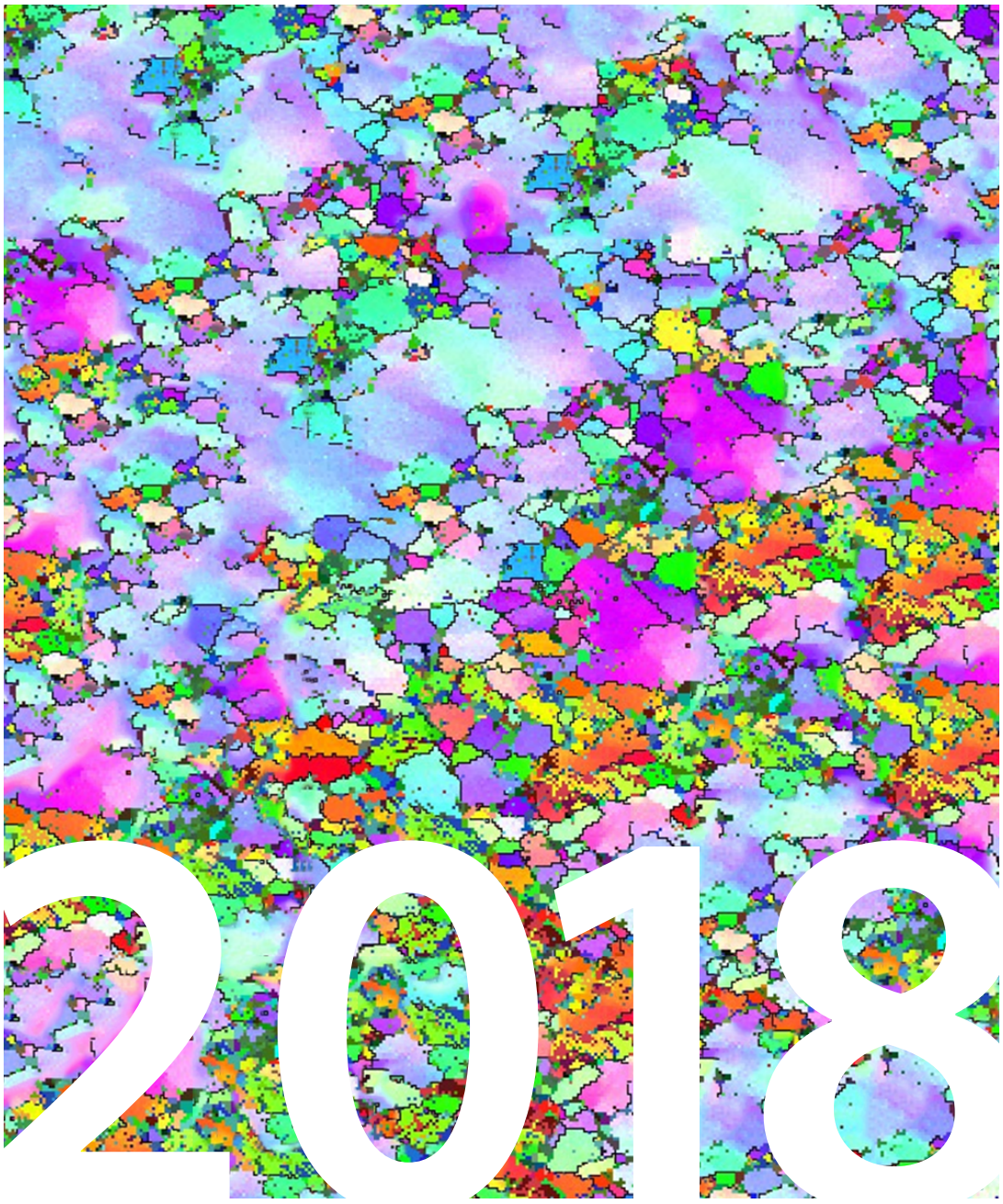

CAES ANNUAL REPORT

October 1, 2017-September 30, 2018

CAES

Center for Advanced Energy Studies

> I've never seen collaboration more successful than at CAES.

Brad Little
Lieutenant Governor, Idaho
(elected Governor Nov. 6, 2018)

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ON THE COVER:
AN ELECTRON BACKSCATTER DIFFRACTION PATTERN OF A HIGH-TEMPERATURE, IRRADIATION-RESISTANT THERMOCOUPLE (NIOBIUM-ZIRCONIUM SHEATH) USED FOR TEMPERATURE MONITORING INSIDE A NUCLEAR REACTOR CORE. IMAGE CAPTURED ON A SCANNING ELECTRON MICROSCOPE INSIDE BOISE STATE UNIVERSITY'S CENTER FOR MATERIALS CHARACTERIZATION (BSCMC) IN THE MICRON SCHOOL OF MATERIALS SCIENCE AND ENGINEERING. COURTESY OF BRIAN JAQUES, PH.D.

DIRECTOR'S LETTER

I'll never forget the evening of August 5, 2012, when a NASA probe entered the Martian atmosphere, deployed a parachute, and landed the Curiosity Rover successfully on the Red Planet. People around the world gathered to watch and witness this historic accomplishment. But behind all the action were the herculean efforts of thousands of engineers, researchers, scientists, policy-makers, and support staff who helped make this historical event possible. Moments like these are meticulously prepared, the execution must be precise, and collaboration is more than a desire, it's a necessity. In fact, behind every great event, invention, or organization lies the effort of many.

With thoughts of achieving greatness on our minds, CAES took the opportunity this year to engage in a detailed strategic planning process that allowed us to pause – momentarily – from the daily shuffle of meetings, assignments, and project deadlines to reassess what makes us relevant, valuable, and necessary to our stakeholders. This inclusive and transparent process resulted in an ambitious, forward-looking strategic plan that sets CAES on a course for success over the next 20 years.

Our new strategy earned unanimous support from leaders at each of our five member organizations. The strategy focuses on collaboration and leveraging our collective resources, expertise, and facilities to act as a force multiplier in research, education, and innovation. It's this leverage that will allow us to take on significant technical challenges that will create a better energy future for the region, nation, and the world.

While our new mission, vision, and strategy set the course for the future, it's just as important to reflect on some of the year's other significant achievements. As you read this year's annual report, you'll see numerous highlights, accomplishments, and statistics that provide a glimpse of the value CAES provides its members and where we are headed in the future. You'll read about joint research that is solving critical challenges; you'll see the researcher, staff, and student connections and research wins made through CAES collaborations; and you'll hear about the positive impact we are having on our stakeholders at the universities and INL.

I hope you find this year's report engaging and inspiring. During the last fiscal year, it was the work of many researchers, faculty, staff, students, and countless supporters like you working together to make CAES successful. As an organization centered around collaboration, I truly value your input and feedback. At any time, please reach out to me or anyone on our leadership team. Thank you for your support during this process, and we look forward to hearing from you soon.

Sincerely,

Noël Bakhtian, Ph.D.
CAES Director

Collaboration Inspiring Innovation and Impact 2019-2039 CAES STRATEGY

CAES Releases New 20-Year Strategic Plan

Ten years ago, the Center for Advanced Energy Studies (CAES) was founded as a catalyst to activate world-class research assets at Idaho National Laboratory in combination with research universities in the region. CAES is focusing future collaborative efforts to discover and bring to market the approaches, technologies, and solutions to create measurable and lasting impacts for the people of Idaho and Wyoming, the nation, and the world.

CAES already benefits from a proud tradition, dedicated leadership team, broad community support, and public wins in the form of joint federal projects awarded, collaborative publications, joint appointments, and a wave of new and advanced facilities. As energy, environmental, and national security challenges persist, we believe we can be doing even more to positively impact the world's energy future.

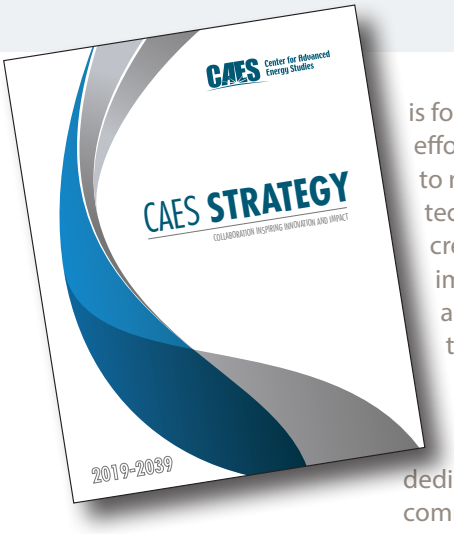
Thanks to your support, CAES spent the last fiscal year redefining its strategic direction through a series of stakeholder engagement meetings, listening sessions, focus groups, surveys, and internal discussions. Beginning in November 2017 and continuing through March 2018, CAES hosted five large working group meetings bringing together the leadership and stakeholders from all five CAES member organizations to discuss specific areas of focus. More than 500 people attended these forums, providing feedback and ideas, and

Vision

Our vision is to create a better energy future through collaboration that inspires energy leadership, ignites technology innovation, and catalyzes global impact.

Mission

CAES is the collaboration that inspires innovation and impact by leveraging our collective capabilities to empower students, researchers, faculty, and industry to accelerate energy solutions.



To read the entire CAES strategic plan, visit www.caesenergy.org

helping craft CAES' major focus areas and strategic direction. Some of the ideas generated led to laboratory funding and the development of federal research proposals, white papers, and capabilities road maps.

Through the summer of 2018, the CAES leadership team worked diligently to capture the best ideas from the year of discussion and develop them into a comprehensive 20-year strategic plan. At least 2,000 hours were spent on this project, and while it was a challenging effort, our future is stronger for having gone through the process. On Nov. 7, 2018, the CAES Steering Committee approved the new strategy. Today, CAES researchers, faculty, staff, and students are working to implement the tactical actions that will lead to lasting, long-term results that elevate CAES' potential impact.

