CAES ANNUAL REPORT

CENTER FOR ADVANCED ENERGY STUDIES

BOISE STATE UNIVERSITY

HAROLD BLACKMAN

April 15, 2021

I am excited to share with you Boise State's first Center for Advanced Energy Studies (CAES) Annual Report. As you will see, we have had an exceptional year in meeting our mission to inspire innovation and impact by leveraging our collective capabilities to empower students, researchers, faculty, and industry to accelerate energy solutions. I find even more remarkable that the focus and dedication of our CAES team did not waver during a year saddled with so much uncertainty. CAES continues to grow, new collaborations continue to be cultivated, existing collaborations continue to strengthen, and our research, education, and innovation ecosystem continues to address the world's most pressing energy challenges.

CAES has been a special part of my career since its inception in 2005 and represents the collective realization of thousands of people working toward a common goal — securing our nation's energy independence and ensuring a sustainable energy future. Prior to coming to Boise State University, I served as the Director of CAES, where I helped build the foundation for what has evolved into a formidable workforce development and energy innovation consortium. With its formal dedication on February 20, 2009 in Idaho Falls, CAES has enjoyed more than 10 years of enabling a new generation of energy-related technology development, policy engagement, and energy leaders.

At Boise State, our CAES leaders and affiliates have rallied around the three strategic pillars of research, education, and innovation. Based on the seven strategic focus areas of the CAES 2019 – 2039 strategic plan, we have established campus Focus Area Leads in nuclear energy, the energy-water nexus, cybersecurity, advanced manufacturing, innovative energy systems, energy policy, and computing, data, and visualization. The Boise State leads are establishing new collaborations, identifying resource gaps, and pooling resources toward workforce development initiatives and research opportunities. In the past year alone, this has led to over $12 million in extramural funding to innovate in wildfire containment, energy harvesters, batteries, nuclear materials, cyber-physical systems security, food safety, and more! As excited as I am to share our accomplishments with you, I am equally excited about the future impacts of CAES on campus, in Idaho, and across the globe.

Sincerely,

Harold S. Blackman

Harold Blackman, Ph.D.

DAVID ESTRADA

April 15, 2021

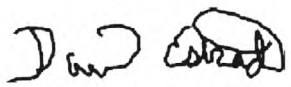
The Center for Advanced Energy Studies at Boise State University is excited to highlight the impact of CAES Focus Area Leads and Affiliates in research, education, and innovation for Federal Fiscal Year 2020 (10/1/2019 – 9/30/2020). The year started with a celebration of the 10th anniversary of CAES, and ended in the middle of a global pandemic with the CAES Technical Assistance Program working with other community members to provide personal protective equipment to healthcare workers.

An important component of CAES is collaboration, which is one of the drivers of the programs we established over the last year and the programs that continue to be a hallmark of CAES. The CAES Steering Committee approved several new programs, including the CAES Energy Frontiers, CAES Fellows, and CAES Definitions to stimulate planning grants for CAES Centers of Excellence, recognize excellence, and to better define CAES Affiliations for people, equipment, and projects. CAES Working Groups focused on connecting CAES affiliates across seven focus areas in order to build new collaborations. And with the pandemic, the CAES Summer Visiting Faculty program moved to a virtual environment as did much of the work of CAES. Particularly notable are the efforts of the CAES Energy Policy Institute, led by Prof. Kathy Araujo, whose virtual meetings are attracting worldwide attendance.

In addition to programming, new infrastructure investments are transforming CAES research capabilities. The Idaho National Laboratory invested approximately $6 million through Integrated Priority List funding. This funding supported the purchase of a state-of-the-art Scanning Transmission Electron Microscope capable of atomic scale imaging materials and a suite of advanced manufacturing tools and equipment at the CAES-HQ building in Idaho Falls. Efforts by Boise State faculty and Idaho National Laboratory researchers resulted in a number of other infrastructure awards this past year, including a 3D metal printer which will be part of the Nuclear Sciences User Facilities (NSUF) network and an atomic force microscope capable of mapping chemical, optical, and thermal properties of materials at the nanoscale. Other CAES investments helped seed new cybersecurity programs, new equipment for cryptology research, and short courses led by Boise State faculty.

I hope you enjoy reading about CAES affiliates and activities. I want to thank all our CAES Affiliates for their efforts to advance energy related research, innovation, and education activities at Boise State. I look forward to another successful year of CAES collaborations!

Sincerely,



David Estrada, Ph.D.

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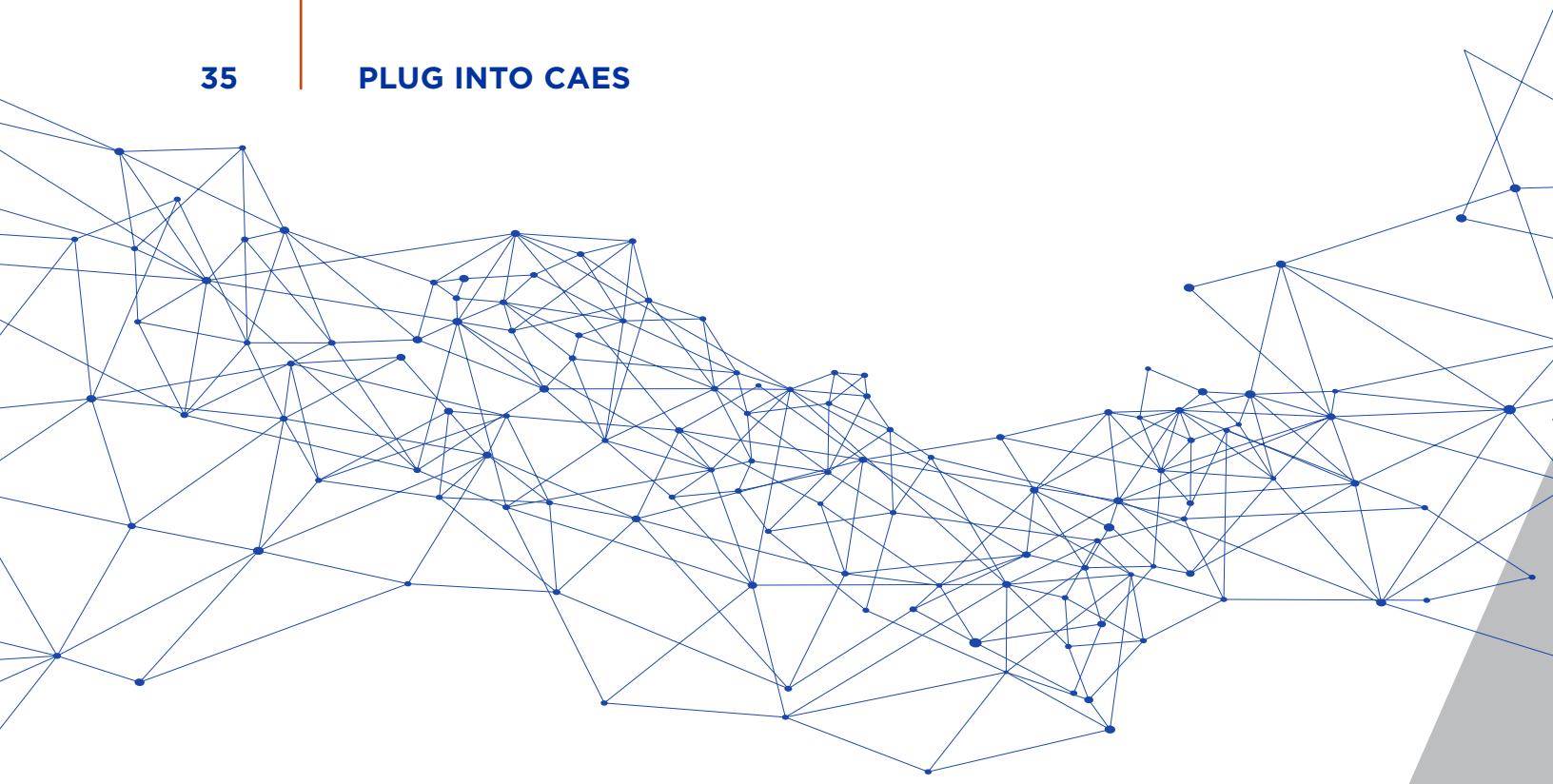


CAES AT A GLANCE

THE CENTER FOR ADVANCED ENERGY STUDIES (CAES) is a research, education, and innovation consortium that brings together students and faculty from the public research universities in Idaho and Wyoming, along with Idaho National Laboratory researchers. CAES is conducting transformative energy research, educating the next generation of scientists and engineers, and partnering with industry to advance the nation's global economic competitiveness. Our vision is the creation of a better energy future through collaboration that inspires energy leadership, ignites technology innovation, and catalyzes global impact.

