UNIVERSITY OF UTAH
COLLEGE OF ENGINEERING

RESEARCH REPORT

2022

FROM THE DEAN

Each year, we bring you an exclusive look at some of the College of Engineering's most exciting research endeavors. From improving energy efficiency for small manufacturing to creating an open-source test bed for cellular and wireless technology experimentation, our 213 faculty are generating nearly $100 million in externally funded research expenditures each year. The college is the largest contributor to the university's research totals outside of the School of Medicine. As important, our faculty are responsible for 98 startup companies in the last 15 years.

The projects you'll read about in this year's report show not only the range of research activity, but also the importance of faculty innovation to industry. It is our focus on solving some of the nation's most pressing challenges that led to the signing of a SUPER agreement with Idaho National Labs in March. The five-year agreement solidifies what had been individual peer-to-peer agreements between laboratory researchers and university faculty members.

Our faculty are already collaborating with INL scientists on a wide range of projects, including just a few that are highlighted in this year's report. In addition to more joint research, I anticipate even greater collaboration with INL through shared academic materials, visiting research scholars and cooperative symposia, seminars, workshops and conferences.

With so much research activity going on, our students have the opportunity to take part in some of the most exciting discoveries of the future. From first-year students in the Engineering Scholars Program to upper division students pursuing the Engineering Entrepreneurship Certificate, the College of Engineering provides an immersive experience into how ideas become technologies that become companies. Many graduates go on to start companies of their own.

It's exciting to be leading Utah's most respected state engineering and computer science program, adding more than 1,250 graduates a year to the number-one-ranked, tech-based economy in the nation. And now, with support from the legislature, we have begun planning and design for the 200,000-square-foot John and Marcia Price Computing and Engineering Building that will serve as the hub of computing across campus. Given our current trajectory, we have the potential to double again the number of students as well as the amount of research innovation and technology commercialization. After 127 years as Utah's flagship engineering program, the best is yet to come!

Richard B. Brown
H.E. Thomas Presidential Endowed Dean, College of Engineering

CONTENTS

Dean, College of Engineering: RICHARD B. BROWN
Associate Dean for Research: KEVIN WHITTY
Excecutive Director, External Relations and Development: JOSH GRANT
Senior Advisor, Development: MARILYN DAVIES

Research Report Editor: VINCE HORIUCHI
Photography and Graphic Design: DAN HIXSON
Contributing Writers: MARILYN DAVIES, MARK HELZEN DRAPER
Additional photos and illustrations provided by Adobe Stock & John A. Moran Eye Center

A NEW INFLECTION POINT

Once again, Utah's legislative leaders demonstrated their strong support for engineering education during the 2022 session when they voted to add a $5 million ongoing appropriation to the state's long-running engineering initiative. Of that amount the College of Engineering will receive $2.3 million, to be matched by the university. The college will use the funds to sustain its exponential growth in enrollment, primarily by adding new faculty positions in the areas of greatest student demand.

The legislature also approved an initial increment of $20 million for the college's new 200,000-square-foot building that directs $4.8 million to cover the planning and design phase. The John and Marcia Price Computing and Engineering Building will be located along Central Campus Drive, directly east of the John and Marva Warnock Engineering Building. The structure will be named in recognition of the Price's $15 million leadership gift.

This new building is crucial to the college's future growth by providing space for the School of Computing students and faculty, along with highly specialized centers for emerging areas like fintech and cybersecurity. The $120 million building is expected to include 100 faculty and staff offices, 70,000 square feet of research space, 12 classrooms, a 400-seat auditorium, and 15 conference rooms, all designed around open collaboration space.

The University of Utah produces 46% of the B.S., M.S. and Ph.D. computer science graduates in Utah's statewide system. The college's number one constraint to producing enough graduates to meet industry demand is the severe shortage of space. The School of Computing currently occupies approximately 45,000 square feet of space on two floors of the 60-year-old Merrill Engineering Building. To meet existing and future needs, the School of Computing must expand its footprint significantly.

The timeline for the new building anticipates occupancy by 2025. The college has formed a campaign committee led by visionary alumni: John Warnock, Ed Catmull and Shane Robison. In addition to the state's contributions, the college will raise $30 million in private donations. With the Price gift and other early commitments, the campaign is well on the way toward that goal.

THE LEADING EDGE

Researchers in the University of Utah's College of Engineering are continually discovering new ways to improve our world. Here are examples of their pioneering research that are making headlines. To read more about these and other projects, go to www.coe.utah.edu.

DIAGNOSING BREAST CANCER

Electrical and computer engineering assistant professor Benjamin Sanchez-Terrones is developing a safe, painless diagnostic tool for detecting breast cancer that uses a low electrical current instead of radiation, opening the door for younger people to be tested without the fear of radiation exposure from mammograms. The research is based on the notion that cancer causes a person's lymphatic interstitial fluid to change due to the increased presence of white blood cells and other physiological changes that happen as the body reacts to the tumor. To detect that change, Sanchez-Terrones is creating a diagnostic device with two electrodes that send a low-voltage electrical current through the body to detect these lymphatic changes.

POWERING UP A COMMUNITY

In the Kayenta Chapter of the Navajo Nation in Arizona, there are 24 households that have never enjoyed stable electrical power or an internet connection. A team of University of Utah engineering and architecture faculty, along with the Kayenta Chapter of the Navajo Nation, has been working to change that. The researchers are designing and building a solar-based electrical microgrid and deploying Wi-Fi connectivity for the Comb Ridge/El Capitan community in Kayenta, near the Utah border. The future goal of the project is to research why similar communities lag behind the rest of the country in infrastructure and how these areas can overcome those barriers. The team also wants to create other pilot projects like the one in Kayenta and then adopt larger-scale solutions around the country.

PRODUCING BETTER CANCER MEDICINE

Civil and environmental engineering assistant professor Tara Mastren, along with researchers from the Idaho National Laboratory, have developed a novel technique using high-energy photons to produce scandium-47 from the element vanadium, a less expensive method of producing this important radioactive material for the detection and treatment of cancer. This research opens the door for the potential use of scandium-47 as a dual-purpose diagnostic and therapeutic tool that could be especially useful for diagnosing and treating neuroendocrine tumors and prostate cancers.

TERRIBLE THING TO WASTE

A major environmental concern about the use of nuclear reactors is what's left behind — the nuclear waste from spent fuel rods. Instead of burying spent fuel rods, what if you could recycle them to be used again? University of Utah materials science and engineering professor Michael Simpson is working with a team from the Idaho National Laboratory to develop an innovative yet simple process for recycling metal fuels for future advanced nuclear reactors. These reactors are designed to be safer than existing reactors, more efficient at producing energy, and less expensive to operate.

WHERE THERE'S SMOKE THERE'S FIRE

Scientists have been unable to accurately predict whether wildfire smoke will reach the lower altitudes of an area where it can affect residents, even by examining satellite data of the smoke's spread. But chemical engineering associate professor Heather A. Holmes has developed a method of combining a meteorological model with NASA satellite data to predict whether wildfire smoke will stay at high altitudes or come down to the ground. That will lead to more accurate predictions of whether and when smoke from a nearby wildfire could reach people on the ground.

SPACE TRASH

With more than 27,000 pieces of space debris bigger than the size of a softball currently orbiting Earth, space has become a trash heap. Mechanical engineering professor Jake J. Abbott is leading a team of researchers that has discovered a method for manipulating orbiting debris with spinning magnets. With this technology, robots could one day gently maneuver the scrap to a decaying orbit or further out into space without actually touching it, or they could repair malfunctioning objects to extend their useful lifetimes. New Hampshire-based Rogue Space Systems, which develops orbital robots for satellite servicing, is partnering with Abbott to use this technology for the U.S. Space Force.