The new CAES strategy rests on three strategic pillars: Research, Education, and Innovation. These pillars set the foundation for a series of major deliverables that will be achieved through a concerted, multiyear effort leading to an unprecedented level of collaboration between researchers, faculty, students, staff, policy-makers, members of industry, entrepreneurs, and many more. Our efforts will focus on several grand challenges including nuclear energy; advanced manufacturing; cybersecurity; energy-water nexus; innovative energy systems; energy policy; and computing, data, and visualization. In each of these areas, there are stark challenges, but enormous opportunities we look forward to tackling together.

Over the next year, we will broadly share our strategy as we begin the long but necessary road toward implementation. We know that to achieve success, we must work together to accelerate research, develop the workforce of the future, and innovate technology for global impact. Our goal is to move the world forward toward a better energy future. We hope you'll join us.

3
PILLARS

7
FOCUS AREAS

20
YEARS

> Sakae Casting opened its Idaho Falls office … They have been busy collaborating with CAES to bring their unique technology to bear in the nuclear industry—it could greatly impact how we handle storage of spent fuel.

Rebecca Casper, Ph.D.
Mayor, City of Idaho Falls
2018 State of the City address

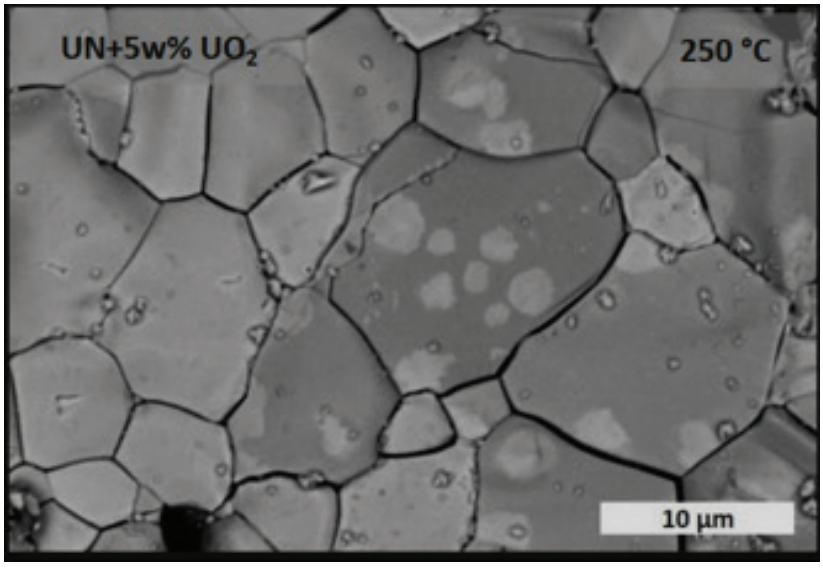
RESEARCH HIGHLIGHTS

CAES Research Team Wins $237,000 IGEM Grant for Spent Nuclear Fuel Storage Research

In 2018, a CAES research team was awarded a one-year, $237,000 grant from the Idaho Global Entrepreneurial Mission (IGEM) program. The funding was used to model heat-transfer properties for a new spent nuclear fuel storage cask that aims to reduce the amount of time irradiated nuclear fuel stays in water-cooled fuel pools. The project is led by researchers Bob Borrelli and Rich Christensen, both from the University of Idaho, with support from Boise State University's Brian Jaques, and Idaho National Laboratory's Piyush Subharwall.

Using computer-aided design software, researchers designed models of aluminum plates infused with boron – a material particularly suited for neutron absorption – capable of fitting inside a newly designed spent nuclear fuel cask. If successful, the plates and cask design will work together to provide additional layers of neutron and gamma ray shielding, while also cooling the spent nuclear fuel assemblies. This means spent nuclear fuel could be moved out of water pools and into dry storage faster than with the current cool and wait method.

This project also involved technical experts from Tokyo, Japan's Sakae Casting and Blackfoot, Idaho's Premier Technology, along with team members from the College of Eastern Idaho, and Table Rock LLC, a Virginia-based consulting firm focused on Nuclear Regulatory Commission compliance.



CAES Researcher Wins $300,000 Grant from DOE's Geothermal Technology Office

As more renewable energy sources are added to the electric grid, power plant operators must continually adjust output to match needs. Since the bulk of U.S. electricity is produced using large spinning turbines and generators powered by natural gas, coal, and nuclear plants, cycling the power flow on and off is time consuming and taxing on the machinery. A potential solution could come by storing excess heat energy in a dynamic earth energy-storage system, or deep underground battery. This concept was proposed by CAES researcher Travis McLing, who picked up a $300,000 grant from the U.S. Department of Energy's Geothermal Technology Office, to study the feasibility and methods for pumping excess power plant heat into briny, subsurface reservoirs located deep beneath the earth. The project involves several researchers, including McLing and Daniel Wendt from Idaho National Laboratory; Christine Dought, Nic Spycher, and Pat Dobson from Lawrence Berkeley National Laboratory; Dakota Roberson from the University of Idaho; and Fred McLaughlin from the University of Wyoming. Support for the project will also come from Rocky Mountain Power.

The surface sheath of a High Temperature Irradiation Resistant thermocouple after a ductility test as captured on a scanning electron microscope. The image is part of a collaborative research project between BSU and INL geared toward instrumenting nuclear reactor cores.

> The days are done when a single researcher can solve a problem alone. CAES is effective because it has a deep bench of talent to draw from, and I know there are some grants and proposals we wouldn't have gotten had it not been for our affiliation with CAES.

Mark Rudin, Ph.D.
President, Texas A&M Commerce
Former Vice President of Research and Economic Development, Boise State University and former CAES Steering Committee Member

University of Idaho Wins $700,000 IGEM Grant with CAES Support

The University of Idaho (UI) will work with food processors and suppliers in the Pacific Northwest to support reductions in their energy, water, and waste footprints as part of a new Idaho Global Entrepreneurial Mission (IGEM) grant awarded to UI and its partners around the state. The Idaho Department of Commerce recently released the first $700,000 installment of the $2.1 million grant earlier this month, with an additional $1.4 million in funding anticipated over the next two years. Professor Karen Humes, an expert in hydrology and geospatial science in UI's College of Science, will lead efforts to pilot, demonstrate, and transfer technologies that will help food processors and producers reduce water and nutrient use, as well as recycle nutrients and other valuable byproducts. Initial funding to develop the grant proposal was provided by CAES.

Students and faculty conduct research at the University of Idaho's Water Research Center in Boise.

CAES Hosts Five Major Working Meetings to Inform Strategy Development

Approaching its 10-year anniversary, CAES underwent a significant revision of its strategic plan during the fiscal year. To help inform the development of the new strategy, five large collaborative meetings were held. Of the meetings, three had a focus on research in nuclear energy, national security, and clean energy. Participants shared their capabilities and expertise, offering their wants, needs, and ideas for the future direction of CAES' success. The goal of each meeting was to share the vision of the major areas of research that will benefit from collaboration in the next 3 years. All five meetings were held to identify gaps and challenges that CAES could help resolve by leveraging shared assets from each of the CAES member organizations.

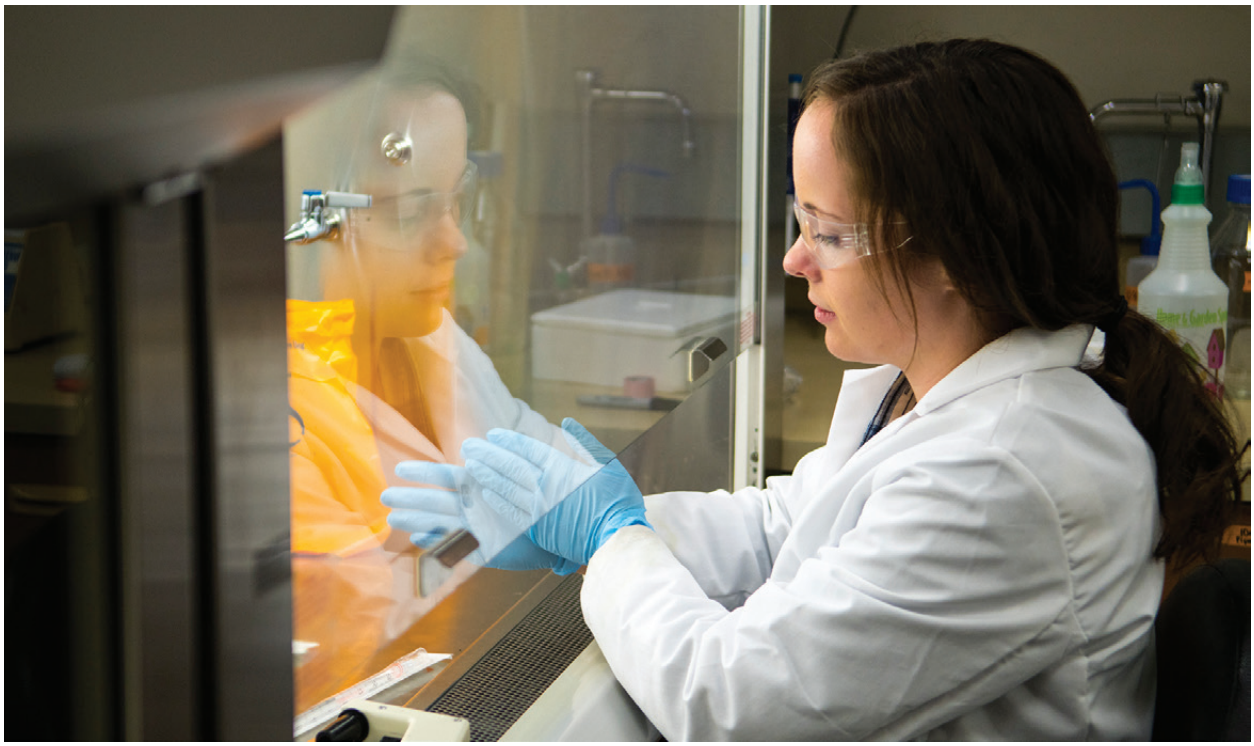
> Think of the earth as a perfect YETI cooler. It's an inherently good place to store heat, and we hope this research will take geothermal energy from a western boutique power source to a nationwide power source.