BOISE STATE UNIVERSITY **CAES** INSTITUTES AND PROGRAMS

CAES Energy Efficiency Research Institute

CAES Energy Efficiency Research Institute (CEERI), based out of Boise State University, promotes the efficient and effective use of energy resources through cutting edge research, accessible education, and effective outreach. Initiatives led by CEERI include (1) Developing energy efficiency concepts through research in applied technology and consumer behavior, (2) Providing specialized education for energy efficiency technicians, engineers and architects, (3) Evaluating existing energy-saving technologies, and (4) Creating infrastructure for the accelerated transfer of ideas from the institute to the marketplace.

Energy Policy Institute

The Energy Policy Institute (EPI) is dedicated to advancing energy policy and decision-making through an evidenced-based approach that is grounded in social and technical understanding of energy systems change. From clean and secure energy to resilient and affordable energy systems, our focus is on interdisciplinary research, advising, collaborative engagement, and training. Our cross-cutting approach leverages strengths in policy, science, engineering, management and economics.

BY THE NUMBERS

6 events, **600+** participants from national labs, industry, public agencies, think tanks, academia and the general public

CAES Technical Assistance Program

The mission of the CAES Technical Assistance Program (C-TAP) is to leverage Boise State's infrastructure and engage the expertise of Boise State researchers to provide scientific and technical assistance to Idaho industry. In supporting Idaho industry, a key goal of C-TAP is to mentor and train students through real-world work experiences in preparation for their careers. In addition to industry-focused work, C-TAP participates in design reviews for project-based engineering courses and student club activities as well as provides regular support for the University Maker Space and College of Engineering Student Shop to further promote skills building and hands on training.

BY THE NUMBERS

28 projects for **24** clients

Industrial Assessment Center

The Industrial Assessment Center (IAC) is a Department of Energy sponsored program that offers an in-depth energy assessment of a plant site including its facilities, services and manufacturing operations. As part of its mission, the IAC provides students hands-on training toward developing facility energy assessments for small and medium-sized manufacturers. An IAC team can evaluate energy usage and examine the site for potential savings from: (1) Energy efficiency improvements, (2) Preventing pollution and minimizing waste, and (3) Improved productivity.

BY THE NUMBERS

9 energy assessments

10 students earned IAC Certificates, A portable credential demonstrating their energy and industrial expertise

Advanced Sensors and Instrumentation Program

Boise State University is working closely with Idaho National Laboratory through the Advanced Sensors and Instrumentation (ASI) program to address critical nuclear energy technology needs for monitoring and maintaining nuclear energy facilities. The ASI program supports novel sensor development for in-pile applications designed to provide real-time, accurate, and spatially resolved information of reactor test conditions, fuel performance, and material integrity during irradiation. This multidisciplinary, cross-cutting program incorporates innovative approaches in materials science, advanced manufacturing, and advanced modeling and simulation to monitor strain, temperature, and thermal transport. Through these efforts, the ASI program provides research opportunities for undergraduate and graduate students in preparation for the future energy workforce.

BY THE NUMBERS

9 research thrusts

10 faculty members

5 staff members

11 graduate research assistants

14 undergraduate assistants

Microscopy and Characterization Suite

The Microscopy and Characterization Suite (MaCS) is a state-of-the-art materials characterization laboratory designed to support the CAES consortium and its mission. Managed by Boise State University, MaCS offers researchers world-class microscopy and analysis equipment to probe the properties of radiological and nonradiological materials. As a recharge center and partner facility within the Nuclear Science User Facilities (NSUF) network, MaCS is available for use by the CAES consortium as well as academic, national lab, and industry partners around the United States.

BY THE NUMBERS

7 instruments and characterization tools

10 Rapid Turnaround Experiment Projects

67 clients

3688 instrument hours logged

CAES Holds Virtual Groundbreaking Ceremony for New Transmission Electron Microscope

Source: CAESenergy.org

TRANSMISSION ELECTRON MICROSCOPE (TEM)

The Center for Advanced Energy Studies (CAES) held a virtual groundbreaking ceremony on July 16 for a $5M project to install a new Transmission Electron Microscope (TEM). This state-of-the-art piece of equipment will enhance the research capabilities and further enable collaboration at CAES. The new TEM is more technologically advanced than any of the current TEM resources at INL in several ways, including:

- Better energy resolution (0.2 eV compared to 0.8 eV)
- Improved spatial resolution at low accelerating voltages enables analysis of light elements such as arbon, nitrogen, oxygen
- Equipped to better capture the behavior of dynamic materials, including phase changes and crystalization in harsh environ ments such as a reactor core
- Broader electron energy range enables research on a wider range of materials

Go **here** to watch a video of the ceremony.

To learn more visit:
caesenergy.org/caes-holds-virtual-groundbreaking-ceremony-for-new-transmis-sion-electron-microscope/

M.J. Murdock Charitable Trust Grant bolsters Boise State's nanoscale research infrastructure

Researchers at Boise State University have been awarded a $320,400 grant by the M.J. Murdock Charitable Trust to purchase an Atomic Force Microscopy–Infrared Spectroscopy (AFM-IR) system. This unique, cutting-edge equipment will enable researchers to chemically map materials at the nanoscale, and will play a critical role in building Boise State's and the region's material science research and education infrastructure.

> **"We are truly honored by the recognition of the M.J. Murdock Charitable Trust and their support of Boise State's transformative research endeavors."**

For students and faculty at Boise State, the AFM-IR system makes it possible to "obtain nanoscale chemical information about a material, how the material interacts with light at the nanoscale, and how materials carry heat at the nanoscale," said principal investigator Dave Estrada, an associate professor in the Micron School of Materials Science and Engineering.

To learn more visit:
boisestate.edu/news/2020/09/23/m-j-murdock-charitable-trust-grant-bolsters-boise-states-nanoscale-research-infrastructure/

3D Metal Printer coming to CAES

MIKE HURLEY

Researchers at Boise State University and Idaho National Laboratory have been awarded a grant through the Nuclear Energy University Program to purchase a 3D metal printer. In collaboration with CAES, the 3D metal printer will advance innovations in materials and sensors for nuclear energy applications. The 3D metal printer, which enables the fabrication of complex and integrated structures not achievable using conventional manufacturing techniques, will be housed at the shared CAES facility in Idaho Falls.

"The addition of a 3D metal printer to Boise State University's additive manufacturing portfolio fills an infrastructure gap, enabling new collaborative research within the CAES consortium and throughout the NSUF network."

Mike Hurley, an assistant professor in the Micron School of Materials Science and Engineering, is the principal investigator. The project stems from Hurley's participation in the 2019 CAES Summer Visiting Faculty Program (CSVFP) and includes his CSVFP partner Donna Guillen from Idaho National Laboratory and Boise State faculty members and fellow 2019 CSVFPP alumni Dave Estrada, who is the CAES Associate Director for Boise State, and Brian Jaques, who is a CAES Fellow at Boise State.

