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before the
UNITED STATES HOUSE OF REPRESENTATIVES
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SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT, AND RELATED AGENCIES

concerning
"ENERGY WORKFORCE DEVELOPMENT OPPORTUNITIES AND CHALLENGES"

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Introduction

Chairwoman Kaptur, Ranking Member Simpson, and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the important issue of energy workforce development. My name is Noël Bakhtian, and I'm the Director of the Center for Advanced Energy Studies (CAES). Our center, headquartered in Idaho Falls, Idaho, is a research, education, and innovation consortium that brings together the U.S. Department of Energy's Idaho National Laboratory (INL) with the four public research universities of Idaho and Wyoming: Boise State University (BSU), Idaho State University (ISU), the University of Idaho (UI), and the University of Wyoming (UWy). The center is committed to conducting cutting-edge energy research, educating the next generation of scientists and engineers, and partnering

with industry to advance competitiveness. CAES harnesses the shared capabilities, expertise, and resources of its five member organizations to provide academic, national lab, and private industry collaborators with cross-cutting opportunities to address complex energy challenges. It does so through transformative research as well as education and entrepreneurial initiatives that benefit the region, nation, and the world. Today, I would like to discuss the shifting energy workforce playing field, tell you how the Center for Advanced Energy Studies has been working to meet the nation's energy workforce needs, and ask for your support in a few critical areas.

Testimony

The generation, distribution, and utilization of energy is fundamental to human life. Whether we consider how energy contributes to basic necessities, such as food production and access to clean water, or priorities such as economic development, quality of life, and national security, it is clear that energy is a key ingredient to our growth and prosperity. According to U.S. Energy Information Administration (EIA) data for 2017, world energy consumption is projected to grow by 28 percent between 2015 and 2040, based on both population and economic growth around the globe. Moreover, in the U.S., the energy market is undergoing significant evolution.[1] The energy playing field has experienced considerable shifts toward low-cost natural gas and low-carbon sources. In line with such change, the accelerating addition of intermittent renewable energy sources to the grid is spurring research and development in transformative and integrated energy system technologies, including storage, advanced nuclear, and smart systems.

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1 National Association of State Energy Officials (NASEO), (May 2018), *U.S. Energy and Employment Report*, https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5afb0ce4575d1f3cdf9ebe36/1526402279839/2018+U.S.+Energy+and+Employment+Report.pdf

This evolving energy future necessitates a robust and dynamic energy workforce. At the same time, the U.S. workforce is shrinking, with the Baby-Boomer generation reaching retirement age[2] and birth rates in decline.[3] In fact, many experts cite the energy and manufacturing sectors as most at risk of running out of qualified workers, sometimes referring to the current predicament as the "Silver Tsunami." For instance, in 2013, the National Academies of Sciences, Engineering, and Medicine identified a supply shortage in qualified power engineers, electrical engineers, and cybersecurity experts that are necessary for operating the electric power grid.[4] More recently in 2017, the growth in new energy areas is apparent with new jobs added: [5]

- Wind energy jobs increased by 107,000,
- Energy efficiency added 67,000 net new jobs,
- Battery storage added 6,000 jobs, and
- Motor vehicles, including component parts, added 29,000 jobs. [6]

While thes are signs of growth, more can certainly be done. Broadly, our energy future is dependent on the development of a robust, highly qualified, educated workforce that will design, construct, operate, protect, repair, and replace the vast energy systems and technologies necessary to keep our country running effectively.

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2 National Commission on Energy Policy, (2009), *The National Commission on Energy Policy's Task Force on America's Future Energy Jobs*, October 1, 2009.

3 Caitlin Cheadle, (2016), "Dropping fertility rates are a threat to the global economy," *Business Insider,* November 28, 2016. https://www.businessinsider.com/dropping-fertility-rates-will-affect-the-economy-2016-11

4 National Academies of Sciences, Engineering, and Medicine, (2013), *Emerging Workforce Trends in the U.S. Energy and Mining Industries: A Call to Action*, Chapter 4, "The Electric Grid," see especially Table 4.3, p. 185.

5 NASEO, previously cited. The numbers cited here refer to direct jobs rather than indirect or induced.

6 NASEO, previously cited. Motor vehicles were included as a group because of the role that the industry plays in energy use.

Nuclear Energy Considerations

Although I am here today representing CAES, I am also on the Senior Leadership Team of Idaho National Laboratory. And because INL is the nation's leading center for nuclear energy research and development, I would be remiss if I didn't address the workforce needs specific to the nuclear energy industry.

According to a soon-to-be-published report by Oxford Economics, the U.S. nuclear energy industry has helped to produce electricity for millions of people and has supported thousands of jobs for more than 50 years.[7] The current nuclear power industry produces 20 percent of the electricity needs in the U.S.[8] and accounts for 56 percent of low-carbon electricity.[9] Nuclear power is uniquely situated in the power-generation industry as a highly efficient, yet complex source of electricity; thus, workers employed in this sector must be highly educated and skilled in order to safely operate nuclear plants. In fact, while the total electric-power-generation industry employed approximately 190,000 people in 2017, earning an average salary of $118,000, the subset of the commercial nuclear power industry employed roughly 50,000 workers, earning an average salary of $136,700 during the same year. This average salary premium is indicative of the high-caliber education that workers need to utilize, manage, and develop the technologies required in the nuclear energy industry.[10] Further, there is ample evidence that, at this occupational level, certain training, skills, and educational attainment are necessary for employment. While not every job in the nuclear energy sector requires

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7 Oxford Economics, (2019), Nuclear *Power Pays: Assessing the Trends in Electric Power Generation Employment and Wages*. March 2019, pg. 4. Report to be published on March 25, 2019. See www.nei.org.]