Travis McLing, Ph.D.
Laboratory Lead,
CAES Fluids Laboratory

CAES and Idaho Accelerator Center Host Isotope and Materials Working Meeting

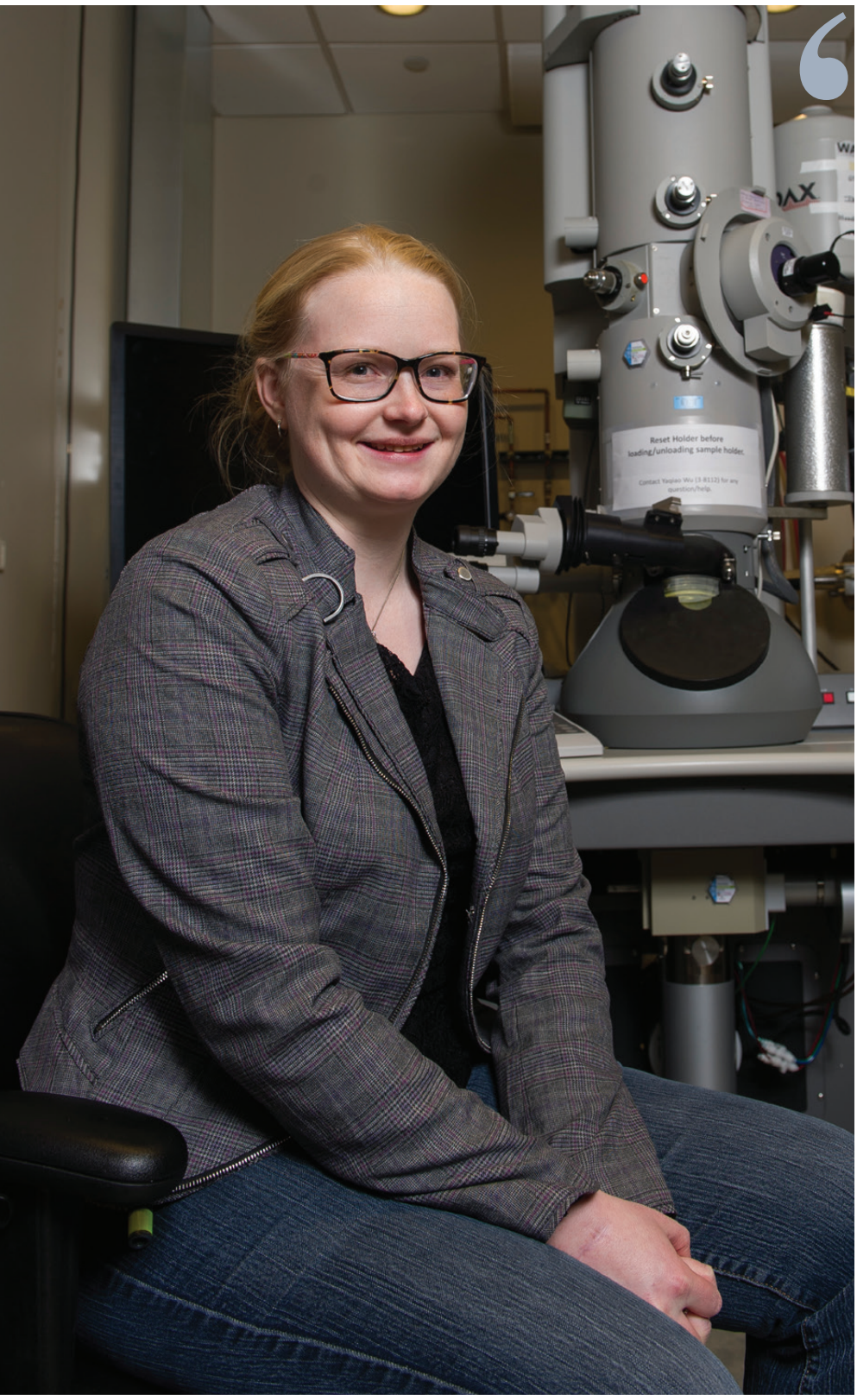
In June, CAES and Idaho State University (ISU) hosted a two-day working meeting in Idaho Falls aimed at forming a collaborative research initiative between CAES member institutions and the Idaho Accelerator Center (IAC). The working meeting began the process of creating dialogue between CAES entities, as well as development of a usage and capabilities road map for the center. It also answered questions about future facility needs for advancing isotope and nuclear materials science. Located in Pocatello, the IAC is a research facility operated by ISU featuring an array of electron accelerators for nuclear physics applications. A collaborative research planning meeting at CAES led to the discussion.

A researcher works inside a fume hood inside the Energy Innovation Laboratory.



CAES Hosts Molten Salt Working Meeting at University of Wyoming

CAES and the University of Wyoming held a collaborative working meeting in July focused on grid-scale energy storage systems. The purpose of the meeting was to discuss the current status, research gaps, CAES comparative advantage, and future prospects for grid-scale energy storage using molten salt systems. The meeting was attended by 32 individuals from Idaho National Laboratory, Boise State University, Idaho State University, the University of Idaho, the University of Wyoming, and Brigham Young University-Idaho. Collaboratively, the group developed a white paper outlining CAES capabilities in scientific, engineering, and economic drivers impacting molten salt energy storage. The group plans to continue meeting to develop a road map for a future federally funded research proposal that relates to molten salt energy-storage systems. The working meeting is the result of a collaborative research planning meeting that CAES held on clean energy.



> The materials challenge is the biggest one for advanced reactors. Ultimately, this research will help engineers understand how long a reactor can be run before adverse conditions in the cladding need to be addressed.

Elizabeth Getto, Ph.D.
CAES MaCS Lab customer
Assistant Professor,
U.S Naval Academy

CAES Energy Policy Research Conference Draws Sell-Out Crowd

CAES' Energy Policy Institute (EPI) hosted the eighth annual Energy Policy Research Conference at Boise State University in early September. Since 2011, the conference has brought researchers together from across the world to discuss a widerange of energy research topics including engineering, economics, law, political science, and other policy-relevant fields. A sellout crowd of more than 200 scholars, students, and practitioners from academia, industry, government, and nonprofits were on hand during this year's event. CAES Director Noël Bakhtian and CAES Fluids Laboratory Lead Travis McLing participated on an energy-water nexus panel session. The event was led by Kathleen Araújo, the new EPI director. Next year's conference will return to Boise Sept. 29–Oct. 1, 2019.

Participants at the 2018 CAES Energy Policy Research Conference in Boise.

Naval Academy First Military School to Use CAES MaCS Lab

In January, Elizabeth Getto, a mechanical engineering instructor at the U.S. Naval Academy, conducted research using tools inside the CAES Microscopy and Characterization Suite. Through the Department of Energy's Nuclear Science User Facilities program, Getto conducted a rapid turnaround experiment to study the effects of radiation and welding on oxide dispersion strengthened steels, commonly used in reactor vessels. The research represented the first time a U.S. military academy had taken advantage of the unique capabilities found in laboratory. Other institutions conducting microscopy work inside CAES this year include the University of Oxford, Purdue University, Texas A&M University, and the Massachusetts Institute of Technology.

University of Wyoming's Coddington Mentions CAES in Senate Testimony

Testifying before the U.S. Senate's Environment and Public Works Committee in November, the University of Wyoming's Kipp Coddington referenced his ongoing, collaborative relationship with CAES. Coddington, the director of the Carbon Management Institute at the School of Energy Resources, testified before the committee at a hearing titled "Promoting American Leadership in Reducing Air Emissions Through Innovation." During his testimony, Coddington outlined the numerous ways the university is examining methods to reduce carbon emissions through innovative technologies including research into carbon capture, utilization, and sequestration technologies. The Senate committee is chaired by Wyoming Sen. John Barrasso.

> Working at CAES has provided me access to remarkable people who took the time to talk with me about any topic of interest I brought to them.

Emma Redfoot
Fellow, OKLO Inc.
Former CAES Graduate Researcher

Idaho State University students examine samples inside a glovebox.

Working Meetings

In FY-18, CAES hosted several collaborative meetings.

Clean Energy Collaborative Research Planning Meeting – November 2017

Nuclear Energy Collaborative Research Planning Meeting – February 2018

National Security Collaborative Research Planning Meeting – February 2018

Education Collaborative Research Planning Meeting – March 2018

Industry Collaborative Research Planning Meeting – March 2018

Idaho Accelerator Center Roadmap Meeting – June 2018

Molten Salt Working Meeting – July 2018

Consolidated Innovation in Nuclear Research Joint Meeting – August 2018

Global Materials Working Meeting – August 2018

Energy Policy Research Conference – September 2018

Carbon Conversion Working Meeting – September 2018

Governor's LINE Commission Receives CAES Update

In May, the Leadership in Nuclear Energy (LINE) Commission 3.0 met in Arco for a quarterly briefing. During the meeting, the commission received an update from CAES Director Noël Bakhtian. This was the first time the commission had received a CAES briefing since 2012. During her presentation, Bakhtian provided an overview of the CAES mission and vision, spoke to the values CAES provides to the state, Idaho National Laboratory (INL), and the four member-universities. She also addressed operational activities including the hiring of a new leadership team and fiscal year plans to produce a refreshed multiyear strategic plan. The presentation concluded with a series of recent accomplishments and questions from commission members. Along with Bakhtian, additional members of the LINE Commission affiliated with CAES include INL's laboratory director and the three vice presidents for Research and Economic Development from Idaho's public research universities.

> At CAES, I have the opportunity to work with experts from diverse fields and areas of expertise. It can be challenging at times, but when you're able to help a researcher succeed, that's rewarding.

Kristi Moser-McIntire
CAES Safety Officer,
Idaho State University

CAES Hosts Materials Science Roadmap and Capabilities Meeting at Boise State University

CAES hosted a materials science road map and capabilities meeting in August. The event was the first in a series of gatherings at CAES member universities to enable INL scientists and university faculty the opportunity to meet and tour the unique capabilities in materials science and other research areas that exist on campus. During the two-day event, attendees received a detailed set of briefings on research and development work currently underway in the materials science field. Attendees also heard about the strategic directions of the university's materials science program. Approximately 60 people from INL and the four CAES member universities attended the event. The next capabilities meeting will be held at a different CAES member university.