To learn more visit:
boisestate.edu/caes/2020/07/17/caes-connections-abound-in-projects-that-receive-ne-up-neet-funding/

Innovative Partnership Powers Student Education in '21st Century Opportunities and Challenges in Energy'

KATHY ARAUJO

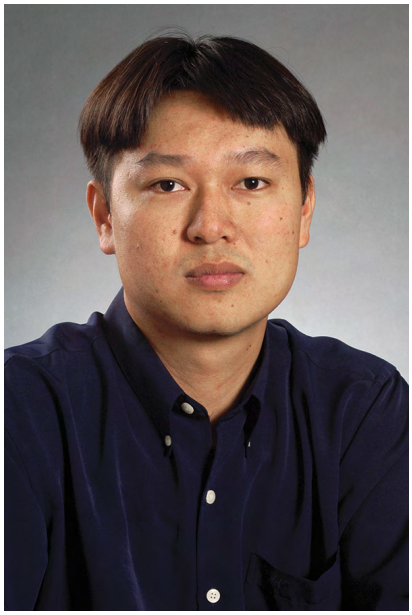
Energy often is taken for granted until its ease of access disappears. Only then, when the car won't start or an entire city grid struggles to bounce back from a catastrophe, does the reality of that reliance hit home. As constant users of energy, communities and industry arefinding a growing need for skilled leaders and informed users to tackle the multifaceted issues of energy sustainability, protection and access.

> **"Energy is fundamental to all aspects of our daily lives, yet most people learn about energy primarily through their utility bills and prices at the gasoline pump."**

That's why Boise State University associate professor Kathy Araújo and Idaho National Laboratory are collaborating to train students on resilience assessments as part of an interdisciplinary course taught by Araújo on the complexities of energy-related decision-making. The new course, which debuted in spring 2020, 21st Century Opportunities and Challenges in Energy – Strategic Decision-making about Systems Change, provides problem-directed training for 20 undergraduate and graduate students from four schools at Boise State.

To learn more visit:
www.boisestate.edu/news/2020/02/26/innovative-partnership-powers-student-education-in-21st-century-opportunities-and-challenges-in-energy/

Boise State Receives Grant to Build Online Cyber Security Certificate Program



SIN MING LOO

Boise State University's College of Engineering and Division of Extended Studies have partnered to secure a grant of $833,958 from the Idaho Workforce Development Council focused on building an online cyber-physical systems security certificate with a proposed fall 2020 launch.

"The partnership between the College of Engineering and Extended Studies leverages expertise from across the university to create a truly unique, highly relevant and fully accessible program for Idaho."

The grant covers 36 months of development and program start-up costs and will enable Boise State to create a high-demand, innovative online cyber-physical systems security certificate. The program is designed to be accessible to anyone interested in earning the credential, regardless of where they live in Idaho.

To learn more visit:
boisestate.edu/news/2019/11/06/boise-state-receives-grant-to-build-online-cyber-security-certificate-program/

‘Cyber 4 All’ Welcomes All Students to Gain Cyber Defense Skills

Taylor Lippman Photo

A recent study by Cybersecurity Ventures, a respected publisher of cybersecurity content, predicted that 3.5 million cybersecurity jobs around the world will be unfilled by 2021. In a technology driven world that is expanding more rapidly than society and policy can react, it is imperative that all students have the opportunity to gain fundamental cyber defense skills.

“Everyone needs to know how to stay safe in a world increasingly driven and controlled by technology.”

To remedy this, starting in August 2020, any student regardless of their degree program or major may pursue a certificate in Cyber-Physical Systems Security-for-All (or Cyber 4 All). These courses provide a cyber security background for everyone. The objective is to raise the cybersecurity awareness across the campus.

To learn more visit:
boisestate.edu/news/2020/02/26/cyber-4-all-welcomes-all-students-to-gain-cyber-defense-skills/

Rocky mountains, photo credit Ken Williams

Lejo Flores to Collaborate on Large–Scale Atmospheric Measurement Project

For the arid climates of the Western United States, water remains a commodity more precious than gold. As the region's climate, agriculture, energy-production and general well-being is shaped by water availability in the form of rain and mountain snowpack, information about how precipitation and the earth's atmosphere interact with mountainous terrain has never been more important.

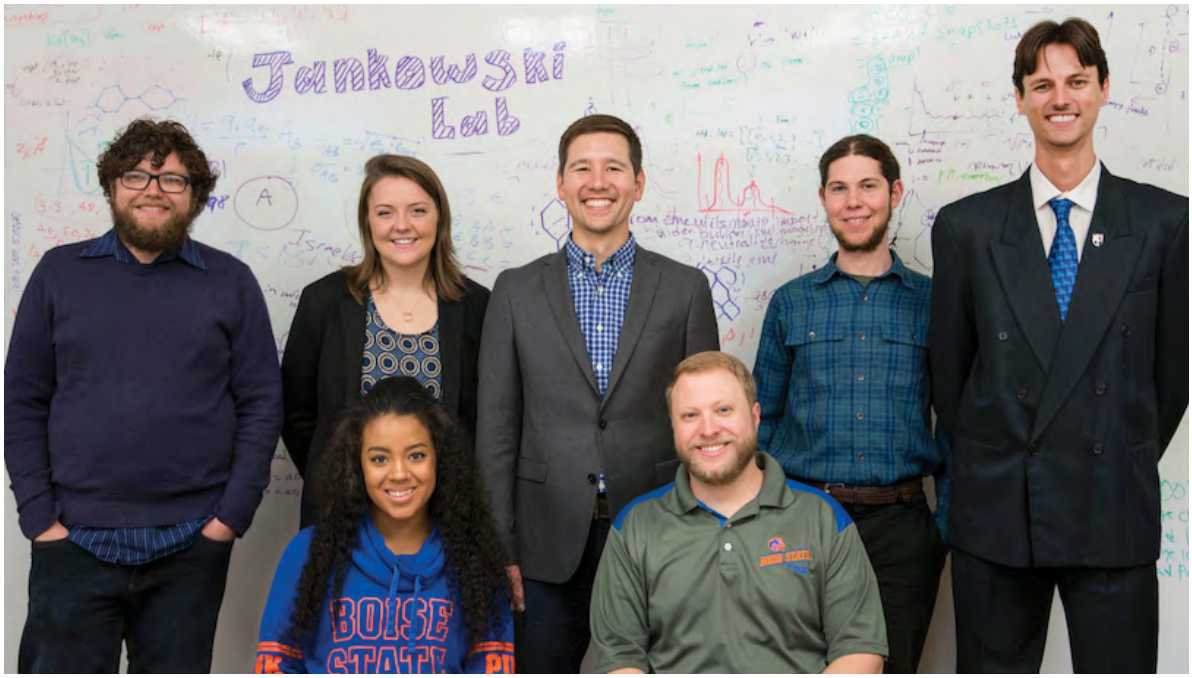
> **"One of the major goals of the project that I am most interested in is how we can improve our knowledge and quantification of precipitation in mountain landscapes to be able to better predict water resources."**

To advance scientific understanding of this field, associate professor of geosciences Lejo Flores is collaborating with Lawrence Berkeley National Lab on a program called the Surface Atmosphere Integrated Field Laboratory (SAIL), whose primary goal is to conduct a large-scale field campaign to improve atmospheric measurement near the land surface in mountain terrain.

This campaign will take a close look at the physical processes of how the Rocky Mountains interact with the atmosphere to produce water resources for the 40 million people that rely on water from the Colorado River, according to research lead Dan Feldman of the Lawrence Berkeley National Laboratory.

To learn more visit:
boisestate.edu/news/2020/06/30/lejo-flores-to-collaborate-on-large-scale-atmospheric-measurement-project/

NASA Grant and Multi–University Collaboration to Revolutionize Aerospace Manufacturing



Micron School of Materials Science and Engineering Undergrad Materials Lab, Eric Jankowski's lab.

When one is lucky enough to get the window seat, the view of an airplane's wing peppered with metal rivets is a familiar one. But through a collaboration with the University of South Carolina and the University of Southern Mississippi and the support of a $5.7 million dollar NASA University Leadership Initiative (ULI) grant, Boise State research will be integral to shaping airframes of the future, made of a completely different material: thermoplastics.