8 National Energy Institute (NEI), (2018) *Nuclear by the Numbers.* April 2018, p. 9. https://www.nei.org/CorporateSite/media/filefolder/resources/fact-sheets/nuclear-by-the-numbers-20180412.pdf

9 NEI, previously cited, p. 5.

10 NEI, previously cited, p. 6

postsecondary education, nearly 35 percent of those employed in the occupation have a bachelor's degree or higher. Of note, these statistics only relate to the commercial nuclear power industry. In nuclear research occupations, required educational attainment can be even higher.[11] When the figures above, describing the workforce that supports operating commercial nuclear reactors, are added to employment figures for nuclear research and development and the supply and service sector, total nuclear energy employment across the U.S. approaches 100,000 people.[12]

Meanwhile, the U.S. Bureau of Labor Statistics projects employment of nuclear engineers to grow by four percent from 2016 to 2026.[13] This comes at a time when the nuclear workforce is aging. In fact, the Nuclear Energy Institute estimates that 39 percent of the nuclear workforce is currently eligible for retirement[14] and that 23,000 jobs will be added in the next 5 years.[15] While employment in the nuclear energy sector is growing at a smaller rate than other energy sectors, the Bureau of Labor Statistics' reporting suggests the largest area of nuclear engineering growth will come in the research and development, management, scientific, and technical consulting-service fields. The modern nuclear workforce will also require new sets of skills to support new and upgraded plants, including digital instrumentation and controls and data collection, analysis,

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11 Bureau of Labor Statistics, U.S. Department of Labor, "Occupational Outlook Handbook, Architecture and Engineering," Nuclear Engineers, https://www.bls.gov/ooh/architecture-and-engineering/nuclear-engineers.htm#tab-4.

12 NEI, "Jobs: A single nuclear power plant creates more jobs than any other type of energy generation facility," https://www.nei.org/advantages/jobs

13 Bureau of Labor Statistics, U.S. Department of Labor, "Occupational Outlook Handbook, Architecture and Engineering," Nuclear Engineers, https://www.bls.gov/ooh/architecture-and-engineering/nuclear-engineers.htm#tab-6

14 NEI, "Jobs: A single nuclear power plant creates more jobs than any other type of energy generation facility," https://www.nei.org/advantages/jobs

15 NEI, (2018), *Nuclear Industry Jobs*, August 2018, https://www.nei.org/resources/fact-sheets/nuclear-industry-jobs

and other advanced systems. Additionally, developments in nuclear medicine, diagnostic imaging, and cancer treatment will also drive demand for nuclear engineers. Taken together, these data suggest a strong need for emphasis on energy workforce development.

Finally, let me provide you with data points from Idaho National Laboratory. INL is one of the state of Idaho's largest employers, and its impact contributes significantly to the region's economy through laboratory programs, business partnerships, community engagement, and workforce income. In fact, INL currently employs 4,548 people with an average salary approaching $100,000 annually.[16] Yet, the need for workforce development is apparent even at the lab, where 43 percent of employees will be eligible for retirement in the next five years, resulting in over a thousand new jobs to fill. With strong requirements for postsecondary and advanced education necessary to fill most commercial and government nuclear energy positions, and as INL and the rest of the nuclear sector vie with other high-tech industries for employees, collaborative workforce development and training initiatives like those offered at CAES will increasingly become more relevant and necessary.

Advancing educational opportunities in support of accelerating energy-sector transformation is one of the reasons I came to work at the Center for Advanced Energy Studies, which is a shining example of an intentional partnership between a national laboratory and regional universities and the many benefits that grow from such cooperation, including addressing this workforce challenge. Having spent time working at NASA, Congress, the Department of Energy, and the White House, I have come to recognize the power of partnership. I would like to tell you about

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[16] INL, (2019), *FY18 Economic Summary: Research and Development*, https://public.inl.gov/public/FY18EconomicSummary/index.aspx?page=1

how the CAES collaboration is helping to strengthen capabilities and fill workforce gaps, as we continue to innovate.

The Center for Advanced Energy Studies

More than a decade ago, the U.S. Department of Energy and the state of Idaho envisioned the development of a centralized research campus near Idaho National Laboratory. Closely integrating the state's public research universities with a national laboratory would allow critical energy challenges to be solved through collaborative research while encouraging economic development and workforce training opportunities to support communities across the region. Although originally envisioned as a consortium between Idaho National Laboratory and the state of Idaho's three public research universities, CAES was proud to welcome the addition of the University of Wyoming in 2014, bringing new expertise and capabilities to the mix. Today, CAES fulfills the Department of Energy's vision for a regional research, education, and innovation hub that brings together a diversity of people, perspectives, and experiences needed to address complex global energy challenges **through the power of collaboration**.

