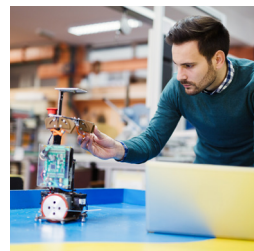
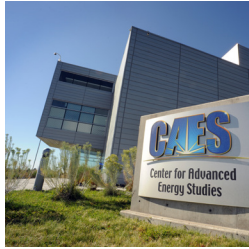
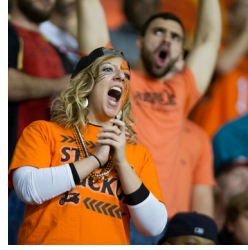




CAES

Center for Advanced
Energy Studies

2020 ANNUAL REPORT



DIRECTOR'S LETTER

THE COVID-19 PANDEMIC MADE 2020 A TUMULTUOUS YEAR for everyone at CAES. The pandemic introduced significant uncertainty to the universities and Idaho National Laboratory (INL). Students and faculty were sent home from the universities when the pandemic hit, as were researchers at INL, and the CAES headquarters in Idaho Falls was shuttered for nearly a month. Restrictions were loosened over the summer, as researchers with approved projects were allowed to resume their work in the laboratories, but the majority of those who work in CAES have been telecommuting since March. At the end of the fiscal year, the CAES facility was still off-limits to visitors, tours remained canceled, and all seminars and most meetings were online only. The uncertainty wrought by the pandemic has not hindered CAES' ability to fulfill its mission and vision, however; in fact, 2020 was a banner year in terms of research wins and accomplishments for the CAES community as the implementation of the CAES Strategy continued to bear fruit. Among the highlights:

- In July, we broke ground on an INL-funded, \$5 million project to install a new transmission electron microscope in one of the eight laboratories at CAES. This move will accelerate the innovative research into advanced materials that is critical to the U.S. maintaining its role as the world leader in nuclear innovation, particularly in the development of new reactors. It will significantly enhance INL collaboration with the universities, helping CAES fulfill its role of training the future energy workforce.
- CAES researchers from Boise State University, Idaho State University (ISU), and University of Idaho either led or collaborated on projects that were awarded nearly \$5 million in funding from two DOE programs, the Nuclear Energy University Program and Nuclear Energy Enabling Technologies.
- A CAES researcher from ISU is leading a collaborative project with INL to build a disaster response complex on the ISU campus in Pocatello. The facility will train first responders from throughout the region and was made possible through a \$1.1 million grant through the Idaho Global Entrepreneurial Mission.
- We named the inaugural cohort of CAES Fellows and are on the verge of launching a new workforce development program, the Joint Certificate in Nuclear Safeguards & Security.
- We wrapped up the third year of our flagship program, the CAES Summer Visiting Faculty Program, which drew 29 participants this year.
- Working groups were formed in all seven of the focus areas outlined in the CAES Strategy, with promising developments emerging from each.
- The first-ever CAES Annual Pitch Event (also known as Baby Shark Tank) attracted nearly three dozen registrants, with every CAES entity represented.
- We celebrated the 10th anniversary of the CAES headquarters facility in Idaho Falls with the Idaho governor proclaiming the first day of the fiscal year, Oct. 1, 2019, as CAES Day.



This is just a glimpse at what we accomplished in the 2020 fiscal year. We also saw several notable departures, including Director Noël Bakhtian and Chief Operations Officer Anita Gianotto, who left at the end of the year, and the announcement that University of Wyoming would exit the consortium in early 2021. More information on these developments can be found in this report.



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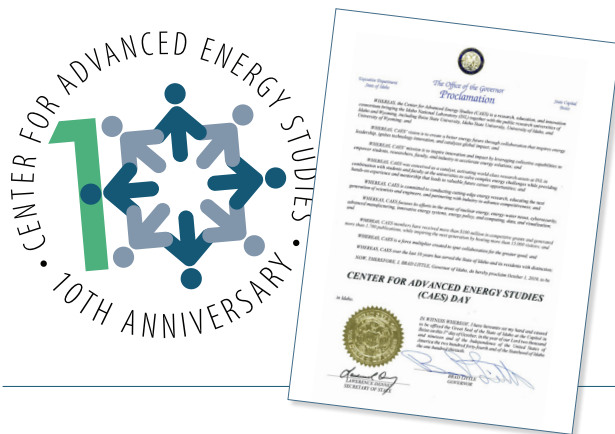
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NEWS

CAES Day proclaimed in Idaho

Idaho Gov. Brad Little proclaimed Oct. 1, 2019, as CAES Day at CAES' 10th anniversary celebration on the same day. 2019 marked the anniversary of the opening for the CAES headquarters in Idaho Falls. The event in Boise was preceded by a celebration in Idaho Falls that drew more than 200 people, including CAES alumni from as far as Utah and Colorado. More than 100 people attended the invitation-only event in Boise, including Battelle Executive Vice President of Laboratory Operations Ron Townsend. The event featured presentations by:

- Gov. Brad Little
- Idaho National Laboratory Director Mark Peters
- Former Idaho Gov. C.L. "Butch" Otter
- Nuclear Energy Institute Vice President of Policy Development and Public Affairs John Kotek
- Boise State University President Marlene Tromp
- University of Idaho President Scott Green



COVID-19 impacts CAES operations

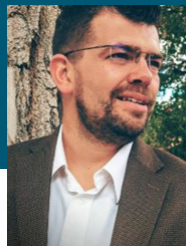
COVID-19 had a significant impact on operations at the CAES facility in fiscal year 2020. Access to the facility was restricted in mid-March, when only CAES residents and approved visitors were allowed inside the facility. All tours were canceled, and all CAES-sponsored travel has been on hold since then. INL employees at CAES began telecommuting on March 17, and university students, faculty and staff followed suit on March 18. After the Idaho governor issued a stay-home order in late March, the CAES facility was closed to everyone except key personnel. That status continued until mid-May, when the governor lifted his order, and access was restored on a case-by-case basis to researchers with an approved project plan. All others continued to telecommute. COVID-19-related policies were implemented, including a Decision and Action Tree to guide CAES residents who were exposed to the virus, developed symptoms or tested positive, and all who entered the facility were required to wear face coverings and practice social distancing, to conduct temperature self-checks upon entering the facility, and to work from home as much as possible to protect those whose work required laboratory access. At the close of the fiscal year, access remains restricted to those with a CAES badge – no visitors are allowed. Although researchers with an approved project plan have full access to the facility, all others must receive approval from their associate director for each visit. At the end of the fiscal year, access restrictions were expected to remain in place until spring 2021.

University of Wyoming announces 2021 departure from consortium

University of Wyoming (UW) notified CAES leadership in July that the university plans to withdraw from the CAES consortium in early 2021. Since joining the consortium in 2014, UW has broadened the potential impact and expanded the pool of students and faculty by 12,000-plus. UW has been a valued partner and, though it was a member for a relatively short time, the university, its faculty and its students made valuable contributions in several key areas, notably carbon management, energy storage and energy-water nexus. The UW School of Energy Resources, Energy Innovation Center, College of Engineering and Applied Science, and the leaders there – Katie Li-Oakey, Kipp Coddington, Amy Banic, Dean Roddick, Jon Brant, and Rob Godby, to name a few – all made significant contributions at CAES or were poised to do so. Though UW will no longer be a full-fledged member of the CAES consortium, CAES leadership is exploring options for the university's continued participation on a more limited basis.

Inaugural CAES Fellows cohort named

CAES ANNOUNCED THE FIRST COHORT OF CAES FELLOWS IN EARLY JUNE. Six Fellows were selected: an Idaho National Laboratory (INL) researcher and faculty members from Boise State University, Idaho State University, and University of Wyoming. The fellows have demonstrated extensive engagement in the CAES community and collaborated with partners at INL and the CAES universities in at least one of the focus areas outlined in the CAES Strategy. Each has exhibited impressive leadership: mentoring students, leading research projects and workshops, representing their organization at CAES events, and taking the initiative to create stronger bonds among the members of the CAES consortium. Fellows serve two-year appointments during which they are provided with resources and opportunities to drive further collaboration among the CAES entities. From its headquarters in Idaho Falls to spoke locations across Idaho and Wyoming, CAES leverages its collective expertise to inspire innovation and impact, empowering students, faculty, researchers, and industry to accelerate solutions to complex energy issues. The CAES Fellows initiative was launched in spring 2020 to advance this effort. Here are the 2020 CAES Fellows:



RON BORING *Idaho National Laboratory*

A distinguished scientist and department manager for Human Factors and Reliability at INL, Ron Boring has been involved with CAES since its inception, when he led the Human Systems Simulation Laboratory. He has collaborated extensively with the CAES universities and participated in the 2020 CAES Summer Visiting Faculty Program. Boring's CAES collaboration dates to a Laboratory Directed Research and Development (LDRD) award he received jointly with University of Idaho that served as seed money for advanced human-machine interfaces for nuclear power plants. This effort led to an additional LDRD award and DOE funding. Boring joined INL in 2003 and has led research projects for the U.S. Nuclear Regulatory Commission, NASA, the U.S. Department of Energy, the

Canadian Nuclear Safety Commission, the Department of Defense and the Norwegian Research Council.

MIKE BOROWCZAK *University of Wyoming*

Mike Borowczak is the founding director of the Cybersecurity Education and Research Center at University of Wyoming (UW), where he has been an assistant professor of computer science since early 2018. Borowczak has championed several CAES endeavors at the university and has been involved in several efforts in the cybersecurity focus area at CAES. He has served as the UW lead for the pilot CAES Nuclear Safeguards & Security joint certificate initiative, is a member of the CAES Cybersecurity working group, and was recently granted a joint appointment with INL, an arrangement in which a researcher

has formal ties to both INL and a university. Borowczak was a participant in the CAES Summer Visiting Faculty Program in 2020.

BRIAN JAQUES *Boise State University*

Brian Jaques is an assistant professor in the Micron School of Materials Science and Engineering at Boise State University who has been involved with CAES since its opening in 2009, when he worked as a research engineer. He has collaborated on several CAES projects in the Nuclear Energy and Advanced Manufacturing focus areas and is currently the Boise State program manager for the In-Pile Instrumentation Program, an \$8 million DOE-funded collaboration between INL and Boise State that calls for developing novel sensors for in-pile, in-situ measurements in

a nuclear reactor core. Jaques, who recently received an INL joint appointment, is also collaborating on several pending proposals with CAES partners. A participant in the 2019 CAES Summer Visiting Faculty Program, Jaques currently serves as the CAES Nuclear Energy Focus Area lead at Boise State.

LAN LI *Boise State University*

Lan Li is an associate professor in the Micron School of Materials Science and Engineering at Boise State who has been actively involved in CAES seminars, workshops, working groups, and proposal development. She led both sessions of the Remote Summer Boot Camp on Computing, Data and Visualization that were sponsored by CAES and INL's Collaborative Computing Center in summer 2020. Li is collaborating on two projects with CAES entities and has led the development of a computational materials science road map report to identify researchers with expertise in the field, equipment, computational power at the CAES institutions, research needs, and funding sources.

MUSTAFA MASHAL *Idaho State University*

Mustafa Mashal is an associate professor in the Civil and Environmental Engineering Department at Idaho State University who has participated in several collaborative projects with INL and the CAES universities. This includes a project he leads that received a \$1.1 million grant from the Idaho Global Entrepreneurial Mission initiative in 2019. CAES provided seed funding for the project, which calls for the construction of a Disaster Response Complex for research, certification and training first responders. Mashal was a participant in the CAES Summer Visiting Faculty Program in 2019 and is a current member of the Advanced Manufacturing and Energy Policy working groups. He also collaborated this year with the CAES Operations team to pilot a training program for Idaho State students that was modeled after Battelle's Laboratory Operations Safety Academy.