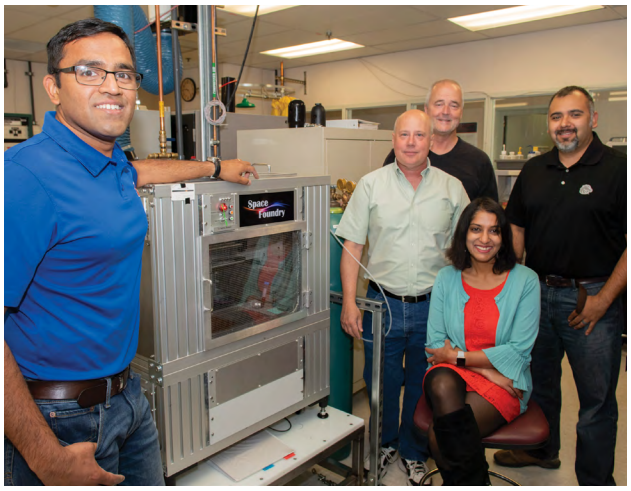
"It's a real opportunity to design airframes from the atoms, all the way up."

Thermoplastics are materials made from polymers that get softer when heated, explained Boise State research lead Eric Jankowski, an assistant professor of materials science and engineering. Recognizable items already made from thermoplastics include snowboards and skis.

– By Brianne Phillips

To learn more visit:
boisestate.edu/news/2020/09/01/nasa-grant-and-multi-university-collaboration-to-revolutionize-aerospace-manufacturing/

Grant to Explore Plasma–Jet Printing for In–Space Manufacturing



Micron School of Materials Science and Engineering Undergrad Materials Lab, Eric Jankowski's Lab, Allison Corona photo.

A team of researchers led by College of Engineering assistant professor Harish Subbaraman have been selected to receive a NASA Established Program to Stimulate Competitive Research (EPSCoR) three-year grant of more than $700,000. With this grant, the team will explore the challenges and opportunities of plasma jet printing for NASA's emerging In-Space Manufacturing (ISM) program.

"ISM is expected to be an enabling capability for NASA's space and interplanetary exploration missions."

Currently, items that have to be resupplied during in-space missions are sent up as cargo-shipments from Earth. However, as missions become more complex and often occur farther and farther from Earth, the need to be able to create necessary materials and components in space is growing. But how would it be possible to create such specialized items in space, in zero-gravity?

Enter plasma-jet printing.

The impressive range of possibilities afforded by plasma jet printing means the technology may also lend itself to purposes beyond manufacturing, such as in-space surface sterilization, decontamination, food treatment and more. Boise State's research team intends to make the most of these opportunities in their design.

-By Brianne Phillips

To learn more visit:
boisestate.edu/news/2019/08/08/researchers-to-explore-plasma-jet-printing-for-nasa-in-space-manufacturing/

Cathie Olschanowsky Wins CAREER Award to Improve Performance of Scientific Applications

CATHIE OLSCHANOWSKY

The word "supercomputer" evokes images of massive walls of computers that are both efficient and have the potential to process extremely complicated tasks with ease. Supercomputers have become ubiquitous with problem solving some of the world's most pressing challenges. However, supercomputers can only accomplish tasks efficiently if the coding of the scientific applications they run is optimized for performance. Unfortunately, many of them are not.

"Scientific applications operate inefficiently in that they typically perform operations at less than 30 percent of the potential maximum rate, and often less than that."

To take supercomputing applications to new levels of efficiency, Olschanowsky has been awarded a National Science Foundation CAREER Award of more than $540,000 over a period of five years. Her research aims to decrease the execution time of scientific applications without requiring large code rewrites.

To learn more:
boisestate.edu/news/2020/04/27/cathie-olschanowsky-wins-career-award-to-improve-performance-of-scientific-applications/

