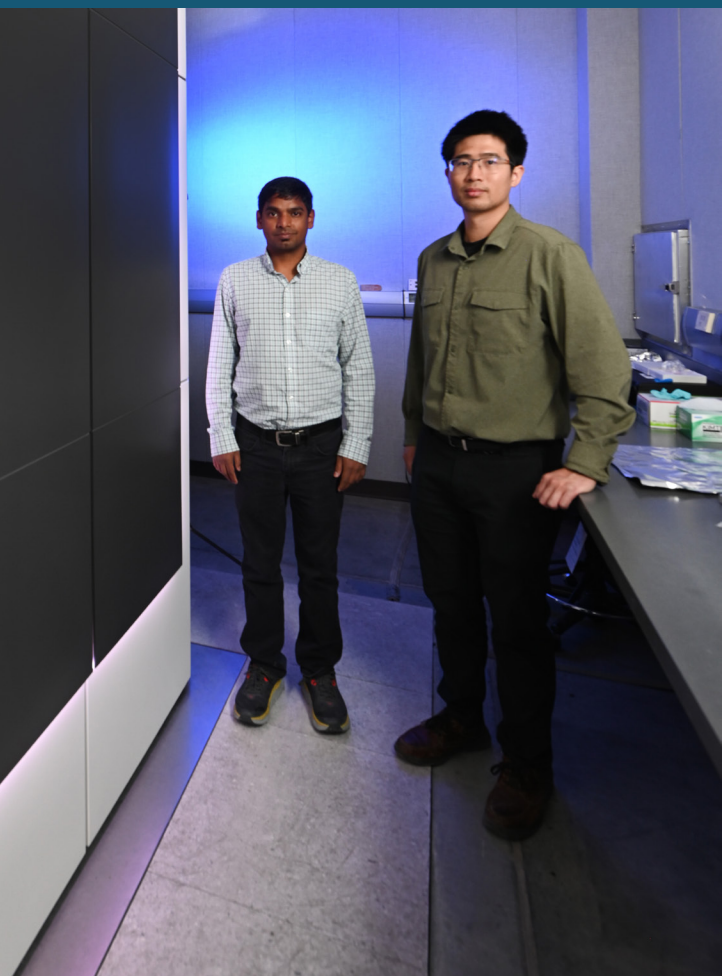
The CAES Executive Board approved the Electronics for Frequency-Domain Feedback Laboratory, expanding the capabilities of the Innovation Laboratory. Led by Idaho National Laboratory's Robert England, the project enables research into instrumentation and controls as well as data science. Idaho State University assistant professor Mostafa Fouda and University of Idaho assistant professor Dakota Roberson are co-principal investigators on the project.

CAES launches seed grant program for MaCS

CAES launched the Microscopy and Characterization Suite (MaCS) Seed Grant Program in the spring to boost opportunities for members of the CAES community to conduct research in the MaCS. The program covers the costs of instrument time and MaCS staff time for selected proposals. The goal is to seed opportunities that advance the vision and mission of CAES, promoting research in all science fields and increasing the MaCS user base.

MaCS is a state-of-the-art materials characterization laboratory with a range of technologically advanced equipment including two scanning transmission electron microscopes and local electrode atom probe that provides cross-cutting capabilities in support of the CAES mission in several areas. MaCS is largely made possible through its partnership with the Nuclear Science User Facilities.

The seed grant program is led by Boise State University and Idaho State University, as well as Boise State's Micron School of Materials Science and Engineering.



Boise State University, INL collaborate on high-density fuel project

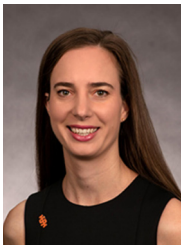
A collaborative project led by Boise State University assistant professor Brian Jaques, Boise State Ph.D. student/Idaho National Laboratory Graduate Fellow **Jennifer Watkins,** and INL researcher Adrian Wagner is the subject of three recent review articles. The articles provide a review of the challenges and opportunities associated with the use of four types of high-uranium density fuels in existing and future light water reactors — uranium diboride, uranium carbide, uranium silicide and uranium mononitride.