CLAIRE XIONG *Boise State University*

Claire Xiong is an associate professor in the Micron School of Materials Science and Engineering at Boise State who has been a CAES collaborator since 2012, participating in several projects involving INL and the CAES universities. Her current projects with INL include a Laboratory Directed Research and Development project with the Energy Storage and Advanced Transportation group at INL, the In-Pile Instrumentation Program, and a project focused on nuclear materials for molten salt reactors. She is collaborating with researchers at the University of Idaho and University of Wyoming on a project aimed at the development of carbon electrode materials. She also has partnered with INL researchers Erik Dufek and Kevin Gering to write a book chapter on batteries and is the recipient of a National Science Foundation CAREER Award. Xiong has co-organized several CAES workshops and contributed to a CAES Nuclear Energy roundtable in 2020.

CAES unveils new fellowship, names inaugural Fellow



Dr. Veronika Vazhnik was named the inaugural Idaho Science and Technology Policy CAES Fellow. Closely aligned to the mission needs of CAES and INL, this fellowship is one of two offered through the newly launched Idaho Science and Technology Policy Fellowship program, a collaborative effort among University of Idaho, Boise State University and Idaho State University. The Fellows spend a year embedded in an Idaho state government agency, developing and implementing solutions that address challenges in areas such as energy, cybersecurity, water, public health, and economic development. The CAES Fellow will concentrate her efforts on one or more of the focus areas outlined in the CAES Strategy. The goal is to develop a network of leaders who understand government and policymaking and are

prepared to use their knowledge and skills to create a better future, complementing CAES' vision of accelerating energy solutions and creating the next generation of energy leaders.

Vazhnik is a former graduate fellow at INL whose research has focused on bioenergy and landscape design decision-making. She earned her doctorate in biorenewable systems with a minor in operations research from Pennsylvania State University. She began her fellowship in August with the Idaho Office of Energy and Mineral Resources.

The Idaho Science and Technology Policy Fellowship program is led by U of I's McClure Center for Public Policy Research and is modeled on the American Association for the Advancement of Science, Science & Technology Policy Fellowship (AAAS STPF) Program, which brings scientists and engineers into a policy context where their technical knowledge and networks inform the federal government.

RESEARCHER, FACULTY, STAFF, AND STUDENT ACCOMPLISHMENTS

CAES associate director selected for INL post

CAES Associate Director for Boise State **David Estrada** was named INL's Advanced Manufacturing deputy director for Academic Research in September. Estrada's new role calls for him to support and strengthen the Advanced Materials and Manufacturing for Extreme Environments initiative at INL and support multimission collaboration across the five INL directorates. He is charged with leading and cultivating the academic interactions and activities with the manufacturing initiative. This enables collaboration between industry and academia, and positions INL at the forefront of the U.S. Department of Energy's efforts to develop advanced reactor technology. It also strengthens the United States' position as the global leader in nuclear energy technology.

Collaboration has been a hallmark of Estrada's tenure as CAES associate director. Since assuming the role in 2019, he has amplified Boise State's relationship with CAES. He formalized the faculty and student-CAES community at the university by creating campus leads in each of the seven focus areas identified in the CAES Strategy. He championed the CAES Fellows initiative launched in FY20 and has helped lead Boise State students and

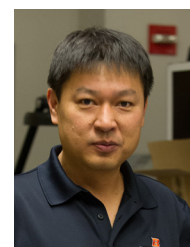


faculty in a litany of accomplishments, including the award of three Nuclear Science User Facilities (NSUF) Infrastructure Awards and two

Nuclear Energy University Program Fellowships. Estrada's leadership has been instrumental in the ongoing development of an advanced manufacturing suite at CAES, which will soon feature a new transmission electron microscope funded by INL and a 3D metal printer made possible by an NSUF-funded, Boise State-led project on which he is a collaborator. An additional benefit of the joint appointment is to provide a national recruiting tool for CAES entities to leverage when seeking to hire top talent to the region and enhance the advanced manufacturing workforce pipeline.

Joint appointments offered to Boise State faculty members

Two Boise State University faculty members with CAES connections were offered joint appointments with Idaho National Laboratory in early 2020: **Brian Jaques**, a materials science and engineering assistant professor who was a cohort in the 2019 CAES Summer Visiting Faculty Program, and **Sin Ming Loo**, an electrical and computer engineering professor who collaborated with CAES to host a cybersecurity workshop in summer 2019. Jaques' research focuses on



nuclear materials and engineering materials for extreme environments. Loo's research focuses on cybersecurity and education.

Two Boise State faculty members with CAES connections receive NSF CAREER awards



Mike Hurley, an assistant professor in the Micron School of Materials Science and Engineering who took part in the CAES Summer Visiting

Faculty Program in 2019, received a five-year, \$500,000 award to further his research of corrosion. **Catherine Olschanowsky**, an assistant professor in the Department of Computer Science who serves as the Boise State campus lead in the CAES focus area of Computing, Data, and Visualization, received an award of more than \$540,000 over five years for research aimed at boosting the efficiency of supercomputers.

Olschanowsky's research calls for collaboration with at-risk teenagers to develop an innovative infrastructure that decreases the execution time of scientific applications without the need for extensive changes to computer code. These changes would remove inefficiencies that occur during translation within supercomputers, optimizing performance.

The goal of Hurley's research on corrosion is to gain a better understanding of the complex interplay between materials and their environment, leading to the development of new methods to predict and assess corrosion, and guidelines for engineers to design new, more reliable materials. Hurley is also a collaborator on the In-Pile Instrumentation Program, a DOE-funded collaborative project between Boise State and INL.

CAREER awards are the National Science Foundation's most prestigious early career awards. They are distinct in that selected faculty must serve as academic role models in research and education and present integrated research and educational plans. While Olschanowsky plans to work with at-risk teens, Hurley will collaborate with K-12 schools and engineering professionals to increase public awareness of corrosion and corrosion control through activities that are being developed. Hurley's grant also will support a unique exchange partnership, expanding opportunities for Boise State students.



U of I professor notches research win

Haiyan Zhao, University of Idaho nuclear engineering assistant professor and CAES resident, received a \$400,000 award from DOE's Nuclear Energy University Program for a project she leads in collaboration with researchers from the University of Utah and University of Nebraska. The project's objective is to improve fundamental understanding of the behavior of multicomponent fission products in eutectic chloride salts for pyroprocessing technology. A complete roundup of research wins for CAES affiliates begins on page 12.

Boise State participating in several new collaborative efforts with INL

CAES' focus on enabling collaboration among its member universities and INL has contributed to several recent collaborative efforts between Boise State and INL, including:

- Hoda Mehrpouyan, an assistant professor in computer science, is working with INL to develop a secure water testbed as part of her research related to the National Science Foundation's CAREER Award she received in April 2019. The \$454,000, five-year CAREER award will allow Mehrpouyan to advance cybersecurity research aimed at protecting critical infrastructure such as water treatment plants.
- Professor Sin Ming Loo with Boise State's Electrical and Computer Engineering Department is working on a cyber culture project involving INL's Char Sample and Boise State's Anthropology Department.
- Professor Marion Scheepers' collaboration with INL's Robert Erbes led to the development of a Vertically Integrated Projects course at Boise State called Security of Portable Devices.
- Peter Risse, associate dean of Extended Studies; Assistant Professor Mehrpouyan; and Math Professor Liljana Babinkostova are participating in INL's Girls Go CyberStart program.
- Babinkostova also is working with INL Researcher Katya LeBlanc to develop a Computing Colloquium discussion that is expected to take place in spring 2021.
- In Spring 2020, Kathy Araújo, director of the Energy Policy Institute and associate professor of sustainable energy systems, innovation and policy, partnered with Kelly Wilson and Ryan Hruska of INL's Infrastructure Assurance and Analysis Group for a new course, 21st Century Opportunities and Challenges in Energy – Strategic Decision-making about Systems Change.

From White House fellowships to INL joint appointments and outstanding student awards, CAES-affiliated professors and students drew notice in FY20.



U of I professor completes White House fellowship



CAES resident **Dakota Roberson**, an assistant professor of electrical and computer engineering at the University of Idaho,

recently completed a yearlong stint in the 2019-2020 Class of White House Fellows. The nonpartisan White House Fellows Program was created in 1964 by President Lyndon B. Johnson to provide professionals from diverse backgrounds an opportunity to engage in public service by serving in various roles in the federal government. Fellows participate in education programs that expand their knowledge of leadership, policymaking and contemporary issues. Roberson was placed at the Department of Defense for the yearlong fellowship. At CAES, he leads an interdisciplinary research team studying electrical grid stability and security, and he is an appointed nuclear engineering affiliate faculty at University of Idaho. Roberson has collaborated with numerous national laboratories, electric utilities, private stakeholders and universities to mitigate 21st century energy system threats. His engineering courses are structured to prepare students for careers in this area. Before joining the University of Idaho, he was with Sandia National Laboratories. In addition to his professorial duties, Roberson promotes science, technology, engineering and mathematics education through secondary school outreach and public speaking engagements to spark the curiosity of young scientists. He also volunteers as an advisor to regional energy infrastructure programs and a tech startup. Roberson was in the first cohort of the CAES Summer Visiting Faculty Program in 2018, and he was integral to launching CAES' monthly Codebreaker seminar series.



ISU dean sworn in as president of the American Nuclear Society

Mary Lou Dunzik-Gougar, CAES resident and associate dean of Science & Engineering at Idaho State University, was sworn in as president of the American Nuclear Society in June. Dunzik-Gougar is an associate professor of nuclear engineering and a senior reactor operator of ISU's Aerojet-General Nucleonics nuclear reactor. She also serves as co-lead of the Nuclear Energy working group at CAES. Dunzik-Gougar previously held a



joint appointment with INL, where she led the Simulation Institute for Nuclear Enterprise Modeling and Analysis fuel cycle modeling project. She

also worked at Argonne National Laboratory with various duties associated with pyroprocessing spent fuel.

CAES collaborator named ISU College of Science and Engineering's outstanding student



Kathryn Hogarth, a civil engineering student at Idaho State University and collaborator on a CAES-inspired project, received the

ISU College of Science and Engineering's Outstanding Student Award in the spring. An undergraduate student with a 3.81 GPA, Hogarth is a member of a team led by ISU Associate Professor/CAES Fellow Mustafa Mashal that is working to build the Disaster

Response Complex in Pocatello. CAES provided seed funding for the collaborative project, which includes INL researchers and received a \$1.1 million grant from the Idaho Global Entrepreneurial Mission initiative in 2019. Hogarth was named ISU Student Employee of the Year in 2018-2019, served as president of the student chapter of the American Society of Civil Engineering for the 2019-2020 school year, is a member of ISU's University Honors Program, and is the goalkeeper for the ISU women's soccer team.