FEROCIOUS FUNGUS

It's called Armillaria ostoyae, and it's a gnarly parasitic fungus with long black tentacles that spread out and attack vegetation with cordlike structures called rhizomorphs that suck out their nutrients. Not much was known about what makes the Armillaria ostoyae so hard to kill — until now. A team of researchers led by University of Utah mechanical engineering assistant professor Steven Naleway have learned the outer layer of the rhizomorphs is less porous near the surface yet more porous in the inner layer so they can still soak in water and nutrients. And the fungus contains calcium, which can protect itself from the acidic attacks of insects and chemical compounds. Naleway hopes that farmers, forestry officials and pest control developers armed with this new knowledge can come up with a more effective method for containing this resilient fungus.

MIRACLE OF MUCINS

University of Utah biomedical engineering assistant professor Jessica Kramer has learned why the coronavirus is not really transmitted by touching surfaces like countertops, and it all has to do with our mucus, the slimy gunk that comes from our noses. Human mucus and saliva, when dry on a surface, may actually prevent the spread of coronaviruses. People produce different forms of mucus and salivary proteins, called mucins, depending on their unique genetics, diet, and environment. And certain forms of mucins form a barrier around the live virus which prevents the spread of infection. This knowledge could help lead to new drugs that might be used by healthcare workers and first responders in high-risk environments.

FORECAST FOR SNOW

University of Utah civil and environmental engineering assistant professor Carlos Oroza and U geography assistant professor McKenzie Skiles are helping the National Oceanic and Atmospheric Administration better forecast how mountain snowpack contributes to our water supply. It is part of a new consortium of institutions that is analyzing resources and developing more accurate models for predicting catastrophic flooding. Oroza and Skiles are combining remote aerial lidar sensors, ground sensors, and satellite imagery to collect data on snowpack in Utah. The professors will also develop software algorithms that use the data to measure how quickly the snow melts due to factors such as atmosphere, sunlight, thermal radiation, and phase changes.

HELPING THE BLIND SEE AGAIN

Biomedical engineering Distinguished Professor Richard A. Normann, along with researchers from the U's John A. Moran Eye Center, has created a form of artificial vision for a blind woman in Spain using technology hard-wired into her brain. A neurosurgeon implanted a microelectrode array invented by Normann, called the Utah Electrode Array (UEA), into the visual cortex of the woman to record and stimulate the electrical activities of neurons. She wore eyeglasses equipped with a miniature video camera, and specialized software encoded the visual data collected by the camera and sent it to the UEA, creating an image she could perceive.


bright
future

Whether tanning on the beach or taking a stroll, there's much to appreciate about sunshine on a bright summer's day.

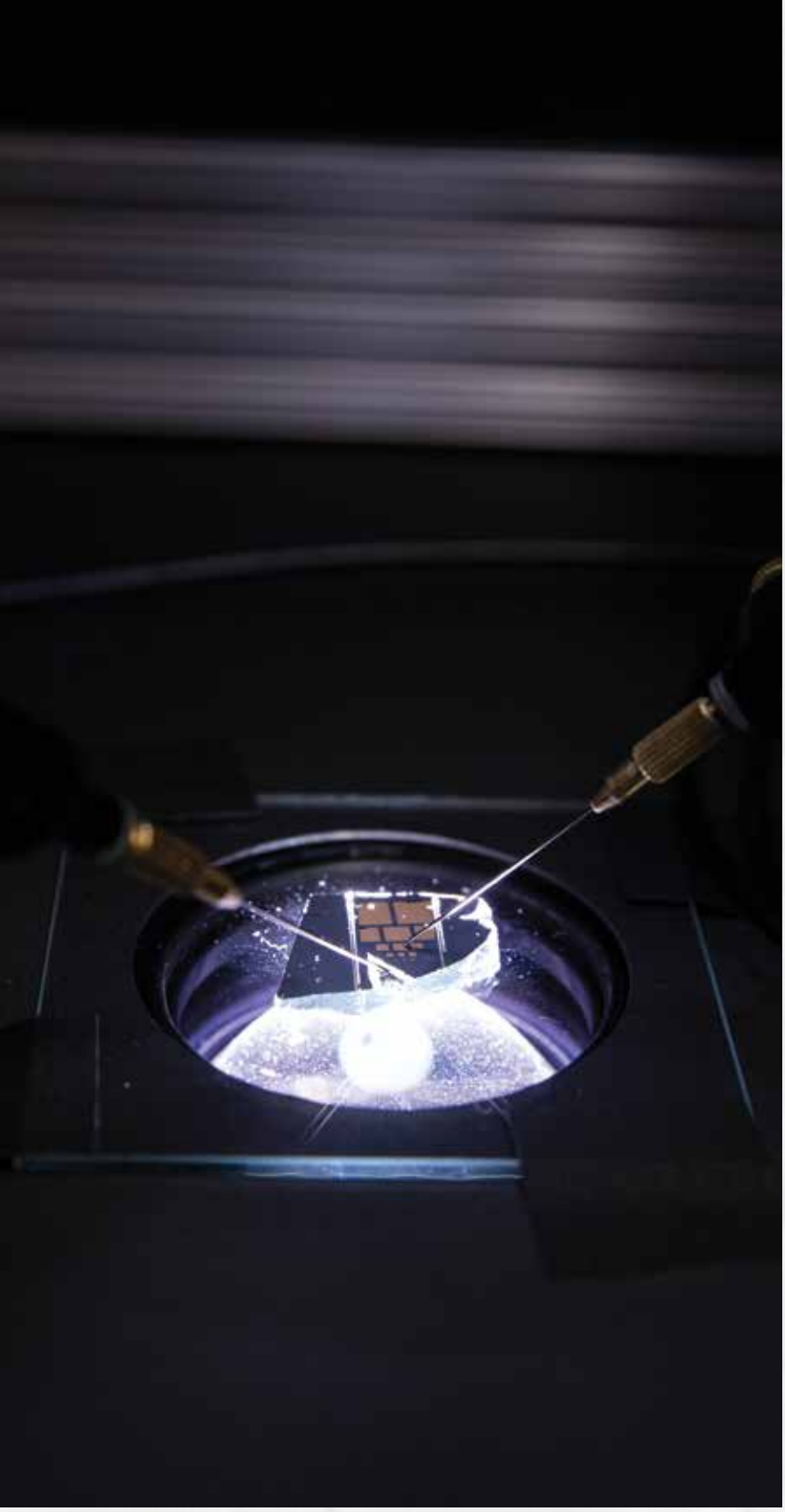
Yet University of Utah electrical and computer engineering associate professor Heayoung Yoon has always seen the sun as something more valuable. She thinks about its untapped energy potential that is still not being fully realized.

"Whenever I see all the sunlight, I think, 'Can we do something with this?'" said Yoon. And in her lab, she's doing just that, working at the nano-level to improve the efficiency, cost, and longevity of solar cell technology.

Current solar panels rely on a relatively thick and high-purity silicon to act as a sunlight absorption layer that is not only expensive but bulky. Most commercial silicon-based panels on the market today only convert about 15% to 20% of the solar energy gathered into usable electricity. It requires considerable space and adds weight, restricting where the technology can be applied.

Yoon and her collaborators are developing an alternative that will be cheaper, thinner, and more efficient.

Instead of the single crystalline silicon, Yoon and her team want to use metal-halide perovskite thin-films – so-called "perovskite solar cells." "Mixed organic and inorganic perovskites have shown to have excellent solar cell properties," she explained.