CAES BY THE NUMBERS

$12,765,507

TOTAL FUNDING AMOUNT

86

EXTRAMURAL AWARDS

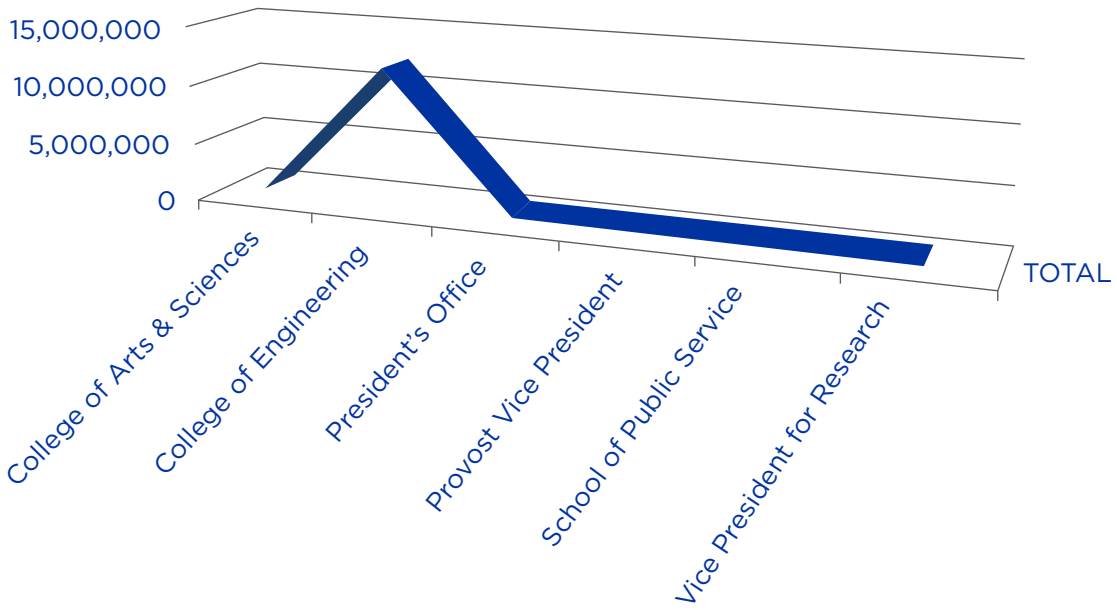
37

PUBLICATIONS

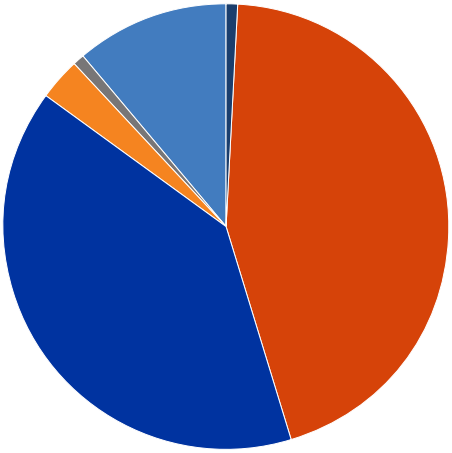
57

NUMBER OF CAES AFFILIATE FACULTY AND STAFF

AWARDS BY COLLEGE/DEPARTMENT/SCHOOL

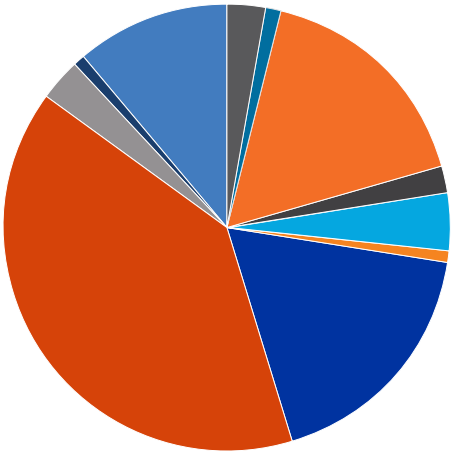


BY THE NUMBERS



AWARDS BY SPONSOR

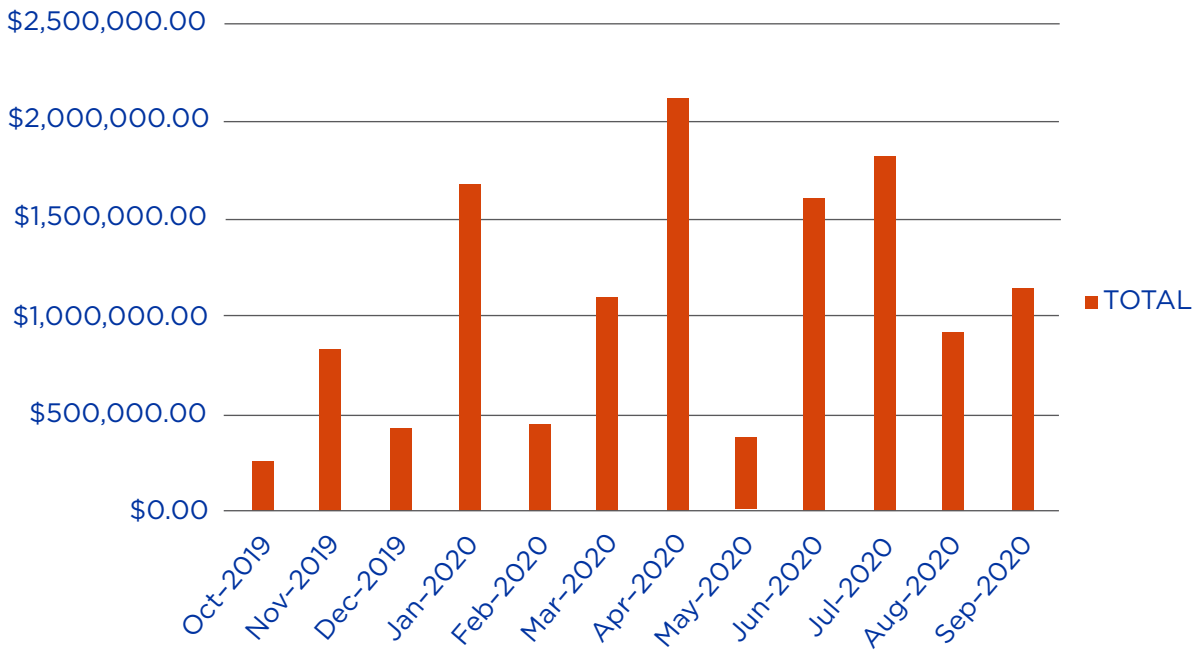
- College/University — **1%**
- Federal — **45%**
- Federal Flow-Through — **40%**
- Non-Profit Organization — **3%**
- Private for Profit — **1%**
- State of Idaho Entity — **11%**



AWARDS BREAKDOWN

- Air Force Office of Scientific Research/AIR FORCE/DOD — **3%**
- Bureau of Reclamation/US Department of the Interior — **1%**
- National Science Foundation — **17%**
- National Security Agency — **2%**
- US Department of Agriculture — **4%**
- US Department of Defense — **<1%**
- US Department of Energy — **18%**
- Federal Flow-Through — **40%**
- Non-Profit Organization — **3%**
- Private for Profit — **1%**
- State of Idaho Entity — **11%**

AWARDS BY MONTH



Mike Hurley Wins NSF CAREER Award to Answer the Questions of Corrosion

MIKE HURLEY

Red, crumbly and inevitable. Corrosion, or "rust" as it is more commonly known, is a result of materials breaking down in certain environments. Controlled by a material's reactiveness to air, water and other elements, it can be seen everywhere from garden tools in the backyard to a bridge girder.

Yet this natural process, when disregarded, can be particularly dangerous.

"The ongoing impacts of corrosion are so common and pervasive that it only rises into the general public's consciousness when something catastrophic happens, like an oil spill or the Flint water crisis."

With a five-year National Science Foundation CAREER award of $500,000, Hurley is determined to unpack the mystery of how and why materials corrode in certain environments, and then design new corrosion-resistant materials. Implications of Hurley's research could be vastly improved and stronger infrastructure, impacting everything from water treatment and building materials to the creation of novel materials for defense and space exploration.

Mike Hurley is one of five College of Engineering faculty awarded a NSF Career Award in 2020.

To learn more visit:
boisestate.edu/news/2020/04/27/mike-hurley-wins-nsf-career-award-to-answer-the-questions-of-corrosion/

Dick Sevier and CTAP Team Help With COVID Response

DICK SEVIER

GRIFF ALLEN

The CAES Technical Assistance Program (C-TAP), under the direction of Dick Sevier, was part of a multi-disciplinary team at Boise State University that created hundreds of face shields for medical personnel, law enforcement and others across Idaho whose jobs put them at risk of contracting COVID-19. Other participants in the collaborative project were Boise State faculty and staff members from the Albertson's Library MakerLab and College of Engineering. Together, they worked on the design, manufacture, assembly, and distribution of the shields. A key component to the project's success was the engagement of the 3D printing community by Amy Vecchione, MakerLab director. Under Vecchione's leadership, makers produced over a thousand 3D printed headbands. These headbands, along with clear visors laser-cut by Griff Allen in the College of Engineering's Innovation Studio, were the components needed to make the face shield.

"The call to action and subsequent response by this dispersed team of students, staff, and faculty was nothing short of impressive."

~ Dave Estrada

The team delivered face shields to regional health care facilities, law enforcement agencies, and schools. In addition, 200 face shields were donated to the Gregory C. Carr Foundation for use by health care workers in Mozambique. The Carr Foundation, founded by Idaho Falls native Greg Carr, has been involved in several projects with Boise State, including the restoration of Gorongosa National Park in central Mozambique.

Department of Energy Awards Two Fellowships to Boise State Graduate Students

KAELEE NOVICH

KATI WADA

Two Boise State University students were awarded fellowships through the Department of Energy (DOE) Office of Nuclear Energy's Integrated University Program (NEUP) in mid-April. Kaelee Novich and Kati Wada were among 34 students nationwide to receive one of the prestigious three-year fellowships, which provide $52,000 per year for graduate studies. The fellowships also include 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.

"I am currently working on the development of sensing technology to better monitor systems in nuclear reactors. I hope to continue this research through the first year of my degree. Through graduate school, I hope to find a path forward that will include scientific research and policy management that is tied to nuclear energy," said Novich.

"The Integrated University Program is focused on attracting the best and the brightest to nuclear energy professions."

Wada's fellowship will enable her to work with David Estrada, associate director of the Center for Advanced Energy Studies for Boise State and an associate professor in the Micron School of Materials Science and Engineering. Her research will focus 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.

"This research has made me feel more accomplished than any other I've been a part of, and will help me grow as a professional in the nuclear energy field. I am excited to collaborate with experts at Idaho National Laboratory. Such collaborations not only provide access to world class researchers and equipment, but also provide the knowledge, skills, and mentoring needed to succeed in a career in nuclear energy," said Wada.

To learn more visit:
boisestate.edu/caes/2020/04/21/department-of-energy-awards-two-fellowships-to-boise-state-grad-students/

Kiyo Fujimoto Appointed to Subcommittee of the President's Council of Advisors on Science and Technology

KIYO FUJIMOTO

Fifth-year materials science and engineering doctoral student Kiyo Fujimoto has received a national appointment within the Students, Post Doctoral and Early Career (SPEC) Professionals Subcommittee of the President's Council of Advisors on Science and Technology. Through this appointment, Fujimoto will provide input on how the STEM experience and environment can be improved for students, postdocs and early career professionals at colleges throughout the nation.

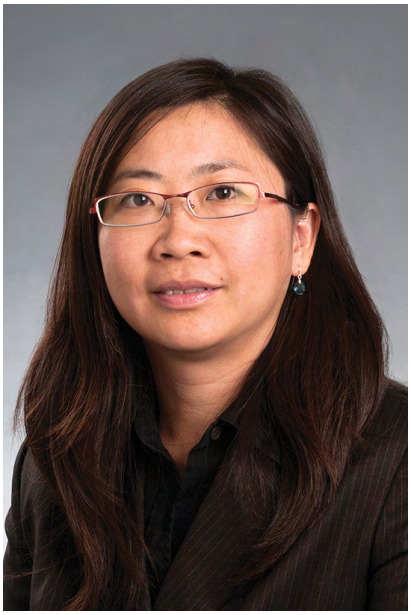
"Kiyo has been a natural leader in our group and she will surely be a global leader in her field after graduation."

"This appointment truly is a once-in-a-lifetime opportunity," said Fujimoto. "It is exciting to know that my experiences and input can be utilized to potentially improve the STEM experience for current and future generations of scientists and engineers."