ISU/CAES Assistant Professor Leslie Kerby, third from right, with her IEEE Brain Hackathon team.

ISU's Kerby Part of Winning Team at Big Data Competition in Japan

This summer, Idaho State University assistant professor Leslie Kerby and her team won the Institute of Electrical and Electronics Engineers (IEEE) Hackathon on Big Data Governance and Metadata and Management. The event, held in Tokyo, challenged teams to develop a data mashup scheme to cross reference datasets and apply statistical analysis, machine learning, and visualization tools to analyze and develop predictive models. Kerby's team included Frederic Andres, with the National Institute of Informatics in Tokyo, and Joey Costoya, senior researcher at Trend Micro Incorporated at National Capital Region, Philippines. The competition took place during the IEEE's 42nd International Conference on Computers, Software, and Applications, which explored the evolving relationship between humans and autonomous technology.

CAES Hosts Carbon Conversion Working Meeting in Idaho Falls

A Carbon Conversion working meeting was hosted in September at CAES' Idaho Falls headquarters facility. The event brought together research and technical collaborators from Idaho National Laboratory, the University of Wyoming, Idaho State University, and the University of Idaho. During the event, participants presented information on university and laboratory capabilities, and discussed opportunities for joint proposals and federal grants in the areas of carbon capture, sequestration, and conversion. The event was a follow-up to a related meeting held last year at the University of Wyoming campus.

FY2018 NUCLEAR ENERGY UNIVERSITY PROGRAM (NEUP) PRIME AWARDS

NEUP R&D AWARD	$640,000	DR. VIVEK UTGIKAR (UI)	DEVELOPMENT OF NUCLEAR HYBRID ENERGY SYSTEMS: TEMPERATURE AMPLIFICATION THROUGH CHEMICAL HEAT PUMPS FOR INDUSTRIAL APPLICATIONS
NEUP R&D AWARD	$574,638	DR. VIVEK UTGIKAR (UI)	NOVEL PROCESSES FOR CAPTURE OF RADIOACTIVE IODINE SPECIES FROM VESSEL OFF-GAS STREAMS
NEET AWARD	$830,000	DR. VIVEK AGARWAL (INL)	ANALYTICS-AT-SCALE OF SENSOR DATA FOR DIGITAL MONITORING IN NUCLEAR PLANTS
NEUP R&D AWARD	$800,000	DR. INDRAJIT CHARIT (UI)	FRICTION-STIR-BASED REPAIR WELDING OF DRY STORAGE CANISTERS AND MITIGATION STRATEGIES: EFFECT OF ENGINEERED BARRIER LAYER ON ENVIRONMENTAL DEGRADATION
NEUP R&D AWARD	$611,640	DR. RICH CHRISTENSEN (UI)	MODELING AND EXPERIMENTAL VERIFICATION OF THERMAL ENERGY STORAGE SYSTEMS TO ENABLE LOAD-FOLLOWING CAPABILITY FOR NUCLEAR REACTORS

FY2018 NUCLEAR ENERGY UNIVERSITY PROGRAM (NEUP) PARTNER AWARDS

NEUP R&D AWARD	$169,000	DR. VIVEK UTGIKAR(UI), DR. PIYUSH SABHARWALL (INL)	DEVELOPMENT OF NUCLEAR HYBRID ENERGY SYSTEMS: TEMPERATURE AMPLIFICATION THROUGH CHEMICAL HEAT PUMPS FOR INDUSTRIAL APPLICATIONS
NEUP R&D AWARD	$225,362	DR. VIVEK UTGIKAR (UI), DR. KRISHNAN RAJA (INL), DR. PIYUSH SABHARWALL (INL)	NOVEL PROCESSES FOR CAPTURE OF RADIOACTIVE IODINE SPECIES FROM VESSEL OFF-GAS STREAMS
NEUP R&D	$150,000	DR. RICH CHRISTENSEN (UI), DR. PIYUSH SABHARWALL (INL)	MODELING AND EXPERIMENTAL VERIFICATION OF THERMAL ENERGY STORAGE SYSTEMS TO ENABLE LOAD-FOLLOWING CAPABILITY FOR NUCLEAR REACTORS
NEET AWARD	$170,000	DR. VIVEK AGARWAL (UI), DR. AHMAD AL RASHDAN (INL), DR. RON BORING (INL)	ANALYTICS AT SCALE OF SENSOR DATA FOR DIGITAL MONITORING IN NUCLEAR PLANTS

FY2018 LABORATORY DIRECTED RESEARCH AND DEVELOPMENT (LDRD) PRIME AWARDS

$430,185	DR. MAOHONG FAN (UW), DR. DONG DING (INL)	DEVELOPMENT OF DIRECT CARBON FUEL CELLS
$258,017	DR. BRIAN JAQUES (BSU), DR. CHAO JIANG (INL)	MICROSCALE TECHNIQUE TO EVALUATE GRAIN BOUNDARY COHESION OF IRRADIATED ALLOYS

FY2018 LABORATORY DIRECTED RESEARCH AND DEVELOPMENT (LDRD) PARTNER AWARDS

$160,699	DR. BRIAN JOHNSON (UI), DR. MICHAEL HANEY (UI), PHILLIP RICHARDSON (UI), DR. CRAIG RIEGER (INL)	RESILIENT, SCALABLE CYBER STATE AWARENESS OF INDUSTRIAL CONTROL SYSTEM NETWORKS TO THREAT
$95,347	DR. HAIYAN ZHAO (UI), DR. JEREMIAH DUSTIN (UI), DR. JIEUN LEE (UI) DR. SHELLY LI (INL)	INVESTIGATION OF SONICATION-ASSISTED ELECTROLYTIC REDUCTION OF USED OXIDE FUEL IN MOLTEN SALT
$431,918	DR. MICHAEL GLAZOFF (UI), DR. DONGMEI (KATIE) LI (UW), DR. SHUAI TAN (UW), DR. REBECCA FUSHIMI (INL)	TAILORING THE KINETIC FUNCTION OF A SURFACE THROUGH ELECTRONIC EFFECTS OF NANOSCALE ARCHITECTURE
$114,961	SAM GIEGEL (ISU), DR. CHAD POPE (ISU), DR. GEORGE IMEL (ISU), DR. AARON CRAFT (INL)	CHARACTERIZATION OF NEUTRON BEAMLINES AT NEUTRON RADIOGRAPHY REACTOR
$316,328	DR. HAIYAN ZHAO (UI), DR. LUKE WILLIAMS (INL)	ADVANCED CARBON-FEEDSTOCK PROCESSING USING IONIC LIQUIDS
$222,180	DR. VIVEK UTGIKAR (UI), DR. JARED PERKO (BSU), KEVIN LYON (INL)	MODELING AND SIMULATION FOR NUCLEAR FUEL-CYCLE SEPARATIONS USING MODULAR COUPLING
$255,641	BRANDON DAY (UI), DR. DONNA BAEK (INL)	ELECTRO-REDUCTION OF METALS IN SUPERCRITICAL-FLUID ROOM-TEMPERATURE IONIC LIQUIDS
$258,017	DR. RAY FERTIG (UW), DR. INDRAJIT CHARIT (UI), DR. CHAO JIANG (INL)	MICROSCALE TECHNIQUE TO EVALUATE GRAIN BOUNDARY COHESION OF IRRADIATED ALLOYS
$271,913	DR. RICHARD CHRISTENSEN (UI), DR. COLBY B. JENSEN (INL)	IN-PILE INVESTIGATION OF TRANSIENT BOILING IN TREAT
$248,127	DR. HAROLD BLACKMAN (BSU), DR. RON BORING (INL)	HUMAN RELIABILITY ANALYSIS FOR ADVANCED-REACTOR TECHNOLOGIES AND SYSTEMS
$277,887	DR. ERIC JANKOWSKI (BSU), DR. MATTHEW JONES (BSU), MIKE HENRY (BSU), BRYTON ANDERSON (BSU), DR. KEVIN GERING	SURFACE MORPHOLOGICAL PATTERNING, STRUCTURE-ACTIVITY MODELING, AND AGING ANALYSIS OF CATALYST MATERIALS TO ENHANCE ODH-REACTION CONVERSION EFFICIENCY AND IMPROVE CATALYST LIFETIME
$245,319	RYAN CARNAHAN (ISU), DR. CHENG SUN (INL)	ADVANCED MANUFACTURING OF FUEL-CLADDING MATERIALS BY EQUAL-CHANNEL ANGULAR PRESSING
$104,972	DR. KUMARI SHARMA (ISU), DR. CHRISTOPHER ZARZANA (INL)	SOLVENT RADIOLYSIS-PRODUCT PRODUCTION USING PREPARATIVE HPLC

> CAES has been a fantastic experience. I was able to connect with people in industry that I wouldn't have had access to before. Working here is how I got my internship, how I got connected to the lab system, and a big part of how I was able to receive my fellowship.

Seth Dustin
Fellow, Los Alamos National Laboratory
Former CAES Graduate Researcher

EDUCATION HIGHLIGHTS

CAES First Annual Summer Visiting Faculty Program Begins

CAES launched its first annual Summer Visiting Faculty program in June. The program works to foster interaction and networking between university faculty and Idaho National Laboratory (INL) researchers with the goal of developing a joint-funded research proposal of value to both parties.

The program allows each faculty member and INL researcher to spend a week at CAES headquarters outlining their research proposal. Then, the pair continues to collaborate throughout the summer. Participants provide a presentation on their proposal at CAES in August before submitting it for funding. The CAES Summer Visiting Faculty program was developed following a series of collaborative planning meetings held earlier this fiscal year between the CAES member universities and INL.

During the inaugural year, CAES provided a part-time summer salary and travel for six faculty members from CAES member universities. The three research areas selected for this year's program included nuclear energy, cybersecurity, and energy-water nexus.