"In general, people are using silicon, which is a very thick material. At the same time, it's a high-purity material, meaning the production cost is very expensive," she said. "Instead, if I use a less-than-one-micron-thick layer of metal-halide perovskite versus 300 microns, that would be great. And perhaps this one doesn't need to be high purity. Somehow, I can just mix chemicals, coat it, and done!"

Yoon's research into "perovskite (HP) thin-film solar cells," funded by both the National Science Foundation and the U.S. Department of Energy (DOE), focuses on measuring their unique optoelectronic characteristics at the nanoscale. HP is a hybrid organic-inorganic semiconductor, noted for its low production cost and diverse engineering applications. Of the 20 solar cell technologies investigated by the DOE, this miniscule perovskite was one of two found to rival, and even beat, the efficiency of silicon-based solar cells.

"At this moment, with one layer of perovskite one-hundredth the thickness of a human hair, we are reaching 25% efficiency, but we want to push it further," said Yoon.

One way to do this is to understand its limited performance and develop new HP materials and interfacial layers. "We are combining not only single-layer perovskite but two different perovskite layers, or perovskite with silicon, or other materials. Then we can even get to an efficiency of over 40%," she said.

But for all of its promise, HP is not without its challenges.

The issue with this particular perovskite solar cell is that it degrades under ordinary environmental conditions. "If I fabricate this beautiful perovskite solar cell and then put it out in the air, it dies within a day."

Exposed to oxygen, moisture, or heat, perovskite structures undergo "ion migration," when mobile defects move around and subsequently destabilize and decompose the HP material, rendering it unusable.

Understanding and combating this process is the focus of the Yoon Research Group. Using high-resolution nano/microscopy

and nanofabrication technology, Yoon can monitor the local interactions of perovskite microstructures and molecular defects, figuring out what exactly leads to its degradation and how to prevent it. Her lab's ability to do this nanoscale measurement has led to solar cell research with many institutions, including First Solar, Corning, University of Toledo, Colorado State University, National Renewable Energy Laboratory, Los Alamos National Laboratory, and the National Institute of Standards and Technology.

Early perovskite devices would die within minutes or hours. But thanks to the rapid progress in this field, the lifespan has been increased to nearly a year. Yet more work needs to be done — for a solar technology to be commercially feasible, the Solar Energy Technology Office has an ideal target of a 30-year operational lifespan.

"At first, it lasted a day. Now it's a year. That's awesome." Yoon said. "But we still need to go further."

The possible applications of this lighter and cheaper technology are endless. Because it requires only a thin coat, Yoon believes it could be painted on planes or sail boats or be used as a much less expensive source of energy for cities.

Yoon's hopes for the "sustainable and durable future of energy," as she calls it, are not just restricted to this planet. She's especially excited by the application of this technology for space travel.

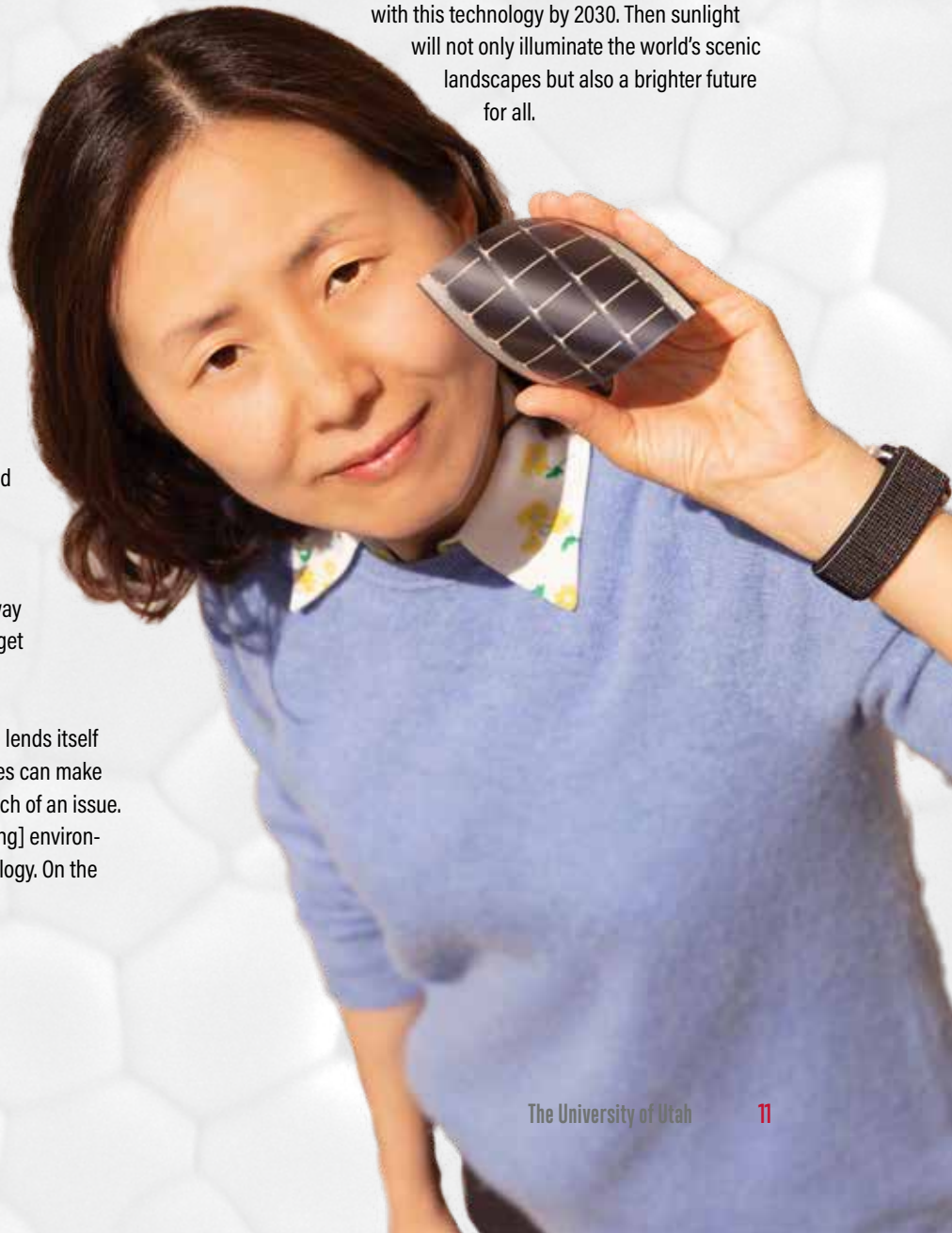
"We want to go to Mars, to Venus, to very faraway places," she said. "What energy can we use to get there? I think solar is the most viable option."

The lightweight nature of perovskite solar cells lends itself for use in space exploration where a few ounces can make all the difference and degradation is not as much of an issue. "In space, we don't have moisture, no [degrading] environmental stuff, so that's awesome for this technology. On the other hand, we will need to understand the impact of space radiation on HP solar cells," Yoon says.

She emphasizes that to reach all these heights takes more than a single field of engineering. "It all goes together. My collaborators are not all in electrical engineering, many of them are in materials science, chemistry, physics, and nuclear engineering. It's all combined together, and I love that," she said.

Even Yoon's background draws from multiple fields, including physics and computer science, making her all the better equipped to engage with other domains of engineering. As she points out: "We can't play by ourselves."

Yoon is confident she can create a viable solar panel with this technology by 2030. Then sunlight will not only illuminate the world's scenic landscapes but also a brighter future for all.