RESEARCH HIGHLIGHTS

The research pillar of the CAES Strategy was a focus in FY20, the second year of the plan's implementation. The results were a significant number of research wins and developments aimed at gathering momentum for impactful collaborative proposals, incentivizing new and existing one-on-one collaborations, and enabling more complex collaborations in the pursuit of research hubs. Among the goals in FY20 was to grow new capabilities in the CAES facility that would provide new value and draw faculty, students and researchers into the laboratories and offices. Efforts on this front included:

- Installing a 4.7-kilowatt research wind turbine outside of CAES headquarters that feeds generation data to DOE's Microgrids, Infrastructure Resilience and Advanced Controls Launchpad program and Wind for Schools. The turbine is virtually connected to a microgrid at INL's Energy Systems Laboratory. The installation of the 70-foot tall turbine in January made the front page of the Idaho Falls newspaper.
- In July, CAES hosted a virtual groundbreaking ceremony for a \$5 million project to install a new Transmission Electron Microscope (TEM) in the CAES facility. The TEM is expected to be operational in early 2021 and represents the most technologically advanced TEM resource across the CAES complex (energy/



spatial resolution, dynamic capture, broad electron range). This benefits the CAES universities, Nuclear Science User Facilities (NSUF), and several aspects of INL's mission and its Advanced Materials and Manufacturing for Extreme Environments initiative.

- The TEM will be a key feature in developing an Advanced Manufacturing Suite at CAES, complimented by the installation in FY21 of a 3D metal printer that will establish CAES' capability to additively manufacture metallic nuclear grade materials at CAES and within the NSUF network.
- Funding for the printer came via an NSUF award granted to Boise State University faculty member Mike Hurley for a project that sprung from Hurley's participation in the CAES Summer Visiting Faculty Program in 2019.
- CAES leadership and staff continue to prioritize and support the installation of a state-of-the-art NuScale power plant control room simulator, the result of a \$285,000 Nuclear Energy University Program (NEUP) award in FY19 to a University of Idaho-led project, *Multi Universities SMR Simulators: NuScale*. Rich Christensen, UI's Nuclear



Engineering Department director, is the project's principal investigator.

- Outside the CAES facility, construction began in summer 2020 on the Disaster Response Complex, a collaborative project involving Idaho State University and INL. This will lead to a regional/national training center complex in Pocatello that mimics the features of a structure collapsed by an earthquake, hurricane or other natural disaster, for the research, certification, and training of first responders. ISU was awarded \$1.1 million from the Idaho State Board of Education's Idaho Global Entrepreneurial Mission in summer 2019 to build the complex. Seed funding for the project came via a 2018 CAES program development award and a 2018 CAES Collaboration Fund award. The collaboration between INL and ISU provides expertise in chemical, biological, radiological, and nuclear research.

Collaboration funds recipients announced

CAES announced the 2020 recipients of \$139,000 in CAES Collaboration Program Development Funds in May and nearly \$116,000 in seed grants through the ISU-CAES Collaboration Fund. These initiatives are designed to help establish collaborative relationships between INL researchers and the CAES universities in research, education, and innovation, by directing funds to INL principal investigators and ISU project leads. After reviewing the submissions, CAES leadership determines which proposals are best suited to enhance collaborative relationships among the CAES entities in at least one of the seven focus areas outlined in the CAES Strategy. High priority was given to projects with a tie to future direct-funded work such as through a DOE solicitation. CAES congratulates the following teams:

CAES Collaboration Fund:

Advanced Manufacturing

- Rare Earth Elements, INL researchers Donna Baek and Mary Case, Energy & Environment Science & Technology (Caleb Hill, University of Wyoming)
- Atomic Layer Deposition, INL researchers Mary Case and Robert Fox, Energy & Environment Science & Technology (Elton Graugnard, Boise State)

Innovative Energy Systems

- Non-Thermal Plasma, INL researcher Hongqiang Hu, Energy & Environment Science & Technology (Haiyan Zhao & Sarah Xiao, U of I)

Computing, Data & Visualization

- Virtual Reality, INL researchers Rajiv Khadka & John Koudelka, Nuclear Science & Technology (Mustafa Mashal, ISU)

Nuclear Energy

- Molten Salt Nuclear Batteries, INL researcher Piyush Sabharwall, Nuclear Science & Technology (Rich Christensen, U of I, and Dan LaBrier, ISU)

Innovative Energy Systems

- Unique Carbon Materials, INL researcher Eric Dufek, Energy & Environment Science & Technology (Patrick Johnson, University of Wyoming)

ISU-CAES Collaboration Fund

Advanced Manufacturing

- Arch Culvert Bridges, ISU researchers Bruce Savage, James Mahar, Mustafa Mashal, Arya Ebrahimpour, Civil Engineering (Gabriel Ilevbare, Chris Wright and Richard Boardman, INL)
- Boron Nitride Films, ISU researcher Rene Rodriguez, Chemistry (Kris Campbell, Boise State; Mary Case and Robert Fox, INL)

Nuclear Energy

- Heat Exchanger Technology, ISU researcher Amir Ali, Nuclear Engineering (Piyush Sabharwall, INL)
- Ionic Liquid Synthesis, ISU researcher Kavita Sharma, Chemistry
- Molten Sodium Testing Program, ISU researcher Dan LaBrier, Nuclear Engineering (Colby Jensen, Bryce Kelly and Nic Woolstenhulme, INL)
- Reactor Transient Diagnostics, ISU researcher Leslie Kerby, Computer Sciences (Bob Borrelli, U of I)
- Wettability Measurements, ISU researchers Mary Lou Dunzik-Gougar, Amir Ali and Dan LaBrier, Nuclear Engineering (Yaqiao Wu, Boise State)



This is a simulation of the control room of a NuScale nuclear power plant, similar to the simulator that will be installed at CAES.

Working groups

Funds were awarded to working groups in the seven CAES Strategic Focus Areas – nuclear energy, advanced manufacturing, cybersecurity, energy-water nexus, innovative energy systems, energy policy, computing/data/visualization – with a priority on creating researcher-led initiatives. Working groups accomplished the following in FY20:

Six organizing workshops

- A workshop and roundtable held by the advanced manufacturing working group on Boise State University's campus in early March drew representatives from several outside organizations, including NASA, Oak Ridge National Laboratory, Air Force Research Laboratory, Boeing, Hewlett Packard, Fiberguide, Optomec and NIST.
- Nearly 200 people registered for a half-day, virtual workshop hosted by the CAES Energy Policy working group. The event featured a panel discussion on energy policy, jobs, industry conditions and economic challenges during the COVID-19 pandemic. The panel was among the highlights of a virtual workshop hosted by the CAES policy working group. The discussion featured John Kotek, Nuclear Energy Institute Policy Development and Public Affairs vice president; Marc Chupka, U.S. Energy Storage Association Research and Programs vice president; and Elise Hunter, Grid Alternatives Policy and Regulatory Affairs director.
- The cybersecurity working group held a workshop in late April, a daylong event that featured three breakout sessions and updates from each of the CAES entities on cyber-related initiatives.
- Technical workshops were held on topics including hydropower; energy storage; regional models of cyber cooperation; and carbon capture, utilization, and storage.

Three roundtables were held to shape future federal funding, convening small groups of thought leaders to write a white paper outlining a pitch to a federal partner for a national-level workshop hosted by CAES, to inform a future agency funding opportunity. White papers emerged from three working groups: cybersecurity, nuclear energy, and advanced manufacturing.

- Written by representatives from INL, University of Idaho, and Boise State University, the Cybersecurity working group's white paper, "Industry 4.0: Emerging Cybersecurity Threats & Challenges," calls for a workshop that would help foment novel ideas and build new partnerships with diverse researchers across disciplinary fields. The two-day event will feature keynotes, panels and breakout sessions with an estimated 150 participants interested in developing cybersecurity solutions to threats that emerge with the development of new technology, particularly smart and connected manufacturing innovations.
- The Nuclear Energy working group's white paper, "Advanced Reactor Technology Initiatives: Bridging the Gap from Microsamples to Macrostructure," calls for revolutionizing the characterization and design processes of advanced reactor technology, potentially shortening the time to licensing for the next generation of nuclear power plants. Advanced reactor technology provides the nation with many strategic advantages and is needed for the U.S. to maintain its position as a global leader in nuclear energy. Based on this, the white paper, written by CAES Associate Director for University of Idaho John Russell, focused on the need to develop cost-competitive reactor technology to replace the nation's fleet of aging light water reactors.
- The Advanced Manufacturing working group was invited to submit a proposal for a NSF Future Manufacturing workshop based on its white paper, "Accelerating the Discovery and Qualification of Intelligent Materials and Methods for Extreme Environments." The paper calls for support for a national workshop to envision solutions to four interrelated future manufacturing challenges for the nuclear power sector. Since the development of new technology and a skilled workforce is critical to the success of future manufacturing in the region, the white paper states, the advice of experts would be invaluable for accelerating discovery and qualification of intelligent materials and methods in extreme environments.



Working groups established in the seven focus areas outlined in the CAES Strategy made significant progress in FY20 on efforts to enhance collaboration among the CAES entities.

The workshop would allow for the development of novel ideas and new partnerships with diverse researchers across disciplinary fields and at every career stage.

- White papers were also produced on these topics: bulk storage of hydrogen; a holistic approach to examining hydroelectric dam viability: economics, public health and environment; distributed pumped hydropower storage; and remote sustainability niches and microreactor potential in rural economic and agricultural development.
- The Cybersecurity working group produced a draft charter for the Cyber Resilience Innovation Council, which envisions Idaho as the nation's industrial cybersecurity resilience hub of expertise while developing a cooperative model and set of best practices that can be leveraged across the U.S. The council would promote the region's prosperity and resilience by creating pilot programs and partnerships designed to advance cybersecurity while building new partnership methods. It also would develop a talent pipeline for the cybersecurity field and support workforce development efforts by providing immersive learning environments and experience-based training programs.

Proposals/reports/white papers funded by CAES include:

Advanced manufacturing (\$22k):

- Proposal by Indrajit Charit (U of I) and Brian Jacques (Boise State)
- White paper by Mustafa Mashal (ISU), Kunal Mondal (INL) and Michael McMurtrey (INL)

Cybersecurity (\$22k)

- Technical workshop report by Justin Wood (ISU) and Ron Fisher (INL)
- Proposal by Sean McBride (ISU), Rob Beason (INL) and Eleanor Taylor (INL)

Energy policy (\$14k)

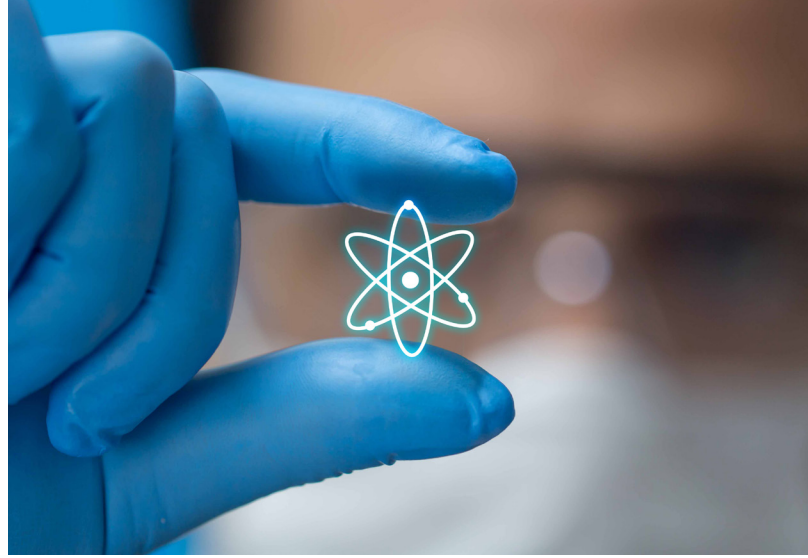
- White paper by Irene van Woerden (ISU), Bruce Savage (ISU), Mustafa Mashal (ISU), and Kathleen Araújo (Boise State)
- White paper by Steven Peterson (U of I), David Shropshire (INL), Geoffrey Black (Boise State), and Kathleen Araújo (Boise State)