In general, increasing the uranium density of fuels in these reactors can provide many benefits, including increased power-up rates, longer cycle lengths, improved performance and increased coping time during accident scenarios. However, the fuels also exhibit undesirable corrosion behavior. The articles delve into the need for increased study into this behavior, to identify ways to protect the fuel matrix from degradation. The project findings indicate that further research is warranted due to the potential benefits of using high-uranium density fuels, from safety, economical and nonproliferation standpoints.

Watkins is a Ph.D. student in Boise State's Micron School of Materials Science and Engineering and is part of the Advanced Fuel Fabrication and Development group at INL's Materials and Fuels Complex. Wagner is a researcher at MFC. Jaques, a CAES fellow, is an assistant professor in the Micron School of Materials Science and Engineering who holds a joint appointment with INL.

The three are joined on the project, which is funded by INL and Westinghouse, by University of Texas at San Antonio researchers Elizabeth Sooby and Adrian Gonzales.

CAES-funded project studying perceptions of nuclear energy featured in publications



A CAES-funded project examining the perceptions of nuclear energy is the subject of two recent publications. The project stems from the 2020 CAES Summer Visiting Faculty Program, where Idaho State University's **Irene van Woerden**, an assistant professor in the Department of Community and Public Health, collaborated with former Idaho National Laboratory Communications Director **Rae Moss** to study the public perception of nuclear energy in Idaho.

The team received $20,000 through the ISU-CAES seed grant program, which provides funding for collaborative projects involving researchers from the university and INL, to launch a survey. More than 6,000 people responded to at least one question in the survey, with more than 2,000 responses from Idahoans. The target audience lived within 50 miles of the INL Site.

"We had a much wider and larger response rate than expected," van Woerden said.

She and Moss recruited three graduate students pursuing their master's in public health at ISU to help conduct the survey and analyze the responses.

The survey included questions related to:

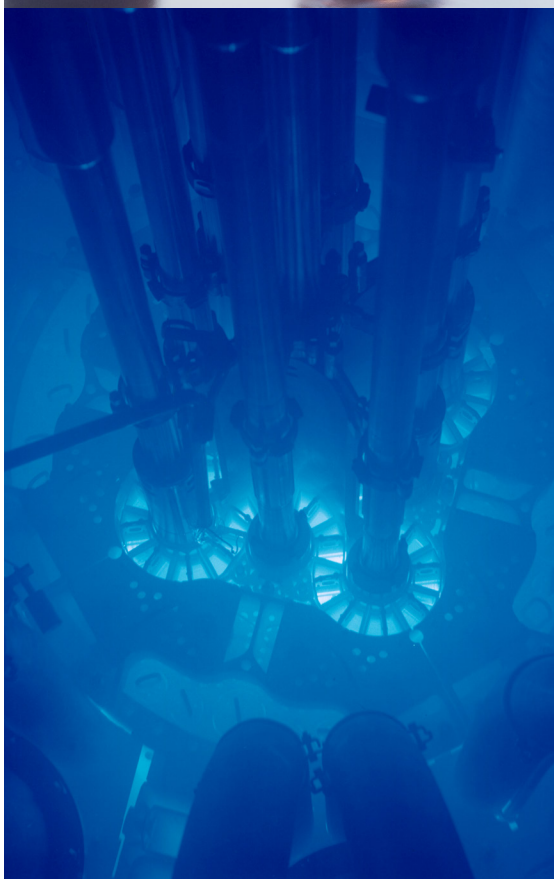
- Demographics
- Attitudes toward nuclear energy
- Perceived risk of nuclear energy
- Environmental factors
- Health concerns related to nuclear energy
- Nuclear waste
- Knowledge of nuclear energy
- Economics of nuclear energy
- Questions on the respondents' health status, food security status, and community and disaster preparedness.

One paper, published in May, was written by van Woerden; Megan Warnement Wrobel, an assistant professor of political science at ISU; and Mark McBeth, a professor of political science at ISU. The article, "Political ideology and nuclear energy: Perception, proximity and trust," was published in May in Review of Policy Research.