In a massive hurricane or other natural disaster, communication is a top priority for emergency responders and rescue operations. But wireless communication can be one of the first critical infrastructures to get bogged down when catastrophes happen.

University of Utah electrical and computer engineering professor Behrouz Farhang says his research can allow emergency services personnel to use the radio frequency spectrum even if it is filled up in times of crises. He has been working with researchers at the Idaho National Laboratory (INL) to develop technology so responders including police and fire can access certain areas of the radio band during what he calls "harsh environments" such as natural disasters, power outages or terrorist attacks. His twelve-year collaboration is just one example of research partnerships INL scientists have with College of Engineering faculty that are leading to important breakthroughs.

Farhang's project involves key technology called "Filter Bank Multicarrier Spread Spectrum," the ability to use a type of signal processing known as filter banks that search the radio frequency spectrum in more efficient and accurate ways. Cognitive radios, a radio programmed to dynamically look for unused parts of the spectrum, work with filter banks to send out multiple copies of the radio signal on different frequencies — a form of redundancy.

lines of COMMUNICATION

"Some of these copies of the message are interference-free, and you take advantage of that to recover your information," Farhang said. "Your receiver is intelligent enough to pick up the information from the less-noisy areas of the spectrum."

The result is the ability to send and receive video and audio feeds without interference, even if tens of thousands of users clog up the spectrum with their cellphones and two-way radios during a disaster. Farhang's team is also working with INL researchers to ensure that these communications remain secure through sophisticated encryption, a critical component for government agencies.

One such organization interested in Farhang's research is the United States Drug Enforcement Administration, which uses video and radio transmissions in their surveillance operations. Other U.S. agencies want to use another form of Farhang's technology to alert communities of impending natural disasters such as tsunamis. His research involves utilizing an older method of transmitting signals by reflecting off the Earth's ionosphere, the boundary between the planet's atmosphere and the vacuum of space in which signals can be sent vast distances by bouncing off of that interface.

"You can use communications across the globe without the need for satellites," he said. "There might be situations like during Hurricane Katrina in which cellular communications collapsed. For first responders it would be great if they had another way to communicate over long distances. We have shown that our technology is more robust than any other communication technique out there."

Farhang's work and collaboration with INL researchers has been so constructive, that INL set up a satellite office in Salt Lake City that focuses on his project. Since he teamed up with them in 2010, he has received more than $3 million in funding for this research. Farhang says: "Because of the nature of the work and the interest from INL, they have been trying to hire as many of my Ph.D. students as they can to build up the team and continue that research."

For years, faculty from the University of Utah's College of Engineering and INL researchers have conducted collaborative research in areas including nuclear energy, power grid security, and high-performance computing. Now the partnership between the institutions will be even stronger. Earlier this year, both institutions signed a Strategic Understanding for Premier Education and Research, or SUPER agreement, that allows them to explore deeper research relationships and expand opportunities for students, faculty, and researchers. This will include sharing academic materials, visiting research scholars and cooperative symposia, seminars, workshops, and conferences.

Farhang said that working with his INL counterparts has enhanced his understanding of the importance of his research, and he believes other faculty members can profit from this new SUPER agreement too. "Working with INL has created an environment where I can see the problems around us and figure out which ones need to be solved," he said. "We are benefitting a lot from the relationship with INL."

P

Experi

OWDER

iments for future wireless technologies are conducted on the most advanced testbed in the world.

Since the first mobile phone network in Japan in 1979, cellular technology has experienced monumental advancements to become one of the most ubiquitous forms of communication on the planet. But there are even more innovations in wireless communication on the horizon, and engineering faculty and students from the University of Utah are an integral part of this next phase of research.

More than three years ago, the University of Utah and Rice University launched one of the world's largest testbeds for advanced wireless communications research. The U's Platform for Open Wireless Data-driven Experimental Research (POWDER) and Rice's Reconfigurable Ecosystem for Next-gen End-to-end Wireless (RENEW) have created an outdoor laboratory that covers an area of approximately four-square kilometers on and around the University of Utah campus, creating a go-to testbed for current and future wireless technologies such as 5G and 6G.

"Mobile and wireless is where it's at," University of Utah School of Computing professor Kobus Van der Merwe, who is leading the POWDER platform, said when it launched. "We have multiple radio technologies and different applications coming. All of those things need platforms to experiment on, to prototype on, to explore."

This dynamic and powerful lab uses custom software on general-purpose hardware, known as software-defined radios, to establish how a communication network functions. Depending on a researcher's requirements, the testbed configuration could mimic any kind of cellular or wireless network and even use spectrum that is currently not available commercially. In addition, the platform uses a massive multi-antenna system (called Massive MIMO) designed by the RENEW team. It is made up of wireless radio base stations that employ hundreds of antennas serving many users on the same frequency with the potential to deliver speeds 100 times faster than wireless networks today.

Since Van der Merwe and his team began building the platform, they have deployed nearly all the testbed's equipment. They have installed base stations — called nodes — on rooftops, at the base of buildings, on posts, and more than 20 mobile nodes on University of Utah shuttle buses. "Dense nodes" that operate at higher frequencies and shorter ranges were positioned near the ground while rooftops nodes are used for lower frequencies and longer propagation.

These nodes can be programmed via the cloud, creating a dynamic system that can fit the needs of any experiment. "If we do an upgrade," Van der Merwe said, "we just upgrade the software, not the radio."

"We built what we set out to make, though it's been a lot harder than we anticipated because we created this thing that hasn't existed before," he said. "But we did it, and we're at the point now where we can support lots of really interesting experiments. We can do more exciting things and at scale, and we're getting more interest from companies. We're on an upward trajectory."

The project has also gained access to Citizens Broadband Radio Service (CBRS), a radio frequency spectrum reserved for the U.S. Navy's radar system that the Federal Communications Commission dubbed the "Innovation Band" and can now be used for new mobile users. While the Navy still has priority use of the band, wireless carriers like AT&T and Comcast and projects like POWDER can access the spectrum. This has given POWDER much needed spectrum to conduct more experiments.

Since the outdoor lab launched in 2018, more than 650 users have conducted over 12,000 experiments involving more than 150 separate projects, Van der Merwe said. These projects are not only with leaders in the telecommunications industry but also with the world's top research institutions, including collaborations with the U.S. Department of Energy's Idaho National Laboratory.

For example, one project used the testbed to prove the viability of two separate cellular networks quickly creating one virtual network for emergency responders during a natural disaster. "This was a really challenging use case because these networks are completely separate, so it's not easy to do," Van der Merwe said. "But this platform made it possible."

With the mobile nodes on buses, scientists have also used the platform to measure when and where people use spectrum so they can come up with better ways to dynamically share the bandwidth. "People want to use more and more spectrum, so there is a crunch," Van der Merwe said. "One of the questions is how much of the spectrum is actually being used? We can do measurements on how much is being used and in what locations."

Most recently, Maryland-based Zylinium Research used the POWDER testbed to successfully demonstrate its spectrum allocation system, which dynamically schedules spectrum use and assigns resources when multiple user types are vying for connectivity at the same time over the same bands. The demonstration used POWDER's live, over-the-air network to show how 5G network users could be prioritized over less-critical Internet of Things clients.

The POWDER team is also working with the Utah Department of Transportation, a leader in connected-vehicle communication research to determine whether there will be interference between new technologies developed for autonomous-vehicle networks and new Wi-Fi 6 standards that have become common in mobile devices.

The POWDER-RENEW project is part of The Platforms for Advanced Wireless Research (PAWR) program, a $100-million joint effort by the National Science Foundation and an industry consortium of wireless and other tech companies to create city-scale testing platforms for wireless communication and networking technologies. The program is managed by the PAWR Project Office, which is run by U.S. Ignite, Inc., and Northeastern University.