An alumna of Boise State (BS, chemistry, '16) Fujimoto also was an Idaho Space Grant Consortium Scholarship recipient for the first year of her graduate fellowship. Additionally, she was funded by the Nuclear Energy University Partnerships (NEUP) Fellowship and the Idaho National Laboratory Graduate Fellowship, which now fuels her current research. Fujimoto's work utilizes 3D printing for the development and fabrication of advanced nuclear instrumentation and sensors to help qualify new nuclear fuels and structural materials for next generation nuclear reactors.

To learn more visit:
boisestate.edu/news/2020/09/03/kiyo-fujimoto-appointed-to-students-post-doctoral-and-early-career-subcommittee-of-the-presidents-council-of-advisors-on-science-and-technology/

Three College of Engineering Faculty Named CAES Fellows



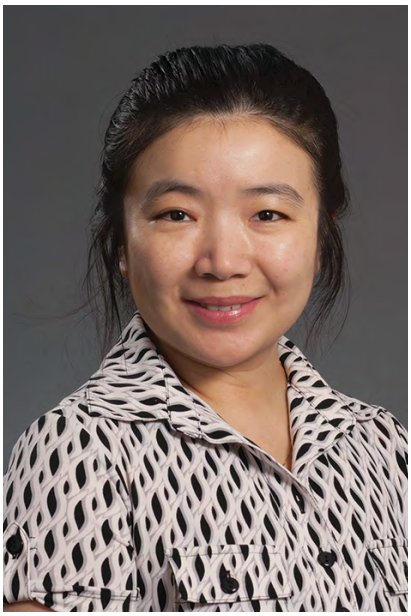
CLAIRE XIONG

College of Engineering faculty Claire Xiong, Brian Jaques and Lan Li have been named 2020 fellows of the Center of Advanced Energy Studies (CAES). The fellows initiative was launched in spring 2020 to provide recognition, resources and opportunities to members of the CAES community.

Xiong is an associate professor in the Micron School of Materials Science and Engineering who has been a CAES collaborator since 2012, participating in several projects involving Idaho National Laboratory (INL) and the CAES universities. Her current projects include a laboratory directed research and development project with INL's energy storage and advanced transportation group, work with the In-Pile Instrumentation Program, and a project focused on nuclear materials for molten salt reactors.

BRIAN JAQUES

Jaques is an assistant professor in the Micron School of Materials Science and Engineering who has been involved with CAES since its opening in 2009. He has collaborated on several CAES projects in the areas of nuclear energy and advanced manufacturing and currently is the Boise State program director for the In-Pile Instrumentation Program, an $8 million Department of Energy-funded collaboration between INL and Boise State that calls for developing novel sensors for in-pile, in-situ measurements in a nuclear reactor core.



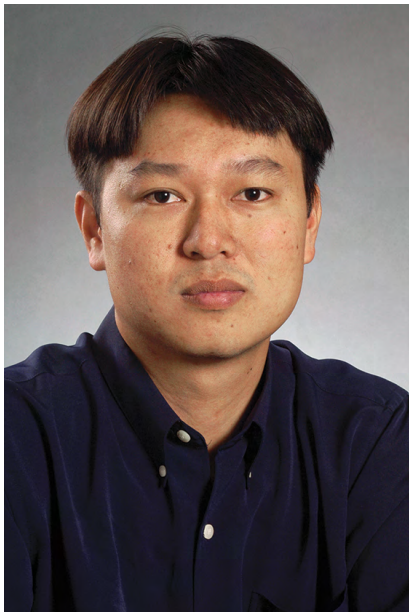
LAN LI

Li is an associate professor in the Micron School of Materials Science and Engineering who has been actively involved in CAES seminars, workshops, working groups and proposal development. Li currently is participating in two projects with CAES entities and has led the development of a computational materials science roadmap report to identify researchers with expertise in the field, equipment, and computational power at the CAES institutions, as well as research needs and funding sources.

To learn more visit:
boisestate.edu/news/2020/06/10/three-college-of-engineering-faculty-named-caes-fellows/

Two Faculty Begin Joint Appointments With Idaho National Laboratory

BRIAN JAQUES



SIN MING LOO

Brian Jaques, an assistant professor of materials science and engineering, and Sin Ming Loo, a professor of electrical and computer engineering, recently have been offered joint appointments with Idaho National Laboratory. This unique appointment offers faculty the ability to enhance collaboration between both institutions, expand research endeavors and offer rich opportunities for Boise State students.

> **"These joint appointments exemplify the collaborative spirit between Boise State and INL that empowers Idaho."**

Jaques and Loo are the most recent INL joint appointment positions at Boise State. They also serve as faculty leads in the areas of nuclear energy and cyber security, respectively, for the Center for Advanced Energy Studies.

To learn more visit:
boisestate.edu/news/2020/01/24/two-faculty-begin-joint-appointments-with-idaho-national-laboratory/

Top Ten Scholar 2020 Honorees

KENDRA NONEMAN

KAELEE NOVICH

Presented by the Boise State Alumni Association and Boise State Honors College, the Top Ten Scholar Award is one of the highest academic honors granted to a Boise State University undergraduate student. Each spring the recipients are recognized, along with their honored faculty, at the annual Top Ten Scholars Award Ceremony.

KENDRA NONEMAN, EAGLE, IDAHO
DEGREE: Bachelor of Science in Materials Science and Engineering
FUTURE PLANS: Noneman will pursue a doctorate in neural computation and machine learning at Carnegie Mellon University in Pittsburgh. She also has aspirations to compete in Olympic weightlifting competitions.
HONORED FACULTY: Eric Jankowski, assistant professor of material science and engineering

KAELEE A. NOVICH, NAMPA, IDAHO
DEGREE: Bachelor of Science in Mechanical Engineering
FUTURE PLANS: Novich plans to earn a doctorate in materials science and engineering with an emphasis in nuclear engineering and policy management at Boise State.
HONORED FACULTY: Brian Jaques, assistant professor of material science and engineering

To learn more about the Top Ten Scholars, visit:
boisestate.edu/news/2020/04/23/boise-state-alumni-association-honors-top-10-scholars-at-virtual-may-7-event/

Energy Policy Institute Adds Assistant Director of Research

CASSANDRA (CASSIE) KOERNER

The Energy Policy Institute is delighted to share the news that Cassandra (Cassie) Koerner will be joining us as the Assistant Director of Research, Communications and Development.

Cassie will bring valuable experience to our Institute. Since 2018, she has been working for the Idaho Public Utility Commission. Previously, her work included positions with EPI, the Washington Department of Natural Resources, and the Rocky Mountain Research Station, Fire Sciences Laboratory.

Cassie graduated with a Master of Public Administration from Boise State in 2012 and a Master of Arts, Political Science and Environmental Policy from Colorado State in 2017.

Image provided by NuScale Power, LLC

Clean Energy for All

– By Matt Jones

"It's going to be big," said Boise State economics professor Geoff Black.

For the past decade, Black has conducted research on energy and economic development, including studies on small modular reactors (SMRs), the impacts of energy development on economic activity and tax revenues, and the economic impacts of large federal research and development facilities.

Regional Economic Development for Eastern Idaho contacted Black to analyze the potential economic impact of bringing new nuclear technology to Idaho Falls. He partnered with the Idaho Policy Institute at Boise State and the McClure Center for Public Policy Research at the University of Idaho to conduct his work.

His conclusion? Idaho is poised to become a hotbed of production for the most innovative, carbon-free nuclear energy technology in the world within the next few years – a new energy production facility will be developed by 2026 at the Idaho National Laboratory in Idaho Falls.

The new eastern Idaho development will rely on technology from NuScale Power, a leading innovator of SMR technology based in Portland, Oregon. The company received funding from the U.S. Department of Energy and it designed the world's first and only SMR to undergo design certification review by the U.S. Nuclear Regulatory Commission. "NuScale's going to be the first to deploy these things," Black said. "And if we don't produce SMRs now, we'll be importing them from other places in no time. Why not create the jobs here?"