Faculty members and INL researchers participating in the inaugural program included:

Nuclear Energy

- Mike Hurley (Boise State University) worked with Gabriel Ilevbare
- David Arcilesi (University of Idaho) worked with Donna Guillen
- Mike McKellar (University of Idaho) worked with Donna Guillen

Cybersecurity

- Dakota Roberson (University of Idaho) worked with Steve Hartenstein and Wayne Austad
- Michael Haney (University of Idaho) worked with Steve Hartenstein and Wayne Austad

Energy-Water Nexus

- Jon Brant (University of Wyoming) worked with Travis McLing

CAES Launches Seminar Series Featuring University, Laboratory, and Industry Leaders

A monthly seminar series focused on collaboration and problem-solving was launched at CAES in March. The brainchild of the University of Idaho's Dakota Roberson, the CODEBREAKER seminar series features talks by students, university faculty, Idaho National Laboratory researchers, and outside guests from academia and industry. Each 90-minute session includes a technical or informative lecture on a CAES research or focus area. Presenters also answer audience questions and seek collaborative opportunities for joint proposals or research development. The seminars are broadcast online for those who can't attend in person.

FY-18 CAES Seminar Series Speakers

March **Dakota Roberson** – University of Idaho
Stability of the Western North American Electric Grid

April **Travis McLing** – Idaho National Laboratory
The Water-Food-Energy Nexus

May **Michel Haney** – University of Idaho
Bitcoin, Litecoin, and the Future Economy

June **James Money** – Idaho National Laboratory
The Future of Real-time 3D Visualization

July **Emma Redfoot** – University of Idaho
Nuclear Renewable Hybrid Energy Systems

Aug. **Nicolas Lee** – Stanford University
Space Energy Harvesting and Wireless Power-transfer Concepts

Sept. **John Kotek** – Nuclear Energy Institute
The Future of Nuclear Energy in the U.S.

> Over the years, Wyoming researchers have benefited from a variety of regional relationships from Idaho National Laboratory, including the Center for Advanced Energy Studies.

Kipp Coddington
University of Wyoming,
U.S. Senate Testimony
Nov. 2017

CAES Supports *My Amazing Future* with Interactive Events, Guest Speakers

The 2018 *My Amazing Future* event, which brought together 150 eighth-grade girls from four school districts to learn about science, technology, education, and math (STEM) careers, was held at INL and CAES in March. During the event, students performed dozens of hands-on science experiments, listened to laboratory researchers address career and education opportunities, and toured laboratory facilities. At CAES, several facilities and labs were temporarily turned into interactive learning spaces. CAES staff and students—including Donna Wuthrich, James Money, Tammie Borders, Leslie Kerby, Ross Kunz, Meng Shi, Eugene Engmann, Emma Redfoot, Charles Elverson, Derek Stucki, and Jieun Lee—ushered students through a series of activities and events involving advanced visualization, robotics, and renewable energy. CAES Director Noël Bakhtian provided closing remarks to the students.

Students participate in the 2018 My Amazing Future event at CAES.

Wyoming Women of Influence Conference Hosts CAES Director for Motivational Talk

During the 6th annual Wyoming Women of Influence awards ceremony in Cheyenne in August, CAES Director Noël Bakhtian delivered the keynote address. Nearly 400 people gathered at the event to honor 10 women from across Wyoming for their outstanding work in business, achievement, and mentorship. As an invited guest, Bakhtian spoke about ways to make women visible in work environments traditionally dominated by men. She also addressed her personal education pathway that led to degrees from Duke, Cambridge, and Stanford University. In addition, she shared her curiosity for science and engineering, and how it led to career opportunities with NASA, the Department of Energy, the White House, and now CAES. The event was sponsored by the Wyoming Business Report and the University of Wyoming, a CAES member university.

CAES Director Keynotes Idaho Conference on Undergraduate Research

CAES Director Noël Bakhtian provided the keynote address at the July 2018 Idaho Conference on Undergraduate Research at Boise State University. The event is the state's premier annual conference for undergraduate students working on degrees in STEM-focused areas. During the keynote, Bakhtian spoke to an estimated 200 students about her education and career path, including her research opportunities at the National Aeronautics and Space Administration, the U.S. Department of Energy, and the White House's Office of Science and Technology Policy.

> National laboratories and universities have strong research and education cultures that lead to critical innovations and technological advancements. We see tremendous opportunity to link our strengths more closely with private sector research and work-force needs.

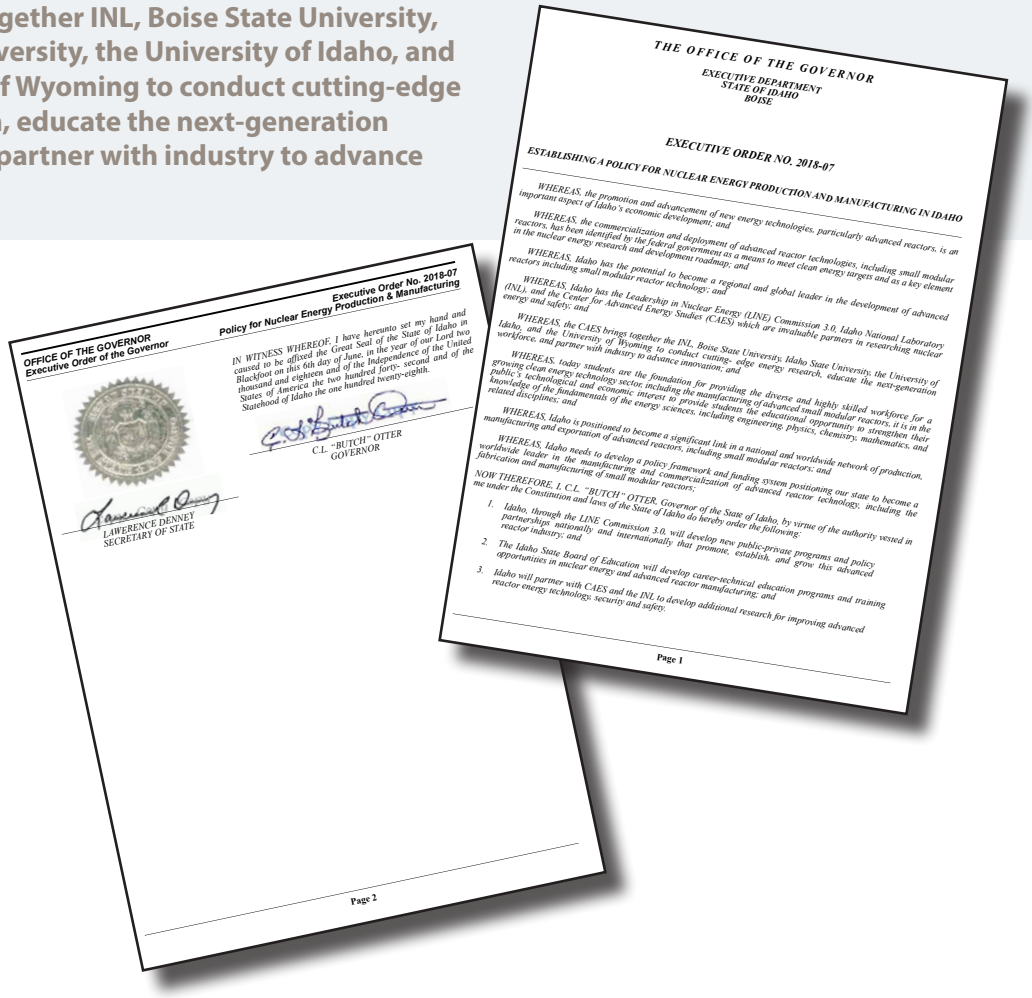
Leah Guzowski
Director,
CAES and INL Industry
Research and Development

INNOVATION HIGHLIGHTS

Idaho Governor Signs Nuclear Energy Executive Order Highlighting CAES

In early June, Idaho Gov. C.L. "Butch" Otter signed Executive Order 2018-07, establishing a policy for nuclear energy manufacturing and production in Idaho. The order calls on the state of Idaho to partner with CAES and INL to develop research for improving advanced reactor energy technology, security, and safety. Specifically, it asks the LINE Commission 3.0 to develop new public-private programs and policy partnerships nationally and internationally. These will promote, establish, and grow the advanced nuclear reactor industry. It also directs the Idaho State Board of Education to develop career and technical education programs and training opportunities in nuclear energy and advanced-reactor manufacturing.

"CAES brings together INL, Boise State University, Idaho State University, the University of Idaho, and the University of Wyoming to conduct cutting-edge energy research, educate the next-generation workforce, and partner with industry to advance innovation."



THE OFFICE OF THE GOVERNOR
EXECUTIVE DEPARTMENT
STATE OF IDAHO
BOISE

EXECUTIVE ORDER NO. 2018-07

ESTABLISHING A POLICY FOR NUCLEAR ENERGY PRODUCTION AND MANUFACTURING IN IDAHO

WHEREAS, the promotion and advancement of new energy technologies, particularly advanced reactors, is an important aspect of Idaho's economic development; and

WHEREAS, the commercialization and deployment of advanced reactor technologies, including small modular reactors, has been identified by the federal government as a means to meet clean energy targets and as a key element in the nuclear energy research and development roadmap; and

WHEREAS, Idaho has the potential to become a regional and global leader in the development of advanced reactors including small modular reactor technology; and

WHEREAS, Idaho has the Leadership in Nuclear Energy (LINE) Commission 3.0, Idaho National Laboratory (INL), and the Center for Advanced Energy Studies (CAES) which are invaluable partners in researching nuclear energy and safety; and

WHEREAS, the CAES brings together the INL, Boise State University, Idaho State University, the University of Idaho, and the University of Wyoming to conduct cutting- edge energy research, educate the next-generation workforce, and partner with industry to advance innovation; and

WHEREAS, today students are the foundation for providing the diverse and highly skilled workforce for a growing clean energy technology sector, including the manufacturing of advanced small modular reactors; it is in the public's technological and economic interest to provide students the educational opportunity to strengthen their knowledge of the fundamentals of the energy sciences, including engineering, physics, chemistry, mathematics, and related disciplines; and

WHEREAS, Idaho is positioned to become a significant link in a national and worldwide network of production, manufacturing and exportation of advanced reactors, including small modular reactors; and

WHEREAS, Idaho needs to develop a policy framework and funding system positioning our state to become a worldwide leader in the manufacturing and commercialization of advanced reactor technology; including the fabrication and manufacturing of small modular reactors;

NOW THEREFORE, I, C.L. "BUTCH" OTTER, Governor of the State of Idaho, by virtue of the authority vested in me under the Constitution and laws of the State of Idaho do hereby order the following:

1. Idaho, through the LINE Commission 3.0, will develop new public-private programs and policy partnerships nationally and internationally that promote, establish, and grow this advanced reactor industry; and
2. The Idaho State Board of Education will develop career-technical education programs and training opportunities in nuclear energy and advanced reactor manufacturing; and
3. Idaho will partner with CAES and the INL to develop additional research for improving advanced reactor energy technology, security and safety.