POWDER is one of four testbeds for the PAWR program, including platforms being built in New York City, North Carolina, and Iowa. Now that the platform in Salt Lake City is up and running and being used for a variety of critical experiments, Van der Merwe is excited for what the future holds for this important project.

"We are very excited with the instrument we have created," he said, "and we're looking forward to seeing the research results from the academic, industry and government users of the platform."

A key to making sure the world has an abundance of energy involves not just creating more sources of power but also being smarter about using the power we already generate.

University of Utah chemical engineering associate professor Kody Powell says businesses from small line manufacturers to large industrial plants can save significant amounts of energy and money if they make sometimes simple but critical optimizations to their operations. His research on how to use software tools and novel designs for energy systems has helped scores of manufacturers become more efficient. And with this knowledge, Powell has also created one of the top-performing Industrial Assessment Centers (IACs) in the country, tasked with helping businesses cut energy and production costs.

"We have to change our model in regard to energy," he said. "In the past, we just built more power plants. But as we transition away from fossil fuels, we have to be smarter about when and how we use that energy."

As the co-director of the Intermountain Industrial Assessment Center (IIAC) at the University of Utah — one of 39 such U.S. Department of Energy IACs around the country — Powell sends teams of faculty and student researchers to a manufacturer who make a day-long assessment of its plant operations. Their job: to analyze where production schedules or system upgrades can be tweaked to save the company money in energy costs, curb its draw of energy from the city's power grid, and reduce pollution.

In addition to analyzing energy system retrofits via the IIAC, the Powell Research Group analyzes ways for companies to operate more intelligently using cutting-edge computational tools. These tools include artificial intelligence to learn how the manufacturer's process works. The AI uses machine-learning models to determine the variables in the plant's systems that impact energy efficiency the most. They then employ algorithms to optimize the process based on environmental and economic conditions.

The team also looks at whether the facility can be flexible on when certain operations run to determine whether those processes can be turned on only during off-peak hours. The center also considers whether the manufacturer can generate its own power with distributed energy generation systems to lower its reliance on the power grid.

Finally, the team uses other software tools to determine what kinds of system optimization can be made on the fly based on changing conditions, such as adjusting the operation of a cooling tower due to shifts in the humidity or temperature.

Since the center launched in 2016, it has analyzed about 100 manufacturing plants in Utah and surrounding states and was awarded in 2020 the Center of Excellence Award by the DOE for the highest-performing IAC in the country.

In one case study, a regional mining plant that pumps water as part of its operations was wasting money and electricity because of when that water was used. After an analysis, Powell's team devised a better solution: use solar panels for the power to pump water during the day and store extra water in tanks that can be used for operations at night. "Adding solar itself will save them $270,000 per year in energy costs, but when they combine it with the water storage, they can save $755,000 per year," Powell said.

In another case, the center helped a company that manufacturers aircraft parts by creating an algorithm that determined better scheduling of its operations to reduce energy usage during peak demand. "If manufacturers operate a little more intelligently, they can become a big asset for the whole power grid," Powell said. "They could do things like schedule their processes so that the more energy-intensive processes could be done at off-peak times."

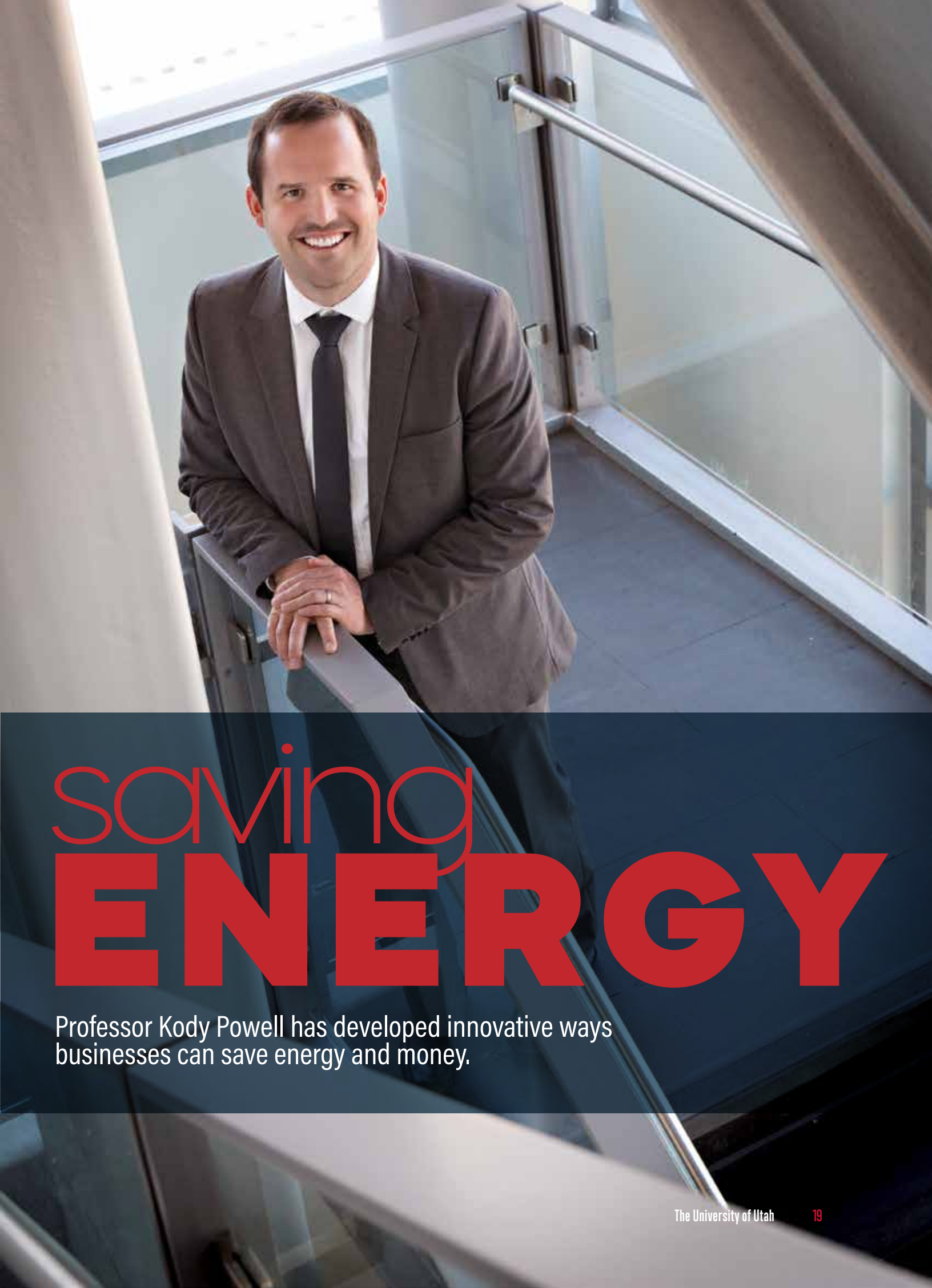
Based on their work thus far, the center's consultants can save businesses anywhere from $20,000 to $600,000 per year in energy costs as well as cut down on emissions.

Now, Powell's research is looking at how manufacturers can be just one part of a larger puzzle for a whole city's power grid. He's working on how the grid can coordinate manufacturing plants in a city or region to determine whether they can work harmoniously to keep power demand manageable.