CAES' strength lies in leveraging partnerships to solve challenges in energy. Several CAES institutions, working together, can provide value in a way that none can do alone. We benefit from a proud tradition, a dedicated leadership team, broad community support, and research wins in the form of joint federal projects awarded, collaborative publications, joint appointments, student graduates, and a series of new and advanced facilities. In a consortium bringing together a national laboratory and four universities, our stakeholders and thus the people we work with every day are the university students, faculty, national lab researchers, and the energy industries in the region. Our center works to pair university students with national laboratory researchers to receive hands-on experience and mentorship leading to valuable future career opportunities, through mechanisms such as internships, fellowships, and post-doctoral opportunities. We bring

together university and national laboratory experts to teach specialized courses unique to the energy field. We provide the teaming, tools, training, and facility access that enable laboratory researchers and faculty to compete for and win major federal-research hubs such as Energy Frontier Research Centers and Industry-University Cooperative Research Centers. And we are beginning to build a regional innovation ecosystem, supporting existing and incoming private-sector partners or even the next big energy startup.

At the end of 2017, as CAES was approaching its 10-year anniversary, we recognized the value of looking forward with a new strategic plan that builds upon past successes while simultaneously setting a course for further engagement and impact. We determined that energy, environmental, and national security challenges continue to loom large, and we must do more to address these challenges. Our recently released strategic plan aims to create a better energy future through collaboration that inspires energy leadership, ignites technology innovation, and catalyzes global impact. Based on feedback from our stakeholders, we organized our strategy around three major pillars: Research, Education, and Innovation. We also considered the energy areas where CAES collaboration could make a difference in addressing regional, national, and global grand challenges, and we downselected to five major focus areas—nuclear energy, advanced manufacturing, cybersecurity, energy-water nexus, and innovative energy systems—with two cross-cutting focus areas: energy policy and computing, data, and visualization. Based on collaboration, our strategy aims to create win-win opportunities that make our member organizations stronger together than the sum of the parts. In this sense, CAES is a force multiplier created to spur collaboration for the greater good.

How CAES Supports Tomorrow's Energy Workforce

At its core, CAES exists to strengthen the connections, exchanges, and resources of our member organizations and the people who pass through our doors. The diverse capabilities, expertise,

facilities, exposure, and perspectives that come together through the consortium develop more than new energy technologies and solutions. Together, we aim to inspire and develop the energy workforce of the future as we stimulate exploration in basic and applied science and bring industry together with researchers, students, and faculty. In the process, we build the relationships that lead to personal and professional development and evolving career opportunities. I'll frame CAES' contributions to energy workforce development through the lens of our three strategic pillars: research, education, and innovation.

Research

CAES's collaborative research broadens teams and brings together world-class capabilities, facilities, and expertise. Together, these teams develop viable new technologies, effective policy recommendations, and networks of subject-matter experts. We grow by cultivating and aggregating capabilities around our focus areas to develop world-class research collaboration, establish research hubs, and connect facilities—both physically and virtually—to accelerate productivity and the impact of advanced energy research.

In a university setting, education and research are inextricably connected, and a robust university research portfolio is necessary to produce a skilled workforce pipeline. Due to the complex and ever-evolving energy portfolio in the U.S., tomorrow's workforce will need a diverse mix of educational opportunities, including classroom instruction, mentorships, and hands-on training. This is where CAES excels because at the heart of our success is the many student lives we have touched through experiences with the national laboratory. Pairing of university research programs with national labs' human and facility resources gives many students an opportunity to contribute to meeting society's greatest challenges that they would not have had otherwise. In short, this collaboration puts students at the cutting edge of research for the national interest; this is of great value to them, and also to the country.

For example, graduate students pursuing an energy-related master's or doctoral degree at the CAES universities have the opportunity, through mechanisms like internships or fellowships, to complete their research in an INL facility alongside nationally recognized research experts, at a joint CAES lab, or even at their home institutions being mentored by INL researchers. I, myself, had a similar Ph.D. research experience through a collaboration between Stanford University and NASA Ames Research Center, and I can't speak highly enough of the impact that experience at NASA had in enabling my research via access to world-class capabilities and experts, providing my mentors with a preview of my abilities during their hiring decisions, accelerating my research impact, and inspiring my passion to continue working on areas of national interest. Let me highlight a few specific examples illustrating the impact of CAES's Research pillar to workforce development:

- In 2017, Idaho National Laboratory began a new nationally-competitive program—the INL Graduate Fellowship—designed to identify exceptional talent in research areas aligned with INL's strategic agenda to enable the current and future mission of DOE and INL. The program provides mentoring and financial support for outstanding students who plan to enroll in graduate degree programs. This is a triad relationship between the student, the university thesis advisor, and an INL technical advisor to provide meaningful research and mentorship throughout the entire graduate program. During the first year of the program, five of the eleven selected fellows came from CAES member universities. During the program's second year, four additional recipients from CAES members universities were awarded this prestigious fellowship.