> **"Ten years ago, we realized that it was past time to begin to take climate change seriously."**

The research by Black and Steven Peterson, a clinical assistant professor in economics at the University of Idaho and researcher for the McClure Center for Public Policy Research, confirms that the addition of an SMR plant in Idaho will create new jobs and increase revenue flowing throughout the region. The three-year construction phase for the facility alone will provide roughly 2,000 new jobs and, in turn, labor income – which accounts for wages and benefits – will increase by $644 million. And as a bonus, $2 billion of annual output is projected, all while reducing carbon emissions.

Clean Energy for All

Through an economic lens, Black is determined to address "energy poverty" as the United Nations calls it, which is the inability of developing countries to acquire cost-effective energy sources. Companies across the world are looking to reduce carbon emissions from power-generating facilities. Meanwhile,

GEOFF BLACK

they are facing an increasing demand for global energy. While the pressures from climate change continue to mount, Black's research explores the economic aspects of this new source of energy: light-water SMRs.

Large nuclear power plants require money and infrastructure and can be out of reach for many nations, especially those with emerging economies. Light-water SMRs have the ability to run on smaller, more dispersed electric grids than large nuclear or coal power plants. Importantly, they can be paired with renewable energy sources such as solar and wind facilities to provide baseload power when renewables are unable to produce. This makes them an attractive, viable option for developing countries as well as industrialized nations seeking to address climate change.

Carbon-free power comes from few sources. SMRs limit carbon and greenhouse gas emissions by creating power that is much cleaner than any type of fossil fuel, much like wind and solar. A study by the Nuclear Energy Institute found that 12 NuScale SMRs can generate the same amount of energy as a 130,000-acre wind farm, which spans over 200 square miles. They require much less space to produce energy. "Ten years ago, we realized that it was past time to begin to take climate change seriously," Black said. "On a global level, one thing that's going to adversely affect everything that we do is if developing countries go down the path of meeting increased energy demand by increasing their use of high carbon fuel."

Safer and Longer-Lasting

Along with the economic benefits, SMRs are designed with enhanced safety features and require less maintenance than other power-generating sources that soak up larger operating costs. On average, the technology lasts 60 years, surpassing the lifespan of wind farms and solar panels.

According to Black, SMRs are smaller than large gigawatt nuclear reactors and therefore easier and cheaper to manufacture, ship and install. Unlike larger nuclear reactors, reactors designed by NuScale automatically shut down and cool off, making them safer. And what if power outages occur? The reactor's core, which is positioned underground, cools naturally and doesn't require any action from humans or computers to reset.

He believes the rest of the world will follow Idaho's lead on redirecting the future of nuclear energy and, at the same time, addressing climate change.

"I've been working with emerging economies and international agencies to explore avenues of facilitating economic development by skipping over the increased use of fossil fuels and providing better options for these countries," Black said.

Once the construction of the facility is complete, the team estimates that 360 on-site jobs will become available. Operations are estimated to increase labor income by nearly $48 million, increase economic output by $81.15 million, add $2.97 million to local and state tax revenues annually, and add $10.86 million to federal tax revenues annually.

This project in rural eastern Idaho has the power to help address "energy poverty" and, at the same time, provide a place where Idahoans can train these emerging economies to install and operate SMR energy projects globally.

Photo by Ron Schwane

How 'Dirty' are 'The Dirty Dozen'?

Reprinted from Boise Weekly, Xavier Ward

If it's approved by the federal Nuclear Regulatory Commission, the NuScale modular nuclear reactor system will be one-of-a-kind. That's not hyperbole, the 12 modular reactors planned for Eastern Idaho's Idaho National Lab would be the first application of modular nuclear reactors in U.S. history. At this point, the technology only exists conceptually.

In its present state, nuclear power is dispatched from a single reactor, outputting a firm amount of energy into the power grid. The NuScale project would output 720 megawatts at full force, but the actual output can be controlled based on the need of the grid, NuScale officials said.

While those proposing the project laud it as the future of dispatchable nuclear power, environmentalists and nuclear skeptics have branded the project "the dirty dozen," saying it poses unnecessary risks when the capacity to use renewable energy is not only safer, but cheaper. The Snake River Alliance, based in Boise, has launched a campaign against the project.

So far, NuScale has hit all of the marks, and is up for preliminary approval in September, according to reporting by the Idaho Falls Post Register.

NuScale's Brand New Toy

"Our SMR (small modular reactors) will be the first to have received approval of this design," said Tiffany Austin, a communications specialist for NuScale power, a nuclear reactor design company out of Portland, Oregon.

If the project does get the green light from the NRC in September, the first reactor will go live in 2026, with the remaining 11 coming online in 2027, according to a statement from NuScale VP of Marketing and Communications Diane Hughes.

Small Modular Reactor

One of the 12 small modular reactors could go live by 2026, if approved by the NRC. The power produced from the small modular reactors would then be sold to customers around the region. The first customer is the Utah Associated Power Systems, which has customers across Utah and Nevada, with one client in California and another in Idaho.

NuScale pitches developing and deploying the cutting-edge reactors in terms of their economic impact as well as its impact on the power grid. According to Hughes' statement, the project will be an economic

boon, creating around 300 permanent jobs with salaries averaging $85,000. It will also add a significant bump to Idaho's gross domestic product over the construction period, according to the statement.

Overall, NuScale supports renewable energy, and sees its Eastern Idaho project as a way to add a consistent, carbon-free alternative to the energy market. The reactors output steam, not carbon emissions, and with a variable output, the small modular reactors can make up what renewable energy does not in terms of firm, dispatchable load.

"That's currently not an option at all today," Austin said. "NuScale is very clear we are a complement to wind, solar and hydro."

While the project is a NuScale effort and operation, Idaho National Lab will host and monitor it. George Griffith, a researcher at INL and overseer of NuScale's operations at the lab, said it's like NuScale has a 99-year camping permit on the lab's grounds.

"We've been sort of helping as needed with that product," he said. "It's a commercial project that will be monitored by the NRC."

In Griffith's opinion, INL is the perfect place for this new technology, as the lab has decades of experience monitoring and operating nuclear reactors.

One of the 12 small modular reactors could go live by 2026, if approved by the NRC.

"The real benefit of that is we've been doing this for 70 years and we have 52 reactors, so we know a lot about our site. We're very confident about the knowledge we have about it," he said.

Much of the fear around nuclear energy is unfounded, Griffith said, but has its roots in the post World War II and Cold War Era, when the line between nuclear weapons technology and power was fuzzy. While that fear has subsided some, it's still present, he said.

"I think way back in the beginning, there was a concern crossing over between weapons and nuclear power," he said. "When they started there wasn't a clear differentiation between commercial and military purposes and that concerned a lot of people. That fear, the connection between those two, that would be a big deal if they were really joined."

Incidents such as Three-Mile Island, in which a nuclear reactor melted down in Pennsylvania; or Chernobyl, where a nuclear reactor exploded near Pripyat, Ukraine, didn't improve the public's level of confidence in nuclear technology. However, modern reactors are extremely safe, Griffith said, and in the wake of those disasters, American regulatory standards for nuclear energy have become far more rigorous.

"The more educated people become about it, the more accepting people are about it," he said. "I think in the market, as they succeed on deploying this unit here, there are a number of places that would be interested in deploying these reactors locally, where they're at."

The energy market needs clean, dispatchable power, he said. If you ask him whether he wants wind, solar, hydro or nuclear, Griffith would tell you: "I want all of the above."

"This new generation of reactors is sort of designed to fit in with that," he said. "The fact that it's 12

smaller units allows you to customize your output to match what the demand is on the grid. … I want all of the above in the appropriate amounts to get the best system possible."

It Has to Go Somewhere

Sitting right above the Snake River aquifer, which provides drinking water for much of Southern Idaho, INL keeps close watch on its waste, Griffith said. Contaminating the aquifer could be catastrophic for Idahoans.

In terms of processing the waste that comes out of the reactors, the bundles are set to cool in massive pools of water contained within the facility. Once those are cooled, they are taken out of the pool and moved into what is called "dry-cast storage," where it is encased in massive cement blocks.

"They'll have to be pulled out and put into a dry-cast storage," Griffith said. "These are amazingly robust products. … they're essentially immune to outside forces."