He's also coming up with new models that can help smaller manufacturers optimize operations with less investment by aggregating resources. With new proposed funding from the federal government's Build Back Better Regional Challenge, Powell hopes to launch a remote operations center in rural Utah to help monitor smaller businesses around the state from a central location. "We want to have a team of researchers to help manufacturing sites and give them the technology they need as well as set up live data streams to monitor their processes so we can troubleshoot the system in real time," he said.

Powell came to the realization early in his career that the power grid can break down if cities rely too much on energy sources that they can't control.

"I did my Ph.D. in energy storage, and I see this as a critical problem," he said. "The Industrial Assessment Centers program helped me better understand these undiscovered assets. There's untapped potential out there to help solve this problem."



saving ENERGY

Professor Kody Powell has developed innovative ways businesses can save energy and money.

NEW FACULTY

The University of Utah's College of Engineering attracts the most inventive researchers from around the world. This year's newest tenure-track faculty members represent some of the best minds in science and technology and are also known as first-rate educators. As of July 2022, 16 new members will join the college with more expected to come.

DEISY CARVALHO FERNANDES

ASSISTANT PROFESSOR
CHEMICAL ENGINEERING

ALEX NOVOSELOV

ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

SHUAIHANG PAN

ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

SAMIRA SHIRI

ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

ZIAD AL-HALAH

ASSISTANT PROFESSOR, SCHOOL OF COMPUTING

DANIEL BROWN

ASSISTANT PROFESSOR SCHOOL OF COMPUTING

ANTON BURTSEV

ASSISTANT PROFESSOR, SCHOOL OF COMPUTING

SHIREEN ELHABIAN

ASSOCIATE PROFESSOR, SCHOOL OF COMPUTING

KATE ISAACS

ASSOCIATE PROFESSOR, SCHOOL OF COMPUTING

ANA MARASOVIC

ASSISTANT PROFESSOR, SCHOOL OF COMPUTING

STEFAN NAGY