- In 2018, we launched a new initiative called the CAES Summer Visiting Faculty program. This initiative provides summer funding for selected faculty members from

the CAES consortium to work jointly with an Idaho National Laboratory researcher on a joint proposal for external funding. The program is highly beneficial for both the faculty member and the laboratory researcher. Faculty members are exposed to the inner workings of a national laboratory, learn about national laboratory capabilities and expertise, and build lasting networks while laboratory researchers build new academic connections, are exposed to diversified funding opportunities, and have the potential to work with and connect with students supporting the faculty member. In 2018, six faculty members from CAES member universities participated in the pilot program. In 2019, we will be able to support almost 20 participants. Creating robust connections between university faculty and INL researchers allows for an easier integration of university students into joint research programs. The program's impacts don't end there; faculty members often take the lessons they've learned working alongside national laboratory researchers and weave these experiences into classroom instruction that benefits their future students as well.

- The Microscopy and Characterization Suite (MaCS) is a state-of-the-art materials characterization laboratory that provides broad material-analysis capabilities at CAES. MaCS was established at CAES to provide a world-class characterization facility in order to attract more students into science and engineering careers, to improve science and engineering education at the undergraduate and graduate levels, and to foster leading research and interaction with local industry. A true collaboration, the user facility is managed by a technical lead from BSU, a laboratory lead from UI, a safety officer from ISU, and equipment investments from INL. MaCS staff provide one-on-one mentorship and training on specialized equipment that can be helpful in developing skills that individuals, whether students or other researchers, can draw on in future

materials-characterization, nuclear energy, and advanced-manufacturing projects and employment. MaCS operates as a user facility, meaning students, faculty, researchers, and private industry from across the U.S. and around the world have access to this state-of-the-art laboratory. Many students, faculty, and researchers access MaCS through its partnership with the Department of Energy's Nuclear Science User Facilities (NSUF), which offsets some of the management and operations costs of MaCS and its associated microscopes and high-end imaging equipment. Private industry can also use the MaCS laboratory and receive the same training from our skilled technicians by paying a market-value rate. Some private organizations that have taken advantage of the capabilities at CAES' MaCS include the NanoSteel Company, J.R. Simplot Company, Micron, TORtec Group Corporation, and Sentient Science Incorporated.

- The integrative research that is characteristic of the CAES Energy Policy Institute (EPI), led by Dr. Kathy Araújo at BSU, also adds timely and relevant value to CAES' research endeavors. By fostering new channels of connectivity between industry, the public sector, and the CAES entities, EPI brings an important focus to CAES on the challenges and opportunities that are inherent in energy-systems change. Moreover, areas of EPI research, including work underway on energy job adaptation in regional innovation systems, could inform the way that new workforce needs are met by channeling or repurposing expertise from one technology or sector to another.

Education

CAES's collaborative education strengthens the personalized learning experiences of students in the region through unique experiences afforded by the national laboratory. By complementing and bridging academic offerings, CAES connects higher education to the workforces at the

laboratory, in regional industry, and across the universities to build a diversified future workforce with the experiences and relationships needed for success. We also strengthen the curricula offered by each university, not by offering degrees and certificates directly through CAES, but by combining and expanding upon the academic offerings in ways not possible with any one university. We encourage qualified researchers to bring their expertise into the classroom, and we support faculty in devoting more time and effort to specialized energy research. Through different forms of training, we encourage continuing education at all levels across the region and maintenance of skills and abilities needed for success in all aspects of energy industry and energy research and development, enabling a workforce more prepared to secure and succeed in the energy workforce of the future.

- An example of the information flow between INL and the universities leading to optimized course offerings is the development of cybersecurity programs offered at Boise State University (BSU). Based on significant feedback from INL and private industry, BSU has established a new doctoral degree in computing, with a security emphasis that aims to design secure and privacy-preserving protocols for computers, networks, programs, and data. This program will add to the workforce currently working to secure the nation's power grid, water supply, and other critical infrastructures. Additionally, this new Ph.D. is being offered to INL employees through synchronous online courses.
- Beyond graduate coursework, BSU established an undergraduate Cyber-Physical Systems Security certificate, the focus of which includes software, hardware, firmware, power systems, and industrial processes. This certificate is of interest to a wide variety of majors, including math, physics, economics,

computer science, electrical engineering, and mechanical engineering. This effort was initiated with seed funding provided by CAES to design the Introduction to Security in Cyber-Physical Systems course, with faculty at BSU collaborating with INL personnel when designing this introductory course.

- In 2018, CAES began a new initiative exploring the creation of a Nuclear Safeguards and Security joint-certificate program using the shared resources of our five member organizations. As envisioned, this joint effort would allow a student to take a series of four 4-credit courses, each taught by a different CAES member university. Following completion of the online course work, students would participate in a field exercise at Idaho National Laboratory, receiving world-class hands-on training in the field of nuclear nonproliferation and nuclear cybersecurity. Students completing the 16-credit course would be awarded an accredited certificate from the institution in which they initially enrolled. More importantly, the student would gain valuable education and practical experience in a specialized field of study not commonly taught at U.S. universities but with current workforce needs. If piloted successfully, this model could become the foundation for joint educational offerings expanded into other relevant energy areas, attracting enrollment to the CAES universities from all over the region and beyond.
- Beyond the traditional student matriculating through the university system, collaborations between INL and the universities support development of the current workforce at INL. Training and coursework for current INL employees is provided by some CAES universities, allowing for follow-on and specialized educational needs identified by the national laboratory. CAES universities—Idaho State University and

the University of Idaho—have established the University Place campus proximate to the national laboratory to better support the educational needs of the laboratory. With faculty and graduate students at the campus next door to INL, CAES research, education, and innovation connections are numerous and even more streamlined.