Energy-water nexus (\$7k)

- Technical workshop report by Karen Humes (U of I) and Bruce Savage (ISU)

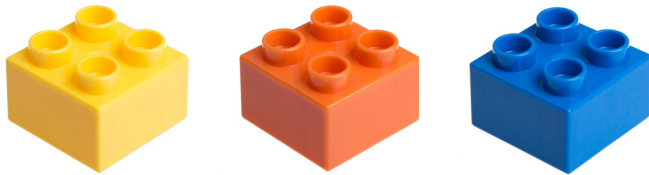
Research wins

- Amir Ali, an assistant professor of nuclear engineering at Idaho State University, is leading a project in collaboration with fellow ISU faculty members Dan LaBrier, Chad Pope, and Jonathan Scott to upgrade the AGN-201M nuclear reactor at ISU. The project was one of 21 university-led projects awarded infrastructure grants through DOE's Nuclear Energy University Program (NEUP) to perform research reactor and infrastructure improvements. The reactor at ISU is essential to advancing the nuclear engineering science knowledge and serves as a fundamental tool in training reactor operators. This allows students to gain valuable experience before entering the nuclear workforce. Ali's project, which received a \$59,262 award, calls for replacing the control rod drive mechanism on the half-century-old reactor with a newly developed alternative. The new design reduces complexity and probability of failure, and it improves the overall reliability and safety of the reactor.
- University of Idaho faculty member R.A. Borrelli, assistant professor of nuclear engineering, will help lead a \$1 million Nuclear Energy Enabling Technologies-funded project in partnership with Brookhaven National Laboratory to build an adaptive control and monitoring platform for autonomous operation of advanced nuclear reactors. Researchers will develop an artificial intelligence-based platform that can support autonomous control of advanced reactors. The platform will use and integrate information from multiple sensors and support systems to issue appropriate commands to plant systems to keep the reactor within a safe operating envelope and avoid unnecessary shutdown. The work will include a cost-benefit analysis to evaluate the performance of the platform and the anticipated cost savings from its deployment.
- ISU Dean Mary Lou Duzik-Gougar and ISU professor Dan LaBrier, CAES-affiliated faculty members, are collaborators along with INL researcher Wen Jiang on a project led by a researcher at University of Wisconsin that received an \$800,000 NEUP award. The goal of the research is to gain a mechanistic understanding of and develop a predictive model for the tearing of the buffer layer in tristructural isotropic fuel particles.
- CAES Fellow Ron Boring of INL is a collaborator, along with INL researcher Vaibhav Yadav, on a University of Tennessee-led project that received an \$800,000 NEUP award to develop a holistic artificial intelligence tool to increase the detection and mitigation of human factors errors in nuclear power plants.



- ISU research professor Richard Schultz and Don McEligot, an INL researcher and visiting professor with U of I, are collaborators on a project led by a researcher at City University of New York. The project aims to generate an experimental database for validating models used to analyze high-temperature gas reactors, to ensure passive cooling occurs when there is a loss of forced circulation or pressure. The project, which also includes industry partner Framatome, received \$800,000 in NEUP funding.
- U of I chemical engineering professor Indrajit Charit received a three-year, \$799,950 NEUP award, in partnership with University of Nevada, Reno, to make spent nuclear fuel short-term storage safer by better understanding how welds on stainless steel fuel canisters respond to compressive stress, surface texture modification and corrosion. Charit also is a collaborator on a project led by Boise State's Brian Jaques that won an award through the Idaho Global Entrepreneurial Mission last year.
- A team led by researchers from INL and U of I received a two-year, \$1.5 million award through DOE's Energy Technology Commercialization Fund. The project, Development of a Prototype Control Room for an Advanced Reactor Vendor, is led by Ron Boring and Thomas Ulrich at INL; Roger Lew, a research assistant professor of virtual technology and design at U of I; and industry partner Kairos Power. It calls for the use of an INL-developed and copyrighted simulation tool, the Rancor Microworld. The tool would create a prototype of the control room for the Kairos Power reactor, a fluoride salt-cooled high-temperature small modular reactor designed to compete with natural gas for electricity generation. This is a critical step to ensure the proper design of control rooms for advanced reactor designs now under development.
- Boise State's Mike Hurley, in collaboration with INL researcher Donna Guillen, CAES Associate Director to Boise State David Estrada, and Boise State assistant professor Brian Jaques, led a project that received a NSUF award and will lead to the installation of a 3D metal printer at CAES for nuclear grade materials. The project emerged from the CAES Summer Visiting Faculty Program in 2019.

- Edoardo Serra received a grant for the project that emerged from his participation in the CAES Summer Visiting Faculty Program. Serra, an assistant professor in Boise State's Computer Science Department, was one of 18 visiting faculty in the visiting faculty program's first full year in 2019. He collaborated with INL researcher Shane Stailey from INL's National and Homeland Security Directorate on a project that covered two CAES focus areas: cybersecurity and computing, data, and visualization. The project calls for the creation of a framework for outreach activities to help teachers inspire students in grades 5-8 to pursue careers in cybersecurity. The outreach utilizes Lego Mindstorms in the field of cyber-physical system security and controls to spark interest. Lego Mindstorms kits allow students to build programmable robots using a brick computer that controls the system, plus sensors, motors, and Lego pieces. The project received a \$25,000 grant through



- a public-private partnership between Battelle Corporate Education Giving Funds and Idaho STEM Action Center.
- A project led by CAES Associate Director to Boise State assistant professor Brian Jaques and Boise State David Estrada received an award through the Idaho Global Entrepreneurial Mission grant program initiative. Jaques is the principal investigator on the project, Scalable Manufacturing of On-Chip Color Tunable Lasers, which calls for collaboration with industry partner Iris Light Technologies to design and develop materials for efficient and cost-effective lasing solutions. Boise State's role is to develop scalable processes to create nanomaterial inks from low-cost commodity materials in collaboration with the company's effort to commercialize a hybrid silicon nanomaterial laser produced with additive manufacturing printing of photonic inks.
- A project involving Boise State and INL, led by industry partner Applied Nanotech, was selected for a Phase I DOE award of \$199,999 from the SBIR and STTR Programs Office within the DOE Office of Science. The project, Printed Sensor for Monitoring Reactor Health, calls for the development of innovative sensors to better monitor nuclear power plants, improving efficiency while reducing operations and maintenance costs. The project's first phase focuses on developing materials for printing multimodal sensors that can survive in extreme environments like those found at nuclear power plants. Manufactured with a 3D printer,

the durable, low-cost sensors could be used for monitoring and controlling reactors and fuel cycle facilities. They can be directly printed onto fuel, cladding and structural components, and they would lead to efficiency gains and improved reliability in new and existing reactors. This creates cost savings. Other potential benefits include new materials and sensors for automotive, aerospace, renewable energy and manufacturing sensors and components for extreme environments.

Research wins (CAES affiliates)

- Dan Deng, assistant professor in Boise State's Department of Mechanical and Biomedical Engineering; Haarish Subbaraman, assistant professor in Boise State's Electrical and Computer Engineering Department; and CAES Associate Director for Boise State David Estrada were awarded \$100,000 through the FlexTech Consortium for a project that calls for printing flexible piezoelectric sensors and energy harvesters.
- Subbaraman and Estrada also collaborated on a project awarded \$200,000 through NextFlex, the Flexible Hybrid Electronics Manufacturing Institute in the Department of Defense's Manufacturing Technology Program, for a project involving an Advanced Flexible Hybrid Demonstrator for Unmanned Aerial Vehicle applications.
- University of Wyoming associate professor Jon Brant received a \$1 million grant from DOE for a project to develop new membrane technology that could be used to treat produced water, or water that surfaces during hydraulic fracturing. Produced water is currently seen as a waste product in the natural gas industry, but Brant's project could change that by enabling the produced water to be reused in industrial applications. Brant's project, Resource Recovery and Environmental Protection in Wyoming's Greater Green River Basin Using Selective Nanostructured Membranes, got underway in early 2020. Some of the research is expected to be conducted in the CAES facility. Brant is co-lead of the CAES Energy-Water Nexus working group.
- Boise State's College of Engineering and Division of Extended Studies collaborated to secure a grant from the Idaho Workforce Development Council allowed them to create an online cyber-physical systems security certificate. The \$833,958 grant covered costs related to starting up and developing the program, which launched in fall 2020.



EDUCATION HIGHLIGHTS

The education pillar was focused on the first-ever CAES joint certificate this year. CAES successfully completed the second year of a three-year plan to launch the pilot Nuclear Safeguards & Security joint certificate in fall 2021 by completing the course development, creating a road map, writing a business model, securing the support of university leadership, ensuring the participation of INL’s Cybercore and Collaborative Computing Center, and beginning final administrative streamlining with university provosts and registrars.

CAES Summer Visiting Faculty Program completes third year

The CAES Summer Visiting Faculty Program completed its third year in August with 11 faculty members from CAES universities partnering with INL researchers to develop proposals in one of the CAES focus areas. The program is designed to create robust connections between the faculty members and INL researchers, creating long-term impact to the universities and INL; to bring in external funding to complete innovative and inspiring research, providing value to the institutions, INL, and the funding agency; and to facilitate student integration into joint research. Participants work together throughout the summer to produce a ready-to-submit CAES-branded proposal or, if a funding opportunity is not yet open, an extensive white paper.

CAES co-sponsors data science events



Sponsored by CAES and INL’s Collaborative Computing Center, Remote Boot Camp: Computing, Data, and Visualization I and II drew more than 300 people. The virtual, collaborative symposiums drew representatives from every CAES entity and featured workshops on Software Carpentry and Computational Modeling and Data Science, and panel discussions. The goal was to advance CAES’ efforts related to workforce development by sustaining continuing education among young researchers in order to maintain the skills and abilities needed for success in all aspects of advanced energy research and development.

CAES hosts panel discussion on journal writing



CAES hosted a panel discussion on journal writing in late February that sold out the day registration went live. The discussion featured panelists from CAES universities and INL and provided students, faculty, and early-career researchers with information to help them navigate the process of developing and submitting their work for publication. The Science of Science Writing: Effectively Communicating Through Journal Publications was held as part of the CAES Academy outlined in the CAES Strategy. CAES Academy serves as a construct for creating new joint educational offerings through the CAES universities and INL, to not only help build a future workforce with the skills and relationships needed for success but also to provide specialized training offerings for the current workforce. The goal of the panel discussion was to help CAES universities and INL maximize the quality and caliber of research in order to optimize its impact. The panelists provided attendees with the principles and effective tactics for developing and submitting a journal article that has high likelihood of being accepted. Topics ranged from ethics to references, available resources to traceability. Steve Hartenstein, chief science officer for INL's National and Homeland Security Science and Technology Directorate, served as moderator, and the panelists included Lyle Castle, ISU's vice provost for Academic Outreach and dean for Idaho Falls and a former editor for the Journal of Heterocyclic Chemistry, and David Petti, emeritus laboratory fellow at INL.