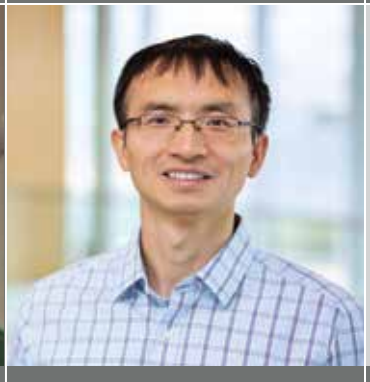
ASSISTANT PROFESSOR, SCHOOL OF COMPUTING

PRASHANT PANDEY

ASSISTANT PROFESSOR, SCHOOL OF COMPUTING

PAUL ROSEN

ASSOCIATE PROFESSOR, SCHOOL OF COMPUTING



HAITAO WANG

ASSOCIATE PROFESSOR, SCHOOL OF COMPUTING

JUN XU

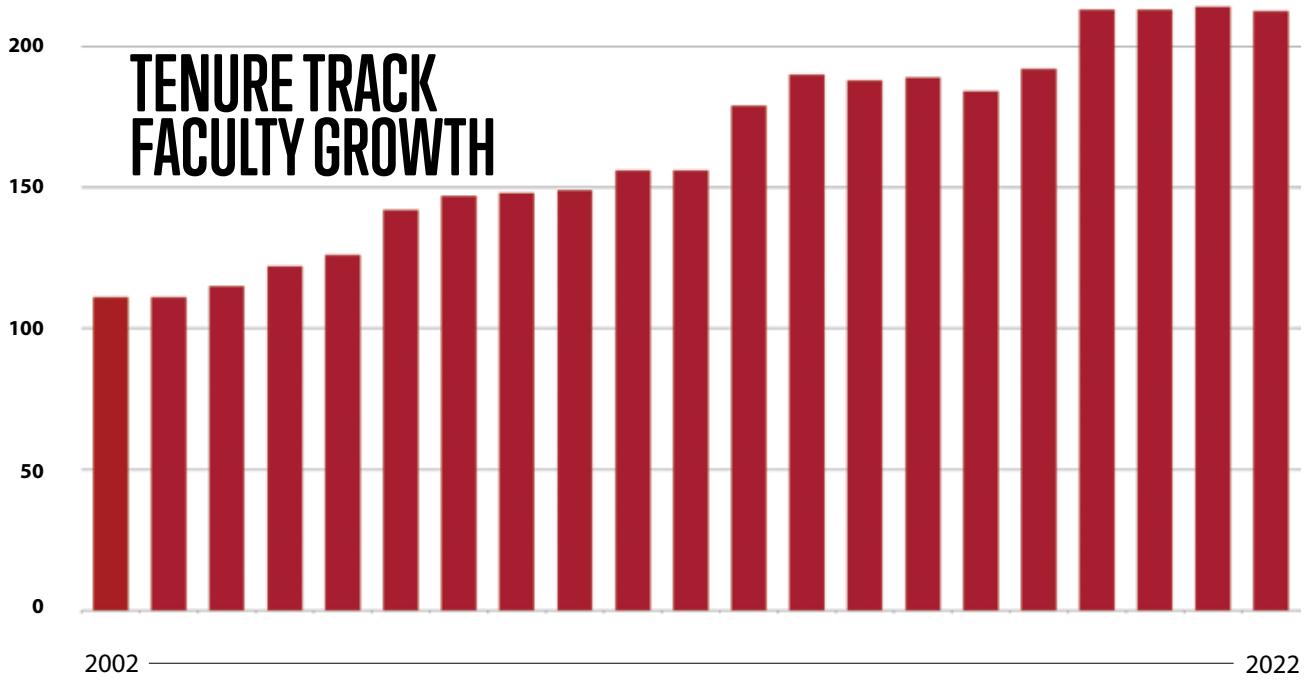
ASSISTANT PROFESSOR, SCHOOL OF COMPUTING

YIN YANG

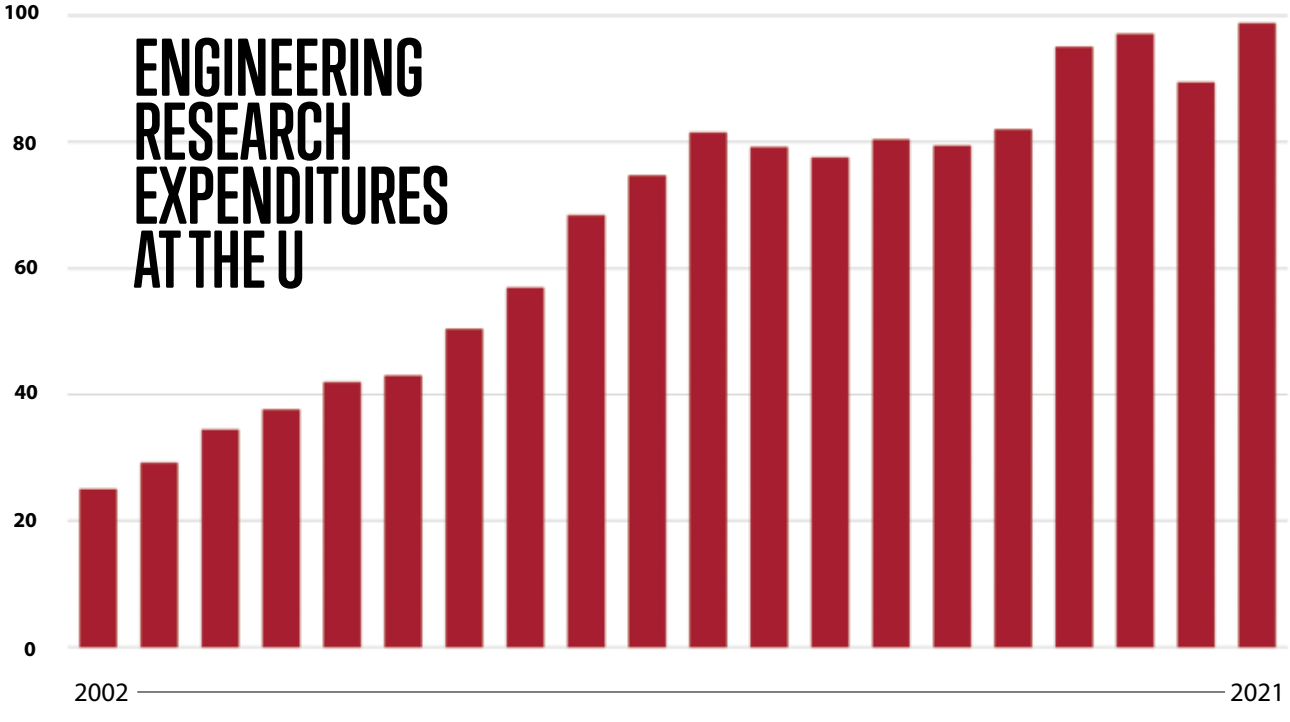
ASSOCIATE PROFESSOR, SCHOOL OF COMPUTING

BY THE NUMBERS

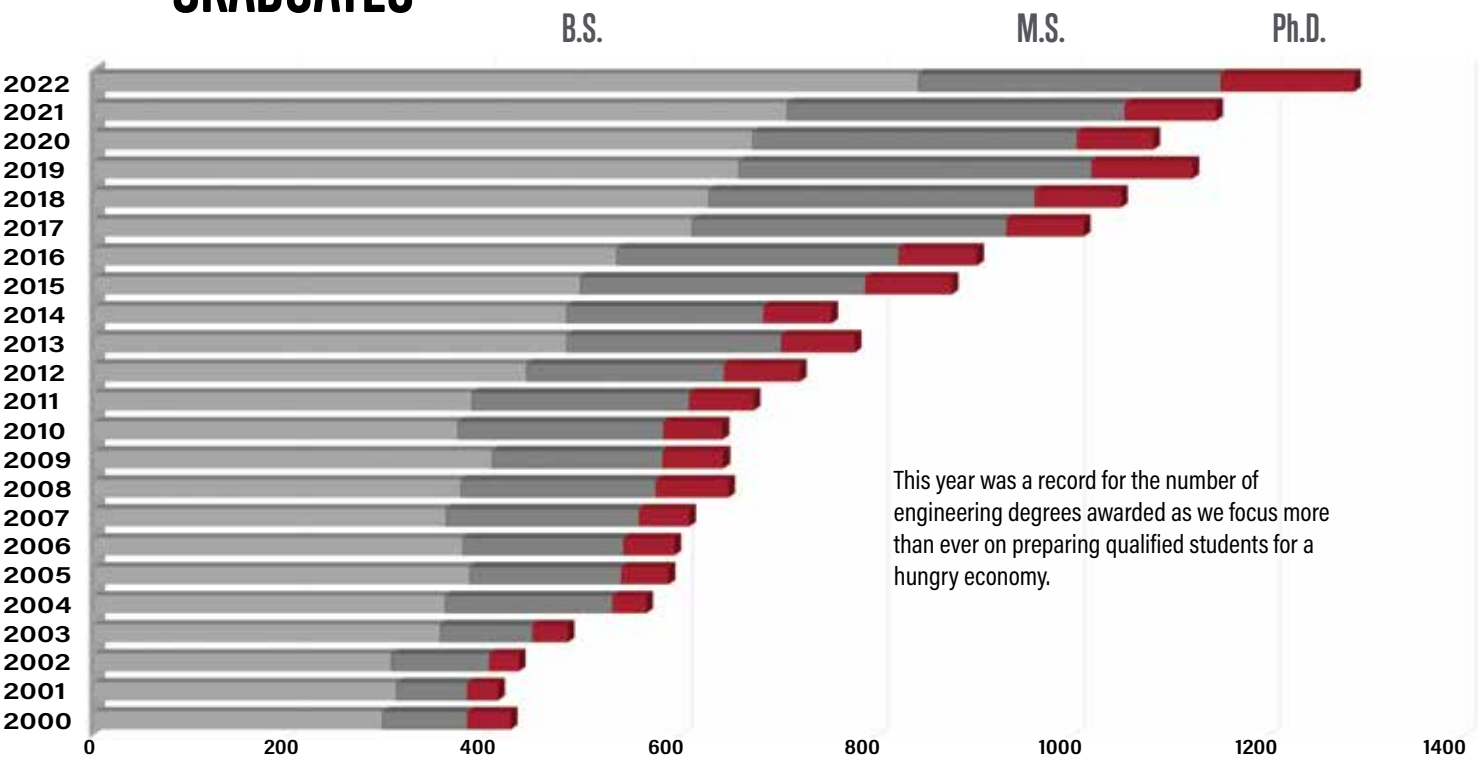
With 213 tenure-track faculty members in 2022, the most ever, the College of Engineering is committed to growing for the future.



Research continues to be a foundation of the College of Engineering's mission. With more than $97 million in engineering-related research funding in 2021 (including sub-awards), the college is moving forward with new and innovative projects.



GRADUATES



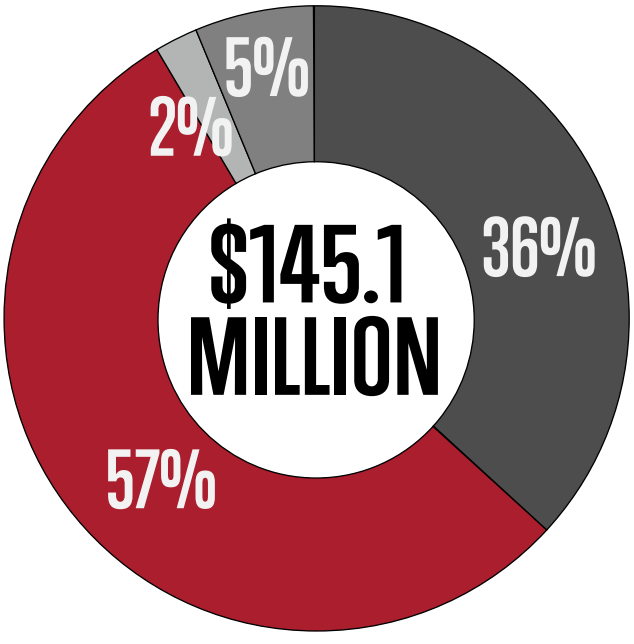
This year was a record for the number of engineering degrees awarded as we focus more than ever on preparing qualified students for a hungry economy.

RANKINGS

The College of Engineering remains one of the most sought-after educational institutions for computer science and technology. Here is how the college ranks in important areas according to the latest statistics from Profiles of Engineering & Engineering Technology by the American Society for Engineering Education.

- Research expenditures — #32 (out of 184 schools reporting).
- Engineering doctoral degrees awarded — #49 (out of 247 schools).
- Doctoral enrollment — #35 out of (out of 228 schools).
- Tenured/tenure-track faculty members — #33 (out of 231 schools).

ENGINEERING BUDGET 2019-2020



- SPONSORED RESEARCH
- STATE APPROPRIATIONS
- OTHER FUNDS
- DONATIONS

ENGINEERING ENTREPRENEURSHIP

A key to the College of Engineering's success is its ability to commercialize its research. Faculty as well as students are continually marketing their technologies to benefit people worldwide. Since 2006, the college has filed 1,113 invention disclosures, 356 U.S. patents, executed 115 licenses and launched 98 companies from its research.