- Educational collaboration crosses over into regional colleges as well. Per the Nuclear Regulatory Commission, one important requirement of the nuclear industry is to educate all employees regardless of job duties on Nuclear Quality Assurance (NQA-1) requirements from the American Society of Mechanical Engineers (ASME). Meeting this mandate is a struggle for many companies in the supply chain for the Idaho National Lab. With funding support from the state of Idaho, the College of Eastern Idaho, in partnership with Idaho State University and INL's NQA-1 subject-matter experts, is developing a course that will be made available to all Idaho colleges to help meet the broad need for regional NQA-1 training. This class will support the state's several-hundred nuclear industry employers and support industry partners and students who want to work in the nuclear industry. For INL in particular, anticipated enrollment to such a program is around 200 people among current employees, new hires, interns, and subcontractors.
- In 2017, Idaho's Leadership in Nuclear Energy (LINE) 3.0 Commission, of which CAES is a member, championed a change in state law to increase the retention of out-of-state university students wishing to pursue an advanced degree in Idaho. The legislation, which became law on July 1, 2018, waives out-of-state tuition fees for any student who is a graduate of an accredited secondary school in the State of Idaho. This means a student from out of state who attends and graduates with an undergraduate

degree from an Idaho university and enrolls in a graduate program within 36 months of graduation at an Idaho university will pay in-state tuition for graduate school.

- CAES member, Idaho State University (ISU), is developing an interdisciplinary community of scholars who will build and sustain educational and research excellence in technology and its energy applications. This effort is central to a polytechnic initiative funded by the state of Idaho and ISU, in partnership with INL and other key industry and educational partners in Eastern Idaho. ISU is in the process of hiring seven faculty members whose proven capabilities complement INL's research emphasis on the generation, distribution, and security of electric power. This "Polytechnic Center of Excellence" will provide educational pathways relevant to the growth of an energy workforce in Eastern Idaho and around the United States. ISU students studying at the Polytechnic will receive an interdisciplinary education as they work closely with CAES and INL researchers. Students will complete undergraduate and graduate degrees in nuclear and electrical engineering, data analytics, and cybersecurity, and as the Polytechnic grows, additional opportunities will be added.
- In 2015 and 2016, the University of Idaho (UI) and the University of Wyoming (UWy) created a CAES graduate assistantship program to catalyze interdisciplinary, cooperative energy research and academic programs, promote workforce development, and engage industry partners in transformational energy programs. The program also promoted enhanced faculty–to-faculty inter-institutional collaboration, requiring students in the program to work on a project that involves participation from at least two CAES member institutions. In 2015, UI funded two graduate students through the program. One student worked on a project to integrate algal biomass into a broad-based dairy-manure resource-recovery technology, and the other worked on novel

heterogeneous catalysts for synthetic fuels. In 2016, the UWy supported seven graduate students through the program, working on a spectrum of energy-research topics, ranging from the development of a web-based, searchable Western Energy Corridor resources map to the study of chemistry and mineralogy of the Woodford Shale in Oklahoma.

- The K-12 science, technology, engineering, and math (STEM) pipeline is of critical significance to the energy workforce pipeline as well. INL and the regional universities focus on professional development for regional teachers, student diversity and access to STEM, matching career STEM pathways to industry needs, and targeting under-represented populations. INL in particular, strategically aligned with the DOE's STEM Rising Initiative, has awarded almost $5M in grants over the last decade to innovative STEM projects through the CAES universities, community colleges, Idaho schools, and informal STEM educators such as museums. Additionally, INL-hosted programs have included My Amazing Future, an annual event at the national laboratory for more than 10 years which brings in the region's 8th grade female students for a day of exploration and science, and INL Team STEMazing, an employee volunteer program which takes STEM learning out into schools and communities in order to spark a class' interest in pursuing STEM careers.

Innovation

CAES' new strategic focus on its innovation ecosystem centers on entrepreneurial opportunities, industry partnerships, and tech-to-market impact. By moving in a direction that fosters regional startup companies and facilitates work with industry partners, CAES aims to be a critical player in transitioning research and development to impactful utilization. We are working to pair key regional industries with researchers, faculty, and students to deliver solutions and new business

opportunities. Likewise, we are leveraging intellectual property created at INL and the universities to bring research and development to market and, in turn, benefit our broader communities and businesses. We contribute to a skilled and capable workforce, and we support job creation and economic development as we begin to foster a regional accelerator-like ecosystem that spins off new industry, in the vein of Breakthrough Energy's recent report.[17]

- An example of our current collaborative ecosystem with industry can be seen in a project led by researchers from the University of Idaho, with support from Boise State University and Idaho National Laboratory, alongside technical aluminum casting experts from Tokyo, Japan's Sakae Casting, prototype assembly by Idaho's Premier Technology, and team members from the College of Eastern Idaho and Table Rock, LLC. This CAES research team was awarded a grant from the state of Idaho in 2018 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. 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 plate-and-cask design will work together to provide additional layers of neutron and gamma-ray shielding while also cooling 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.