LOSA training held at ISU

Idaho State University collaborated with INL and CAES to offer six, four-hour sessions of the Laboratory Operations Supervisor Academy (LOSA), an innovative training program developed by Battelle Memorial Institute, the organization that operates INL and seven other national laboratories. LOSA utilizes simulations and scenarios, with participants assuming various roles, to build and maintain a safety culture at INL and other Battelle-operated national laboratories. The pilot program at ISU was led by Mustafa Mashal, associate professor and CAES Fellow, and Jared Cantrell, research engineer and lab manager in the Department of Civil and Environmental Engineering at ISU, and consisted of six LOSA sessions held over three days in late August. Despite uncertainties related to the pandemic, attendance was at capacity. The successful effort has led Mashal and Cantrell to work with CAES and ISU to make the training available to other interested CAES

students, faculty and staff. The training is an example of CAES' ability to leverage one of its member's expertise for the benefit of other CAES entities. The goal is to expand this best-practice safety training to other CAES universities as CAES fulfills its vision of training the next generation of energy leaders. As an offering of the CAES Academy outlined in the CAES Strategy, LOSA training could one day allow CAESers to gain certification or a safety training designation on student transcripts.

U of I-Idaho Falls team wins CyberForce competition

The University of Idaho-Idaho Falls team took first place in DOE's CyberForce Competition at INL's Energy Innovation Laboratory in Idaho Falls. The local competition drew contestants from nine teams representing regional universities, including all of the CAES universities. There were several CAES connections among the competitors, including UI-Idaho Falls advisers Joe Leister, who formerly worked

in the Applied Visualization Laboratory at CAES; Michael Haney, a U of I-INL joint appointee with an office in CAES; ISU's Sean McBride, an ISU-INL joint appointee; UW's Mike Borowczak, a CAES Fellow and frequent collaborator; and Boise State's Sin Ming Loo, who recently led a Cybercore/CAES cybersecurity workshop. The annual CyberForce competition is an interactive, scenario-based event in which teams engage in cybersecurity activities in collaboration with INL staff. The goal is to increase hands-on cyber education of the college students and professionals while boosting awareness of the critical infrastructure and cybersecurity nexus and developing a better understanding of cybersecurity in real-world scenarios.

The pandemic failed to impede the progress of several CAES initiatives in the education pillar in FY20.

STUDENTS IN THE LAB

Boise State University students recognized

Boise State student **Kiyo Fujimoto**, an INL Graduate Fellow, received a national appointment with the Students, Post-Doctoral and Early Career Professionals Subcommittee of the President's Council of Advisors on Science and Technology.



Kaelee Novich, a Boise State student of Boise State Professor and CAES Fellow Brian Jaques who began her Ph.D. studies in fall 2020, received an internship through Washington Internships for Students of Engineering. Novich applied to the program under the mentorship of Jaques and CAES Director Noël Bakhtian. The prestigious internship program consists of outstanding third- or fourth-year engineering/computer science graduate programs chosen from a nationwide pool of applicants. Novich was president of Boise State's Speech and Debate Team, which went undefeated for two consecutive years. She completed an internship at INL in 2019.

Novich and fellow Boise State student Kati Wada were awarded fellowships through the Department of Energy-Office of Nuclear Energy's Integrated

University Program in 2020. The two were among 34 students nationwide to receive one of the prestigious three-year fellowships, which provide \$52,000 per year for graduate studies along with a \$5,000 stipend to complete a summer fellowship at a DOE national laboratory or other approved research facility to strengthen the ties between students and DOE's energy research programs. Novich's fellowship has enabled her work with Jaques, the Boise State faculty lead on nuclear energy at CAES who's the principal investigator on the In-Pile Instrumentation Program at INL, a collaborative project between Boise State and INL. Wada's fellowship will enable her to continue to work with CAES associate director for Boise State David Estrada, an associate professor in the Micron School of Materials Science and Engineering. Her research focuses on modeling temperature and thermal conductivity for nuclear in-pile measurements and developing new instruments that will allow scientists to look into a nuclear reactor's core and observe never-before-measured phenomena.

U of I student receives NEUP fellowship



Kristen Geddes, a CAES resident and graduate student pursuing her Ph.D. at U of I, also received a fellowship through the NEUP program.

Geddes serves as president of the American Nuclear Society's Student Section. Her research is on a molten salt nuclear battery, with a focus on closing the fuel cycle.

Intern prize winners from Boise State University and U of I



Two students from the CAES universities fared well at INL's 2020 Intern Poster Session, which featured more than 50 posters and eight technical presentations. **Ember Sikorski** from Boise State was named the winner of best technical presentation by a panel of technical reviewers, and University of Idaho student **Graeme Holliday** won for best poster in the business, communication, and support operations category.

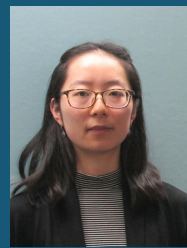
Boise State University student lands 2020 Innovations in Nuclear Technology R&D Award



Boise State Ph.D. candidate in materials science and former INL intern **Ember Sikorski** won a 2020 Innovations in Nuclear Technology R&D Award in June. The award is through DOE's Office of Nuclear Technology Research and Development.



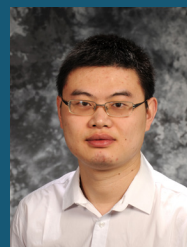
"I had a few ideas, but there are so many wildfires I thought this would be something that could save money and save lives," said Xingyue Yang, winner of the first-ever CAES Annual Pitch Event.



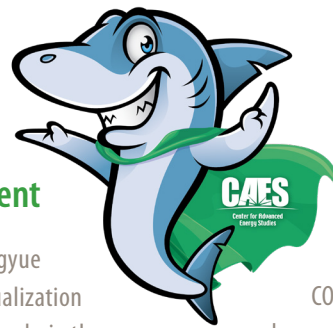
Xingyue Yang



Richard Skifton



Bo Zhang



CAES launches Baby Shark Tank event

CAES resident Xingyue Yang, an INL visualization researcher who works in the Applied Visualization Laboratory at CAES, won the inaugural CAES Annual Pitch Event (CAPE), also known as Baby Shark Tank. Yang's idea to use unmanned aerial vehicles to create enhanced visualization capabilities to train firefighting forces beat out nine other finalists in the competition, including several other CAESers.

access to training via the CO*STAR and Rapid Idea Improvement Session (RIIS) methods. The field was narrowed to 18 in early September, and the finals featured 10 participants competing for cash prizes worth nearly \$4,000. During the finals competition in late September, each finalist had five minutes to pitch their idea to a panel of judges: INL Deputy Laboratory Director for Science and Technology and Chief Research Officer Marianne Walck; ISU Acting Vice President for Research and Economic Development Donna Lybecker; INL Industry Engagement Director and Chief Commercial Officer Corey McDaniel; Nicolas Miller, executive director of the Venture College at Boise State University; and Nick Crabbs, co-chair of Boise Startup Week and a founding member of VYNYL. Yang won the \$1,500 first-place prize for her idea to use drones equipped with thermal sensors and cameras to collect the data needed to create an enhanced visualization capability that would enable firefighters and fire managers to visualize real-time wildfire simulations in a 3D/immersive environment. The second-place winner, INL researcher Richard Skifton, won \$1,000 for his idea: a sublime temperature sensor that measures temperature profiles by precisely locating specific temperatures of interest. INL researcher Bo Zhang was the third-place finisher, receiving \$750 for his idea for a state-of-the-art electromagnetic shield that would allow for safer charging of electric vehicles. Skifton also won the People's Choice award, a \$500 prize.

INNOVATION HIGHLIGHTS

The CAPE/Baby Shark Tank combined elements of the three pillars of the CAES Strategy – research, education, and innovation. Everyone in the CAES community was eligible to participate – students and faculty at the universities and researchers at INL – and CAPE was open to all levels of ideas, from early-stage concepts to investment-ready research. Designed to help transfer the innovation and research that thrive at CAES from the laboratory to the commercial sector, the goal of this year's CAPE/Baby Shark Tank event was to teach the participants how to convince others – funding agencies, potential industry partners, or even investors – to take action in support of an idea. The competition began in August with 33 registrants, with each offered

CAES ENERGY POLICY INSTITUTE



CAES Energy Policy Institute hosts 9th annual conference

The CAES Energy Policy Institute held its 9th annual Energy Policy Research Conference in October 2019.

The theme of the three-day event was “Energy Decision-Making in Times of Disruptive Change.” More than 150 people registered for the event, which included keynote speakers Carol Battershell, the former principal deputy director in the Department of Energy’s Office of Policy; Mitch Colburn, resource planning and operations director for Idaho Power; Barbara Lockwood, vice president of regulation for Arizona Public Service Company; Boise State University President Marlene Tromp; and CAES Director Noël Bakhtian. EPI’s annual conference examines the drivers and impacts of policy in energy-related systems, allowing attendees to explore

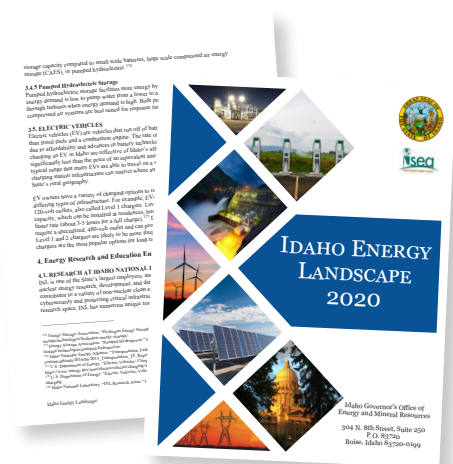
issues and opportunities while fostering in-depth crosscutting exchanges of ideas. It brings together leading researchers, policymakers, industry practitioners, students and members of the private sector. Attendees included John Kotek, vice president of policy development and public affairs with the Nuclear Energy Institute; Zachary Tudor, associate laboratory director

at INL; Desmarie Waterhouse, vice president of government relations and counsel for American Public Power Association; and Fouad Khan, associate editor for Nature Energy journal.

The 10th annual conference, now known as the Energy Policy Conference, was postponed due to the COVID-19 pandemic.

CAES, CAES Energy Policy Institute featured in publications

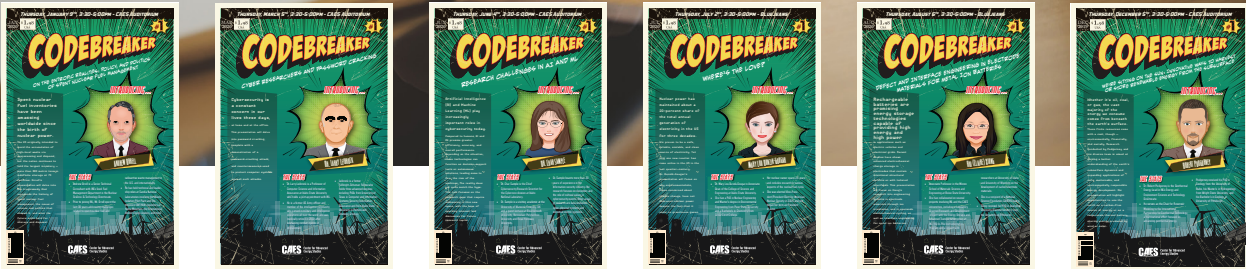
EPI’s 9th annual Energy Policy Research Conference was the focus of a special issue of The Electricity Journal. The special edition features seven research articles focusing on a range of issues, including the nexus between energy policy and national security, energy storage systems, fuel supply chains in the Western Interconnect, and national policy approaches for addressing climate change. The conference was held in fall 2019 in Boise and drew attendees from throughout the world.