The second article, published in April in Energies, was written by ISU graduate student Meesha Iqbal, Moss and van Woerden. It is called, "Peoples' perception toward Nuclear Energy."

The research team is also preparing another article about the perceptions of nuclear energy related to climate change and nuclear waste.

"The general idea behind this work is that the perception toward nuclear energy is a vital factor determining the success or failure of nuclear projects," van Woerden said. "We welcome additional collaboration with those who are interested to use this survey."



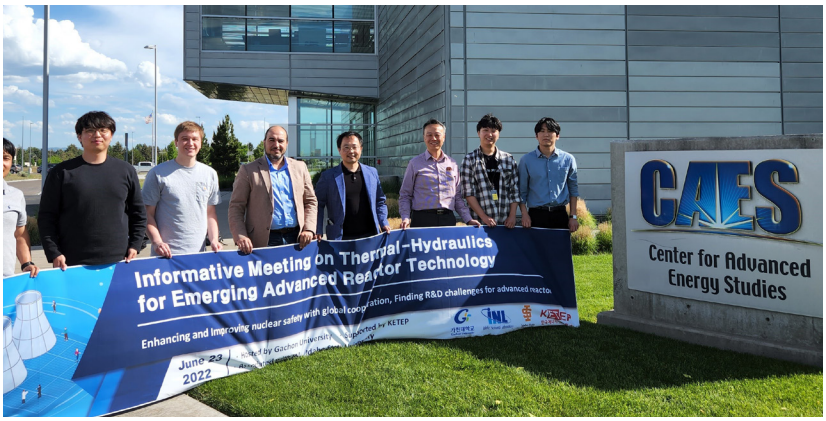
EVENTS

Diverse group turns out for innovation workshop at CAES

More than 70 people attended a workshop at CAES designed to develop a roadmap for receiving funding through the National Science Foundation's Regional Innovation Engines program. The program catalyzes and fosters innovation ecosystems across the nation, providing up to 10 years of funding, as much as $160 million, to each "engine" to establish and support diverse regional coalitions that engage in research and development, workforce development and translating innovation to society. A collaborative team from Idaho National Laboratory, Boise State University and CAES submitted a concept paper to NSF over the summer that was accepted, resulting in the workshop. The workshop drew attendees from industry, academia, INL, local government and community organizations, and resulted in the formation of a comprehensive team charged with developing a full phase 1 proposal to submit to NSF that could lead to an innovation "engine" based in eastern Idaho.

Energy Policy Institute hosts annual conference

The Energy Policy Institute at Boise State University held the 10th annual Energy Policy Conference in mid-October 2021. More than 200 people attended, the best draw in the event's history. Keynote speakers included Idaho National Laboratory Director John Wagner; Abigail Ross Hopper, president and CEO of the Solar Energy Industry Association; William Magwood, director-general of the Nuclear Energy Agency; Jennifer Fordham, former senior vice president of Government Affairs for the Natural Gas Supply Association; and Jon Wellinghoff, CEO of Grid Policy, Inc. and former chairman of the Federal Energy Regulatory Commission. The conference featured sessions on resilience in the power sector and the future of electric vehicles, all revolving around the conference's theme of "Disruption and Megatrends in Energy." The conference was cancelled in 2020 due to the COVID-19 pandemic.



CAES hosts meeting with South Korean scholars

CAES hosted a meeting at its facility last spring with a contingent of researchers and faculty members from Gachon University in South Korea. The meeting was part of an effort started by Idaho National Laboratory in 2020 to develop an international research and education force to support the deployment of advanced reactors. Representatives from the two groups discussed implementing an international student and scholar exchange between Idaho State University and Gachon University to encourage collaboration. A memorandum of understanding is being developed to formalize the relationship.