[17] Breakthrough Energy, (2019) *Advancing the Landscape of Clean Energy Innovation.* February 2019, p. 194. http://www.b-t.energy/reports/advancing-the-landscape

- CAES, Food Northwest, and the University of Idaho have begun discussing ways to reduce energy and water consumption at food-manufacturing plants and facilities and are considering the development of a new CAES research center to provide the regional food industry with transformative technologies, research, and workforce educational programs to sustain the food-processing industry. As one of the largest trade associations representing the food manufacturing industry, Food Northwest would help support the center by encouraging its members to join the industry-funded endeavor. As envisioned, the center will pool the resources, capabilities, and expertise of the CAES entities together to develop technology and training programs aimed at reducing energy and water consumption at food-processing and manufacturing facilities in Idaho, Oregon, and Washington. Like many industries, the food manufacturing sector faces a workforce shortage, so a key aspect of this center will be workforce training. The center plans to develop coursework and training opportunities to support the current workforce and provide them with an energy- and water-efficiency skill set that can be widely applied. Once fully operational, the center will be headquartered at CAES and managed by the University of Idaho.
- The CAES Technical Assistance Program (C-TAP), headquartered at Boise State University, engages the expertise of faculty and students to solve technical challenges that face Idaho industry. In short, if a company has a challenge, it can reach out to C-TAP, which pairs the company with expertise and capabilities—faculty and students associated with a university lab—to resolve the issue. By employing students wherever possible, C-TAP allows young professionals to gain relevant work experience and industry connections that ready them for the workforce after graduation. In some cases, a student's experience serves as a springboard to positions in industry. In addition,

participation in C-TAP projects helps university faculty understand the needs and processes of Idaho industry. Since its inception less than 5 years ago, C-TAP has engaged in 178 projects for 91 clients and provided work experiences to roughly 20 students.

- Another example of CAES industry partnering is the Industrial Assessment Center (IAC), part of the CAES Energy Efficiency Research Institute (CEERI) based at Boise State University and supported by the Department of Energy. The IAC brings together BSU with UI to train engineering students with the hands-on experience in assessing the energy usage at small-to-medium-sized regional industrial facilities. Over the period of operation, nearly 100 engineering students have participated. According to DOE statistics, the IAC is responsible for cumulative savings of $7.2M and over 1.1 TBTU of energy saved. To put that in perspective, the amount roughly equates to constant savings of 5MW of electric power for companies in the region.

Students at all levels are the key to an energy future built on the best in research, education, and innovation. From early outreach and engagement through higher education and beyond, CAES offers experiences and opportunities for early career talent that are simply not possible for member institutions acting alone, or in other parts of the country and the world. Our students can see and experience the amazing things happening in energy and technology, sparking curiosity and lifting go-on rates. The connections we bring across research, academia, and industry build relationships and opportunities that draw undergraduate and graduate students to the area, lifting enrollments and growing our universities. These connections also strengthen employment and retention rates across the region through new opportunities, thriving industries, a growing innovation economy, vibrant communities, and a blossoming next-generation of future energy leaders.

CAES' Value and Major Milestones

Since opening its doors in 2009, CAES has made a concerted effort to demonstrate value to its stakeholders. We work hard every day to support the Department of Energy's vision for CAES as a regional, collaborative research, education, and innovation hub aimed at training the next-generation energy workforce. Our efforts support mandates from the states of Idaho and Wyoming to increase educational attainment, to supply an educated workforce capable of supporting high-technology industries, and to attract and retain new industries by supplying them with a qualified workforce. Our efforts also support our national laboratory and university stakeholders' needs by providing students with hands-on learning experiences through internships, postdocs, fellowships, job opportunities, and mentorship. Similarly, through CAES, faculty members have a mechanism to transfer laboratory and industry knowledge into the classroom; they can both shape coursework based on shared experiences and have increased potential for receiving a joint appointment or grants leading to tenure. The national lab benefits directly by molding and recruiting the nation's next-generation energy workforce and from accelerated research and development through teaming. In short, CAES provides win-wins for everyone associated with our center. Our members jointly leverage shared strengths—resources, capabilities, facilities, equipment, and expertise—leading to new funding opportunities, major proposals, and research hubs, while elevating the stature and expertise of the five CAES institutions and their associated researchers, faculty, and students.

Since 2009, CAES has achieved several significant milestones for our members including:

- Awarded more than $100 million dollars in competitive grants, including
  - More than $26 million from DOE's Nuclear Energy University Program and
  - Nearly $10 million from INL's Laboratory Directed Research and Development.

- Received more than $25 million in state of Idaho funding to support faculty and students,
- Published more than 1,700 journal articles, conference proceedings, and technical reports, and
- Hosted more than 15,000 visitors, including many university student groups.