CAES and EPI were featured in Idaho Energy Landscape 2020, produced by the Governor’s Office of Energy and Mineral Resources. CAES and EPI are featured in Idaho Energy Landscape 2020, a 65-page document produced by the Idaho Governor’s Office of Energy and Mineral Resources. The document addresses all aspects of the state’s energy sector, from consumption and prices to production, utilities and regulatory agencies. EPI also is mentioned in Exploring

Opportunities for Collaboration among U.S. University Energy Institutes, a 143-page document that provides an overview of the status of U.S. academic energy institutes and details opportunities and challenges surrounding the formation of a collaborative network of institutes.





MEETINGS, OPEN HOUSES, SEMINARS, AND SPEECHES

Codebreaker

CAES launched the Codebreaker seminar series in 2018 to provide a forum for students and researchers to address their work, communicate opportunities and challenges to a receptive audience, and to increase dialogue among CAES affiliates leading to further interdisciplinary collaborations and new groundbreaking research. Held on the first

Thursday of each month, Codebreaker is an engaging presentation and Q&A forum that covers a range of topics in energy science, engineering, business and policy. The schedule in FY20 was disrupted by the pandemic, which forced the move to a virtual format. The presenters along with their affiliations and area of expertise are as follows:

Jason Barnes
U of I, Nuclear Energy

Mary Lou Dunzik-Gougar
ISU, Nuclear Energy

Duke Henningsen
INL/U of I, Human Performance Improvement initiative

Larry Leibrock
INL/ISU, Cybersecurity

Andrew Orrell
INL, Nuclear Energy

Rob Podgorney
INL, Energy-Water Nexus

Char Sample
INL, Cybersecurity

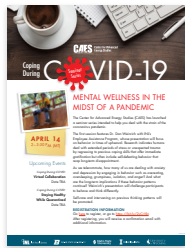
Andrew Slaughter
INL, Computing, Data, & Visualization

Claire Xiong
Boise State, Innovative Energy Systems

CAES-Cybercore Cybersecurity Talks

Before going on hiatus in the spring, this series was held monthly with the intent of furthering the collaborative objectives outlined in the CAES Strategy while bolstering Cybercore’s mission of protecting critical infrastructure systems from an always-evolving threat landscape. Among the seminars in FY20 was a session in April that featured seven lightning presentations by University of Idaho professors and graduate students highlighting the capabilities of RADICL, a cybersecurity research lab developed and maintained by the Center for Secure and Dependable Systems for more than 15 years at U of I’s main campus in Moscow and over the last few years at the Idaho Falls Center. Each presenter had 20 slides and 20 seconds to explain each slide.

Coping During COVID



CAES held a series of virtual seminars in FY20 to help students, researchers, and faculty contend with the pandemic.

The first seminar, Coping During COVID: Mental Wellness in the Midst of a Pandemic, featured a presentation by Dan Weinrich, counselor with the INL Employee Assistance Program, that addressed behavior in times of upheaval.

The second installment, Coping During COVID: Nutrition Wellness through Mindful Eating, featured a presentation by Natalie Christensen, Idaho State University sports dietitian, which focused on the ways in which nutrition is interwoven into every aspect of wellness and the ways that we can be mindful about our food choices and our relationships with food.

The third and final seminar, Coping During COVID: Keeping Physically Active During COVID-19, featured Leslee Blanch, a family and consumer science associate extension educator for the University of Idaho Bonneville County Extension. She discussed the importance of physical activity even in the midst of a pandemic.

Solve Climate by 2030



More than 150 people, from elementary school students to retirees, in Idaho and Wyoming, tuned in to an interactive, online event hosted by CAES that focused on ways to combat climate change locally. The CAES event was one of 52 seminars held

in all 50 states through the Solve Climate by 2030 initiative. CAES represented Idaho and Wyoming at the event, which featured expert panelists from both states sharing climate change solutions. Among the panelists were Kipp Coddington, director of the Center for Energy Research and Policy Analysis at University of Wyoming, and INL's Shannon Bragg-Sitton. The panel discussion was followed by participants sharing their action ideas and voting live for the top three solutions. The goal was to come up with three ambitious but feasible actions that need to take place in Idaho and Wyoming to tackle climate change by 2030.

Collaborative Research Hubs



CAES hosted a panel discussion on winning collaborative research hubs in November 2019. The event filled the CAES auditorium and was streamed live by dozens, including groups at University of Wyoming and Boise State University. Moderated by Todd Combs, INL's associate lab director for Energy and Environment Science and Technology, the event featured several panelists who are currently directors or deputy directors of Energy Frontier Research Centers (EFRs), or collaborative research hubs that receive DOE funding, including University of Wyoming Associate Professor Jon Brant, INL Laboratory Fellow Dave Hurley, and INL Directorate Fellow Simon Pimblott. Also serving as panelists were Andrew Schwartz, DOE's senior technical adviser for EFRs, and John Russell, CAES associate director for University of Idaho. The panelists shared winning strategies for forming teams, creating proposals, and applying for collaborative research hubs such as EFRs.



Events

CAES hosts legislative breakfast in Washington, D.C.

A CAES contingent visited Washington, D.C., in mid-February to host the Idaho Industries Breakfast, meet with DOE officials, and gather information related to the innovation pillar outlined in the CAES Strategy. The state's congressional delegation attended and spoke at the breakfast – senators Mike Crapo and James Risch and congressmen Mike Simpson and Russ Fulcher – along with dozens of Idaho industry representatives. CAES Director Noël Bakhtian updated attendees on CAES' efforts related to workforce development. Members of the CAES contingent, which included Bakhtian; Steering Committee members Harold Blackman from Boise State University and Scott Snyder from Idaho State University; CAES Associate Director for Idaho State University David Rodgers; CAES Associate Director for University of Idaho John Russell; and CAES Energy Policy Institute Director Kathleen Araújo, also met while in the nation's capital with staffers from the Idaho delegation and representatives from Nuclear Energy University Program, Johns Hopkins University's Technology Ventures, WeWork Labs, DOE's Office of Workforce Development for Teachers and Scientists, National Science Foundation's Established Program to Stimulate Competitive Research Section, Halcyon Incubator, and DOE's Clean Energy Education and Empowerment Initiative.



CAES hosts Winter collaboration event

Approximately 145 people registered for the annual Winter Collaboration Meeting at CAES in late January. Sponsored by CAES, INL, and National University Consortium, the event featured an update on INL's Laboratory Directed Research and Development Program, and breakout sessions on a range of topics, including Integrated Energy Systems, Nuclear Energy, Proposal Writing, Industry Engagement, and Advanced Manufacturing. The goal of the meeting was to help faculty and INL researchers establish collaborative networks and learn about opportunities for collaboration.



CAES, NUC host virtual collaboration event

CAES and the National University Consortium hosted a virtual collaboration event over three days in September 2020. The goal was to connect researchers interested in similar topics for the FY21 Consolidated Innovative Nuclear Research Funding Opportunity Announcement. Sessions included Microreactor Cost Reduction and End-User Application Integration, Improving Automation Use in Nuclear Power Plants, Cross-Cutting Research-Cybersecurity Research, and Understanding the Structure and Speciation of Molten Salt at the Atomic and Molecular Scale.



CAES hosts 13th annual My Amazing Future

Approximately 150 eighth-grade young women descended on CAES in February for My Amazing Future, an annual event geared toward boosting the participants' enthusiasm for the STEM subjects (science, technology, engineering and math). This marked the 13th year INL organized the event, which allows the students to interact with researchers, engineers and scientists and explore a range of topics, from DNA extraction from a strawberry to radioisotope thermoelectric generators to hands-on chemistry.

Open house

Recognizing that the CAES community (faculty, students, researchers) could benefit from additional touch points with the Executive Board, CAES began holding open houses to introduce new CAES initiatives and provide students, faculty, and researchers with initiative transparency and the opportunity to provide feedback to the CAES leadership team. In addition to the CAES director's biannual all-hands meetings and a special town hall meeting on the COVID-19 pandemic, CAES hosted these open houses this year:

- **CAES Fellows launch**
 - **CAES Collaboration Fund 2020**
 - **Baby Shark Tank launch**
 - **IT greenfield feedback session**
 - **Transmission electron microscope construction kickoff**
- **DOE student contests**
 - **CAES initiatives**
The Executive Board, with CAES staff, developed and finalized a series of foundational decisions and tools needed to build a successful collaborative consortium framework:
 - **CAES Definitions** – Formalizes when something is a CAES project, CAES equipment/facility, or a CAES affiliate (no formal definitions existed in the past, leading to many lost opportunities to brand, inability to calculate ROI, confusion, frustration, etc.)
 - **CAES Metrics** – Creates a framework for tracking successes in the CAES community
 - **CAES Menu** – A list of CAES offerings describing CAES initiatives in a single document, aka “How do you plug in to CAES?” for example
 - **Lab Space Designation Framework**
– Outlines an inclusive, strategic process to designate facility labs with interdisciplinary “themes,” focused around fostering collaborative, multi-institutional lab activities that provide value far beyond what INL or universities can provide individually, and to increase the ROI of the CAES facility resource
 - **Energy Frontiers Challenge** – Provides resources to CAES teams to develop hub-level proposals around three potential areas of collaboration: resilient critical material economy, accelerating energy transitions, and advanced manufacturing for extreme environments



Applied Visualization Laboratory holds virtual meetings

Rajiv Khadka, an INL visualization researcher with the Applied Visualization Laboratory (AVL) at CAES, held a series of informative open house sessions each Wednesday in August, highlighting AVL's capabilities, demonstrating equipment, and discussing opportunities for collaboration. One of eight laboratories at CAES, AVL boasts several immersive environments for scientists and engineers to walk into their data, examine it and provide deep analysis in pursuit of their research. Khadka recently received his Ph.D. from the University of Wyoming.



Outside events

CAES director represents CAES at several events, moderates panel at LINE Commission

CAES Director [Noël Bakhtian](#) represented CAES at several events throughout the year:

- Bakhtian moderated a panel at the Leadership in Nuclear Energy (LINE) Commission meeting in Sun Valley in fall 2019. The panel discussion, Workforce and Higher Education, included Marianne Walck, deputy lab director and chief research officer at INL; Janet Nelson, at the time University of Idaho's vice president of research and economic development; Rachel Hayes-Harb, director of the Office of Undergraduate Research and Capstone Programs at University of Utah; and Rick Aman, president of College of Eastern Idaho.
- Bakhtian addressed the Idaho state Legislature's Federalism Subcommittee on Education about CAES initiatives during the 2020 legislative session, responding to a request for wins on federal-state partnership.
- Bakhtian took part in a virtual bilateral meeting that DOE hosted with Tunisian officials in July. The conference addressed policy priorities, technical potential, and possible collaborative opportunities between Tunisia and the United States. Bakhtian's presentation was on the Energy-Water Nexus.
- Bakhtian briefed the Idaho State Board of Education's Instruction, Research, and Student Affairs Committee on CAES' Nuclear Safeguards and Security joint certificate. Set to launch in fall 2021, the innovative CAES joint certificate being piloted is a 12-credit educational certificate that enables students to take a course at each of the CAES universities plus an optional capstone summer course at INL that will allow students to get hands-on work experience in nuclear safeguards and nonproliferation.
- Bakhtian and CAES Energy Policy Institute Director Kathy Araújo took part in the University Energy Institute Leaders 2020 Virtual Summit in mid-September 2020. The summit featured several breakout sessions focusing on maximizing policy impact, aligning strengths at universities to better address skills gaps in the energy industry and the future workforce, and maximizing the impact of policy work through collaboration.
- Bakhtian participated in the Eighth Annual International Conference on Sustainable Development. The theme of the event was Cross-Cutting Solutions for the Decade of Action, and Bakhtian's presentation focused on CAES' collaborative efforts to develop the future energy workforce.