The long-term solution for the waste is somewhat up in the air at this point, but there are two main options for it, Griffith said.

One such option is storing it deep underground, the main project for which is Yucca Mountain, a federal nuclear storage initiative in Nevada, which is presently on hold. The deep salt mine keeps the waste away from civilization, and Griffith said the other option is reprocessing the waste, which is not considered economical at this time.

Some of the elements processed in a reactor can decay to a safe level within hundreds of years. However, other elements may take tens of thousands of years to fully break down.

"We haven't quite solved which one is going to be the solution right now," Griffith said. "These bundles can go into the dry-cast storage and not be hot enough to cause trouble after five to 10 years. … If you were to wait until you could walk up and give one a hug, it would be some hundreds of years before that would be OK."

Reprocessing the waste takes some effort, though it's not impossible, said Brian Jaques, an assistant professor in the Micron School of Material Science and Engineering. Jaques researches nuclear technology, and is personally a proponent of nuclear energy. He said that as nuclear technology continues to develop, it's possible that reactors could become more efficient, even self sustaining. For now, however, the waste has to be stored.

"When we pull that fuel out right now, we just store it because it has mechanically degraded and it has isotopes in it that are challenging to handle," he said. "The new technology of reactors allows for a closed fuel cycle where the fuel can burn more completely." As it stands, only roughly 4% of the full potential of nuclear fuel is used in a reactor, then discarded, which is typically after three to five years. The fuel, once it degrades to a certain point, emanates a different level of atomic energy, which is why the current reactors do not have the capacity to process it.

"As soon as there is an economic reason to do so, we have the capabilities to reprocess the fuel and put it back into a usable form and more completely burn the fuel," he said.

The Dirty Dozen

While many in the nuclear industry have lauded this project as a step in the right direction, some on the environmental and conservation side have serious reservations about not only the project's safety, but its viability as an energy source. Holly Harris, the

executive director of the Snake River Alliance, said not only is the project unnecessary in terms of power need, but it is needlessly expensive, too.

"This kind of nuclear technology doesn't even fit into the equation; it's too expensive," she said.

Harris noted that Idaho Power does not have the NuScale project listed in the Integrated Resource Plan which forecasts its power load, as enough power is generated by existing sources. Nuclear plays a marginal role in Idaho Power's deliverable load already, with wind and solar individually making up more than six times what nuclear does.

"You can get a wind farm operating next year, we can get a solar farm operating next year," she said. "[Renewable] is supporting Idaho—it's supporting Idaho communities."

From Snake River Alliance's position, the NuScale project is a new variation of an old experiment, and Idaho is the guinea pig. It's also time-consuming, and Harris noted that the NuScale project kicked off in 2008, and still hasn't seen physical development. "Nuclear technology is still a dream. This kind of technology has been sitting there in labs for decades," she said.

To Harris' mind, nuclear makes no sense. There are a number of countries around the globe that operate on 100% renewable energy, and many others are approaching that same benchmark.

"That was a conversation that was taking place several years ago," she said. "Batteries are proving up all over the world. Why are you able to see countries now moving to 100% renewable energy? Because technology in the renewable energy field is moving fast, and we now have 100%, not just commitment, but utilization of 100% renewable energy for that reason."

While nuclear energy is carbon free, its output presents a direct nuclear hazard. The uranium mining required to power these machines isn't clean, either, Harris said.

"What you're seeing is really an evolutionary switch. Renewable energy wasn't going to be fast enough, it wasn't going to come online soon enough, and I think what you're seeing is that's not proving [to be] the case," she said.

The Snake River Alliance has launched an awareness campaign about the project dubbing the proposed reactors "The Dirty Dozen." It aims to spread awareness about the project, as well as its potential harms and lack of need on the local power grid. Harris added that with climate change causing increasing wildfires in the state, and with some seismic activity in Eastern Idaho, the safety of the modular reactors is questionable, too.

"The fact is, nuke doesn't scale up fast enough," she said. "The days of this old dinosaur grid are quickly falling by the wayside."

Harris also points to the fact that, currently, the main beneficiary of this project is Utah, with the sole customer being based there and serving largely Utah cities. In her mind, it's a bad deal for Idaho.

"Idaho gets virtually none of the power, but all of the waste and all of the risk," she said.

A Nuclear History

Nuclear power, and Idaho National Lab, by extension, have not always been positive for Idaho. In fact, years ago, the Snake River aquifer was tainted by radioactive waste.

NUCLEAR ENERGY HIGHLIGHTS

From 1952 to 1988, nearly 31,000 curies of Tritium, a radioactive isotope of hydrogen, were found in the aquifer near the Idaho National Lab site, according to a U.S. Geological Survey report. A curie is a unit of radioactive material. The Tritium made its way into the aquifer through a 580-foot disposal well on the site. According to a 2007 report from the Environmental Protection Agency, INL did remedy the issue, noting that Tritium levels were below the federal drinking water standard.

In other cases, indigenous communities have been harmed by the mining necessary to obtain fuel for the reactors and other purposes such as weaponry. According to a 2019 story from the Navajo Times, indigenous uranium miners and generations of Navajo are still affected by the toxicity.

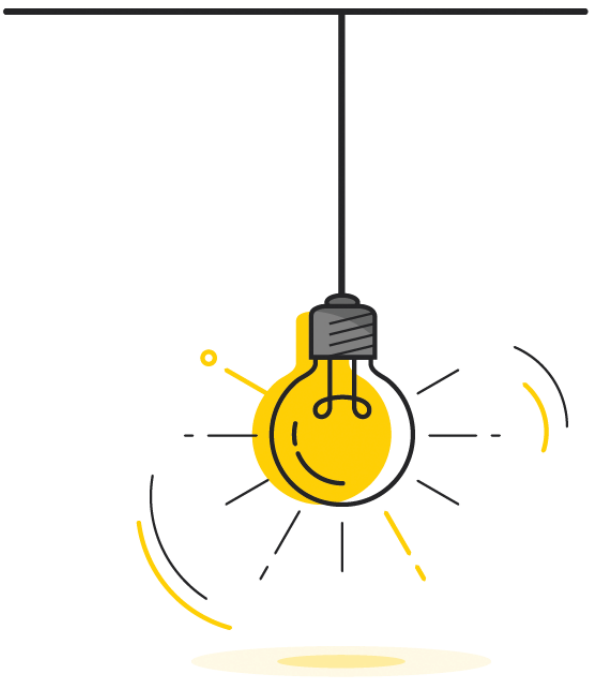
"Someone must be held accountable. ... My mother died of liver cancer. My whole family has suffered," Leslie Begay, a former Uranium miner on the Navajo land in Church Rock, New Mexico, told the Navajo times.

Begay, who had contracted lung disease and developed cancer as a result of the mining, was not covered by the Radiation Exposure Compensation Act, which only offered miners who worked the mines between Jan. 1, 1942, and Dec. 31, 1971, compensation for their ails. In 1979, a uranium spill from a mill contaminated a large area surrounding the mine, according to the Navajo Times.
Paired with the available capacity for more renewable energy resources, stories such as these inform the Snake River Alliance's opposition to the reactors.

"Our energy choices have consequences, and we should be held accountable," Harris said.

Plug Into CAES

The Center for Advanced Energy Studies is a research, education, and innovation consortium that brings together students and faculty from the public research universities in Idaho, along with Idaho National Laboratory re-searchers to conduct cutting-edge energy research, educate the next generation of scientists and col-laborate with industry to advance competitiveness. **Visit the CAES Energy website boisestate.edu/caes.**



How Can You Plug Into CAES?

For information about these and other programs, contact:

David Estrada, Boise State University

David Rodgers, Idaho State University

John Russell, University of Idaho

Public

- Director's Colloquim
- CAES Currents
- CAES Energy Efficiency Research Institute (CEERI)
- CAES Tours
- Energy Policy Institute (EPI)

University Faculty & INL Researchers

- CAES Summer Visiting Faculty Program
- CAES Fellows
- Roundtables
- Seed Grants (ISU)
- Joint Appointment

Students

- Internships
- INL Graduate Fellowships
- My Amazing Future (K-1

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