CAES hosts student chapters of American Nuclear Society

CAES hosted an event for the American Nuclear Society student chapters from Boise State University, University of Idaho and Utah State University last spring. The group consisted of 16 students from Boise State, nine from UI and eight from Utah State. Interim CAES Director Terry Brog provided an overview of CAES, and the students toured several laboratories, including the Small Modular Reactor Simulator Laboratory, Microscopy and Characterization Suite and Radiochemistry Laboratory. The event was organized by UI nuclear engineering student Sesily Stewart. The faculty adviser was R.A. Borrelli, an associate professor in nuclear engineering at University of Idaho.

Boise State University hosts workshop

More than a dozen researchers, from Boise State University, Idaho National Laboratory and Idaho State University, attended a workshop hosted by Boise State in August. The goal of the event was to formulate a plan to develop an Engineering Research Center proposal. Engineering Research Centers are university-led institutions developed through the National Science Foundation's Directorate of Engineering. The center would be housed at Boise State, would include all of the CAES institutions, and would focus on advanced manufacturing for renewable energy.

CAES hosts ASME Lunch and Learn

CAES hosted a lunch-and-learn event for the American Society of Mechanical Engineers in August. The event featured a presentation by Bin Li, a senior staff scientist in Idaho National Laboratory's Energy and Environment Science and Technology directorate whose research focuses on energy storage technologies, from discovering new materials to developing novel technologies for lithium-ion and Li-metal batteries.

CAES hosts My Amazing Future

CAES hosted 165 eighth-grade girls and more than two dozen teachers as part of Idaho National Laboratory's annual My Amazing Future in May. The annual event gives the young scholars the chance to explore topics such as DNA extraction from a strawberry, cybersecurity, radioisotope thermoelectric generators, hands-on chemistry and more, at more than a dozen workshops set up across INL's Research and Education campus. They conducted five workshops at CAES.

CAES hosts reception, poster session for REU fellows

Dozens attended a reception at CAES in late July honoring the first cohort of the CAES Research Experience for Undergraduates: Advanced Manufacturing for a Sustainable Energy Future program. The reception featured introductions by Idaho National Laboratory Deputy Director for Science and Technology and Chief Research Officer Marianne Walck and CAES Director Philip Reppert, a poster session and lightning talks on the projects the 10 members of the inaugural cohort worked on throughout the summer.

CAES hosts meeting of regional economic development organization

CAES hosted the quarterly meeting of the Regional Economic Development for Eastern Idaho in June. The group received a briefing from former interim CAES Director Terry Brog and INL Technology Deployment Director Jason Stolworthy on INL's economic impact and the laboratory's role before taking a tour of the CAES facility highlighted by a demonstration in the Applied Visualization Laboratory.

MEETINGS, OPEN HOUSES, SEMINARS AND SPEECHES

CAES scientist featured in EPI Power Talk webinar

Travis McLing, a research scientist with INL and the lead for the Geochemistry Laboratory at CAES, presented at a Power Talk webinar hosted in mid-June by the CAES Energy Policy Institute at Boise State University. More than 150 people tuned in to the event, called "Geothermal Prospects: Federal Policy, Jobs and Technology Build-out." McLing was joined on the panel by Roy Mink, former director for DOE's Geothermal Technologies Program; CAES Energy Policy Institute Director Kathy Araújo, who is also an associate professor of Sustainable Energy Systems, Innovation and Policy at Boise State; and Jeff Tester, a professor of Sustainable Energy Systems at Cornell University.

McLing, who serves as INL's Carbon Storage lead, is an expert in the fields of geologic mapping, carbon sequestration, geomicrobiology and hydrochemistry. He has developed geochemical models to characterize carbon dioxide transport at potential storage sites, and his primary interest in this field is the study of the geochemical mineralization reactions controlling the fate and transport of carbon dioxide in subsurface environments.

Other Power Talk webinars held throughout the year included "EV Infrastructure, Policy, and Fleet Change," "Economic Opportunities and Challenges for Idaho with Low Carbon Energy Across Sectors" and "Content-Based Siting for Nuclear Energy."