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OFFICE OF THE GOVERNOR
Executive Order of the Governor

Executive Order No. 2018-07
Policy for Nuclear Energy Production & Manufacturing

IN WITNESS WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Idaho in Blackfoot on this 5th day of June, in the year of our Lord two thousand and eighteen and of the Independence of the United States of America the two hundred forty- second and of the Statehood of Idaho the one hundred twenty-eighth.

C.L. "BUTCH" OTTER
GOVERNOR

LAWERENCE DENNEY
SECRETARY OF STATE

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> The value of CAES comes in the opportunity to perform collaborative research. It's easy to walk 100 feet to talk with a researcher from another university who's just down the hall. It's harder to do that when they work on the other side of the state.

Bob Borelli, Ph.D.
Assistant Professor,
Nuclear Engineering
University of Idaho

CAES Hosts Idaho Industries Breakfast, Meets with Congressional Delegations

Several members of the CAES leadership team traveled to Washington, D.C., in June to host the Idaho Industries Breakfast and hold meetings on Capitol Hill with federal elected officials from Idaho and Wyoming. During the industry breakfast, CAES Director Noël Bakhtian updated the 80-plus attendees on the CAES mission, vision, strategy development, and recent accomplishments. Later in the day, the team met individually with Idaho Senators Mike Crapo and Jim Risch and Congressman Mike Simpson. The team also met with staff members from Congressman Raúl Labrador's office. Similarly, the group met with Wyoming Sen. John Barrasso and staff from Sen. Mike Enzi's office.

A Boise State University student explores computer-generated imagery through a set of Oculus Rift 3D goggles.

BY THE NUMBERS

Through collaboration, CAES member organizations leverage the following collective assets:

8,000 More than 8,000 scientists, engineers, faculty, and support staff

63,000 More than 63,000 students

1,100 More than 1,100 degrees and certificates offered

100 Nearly 100 laboratories and engineering facilities

$1.8B Approximately $1.8 billion in annual research funding

Investments

$7.1M **$7.1 million Idaho National Laboratory investments in CAES**

$3M **State of Idaho investments in CAES**

Outreach

1,669
Visitors to CAES and the CAVE 3D immersive research environment

48
Working meetings, seminars, and speeches hosted or sponsored by CAES

343
CAES publications and proceedings

Research and Program Funding

$3,456,278 Federal nuclear energy funding awarded to CAES member faculty members (primary award)

$705,362 Federal nuclear energy funding awarded to CAES member faculty members (secondary award)

$688,212 Laboratory Directed Research and Development funding (primary award)

$4,000,000 Laboratory Directed Research and Development projects (secondary award)

$878,465 Program-development funding awarded to CAES member organizations for 30 strategic research projects.

University Impact at INL

NINETY-TWO
students from CAES member universities interned at Idaho National Laboratory

SEVENTEEN
faculty members from CAES member universities were awarded joint appointments at Idaho National Laboratory

9 students from CAES member universities were offered graduate fellowships at Idaho National Laboratory

6 faculty from CAES member universities participated in the inaugural Visiting Summer Faculty program

5 students from CAES member universities were awarded postdoctoral appointments at Idaho National Laboratory

RESEARCHER, FACULTY, STAFF, AND STUDENT ACCOMPLISHMENTS

CAES Graduate Researcher Earns Fellowship at Los Alamos National Laboratory

This summer, CAES graduate researcher Seth Dustin earned a research fellowship at Los Alamos National Laboratory. As a student at CAES, Dustin worked alongside Idaho National Laboratory researchers Prabhat Tripathy and Michael Shaltry on a project for the Critical Materials Institute involving electrochemical measurements of rare-earth materials in molten salt.

CAES Graduate Student Earns Industry Fellowship at Oklo, Inc.

CAES graduate student Emma Redfoot earned a six-month fellowship at microreactor startup Oklo, Inc. The company is designing a small, portable nuclear reactor that is waste and carbon negative. Based in Sunnyvale, CA, the company was founded in 2013 and is working to develop a 2-megawatt compact fast reactor to bring distributed, clean, affordable, and reliable nuclear power to the market. During her time at CAES, Redfoot also defended her master's thesis, "Allocating Heat and Electricity in a Nuclear Renewable Hybrid Energy System Coupled with a Water Purification System."

The Materials Society Awards Best Poster to CAES Student

During the 2018 Minerals, Metals, & Materials Society's annual meeting, CAES graduate researcher Meng Shi was awarded best student research poster for her work on Electrolytic Reduction on TiO2 in Molten Li2O/LiCl. Her research project used an electrochemical method to reduce metal oxide in spent nuclear fuel to a lower oxidative status. She found that by controlling parameters, like cathodic potentials, the carbon efficiency can reach 17 percent with a possible reduction extent up to 25 percent.

Four CAES University Students Part of INL's 2018 Graduate Fellows Program

Idaho National Laboratory welcomed 13 students into the second cohort of the Graduate Fellows program, four of whom came from CAES member universities. The program integrates students into the national laboratory and allows them to contribute to significant research projects that will help them fulfill their thesis research requirements. The laboratory gains access to skilled staff, along with the opportunity to build long-term collaborations with universities, increase recruiting opportunities, and interact with a continuous pipeline of students interning and conducting research at the lab. Both the universities and INL have the opportunity for joint publications and intellectual property. Fellows from CAES member universities include Corey Michael Efaw, Sohel Rana, and Jennifer Kay Watkins from Boise State University, and Emerald Dawn Ryan from Idaho State University.

CAES Intern from Idaho State University Supports LINE Commission Study

Idaho State University Career Path Intern Pedro Mena, working alongside ISU's Leslie Kerby, supported a research study evaluating the value chain for advanced reactors, specifically as it pertains to opportunities for the state of Idaho. The study was coordinated with the Idaho Leaderhip in Nuclear Energy Commission to inform state leaders about the market potential, value propositions, types of energy sector markets (e.g., utilities, industry, transportation), mechanisms to attract advanced-reactor manufacturers, and the potential for the development of a reactor-manufacturing industry in the state.

CAES would like to congratulate the following students from CAES member universities working as graduate assistants or supporting our research in a range of subjects including nuclear engineering, physics, and chemistry. The following students defended their master's thesis or doctoral dissertation:

University of Idaho
- WaiLam Chan
- Stephen Hancock
- Jieun Lee
- Emma Redfoot
- Amey Shirekar

Boise State University (doctoral students)
- Steven LeTourneau
- Kassi Smith

Idaho State University
- Shawn Fredstrom
- Nathaniel Gardner
- Brittany Grayson
- Connor Harper
- Mason Jaussi
- Daniel Sluder
- Aaron Thompson
- Kory Walling

Christensen Named University of Idaho's College of Engineering's Outstanding Faculty Member of the Year

In May, CAES Associate Director Rich Christensen was named the University of Idaho (UI) College of Engineering's outstanding faculty member of the year. Following selection by an executive committee of peers, the annual award was given to a faculty member who serves as a role model and helps shape the college's high standard of achievement through their hard work and dedication to engineering. Christensen, who joined the university in 2015, is an internationally recognized scholar and leader in a wide range of nuclear and thermal science research areas. Prior to his time at UI, Christensen had a distinguished 37-year career at The Ohio State University, where he achieved professor emeritus status.

Jaussi Completes Master's Degree, Earns Radiation Safety Officer Certification

Mason Jaussi, CAES Health Physicist, received his master's degree this year from Idaho State University, and is now a certified radiation safety officer. He completed his thesis, "Developing Am-DTPA (Americium-Diethylenetriamine pentaacetate) and Biokinetic Model," based on chelation treatments to model Am-DTPA to excrete radiation and determine dosage for the human body. Jaussi is currently working on his Certified Health Professional Certificate, gaining operational experience, and training on radiological materials.

Business Insider Names CAES Director One of 2018's Top Female Engineers

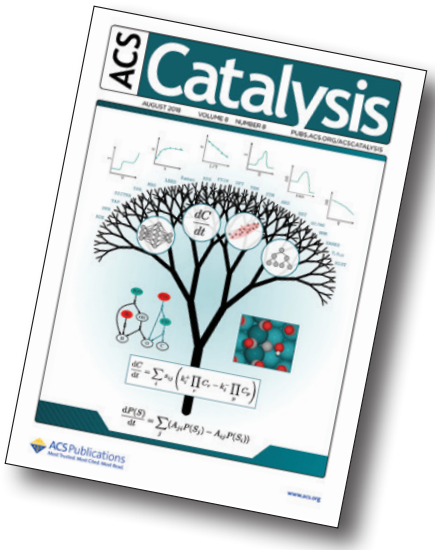
In honor of International Women in Engineering Day, *Business Insider* published a list of the 39 most powerful female engineers of the year. CAES Director Noël Bakhtian came in as No. 11 on the most powerful list. *Business Insider* is one of the most widely read business and technology websites in the world with more than 80 million monthly visitors. In naming each awardee, the editors noted that despite the "arm waving about a lack of female STEM professionals…these are women with engineering backgrounds who are running big business units at important companies, are building impressive up-and-coming technologies, or acting as leaders and role models in the tech communities."