In the last five years, CAES members have collaborated on personnel exchanges, with:

- 226 interns working at INL from CAES member universities,
- Seven INL graduate fellows from CAES member universities (through a program started in 2018),
- Seven INL postdoctoral researchers from CAES member universities,
- 25 CAES Summer Visiting Faculty (a program started in 2018), and
- 35 joint appointees between INL and CAES member universities (i.e., 29 faculty at INL and 6 INL researchers at a university).

And related to direct support of INL's specific workforce development and pipeline needs:

- 36 former student interns or post-docs were subsequently hired by INL.
- In fiscal year 2018, former INL interns and postdoctoral students accounted for 37 percent of the laboratory's overall hiring. Many of these interns and postdoctoral students came from CAES member universities.
- 485 INL employees returned to a CAES university for postsecondary education through the laboratory's employee education program.
- 27% of INL employees have one or multiple degrees from a CAES university; over the years, CAES universities have awarded 1,546 degrees to current INL employees.

Individual Success Stories

Although hundreds of students and faculty members have passed through, been impacted by, or received funding from CAES, I would like to highlight three individual success stories.

Kelley Verner

Kelley is a native of Idaho Falls, Idaho and attended the University of Idaho in Moscow, where she received a bachelor's degree in biological and agricultural engineering. As Kelley turned to graduate school, CAES helped her continue her education through the study of advanced hybrid-energy systems. Now a Ph.D. student, Kelley has been able to take advantage of CAES' connection to INL through internships with the Nuclear Science User Facilities and subcontract work with the INL's Materials and Fuels Complex. The Ph.D. work she is performing would not have been an option without the space and proximity to INL that CAES provides to students. As a result of CAES opportunities afforded to her, Kelley will be participating in the nationally competitive Dr. G. Robert Keepin Nonproliferation Science Summer Program this year at Los Alamos National Laboratory.

Michael Shaltry

Michael was the very first university student to receive authorization to conduct student research in the CAES facility when it opened in 2009. At the time, he was an undergraduate student at Idaho State University, pursuing a bachelor's degree in physics. While conducting his student research, he worked under the direction of University of Idaho's Dr. Supathorn Phongikaroon at CAES, performing chemical and electrochemical research associated with nuclear molten-salt systems. With his bachelor's degree complete, and having had excellent mentorship at CAES, Michael decided to pursue a master's degree in nuclear engineering from the University of Idaho. While completing his thesis, he continued to work at CAES, moving up the staff ranks to become a laboratory lead, overseeing CAES' Radiochemistry Laboratory and providing

mentorship to new generations of students. Today, Michael works for Idaho National Laboratory as a nuclear engineer.

Olu Omotowa

Olu joined and performed research out of the CAES facility between 2009 and 2013 while he pursued his doctoral degree in nuclear engineering at the University of Idaho under the supervision of Dr. Akira Tokuhiro at CAES. With previous degrees in chemical engineering and environmental and energy engineering, Olu saw CAES as a unique collaborative environment with peers, national laboratory experts, and academics who would enable him to perform advanced research, utilize the user facilities, develop methods, and create sustainable energy solutions. During his time at CAES, Olu worked on several DOE-funded projects, using research tools and testing facilities within CAES to provide solutions to technical challenges facing existing fleet and advanced nuclear reactors. That collective experience prepared him for the nuclear engineering workforce. Today, he utilizes the skills acquired and applies the knowledge gained while at CAES in his current role as a senior engineer at TerraPower, a nuclear innovation company.

These success stories are just a few from dozens of similar stories we hear regularly from former students, faculty members, and laboratory researchers who have been affiliated with CAES during its first decade. While some CAES students become employees at Idaho National Laboratory, others have pursued teaching opportunities or accepted positions in private industry. We are aware of CAES alumni who have gone on to work for the Department of Energy, NASA, Boeing, TerraPower, the Nuclear Regulatory Commission, Los Alamos National Laboratory, the National Renewable Energy Laboratory, Argonne National Laboratory, Oregon State University, the University of Utah, the University of Florida, Boise State University, and the University of Idaho, to name just a few organizations, agencies, or universities that have hired former CAES

faculty and students. As the importance of an educated energy workforce continues to grow, we need further support from the U.S. Congress to meet these workforce demands.

Opportunities for Congressional Support for Energy Workforce Development

Here are three ways the U.S. Congress can aid the development of a thriving energy workforce:

Robust Research Portfolio

A robust energy workforce pipeline is supported by a similarly robust research portfolio: strong research and development catalyzes the science enterprise, and educators and broader industries mobilize around strategic priorities. A robust research portfolio would include increased and targeted investment by the public and private sectors on energy innovation, seamlessly spanning gaps between fundamental research and commercial application. This approach, especially when combined with an all-of-the above strategy for energy solutions, builds on the core principles of Vannevar Bush's vision for the U.S. scientific enterprise that centers on the importance of scientific research for national security and economic well-being.[18]

But it goes further. We have an opportunity to catalyze all areas of the energy innovation system by recognizing that science and technology can mutually inspire. [19] Here, combining science and applied energy R&D portfolios can encourage performance with cross-cutting innovation.