CAES hosted a number of visitors throughout the year, including:

- Representatives of the Nuclear Regulatory Commission
- Representatives from the National Association of Regulatory Utility Commissioners
- Deputy Assistant Secretary for Nuclear Infrastructure Programs Tracey Bishop
- Representatives of Assistant Secretary for Nuclear Energy Kathryn Huff
- State Rep. Chris Mathias and State Sen. James Ruchti
- Idaho Falls Mayor Rebecca Casper
- Ammon Mayor Sean Coletti
- A contingent from the International Atomic Energy Agency
- Bingham County Commissioners Mark Bair, Jessica Lewis and Whitney Manwaring
- Idaho Falls City Council members Jim Francis and John Radford
- Julie Horman and Josh Sorensen with U.S. Rep. Mike Simpson's office
- A delegation from several minority-serving institutions
- A contingent from the University of Utah
- Representatives from industry, including Westinghouse, Dominion Energy, Exelon, Sargent & Lundy, Southern Company and Florida Power & Light Company
- A contingent from Western Wyoming Community College
- Members of the Idaho Falls Chamber of Commerce
- A representative from ClearPath's Advanced Reactor IES Expert Group
- Members of the state's Leadership in Nuclear Energy (LINE) Commission
- Representatives from the Idaho Public Utilities Commission, Idaho Governor's Office of Energy and Mineral Resources, and Idaho Department of Environmental Quality
- A group from the Federal Reserve Bank's Salt Lake City branch
- A delegation from Montana Technological University.

Codebreaker

This monthly webinar provides a forum for students and researchers to address their work, communicate opportunities and challenges to a receptive audience, and increase dialogue among CAES affiliates. Presenters in 2022:

Indrajit Charit

University of Idaho professor Indrajit Charit discussed the role of materials research and development in advancing nuclear energy.

Sarah Freeman

Idaho National Laboratory Industrial Control Systems cybersecurity analyst Sarah Freeman described cyberthreat intelligence and attacker trends that challenge cyber forensics.

SM Shafiul Alam

Idaho National Laboratory's SM Shafiul Alam, a research scientist in the Power and Energy Systems Group in INL's Energy and Environment Science and Technology directorate, discussed a collaborative effort with Idaho Falls Power that called for the use of an energy storage system in a field demonstration of an islanded distribution grid's black start capabilities.

Damon Woods

Damon Woods, the interim director of University of Idaho's Integrated Design Lab, talked about the research underway at the lab and how the systems we design impact our lives.

Jackson Harter

INL scientist Jackson Harter discussed his research on advanced materials and how he used the Applied Visualization Laboratory at CAES to further it.

Amir Ali

Idaho State University professor Amir Ali, the lead of the Innovation Laboratory at CAES, discussed advanced reactors.

Bryon Marsh and Mustafa Mashal

The Disaster Response Complex at ISU was the focus of a presentation by Bryon Marsh, a manager of business relations and training programs with National and Homeland Security's Emergency Response and Readiness organization at INL, and ISU assistant professor Mustafa Mashal.

Haiyan Zhao

University of Idaho's Haiyan Zhao discussed her work exploring the use of molten salt in applications such as fuel cells, batteries, heat storage and transfer, pyroprocessing of spent nuclear fuels and reactors.

Benny Varghese

INL's Benny Varghese discussed research underway at INL's Electric Vehicle Infrastructure Laboratory.

Yasir Arafat

Yasir Arafat, the technical lead for the Microreactor Applications Research Validation and Evaluation (MARVEL) Project at INL, provided an overview of the project and its potential to pave the way for deployment of a new class of nuclear reactors.