Kunz Receives Doctoral Degree in Statistics from Idaho State University

Idaho National Laboratory employee Ross Kunz received his doctoral degree in statistics this year. His dissertation, "Fused Lasso and Tensor Covariance Learning with Robust Estimation," touched on block structure for estimation using sets of information to explain an event. Kunz, a data scientist in INL's High Performance Computing and Data Analytics department, looked at relationships between gas species of the overall catalytic process rather than physics just using data. Kunz plans to continue his work supporting Dr. Rebecca Fushimi's research in catalysis and transient kinetics.

CAES Researcher Named to INL's Inventors Hall of Fame

During the INL Laboratory Director Awards ceremony in April, CAES researcher Harry Rollins was inducted into the laboratory's Inventors Hall of Fame. Rollins, who supports research and engineering efforts in the CAES Catalysis and Transient Kinetics Laboratory, was honored for being issued five career patents. As an INL principal investigator, his areas of research include synthesis and characterization of novel phosphorous-nitrogen compounds as advanced electrolytes for lithium-ion batteries, preparation and characterization of nanoscale catalysts for the production of synthetic fuels, and preparation of nanomaterials using supercritical fluid technology and nanomaterials characterization. Rollins holds a doctorate in analytical chemistry from Clemson University.



The cover of the August 2018 issue of Catalysis Magazine *features a graphic on multiple ways to analyze catalysis data. The cover resulted from a project that took place inside the CAES Catalysis and Transient Kinetics Laboratory.*

McLing Speaks on Water Security at National Governors Association Conference

In September, the National Governors Association's Center for Best Practices hosted the 2018 Annual Water Policy Institute which brought together water specialists from 31 states along with outside experts to talk about pressing issues surrounding water security. During the event, CAES researcher Travis McLing led a panel discussion on water security with an emphasis on cybersecurity. The panel featured notable experts from across the country speaking on topics ranging from infrastructure hardening to vulnerability assessments. In addition to his role as laboratory lead, McLing is the program manager for Idaho National Laboratory's Water Security Test Bed.

NEW HIRES

Kathleen Araújo
In July, Kathleen Araújo was hired as the director of the CAES Energy Policy Institute. The institute is located on the Boise State University campus and focuses on strategic problem-solving and opportunities in energy through a crosscutting, socio-technical approach that informs policy makers, communities, and private industry. Araújo earned her doctorate at the Massachusetts Institute of Technology, completing postdoctoral research at the Harvard Kennedy School on science, technology and public policy, and nuclear safety. She has worked as an assistant professor of energy-environmental innovation systems and policy at Stony Brook University, and as a researcher with Brookhaven National Laboratory, where she worked in the divisions for nuclear nonproliferation and national security, and sustainable energy. In addition, she is a book-series editor for Routledge's studies in Energy Transitions.

Leah Guzowski
In September, Leah Guzowski was hired as the director of Industry Research and Development for CAES. She also serves as Idaho National Laboratory's director of Industry Engagement in a concurrent role. She comes to CAES from Argonne National Laboratory, where she served as commercial team lead for the U.S. Department of Energy, Building Technology Program. Guzowski's previous work includes strategic consulting and business development for clean technology companies and macro-level economic analysis research for international governments. She is a graduate of Harvard University and the University of Wisconsin-Madison. She also studied economics and policy at the University of Oxford.

Jana Pfeiffer
In May, Jana Pfeiffer joined CAES as the research operations lead. In this role, Pfeiffer supports day-to-day technical, safety, facility, and operational activities for laboratories, equipment, and research operations to ensure successful execution of the CAES mission and vision. She is also the first point of contact for Idaho National Laboratory researchers who want to perform laboratory work at CAES. She provides direction on how to initiate the CAES processes for INL off-site work. Her extensive experience conducting hands-on research in both laboratory and radiological environments adds exceptional operational support to the CAES team. She holds a bachelor's degree in chemistry from Idaho State University.

Jeff Benson
In February, Jeff Benson was hired as the CAES business operations lead. He is responsible for coordination of business outcomes, project management, and CAES process improvement. Prior to joining CAES, Benson worked for the Nuclear Science User Facilities at Idaho National Laboratory as a program administrator. He holds a master's degree in public administration from Marriott School of Management at Brigham Young University and a bachelor's degree in education from Brigham Young University.

PUBLICATIONS AND PROCEEDINGS

In fiscal year 2018, CAES member organizations published 343 papers, journal articles, reports, and conference proceedings. The following pages include an alphabetized list of the CAES publications and proceedings for fiscal year 2018 as reported by each organization's associate director.

Boise State University

1. Aldrich, L., & Koerner, C. (2018). Challenges to trading white certificates. *The Electricity Journal. 31*(4), 41-47.
2. Aldrich, L., & Koerner, C. (2018). White certificates: market status and trends. *The Electricity Journal. 31*(3), 52-63.
3. Aldrich, L., & Koerner, C. White certificate trading: A dying concept or just making its debut? Part II: Challenges to trading white certificates, The Electricity Journal, Volume 31, Issue 4, 2018, Pages 41-47, ISSN 1040-6190, https://doi.org/10.1016/j.tej.2018.05.006.
4. Baatz, R., Sullivan, P. L., Li, L., Weintraub, S., Loescher, H. W., Mirtl, M.,...Van Looy, K. (2018). Integration of terrestrial observational networks: opportunity for advancing Earth system dynamics modelling. *Earth System Dynamics, 9,* 593-609. https://doi.org/10.5194/esd-9-593-2018.
5. Barnes, P., Savva, A., Dixon K., Bull H., Rill, L., Karsann, D.,…Xiong, H. * (2018). Electropolishing valve metals with a sulfuric acid-methanol electrolyte at low temperature. *Surface & Coatings Technology, 347,* 150–156.
6. Bateman, A., Queale, A.J., Butt, D.P., & Jaques, B.J. (2018). Effects of sintering aids on the hydrothermal oxidation of silicon nitride spherical rolling elements. *Corrosion Engineering, Science and Technology*. DOI: 10.1080/1478422x.2018.1523290.
7. Blackman, H. S., & Boring, R. (2017). Assessing dependency in SPAR-H: some practical considerations. In R. Boring (Ed.), *Advances in Human Error, Reliability Resilience, and Performance (Advances in Intelligent Systems and Computing).* Heidelberg: Springer Verlag.
8. Burns, J., Wu, Y., & Taylor, J. (2018, June). The application of an X-ray diffraction to nuclear materials at MaCS, CAES [Powerpoint slides]. Presented at the Isotope and Materials Science Roadmapping Workshop, Idaho Falls, ID.
9. Dangol N., Shrestha,D.S., & Duffield, J. (2017). Life-cycle energy, GHG and cost comparison of camelina-based biodiesel and biojet fuel. *Biofuels,* 1-9. DOI: 10.1080/17597269.2017.1369632.
10. Dunkel C., Shrestha D., Beyerlein S. (2017). *Feasibility and economic analysis for creating a viable cogeneration design for the campus wood-fired boiler.* Paper No. 171201 presented at the meeting of the American Society of Agricultural and Biological Engineers, St. Joseph, MI.
11. Estrada, D. (2017, November). *Aerosol jet printing of flexible electronics*. Paper presented at the 9th Annual International Optomec Users Meeting, Santa Clara, CA.
12. Forsmann, B., Wu, Y., & Burns, J. (2018, June). Center for Advanced Energy Studies Advanced Materials Laboratory radiological capabilities [Powerpoint slides]. Presented at the Isotope and Materials Science Roadmapping Workshop, Idaho Falls, ID.
13. Fowler, L. & Johnson, A. (2017). Overlapping authorities in U.S. energy policy. *The Electricity Journal 30*(9), 1-5.
14. Fujimoto, K., Davis, K., Tsai, K., Watkins, J., Unruh, T., & Estrada, D. (2017, November). *Aerosol jet printing of in-pile nuclear sensors*. Paper presented at the 9th Annual International Optomec Users Meeting, Santa Clara, CA.
15. Fujimoto, K., Unruh, T., Watkins, J., Subbaraman, H., & Estrada, D. (2018, April). *Additive manufacturing of in – pile nuclear sensors.* Poster session presented at the NASA In-Space Manufacturing and Printed Electronics Workshop, Huntsville, AL.
16. Gates, G., Butt, D., Burns, J., Wu, Y., Alanko, G., & Watkins, J.K. (2018, August). *The internal morphology and composition of a purple pigment particle extracted from an ancient Faiyum mummy portrait.* Paper presented at M&M 2018, Baltimore, MD.
17. Godwin†, L., Brown†, D., Livingston, R., Webb, T., Karriem, L., Graugnard, E., & Estrada, D. Open source, automated chemical vapor deposition system for production of two-dimensional nanomaterials, *PLOS One*, in review.
18. Henry, M., Miller, E., Jones, M. & Thomas, S. (2018, March). Poster session presented at the meeting of the American Physical Society, Los Angeles, CA.
19. Hollar, C., Varghese, T., Kongara, M., Lin, Z., Duan, X., Estrada, D., & Zhang, Y. (2018, April). *High-performance flexible thermoelectric thin films from solution processed colloidal nanoplates.* Poster session presented at the NASA In-Space Manufacturing and Printed Electronics Workshop, Huntsville, AL.
20. Hondros, M., Tuft, S., Karriem, L., Pandhi, T., Chandnani, A., Convertino, D.,… Estrada, D. (2018, April). *Differential gene expression in C2C12 cells due to scaffold structure-property-processing correlations.* Poster session presented at the Materials Research Society Spring Meeting, Phoenix, AZ.
21. INTERNATIONAL ATOMIC ENERGY AGENCY, Deployment Indicators for Small Modular Reactors, IAEA-TECDOC-1854, IAEA, Vienna (2018).
22. Jaques, B.J., Pedersen, S.V., Croteau, J., Lupercio, A., Bellomy, R., Kempf, N.,… Butt, D.P. (2018, March). *Novel synthesis and optimization of half-Heusler materials for thermoelectric applications*. Paper presented at the TMS 2018 Conference, Phoenix, AZ.