National Laboratory Support

The country's 17 U.S. Department of Energy national laboratories are crown jewels of research, education, and innovation that deserve continued commitment and support from the U.S. Congress. Each day, thousands of researchers go to work at one of these laboratories where they conduct work in a range of scientific and engineering disciplines. The laboratories have

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18 V. Bush, Science: The Endless Frontier, Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945, https://nsf.gov/od/lpa/nsf50/vbush1945.htm.

19 D. Stokes, (1997). Pasteur's Quadrant: Basic Science and Technological Innovation. Brookings Institution Press: Washington DC.

historically developed intellectual property, inventions, and breakthrough technology that have changed and will continue to alter the course of history. They need your continued support to push the boundaries of science and technology. They also need your support for continued funding for student intern programs, graduate student fellowships, and post-doctoral opportunities, as these are the primary mechanisms by which students enter the lab system. Finally, given the strengths we've discussed in leveraging combined laboratory and university expertise and capabilities, we also recommend that more federal agency calls for research allow opportunity for more collaborative and integrated engagement between universities, national labs, and other federal research centers across the agency complex. Perhaps these are areas where CAES could serve as a model for additional lab-university partnerships.

Advancing Energy Education

Education remains a cornerstone to solving the workforce shortage in the energy sector. We ask the U.S. Congress to continue to provide support and funding for academic scholarships and grants, especially those enabling graduate research studies. We would welcome your encouragement with universities to deepen and broaden degree programs in the energy field. Additionally, fellowships like the American Association for the Advancement of Science (AAAS) Science and Technology Policy Fellowship and the ASME Congressional Fellowship changed my own development path and led to public service and a career in energy. Support for such fellowships, at the federal, regional, or state level, can help develop future government energy workforce. Federal-state partnerships could be beneficial in areas such as Department of Labor and Department of Education initiatives and grant programs as well.

Furthermore, partnerships with high schools, technical colleges, and community colleges must be incentivized, as energy workforce needs span a broad spectrum of talent from technicians to Ph.D.'s. The successes stemming from INL's connections with the College of Eastern Idaho and

regional universities can't be overemphasized. Such collaborations could strengthen regional innovation ecosystems and the workforce pipeline at national labs across the country. Of course, energy workforce pipeline considerations start with K-12 awareness and education. Support of efforts within national labs and at universities, such as those described herein, is critical. Inspired in part by the Peace Corps, a national junior energy league could also be supported, connecting high school and undergraduate students with national lab and industry mentors to tackle community energy challenges.[20] Finally, your support of technical certifications, skilled trades, and apprenticeships for energy industries will strengthen our country's technology leadership and resilience as we adapt with the changing energy playing field.

Conclusion

Chairwoman Kaptur, Ranking Member Simpson, and Members of the Subcommittee, it has been a privilege to address you this afternoon on the very important topic of energy workforce development. I look forward to any questions or recommendations you have on ways we can improve and advance today's energy workforce while simultaneously preparing tomorrow's students for careers in the energy sector. I am honored to be the director of an organization that, between its five members, collectively represents more than 8,000 researchers, 63,000 students, 1,100 degrees and certificates, nearly 100 engineering facilities, and approximately $1.8 billion dollars in annual research and development funding. As we continue to leverage these resources for the benefit of all, it's hard to refute that our future looks bright. I would be remiss if I didn't thank several individuals who have helped elevate CAES from a figurative concept into a collaborative institution that aspires to our organization's vision: to

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[20] This could complement the Energy I-Corps which connects researchers with industry (see https://www.energy.gov/eere/technology-to-market/energy-i-corps) and work collaboratively with groups, like Energy Corps, https://www.energycorps.org/.

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

First and foremost, I would like to thank the Idaho Congressional Delegation, including Representative Mike Simpson who has long been an advocate for CAES and Idaho National Laboratory. I would also like to thank former Idaho Congressman and former Idaho Governor C.L. "Butch" Otter who was instrumental in ensuring CAES received appropriate financial considerations for the construction of our state-of-the-art headquarters facility and continued operational funding every year since 2009. During his tenure, former Governor Otter was supported by Idaho's current Governor, Brad Little, another strong advocate of CAES to whom we are indebted. In 2014, former Wyoming Governor Matt Mead also strongly advocated for the University of Wyoming's association with CAES, enabling new tracks of research and collaboration for the benefit of the region.

I would also like to thank the CAES Steering Committee members: Dr. Marianne Walck from Idaho National Laboratory, Dr. Harold Blackman from Boise State University, Dr. Scott Snyder from Idaho State University, Dr. Janet Nelson from the University of Idaho, Dr. Edmund Synakowski from the University of Wyoming, and all those who have come before, who provided steady guidance and strategic direction to CAES. We are grateful for the University Partnerships team at INL, led by Michelle Bingham, that works side by side with CAES and enables not only our CAES successes, but many others with universities around the country. I would also like to express my sincere thanks to the director of Idaho National Laboratory, Dr. Mark Peters, for his commitment to CAES and his support for our vision and mission. And lastly, I would like to thank the CAES leadership team and the many faculty members, students, laboratory researchers, and staff who believe in and support our mission and who come to work each and every day hoping to make the world a better place, together.