NEW FACES

CAES leadership changes

New director

Terry Brog took over as interim CAES director and chief operations officer in mid-October after former Director Noel Bakhtian accepted a position at Lawrence Berkeley National Laboratory and former COO Anita Gianotto accepted a position at INL.



Terry Brog, who will retain his position as senior technical adviser to Juan Alvarez, INL's Management & Operations deputy

laboratory director, has previously served as research COO at Pacific Northwest National Laboratory and as interim laboratory director and COO at Princeton Plasma Physics Lab.

Bakhtian, who had been CAES director since spring 2017, was appointed the inaugural director of the Berkeley Lab Energy Storage Center. Gianotto, who joined CAES in 2018, is now chief operations officer for INL's Management System Transformation Initiative.

New VPR at ISU

Donna Lybecker assumed the role of acting vice president for Research and Economic Development (VPR) at Idaho State University in June, taking her place on the CAES Steering Committee



alongside the VPRs at the other CAES universities and INL Deputy Laboratory Director for Science and Technology and Chief Research Officer Marianne Walck. Lybecker had been Political Science Department chair at ISU and professor of International Relations, Environmental Politics, and Comparative Politics, and she previously

served as the ISU science co-lead for the NSF EPSCoR Managing Idaho's Landscapes for Ecosystem Services (MILES) project grant. The MILES grant brings together faculty from the biophysical and social sciences, enabling research into the complexity of ecosystems and combining ecological research with public values, citizenship styles and power assessments. Lybecker is a member of the United States Environmental Protection Agency National Advisory Committee and an associate editor for the Social Science Journal and the International Journal for Sustainable Society. Her research interests include the politics of borders, environmental politics in the Western U.S. and Latin America, and the framing of political issues.

New VPR at U of I

Christopher Nomura joined the CAES Steering Committee on Oct. 1, when he became University of Idaho's vice president of research and economic development.



Nomura replaced Janet Nelson, who served in the position since 2016. Brad Ritts, U of I's associate vice president for research and a faculty member

in the Department of Geological Sciences, had served since February as interim vice president of research and economic development.

Nomura earned his doctoral degree in biochemistry, microbiology and molecular biology at Pennsylvania State University and received his bachelor's degree in biology from University of California at Santa Cruz. An internationally recognized scientist and administrator, Nomura has more than 85 publications in top journals in his field and

serves on several editorial boards. Prior to his arrival at U of I, Nomura was vice president for research and a biochemistry professor at State University of New York's (SUNY) College of Environmental Science and Forestry. At SUNY, Nomura also oversaw McIntire-Stennis funding, which is designed to expand forestry research and train future forestry scientists.

"Christopher Nomura has extensive experience fostering industry collaborations and working with both national and international research funding agencies," U of I President Scott Green said in a news release announcing Nomura's appointment. "His talent and energy will be valuable additions as the University of Idaho continues to grow our research enterprise in service to the state of Idaho."

Nomura, who has an extensive record of mentoring high school students, undergraduate and graduate students, postdocs and visiting scientists, has strong international connections to the RIKEN Institute (Japan), Hubei University (China) and Centro Nacional Patagonico (Argentina).



CAES facility staff changes



Rocklan McDowell joined CAES as research laboratory manager. McDowell previously worked in INL's Nuclear Science and Technology (NS&T) Directorate and replaces Jana Pfeiffer, Research Operations lead. She accepted a position as deputy operations lead with INL's NS&T Directorate.



Todd Christensen, with INL's facility operations and maintenance organization, recently came on as CAES facility liaison.



Aleah Lattin joined CAES as administrative assistant to former Chief Operations Officer Anita Gianotto. Lattin comes to CAES after more than five years at Jefferson School District #251 as the administrative assistant to the director of Student Services/Special Education Department.

Lab staffing changes



Amir Ali was named the lab lead for the Catalysis & Kinetics Laboratory in summer 2020. Ali has been a CAES resident since fall 2019, when he joined the Nuclear Engineering Department at Idaho State University as an assistant professor. His research focuses on experimental and computational analysis of the thermal-hydraulic problems of advanced reactors molten salt and liquid metals cooled reactors, and he leads a collaborative project that recently received an award from DOE's Nuclear Energy University Program. The roles and responsibilities of CAES lab leads include authorization for research to be conducted in the lab; collaboration with researchers to determine whether the lab can support the research and, if so, to ensure effective research and development occurs; establishment of environment, safety and health procedures and standards for their lab that complement CAES' procedures and standards; and ensuring that all laboratory work is performed in accordance with the Idaho State University safety manual.

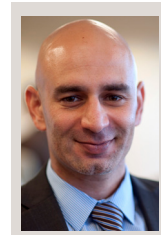


The Microscopy and Characterization Suite added two new staffers in FY20, **Sheng Cheng** and **Yu Lu**. Cheng is senior research associate, instrument co-lead: Focused Ion Beam/Transmission Electron Microscope, and sample preparation lead in the Advanced Materials Laboratory. Cheng



comes to CAES from NanoSteel. Lu is a senior research associate performing Focused Ion Beam/Transmission Electron Microscope/Atom Probe Tomography for MaCS. Lu comes to CAES after earning his Ph.D. from the University of Florida.

Michael Baskin was hired as CAES Innovation Ecosystem Advisor in summer 2020, charged with developing innovation and education portfolios. His background includes a focus on energy security with a particular focus on developing intellectual capital. He previously served as the first professor of energy



studies at Marine Corps University, where he created energy security curriculum and innovation programs for students from multiple schools and colleges.

From 2013-2015, he served as a Fellow for the U.S. Department of Energy, where he catalyzed the Solar Ready Vets program, led a renewable energy sector hiring commitment of veterans for the First Lady's Joining Forces initiative, and was a liaison between the Office of Energy Efficiency and Renewable Energy and the U.S. Department of Defense.



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- Andrew Hoffman, Haiming Wen, Maalavan Arivu, Yaqiao Wu, "Advanced Characterization of Phase Stability Under Ion Irradiation of Ultrafine-grained and Nanocrystalline SS304L," *M&M2020*, August 4-7. 2020, virtual meeting.
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- Scheepers, M. Attended the Post Quantum Crypto track of the International Cryptographic Module Conference.
- T. Phero, K. Novich, B. Gougar, S. Cutler, K. Fujimoto, R. Skifton, D. Estrada, B. Jaques, "Additively Manufactured In-Pile Strain Sensors," *Materials Science & Technology (MS&T) 2020*, (virtual) [Presentation Accepted]
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- Winters, Riley C.; Doyle, Cayden; Lupercio, Adrianna E.; Nelson, Andrew T.; and Jaques, Brian J., "Effects of Oxide Additives on the Microstructure of Surrogate Nuclear Fuels" [Poster]. Boise State Undergraduate Research Showcase, 24 April 2020.
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- Caprice Andrade, Brooke-Lynn, Krishna Pakala, Diana Bairaktarova, Douglas Hagemeyer, and Harish Subbaraman. "Faculty Perspectives on the Impact of Virtual Office Hours in Engineering Courses," 2020 ASEE Virtual Conference, June 22–26, 2020.
- McNeilly, Shelby Ann, Krishna Pakala, and Donald Plumlee P.E., "Revolutionizing the Mechanical Engineering Undergraduate Curriculum," 2020 ASEE Virtual Conference, June 22–26, 2020.
- Pedersen, S., F. Muramutsa, J. Wood, C. Husko, D. Estrada, and B. Jaques, "Mechanochemical Conversion Kinetics of Red Phosphorus to Black Phosphorus for Optoelectronic Applications," Materials Research Society (MRS) Spring Meeting, Phoenix, AZ, in Apr. 2020.
- Fujimoto, K., T. Unruh, and D. Estrada, "Additive Manufacturing for Activation Foil Fabrication," International Symposium on Reactor Dosimetry (ISR), Lausanne, Switzerland, in May 2020.
- Clark, E., N. McKibben, J. Eixenberger, D. Estrada, and Z. Deng, "Additive Manufacturing of Shape Memory NiTi Thin Films," International Society for Optics and Photonics (SPIE) Smart Structures + Nondestructive Evaluation, Anaheim, CA in Apr. 2020.
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- Li, L. Collaborated with CAES institutions to organize the second remote CAES workshop: Li, L. Remote CAES/INL C3 Summer Boot Camp, CAES, Aug 2020
- Araujo, K. (EPI). University Energy Institute Leaders Summit: New network governance structure and initiatives developed.
- Lenhart, S., "Regional Transmission Organization / Independent System Operator Governance Structures and Practices: Framework for Process Tracing," RTOGOV Workshop, Washington D.C. February 10, 2020.
- Araujo, K. "International Decarbonization," Presentation, Santa Fe Institute, Pathways to Deep Decarbonization of the Power Grid, February 26–28, 2020.
- Riley, S., B. Perrine, E. Sikorski, L. Li, R. Skifton, and B. J. Jaques. "Performance of niobium and molybdenum alloys for high temperature sensing applications." Feb 2020. TMS, San Diego CA.
- Mansoor, N.-E., L. A. Diaz Aldana, C. E. Shuck, Y. Gogotsi, T. E. Lister, and D. Estrada, "Ammonia Removal from Simulated Wastewater Using Ti3C2Tx MXenes, in Flow Electrode Capacitive Deionization," 31st International Conference on Diamond and Carbon Materials, Palma, Mallorca, Spain; Sep. 2020.
- Karriem, L., S. Frahs, D. Convertino, T. Webb, T. Pandhi, H. Subbaraman, C. Coletti, J.T. Oxford, and D. Estrada, "Structure—Property—Processing Correlations of Graphene Bioscaffolds for Musculoskeletal Tissue Engineering," Materials Science & Technology Conference (MS&T), Pittsburgh, PA; Oct. 2020.
- Fujimoto, K., T. Unruh, D. Estrada, "Additive Manufacturing for Activation Foil Fabrication," International Symposium on Reactor Dosimetry (ISR), Lausanne, Switzerland, May 2020.
- Jankowski, E., "New computational tool for working with grazing-incidence scattering patterns in molecular simulations," poster accepted to scipy (graduate student Jenny Fothergill).
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- Mondal, K., D. Estrada, K. Fujimoto, Y. Zhang, T. Unruh, and M. McMurtrey "Printing In-Pile Instrumentation for Nuclear Test Reactors," The Minerals, Metals, and Materials Society (TMS) Annual Meeting, San Diego, CA, Feb. 2020.
- Estrada, D. "Nanomaterial Ink Development for Additive Manufacturing of Sensors," The Minerals, Metals, and Materials Society (TMS) Annual Meeting, San Diego, CA, Feb. 2020 (Invited).
- Larsen, B., Osterhout, G., Fry, V. and Araujo, K. "Urban Energy Planning: Policy through Consultative Surveys," Energy Policy Research Conference, Boise, ID, October 1, 2019.
- Lenhart, S. (presenter), G. Chan, M. Grimley, and E. Wilson, "Comparing and Contrasting the Institutional Relationships, Regulatory Frameworks, and Energy System Governance of European and U.S. Electric Cooperatives," Energy Policy Research Conference, Boise, ID, October 1, 2019.
- Araujo, K. (moderator), "A First-hand Perspective on the U.S. Department of Energy," Plenary Session, Energy Policy Research Conference, Boise, ID Sep 29-Oct 1, 2019.
- Gattie, D. and K. Araujo, (moderators), "Decision-Making for Energy Utilities in the Current Policy Environment," Plenary Session, Energy Policy Research Conference, Boise, ID, Sep 29-Oct 1, 2019.
- Ptak, T. and K. Araujo, (moderators), "The Energy Workforce of the Future," Roundtable, Energy Policy Research Conference, Boise, ID Sep 29-Oct 1, 2019.
- Araujo, K., Forum on Cyber Resilience, National Academy of Engineering and Medicine, Wash DC, Oct 17, 2019.
- Araujo, K. "Advancing the Intermountain West's EV Corridor: Critical Infrastructure and Policy Blueprinting in Early Adoption," Integrating Electric Mobility Systems with the Grid Infrastructure, Boston University, Boston, MA, November 6, 2019.
- Araujo, K. Women in Clean Energy (C3E) Annual Meeting, Texas A&M, College Station, TX, Nov 6-8, 2019.
- Araujo, K. "National Energy Transitions," Presentation, Community Library, in partnership with the Sun Valley Institute, Ketchum, ID, December 17, 2019.
- Araujo, K. "What Have We Learned from Four Decades of Danish Wind and French Nuclear Development?" MIT, Boston, MA, November 8, 2019.
- Davis, Paul, C. M. Efav, M. Reynolds, J. L. Vandegrift, K. Smith, Y. Wu, B. J. Jaques, H. Hu, C. Xiong, and M. F. Hurley, "Determination of Zirconium Oxide Chemistry Through Complementary Characterization Techniques," GLOBAL 2019: International Nuclear Fuel Cycle Conference and TOP FUEL 2019: Light Water Reactor Fuel Performance Conference, September 2019, Seattle, WA: 727-736.
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- Wharry, Janelle P., Priyam V. Patki, Kayla H. Yano, George Warren, Chidubem Enebechi, Yash Pachaury, Anter El-Azab, Yaqiao Wu, and Jatuporn Burns, "Nanomechanical Testing of Irradiated Nanostructured and Immiscible Alloys," MS&T 2019, Portland, OR, Sep. 29-Oct. 3, 2019.
- Warren, George, Patrick Warren, Y. Pachaury, C. Nuela Enebechi, Jatuporn Burns, Megha Dubey, Yaqiao Wu, Kevin G. Field, Anter El-Azab, and Janelle P. Wharry, "Mechanical Properties & Dislocation Dynamics in Irradiated FeCrAl using *In Situ* TEM Tensile Tests," MiNES 2019, Baltimore, MD, Oct. 6-10, 2019.
- Wharry, Janelle P., George Warren, Donna P. Guillen, Lucille A. Giannuzzi, Elizabeth Getto, Darren Pagan, Yaqiao Wu, Paula D. Freyer, and David W. Gandy, "Recent progress in testing and qualification of PM-HIP alloys for nuclear applications," MiNES 2019, Baltimore, MD, Oct. 6-10, 2019.
- Mao, K., A. French, M. Pavel, Z. Kroll, Emmanuel Perez, P. D. Freyer, F. A. Garner, Yaqiao Wu and J. P. Wharry, "Characterization of High Dose Ion-irradiated Laser Weld Repairs on Neutron Irradiated Austenitic Steels," MiNES 2019, Baltimore, MD, USA, Oct. 6-10, 2019.
- Patki, Priyam V., Yaqiao Wu, and Janelle P. Wharry, "Deformation-based recovery of irradiation-induced Ostwald ripening in nanocrystalline CuTa alloy," MiNES 2019, Baltimore, MD, USA, Oct. 6-10, 2019.
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Hansena, Samuel, Amin Mirkouei, Maria Magdalena Ramirez-Corredores, Kavita Sharma, Robert Spiers, John H. Kalivas, and Ethan