23. Kempf, N., Chinnathambi, K., Gigax, J., Shao, L., Jaques, B.J., Butt, D.P., Ren, Z., & Zhang,Y. (2018) Proton irradiation effect on thermoelectric properties of nanostructured n-type half-Heusler Hf0.25Zr0.75NiSn0.99Sb0.01. Applied Physics Letters 112(24). DOI: 10.1063/1.502507
24. Kundu, A., Charit, I., Jaques, B.J., & Jiang, C. (2018, March). *A study on the high energy ball milling and spark plasma sintering of Fe-Cr based alloys*. Paper presented at the TMS 2018 Conference, Phoenix, AZ.
25. Lenhart, S. (2018, September). *Innovation in community electric power: Distributed energy resources in municipal utilities and electric cooperatives in the US*. Paper presented at EPRC8, Boise, ID.
26. Lewandowska, K., Seas, M., Pandhi, T., Chandnani, A., Subbaraman, H., Johnson, P., & Estrada, D. (2017, November). *Powder River Basin graphene inks*. Poster session presented at the Society of Hispanic Professional Engineers (SHPE) National Conference, Kansas City, MO.
27. Li, L. (2018, August). *Computational modeling capabilities and deliverables (I3 Project)*. Poster session presented at the Materials Science Roadmap and Capabilities Meeting, Boise, ID.
28. Li, L. (2018, March). *High-throughput computational studies of structural, electrical, phonon and thermal properties of two-dimensional materials.* Paper presented at the Materials Society conference, Phoenix, AZ.
29. Li, L. (2018, January). *High-throughput computational studies of two-dimensional transition metal dichalcogenides*. Paper presented at the 2018 Conference on Electronic and Advanced Materials, Orlando, FL.
30. Li, L. (2018, January). *Tuning thermal transport in two-dimensional transition metal dichalcogenides*. Paper presented at the 2018 Conference on Electronic and Advanced Materials, Orlando, FL.
31. Li, L. (2018, March). *Tuning electrical and thermal transport in atomic layer materials*. Paper presented at the Materials Society conference, Phoenix, AZ.
32. Li, L. (2018, August). *Phase-field modelling of nanoparticle sintering for Cu-Ni alloy printing.* Poster session presented at the Materials Science Roadmap and Capabilities Meeting, Boise, ID.
33. Li, L. (2018, March). *Predict corrosion phenomena and surface properties of Al-based alloys.* Paper presented at the Materials Society conference, Phoenix, AZ.
34. M., Solan, D., & Shropshire, D. (2015). Carbon free energy development and the role of small modular reactors: A review and decision framework for deployment in developing countries. *Renewable and Sustainable Energy Reviews, 43*, 83-94.
35. Ma, C., Fu, Z., Deng, C., Liao, X., He, Y., Ma, Z., & Xiong, H. (2018). Carbon-coated FeP nanoparticles anchored on carbon nanotube networks as anode for long-life sodium-ion storage. Chemical Communications, 2018,54, 11348-11351. DOI: 10.1039/C8CC06291A
36. Mao, K., Wu, Y., Sun, C., Perez, E., & Wharry, J.P. Laser weld-induced formation of amorphous Mn–Si precipitate in 304 stainless steel, Materialia, Volume 3, 2018, Pages 174-177, ISSN 2589-1529, https://doi.org/10.1016/j.mtla.2018.08.012.
37. Mao, K., Wang, H., Wu, Y., Tomar, V., Wharry, J., Microstructure-property relationship for AISI 304/308L stainless steel laser weldment, Materials Science and Engineering: A, Volume 721, 2018, Pages 234-243, ISSN 0921-5093, https://doi.org/10.1016/j.msea.2018.02.092.
38. O'Brien, R.C., & Lessing, P.A. (2017). Controlled relative humidity storage for high toughness and strength of binderless green pellets. *Journal of the American Ceramic Society 100*(10), 4442-4449.
39. Oh, S. & Gardner, J. (2017, December). Impact of window replacement on Yanke Building energy consumption. (CEERI report 17-001).
40. Pandhi, T., Estrada, D., & Koehne, J. (2018, May). *Inkjet printing of graphene for wearable and flexible electrochemical sensors*. Paper presented at the 233rd Electrochemical Society Meeting, Seattle, WA.
41. Pandhi, T., Estrada, D., & Koehne, J. (2018, June). *Fully inkjet printed graphene-based biosensor for flexible and wearable electronics*. Poster session presented at the 28th World Congress on Biosensors, Miami, FL.
42. Pandhi, T., Kreit, E.B., Aga, R.S., Fujimoto, K., Sharbati, M., Khademi, S.,…Estrada, D. (2018, April). *Emerging 1-D and 2-D materials for printed and flexible electronics*. Poster session presented at the NASA In-Space Manufacturing and Printed Electronics Workshop, Huntsville, AL.
43. Pasebani, S., Charit, I., Guria, A., Wu, Y., Burns, J., Butt, D., Cole, J., & Shao, L. A preliminary investigation of high dose ion irradiation response of a lanthana-bearing nanostructured ferritic steel processed via spark plasma sintering, Journal of Nuclear Materials, Volume 495, 2017, Pages 78-84, ISSN 0022-3115, https://doi.org/10.1016/j.jnucmat.2017.08.010.
44. Patil, C., & Cooper, E. (2018, July). *The use of a 3D sonic anemometer for the study of airflow patterns in a hospital patient room*. Paper presented at Indoor Air Philadelphia, Philadelphia, PA.
45. Patki, P.V., Wharry, J.P., Wu, Y. Q. (2018) TEM In-situ Mechanical Testing of proton irradiated nanocrystalline Copper Tantalum alloy (Masters thesis). https://docs.lib.purdue.edu/dissertations/AAI10793974/
46. Perez, A., Letourneau, S., Graugnard, E., & Estrada, D. (2017, November). An electrical thermometry platform for thermal conductivity measurements of 2D materials. Poster presentation at the Society of Hispanic Professional Engineers (SHPE) National Conference, Kansas City, MO.
47. Reinfelde, M., Mitkova, M., Nichol, T., Ivanova, Z.G., & Teteris, J. (2018). Photoinduced mass transport in Ge-Se amorphous films. *Chalcogenide Letters 15*(1), 35-43.
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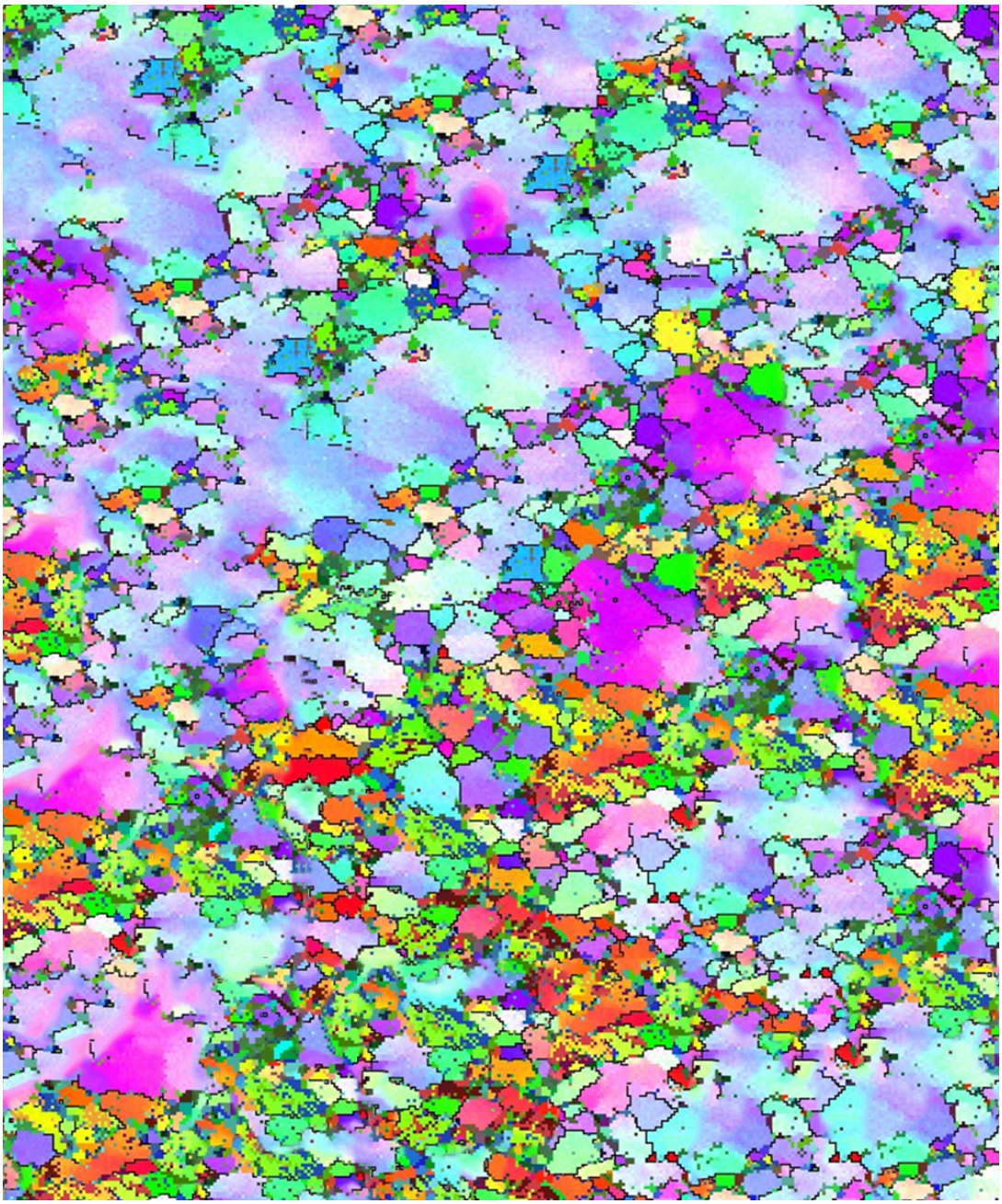

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