BY THE NUMBERS

21
Projects started in FY22

18
Projects completed in FY22

FROM CAES UNIVERSITIES

272 *INL employees participated in Employee Education programs*

6 *Students began postdoctoral appointments at INL*

FROM CAES UNIVERSITIES

8 *Students received graduate fellowships at INL*

95 *Students interned at INL*

FROM CAES UNIVERSITIES

16 *Faculty members awarded INL joint appointments*

7 *INL interns transferred to INL after their internship in FY22*

Nuclear Science User Facilities-funded projects in MaCS in FY22:

Title	Organization
Dislocation loop and bubble evolution in helium irradiated ThO2 and UO2 single crystals	The Ohio State University
Irradiation Effects on Unexpected Deformation-Induced Martensitic Phase Transformation in Ni-alloys	Purdue University
Grain Boundary Evolution During Irradiation in RPV Steels	University of Michigan
Irradiation effects on microstructure and mechanical properties in a laser welded ODS alloy	University of Idaho
Ion Irradiation and Characterization of FeCrAl Oxide Dispersion Strengthened Alloy Manufactured via Laser Powder Bed Fusion	Oregon State University
Irradiation behavior of nanostructured ferritic/martensitic Grade 91 steel at high dose	Missouri Science and Technology
Atom probe characterization of oxide and metal/oxide interface on proton irradiated Zry-4 after exposure in high-temperature water	University of Michigan
Accelerated Irradiation and Evaluation of Ultrastrong and Elastic Glassy Carbon	Idaho National Laboratory

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Boise State University

Aghajanzadeh, M., F. Zamani, K. Rajabi, J. Eixenberger, D. Shirini, D. Estrada, and F. Shirini. 2022. "Synergic Antitumor Effect of Photodynamic Therapy and Chemotherapy Mediated by Nano Drug Delivery Systems," Pharmaceutics 14(2):322. https://doi.org/10.3390/pharmaceutics14020322

Ansolabehere, S., K. Araújo, Y. He, A. Hu, V. Karplus, H. Li, E. Thom, and D. Tingley. 2021. "A Low Carbon Energy Transition in Southwest Pennsylvania," Roosevelt Project Report, MIT-Harvard.

Araújo, K. 2022. "Energy Transitions and Nuclear Technology in the Arctic," Arctic X Conference.

Araújo, K. 2022. "Strategic Directions for U.S. Industrial, Climate and Trade Policy," Atlantic Council.

Araújo, K. 2022. "Transitions to Net Zero Carbon Systems: Domestic and International Strategies in Policy and Infrastructure Change," presented at Santa Fe Institute, November 3, 2021.

Araújo, K. 2022. "U.S. Science, Technology and Policy Imperatives for Methane: Applicability for Renewable Natural Gas," presented at AICHE 3rd Renewable Gas Summit, December 14, 2021.

Araújo, K. 2022. "Adoption of Offshore Wind," presented at Advanced Energy Conference 2022: Charting the Course for Energy, New York City, NY. September 2022.

Araújo, K. 2022. "Bending the Energy Curve: Insights for Planning and Community-informed Decision-making," Alaska Center for Energy and Power.

Araújo, K. 2022. "Disruptive Change: Concepts and Lessons for Sustainability," presented at 3rd Latin American Conference on Sustainable Development of Energy, Water and Environment Systems, Sao Paulo, July 2022.

Araújo, K. 2022. "Energy and Demand," presented as panel moderator and on the scientific advisory board, at the Energy and Climate Transformations: 3rd International Conference on Energy Research & Social Science, University of Manchester, UK, June 2022.

Araújo, K. 2022. "Geopolitics, the Net Zero Carbon Agenda, and Technology Change: Interdependencies in Energy," Federal University of Rio de Janeiro.

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Bateman, A., C. Snyder, S. Schier, A. Stevanovic, A. Fernandez, E. Sooby, and B. J. Jaques. 2023. "Location specific characterization of additively manufactured stainless steel to inform build data analytics," *The Minerals, Metals & Materials Society* (forthcoming).

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Cole, S. E., A. E. Lupercio, A. T. Nelson, and B. J. Jaques. 2022. "Fabrication and Characterization of Doped UO2 Nuclear Fuel," presented at Idaho Conference on Undergraduate Research, Boise, Idaho.

Curtis, M., C. Chen, J. Redwing, and D. Estrada. 2022. "Fundamentals of MOCVD," presented at 2DCC NSF Site Visit.

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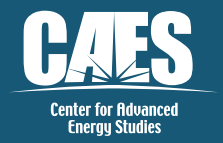
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