- Struh, "Effect of Sono-Catalytic Transfer Hydrogenation and In-Line Characterization on Upgrading Pyrolysis-Derived Oil," *Ultrasonics Sonochemistry*; submitted.
- Noris, Evelin, Peyton Kiggins, Bryson Blad, Karl De Jesus, and Kavita Sharma, "Ionic Liquids for the Removal of Sulphur and Nitrogen Compounds in Different Fuel Systems," *Environmental Chemistry Letters*, submitted.
- Mena, P., L. Kerby, K. Wilsdon, K. Massey, D. Nielson, K. Casanova, C. Hill, and P. Gilbreath, "Using Data Analytics to Improve Government Financial Efficiency," *Athens Journal of Sciences*, in review.
- Juneau, C., A. Johnson, K. Wilsdon, and L. Kerby, "An Introduction to a Generalized Functional Expansion Tally Library," *Transactions of the American Nuclear Society*, in press.
- Mena P. and L. Kerby, "Electricity Markets for Nuclear Power in Western North America," *Progress in Nuclear*, in review.
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- Mena, P. and L. Kerby, "Machine Learning Accident Classification Using Nuclear Reactor Data," *Transactions of the American Nuclear Society* 121, no. 1, 2019: 828-831.
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- Ali, Amir and Edward Blandford, "Experimental Validation of a Compact Double-Walled Twisted Tube Heat Exchanger Concept," DOE-NEUP final report Project No. 15-8667, 2019.
- Beard, DV, *Programming Languages for University Courses*, in Tatnall, A (ed.), *Encyclopedia of Education and Information Technologies*. Springer 2020.
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- Hersh, B., A. Mirkouei, J. Sessions, B. Rezaie, and Y. You, "A review and future directions on enhancing sustainability benefits across food-energy-water systems: the potential role of biochar-derived products." *AIMS Environmental Science* 6, no. 5, 2019: 379–416. 10.3934/environsci.2019.5.379.
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- Garz, Daniel, Jared Cantrell, Kathryn Hogarth, Mustafa Mashal, and Bruce Savage, "A Disaster Response Complex for Training of First Responders in Idaho," Poster Presentation at the 9th Annual Energy Policy Research Conference, Boise, ID, United States 2019.
- Cantrell, Jared, Daneil Garz, Uma Shankar Medasetti, Mustafa Mashal, and Bruce Savage, "A Disaster Response Complex for Research, Curriculum, and Training of First Responders," Poster Presentation at the CAES Winter Collaboration Meeting, Idaho Falls, ID, United States, 2020.
- Dunzik-Gougar, M. L., A. Nagarajan, C. Shull, J. Kunze, J. Larson, W. Phoenix and S. Bondurant, "Conversion of the Idaho State University AGN Control Console to Solid State Circuitry," 2019 meeting of the National Organization of Test, Research, and Training Reactors, Fall 2019, Idaho Falls, ID.
- He, Mingfu, Soon K. Lee, Amir Ali, and Minghui Chen, "A Thermal-Mechanical Properties View of Impacts of Heater Materials on Critical Heat Flux," ANS Winter meeting 2019, Washington DC, 2019.
- Ryan, Emerald, "Determination, Development, and Validation of a Fluid Height Analysis Method and Particle Spacing Protocol for the Smoothed Particle Hydrodynamic Code Neutrino," Idaho State University, PhD Dissertation (December 2019).
- Dunzik-Gougar, M. L., Annual Conference of the International Atomic Energy Agency, 15–20 September, Vienna, Austria, represented the American Nuclear Society.
- Dunzik-Gougar M. L., Global/Top Fuel, October 22–26, 2019, Seattle, WA, guest speaker on low dose radiation economic impacts across the nuclear fuel cycle.
- Dunzik-Gougar, M. L., Winter Meeting of the American Nuclear Society, November 16–21, 2019, Washington, D.C., vice-president duties, presenter at K–12 teacher workshop and panel speaker on ABET accreditation.
- Kerby, L., invited speaker, "Cross Sections for Cosmic Rays @ CERN" XSCRC 2019, November 13–15, 2019, CERN, Geneva, Switzerland.
- Ali, Amir, Hyun-Gil Kim, Khalid Hattar, Samuel Briggs, Dong Jun Park, Jung Hwan Park, and Youho Lee, "Ion irradiation effects on Cr-coated zircaloy-4 surface wettability and pool boiling critical heat flux," *Nuclear Engineering and Design*, 5, June 2020: 362.

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- Ashrafuzzaman, M., S. Das, Y. M. Chakhchoukh, S. Shiva, and F. T. Sheldon, "Detection of Stealthy False Data Injection Attacks in Smart Grid using Ensemble-based Security Analytics," *Journal of Computers and Security*, Elsevier, submitted April, accepted July 2020.

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BY THE NUMBERS

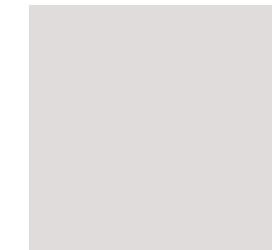
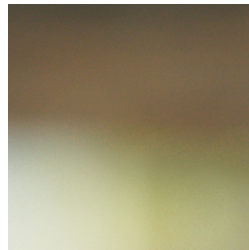


29 *Operational items of concern in FY20, ranging from security issues to fire/oxygen sensor alarms that resulted in building evacuations to a phishing event*

119 *Radiological samples transferred in FY20 in the CAES facility*



252 *INL employees participated in Employee Education programs at CAES universities*



FROM CAES UNIVERSITIES

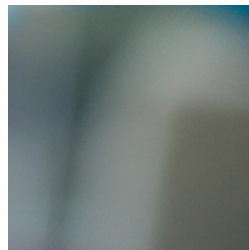
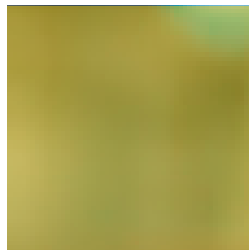
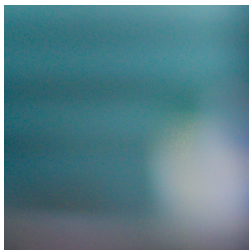
6 *Students received graduate fellowships at INL*

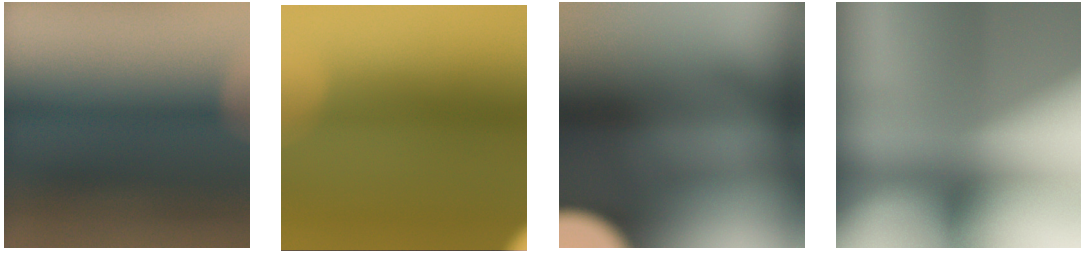
115 *Students interned at INL*

FROM CAES UNIVERSITIES

19 *Faculty members awarded INL joint appointments*

11 *Faculty members participated in the CAES Summer Visiting Faculty Program*





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INJURIES

\$6.4
Million in FY20
Laboratory Directed
Research and Development
at INL

\$1.3 Million Funding to CAES-affiliated faculty through DOE's Nuclear Energy University Program (primary award)
\$2.4 Million Funding to CAES-affiliated faculty through DOE's Nuclear Energy University Program (partner award)



BY THE NUMBERS

5
Project proposals in FY16

5
Project proposals in FY17

0
Project proposals in FY18

15
Project proposals in FY19