ALUMNI PROFILE

LARRY MILNER

For nearly 150 years, America relied on manufactured gas plants (MGP's) to supply the heat and lighting for its cities, streets and homes. The local gasworks provided reliable energy and also employment for hundreds of workers from the early 1800's through the 20th century, lasting into the 1960's in some places. Over time, natural gas began replacing the manufactured variety as a cleaner, cheaper alternative. Left behind were thousands of forgotten underground structures containing tar and other toxic byproducts that resulted from the manufacturing process.

Identifying, removing and remediating these sites became a major career focus of civil engineering alum, Larry Milner, P.E. As vice president in charge of Burns & McDonnell's Chicago Environmental Global Practice, Milner oversaw more than 80 environmental professionals providing services ranging from hazardous waste remediation and site restoration, environmental permitting and planning, risk assessment, soil and groundwater evaluation and investigation, air quality evaluation and control, solid waste management, community involvement, design and implementation of sustainable solutions, regulatory reporting and negotiations.

Over a 30+ year career, he emerged as a nationally recognized leader in the Manufactured Gas Plant (MGP) investigation, remediation and property restoration arena, with more than two dozen industry publications. In 2021, Milner was named a Distinguished Environmental Award Recipient by the Midwest Energy Association (MEA) for his lifetime achievements. He was inducted into the MEA Hall of Fame in 2014.

MGP production facilities are estimated to remain in the thousands, left behind and paved over mainly in former industrial areas, but some are near schools, churches, playgrounds and housing developments. Finding these sites, and evaluating their danger to the soil, groundwater, and air quality is only the beginning. Once a site is identified, the real task of working through remediation plans with local officials, utilities, community leaders and other stakeholders can require a delicate balance.

"You have to remain open minded and be willing to listen to others. I made it a practice to lead with honesty and respectfulness when dealing with constituents who may not have a technical background."

Site remediation can be straight forward or extremely complicated. Over the course of his career, Milner's experience included supervision and management of environmental professionals; negotiation with state, local and federal agencies; community relations; design and construction of small to multi-million-dollar remediation and property redevelopment projects; design and operation of groundwater treatment and product recovery facilities; and coordination of all other aspects of environmental investigation and remediation of residential, manufacturing and industrial properties.

For Milner, the work was extremely gratifying. "I got paid to clean up the environment and when I was done, it was beautiful."

The road to Milner's career success is a profile in hard work and determination. Born in Payson, Utah, he recalls seeing cattle drives as a child. His father moved the family to Salt Lake City, where Milner attended Olympus High School. He began working in construction at age 14, and envisioned a life in the building industry until the 1980's recession made jobs scarce. At age 21, with a wife and new baby to support, Milner enrolled in the University of Utah.

"My grades in high school were pretty bad, and I entered the U on academic probation," recalls Milner. Six years later, he graduated Magna Cum Laude with a degree in civil engineering. He next pursued a master's degree at the University of Arizona with an emphasis in water resources engineering. "While I was at Arizona, I took courses in microbiology. My thesis looked at corrosion on the crowns of LA sewers, and how micro-organisms turned hydrogen sulfide into sulfuric acid."

It was this interest in bioremediation that led to his first job and a career as an environmental specialist. Now, as a retired engineer living back in Salt Lake, Milner remains determined to give back. He is currently serving on the University of Utah Civil and Environmental Engineering Industrial Advisory Board and on the University of Utah Engineering Alumni Association Board. He is also, supporting and serving as the Responsible Engineer in Charge of the University of Utah chapter of Engineers without Borders, and currently working on two water improvement project for a small village in Bolivia and for the Navajo Nation.

In his "spare time," Milner is taking classes in history, economics and constitutional law. "I am a firm believer in life-long learning." He and his wife Jayne have three sons and a daughter, and three grandchildren.

ENAC

UNIVERSITY OF UTAH COLLEGE OF ENGINEERING
ENGINEERING NATIONAL ADVISORY COUNCIL

John LaLonde - Chair
Chief Technology Officer
Abstrax Inc.

David C. Aldous
Chief Executive Officer
Rive Technology, Inc.

Don R. Brown
President
Partnet

Densen Cao
President and CEO
CAO Group, Inc.

Craig S. Carrel
President
Team 1 Plastics

Edwin Catmull
Retired - President
Pixar and Walt Disney
Animation Studios

Ronald H. Dunn
President
Dunn Associates, Inc.

Chris Durham
EVP Acquisition & Product
Integration
Merit Medical Systems, Inc.

Mark Fuller
Chairman and CEO
WET

Scott D. Gochnour
Chief R&D Officer
Civica Rx

Jeanette L. Haren
VP of Product Management
PowerSchool Group LLC

Sheila Harper
Chair
ASM International

Kim P. Harris
Principal
Van Boerum & Frank Associates, Inc.

Brett Helm
Chairman and CEO
DB Cybertech

Paul J. Hirst
Chairman
CRS Engineers

Cary Jenkins
Co-Founder
Visible Equity

Jason E. Job
President and CEO
Job Industrial Services, Inc.

David S. Layton
President and CEO
The Layton Companies

Paul Mayfield
Director of Product Management
Qualtrics

Gretchen McClain
President & CEO
J.M. Huber COrporation

Harold W. Milner
Chairman
VFC, Inc.

Ken Muir
CEO
BUKUShip

Jeff Nelson
Chairman
Nelson Laboratories

Jonathan Oomrigar
CEO & Founder
textcloud.ai

Steven Parker
Vice President, Professional
Graphics
NVIDIA

David W. Pershing
President Emeritus
Distinguished Professor
U of U Dept. of Chemical
Engineering

Christopher H. Porter
Founder
Medical Genesis, Inc.

Shane V. Robison
Senior Technology Advisor

Eric Smith
CTO
OlivierIQ

Jeff Spath
Head, Dept. of Petroleum
Engineering
Texas A&M University

Gregory P. Starley
Managing Director
Star Portfolio Ventures, Inc.

Gerald B. Stringfellow
Distinguished Professor
U of U Depts. of Electrical &
Computer Engineering
and Materials
Science & Engineering

Michael Stubblefield
President & CEO
Avantor

Randal R. Sylvester
Senior Technical Fellow
L3Harris Technologies

Anne Taylor
Retired - Vice Chairman
& Managing Partner
Deloitte

Nick Thomas
Executive VP,
Global Open Finance Innovation
Mastercard

J. Howard Van Boerum
President Emeritus
Van Boerum &
Frank Associates, Inc.

John A. Williams
Founder & General Manager
EPS, LLC

Jerry K. Young
Retired - Director Materials &
Manufacturing Technology
Boeing Company

EX OFFICIO
Dr. Richard B. Brown
Dean
College of Engineering

Josh Grant
Exec. Director, Development &
External Relations
College of Engineering

John C. Sutherland
Information Security
and Compliance Officer
Tula Health

MULTIDISCIPLINARY RESEARCH CENTERS AND INSTITUTES

- Alliance for Computationally-guided Design of Energy Efficient Electronic Materials
- Biomedical Image and Data Analysis Center
- Cardiovascular Research and Training Institute
- Center for Controlled Chemical Delivery
- Center for Engineering Innovation
- Center of Excellence for Biomedical Microfluidics
- Center for Extreme Data Management Analysis and Visualization
- Center for Multi-Scale Fluid-Solid Interactions in Architected and Natural Materials
- Center for Neural Interfaces
- Center for Parallel Computing at Utah
- Energy & Geoscience Institute
- Global Change & Sustainability Center
- Intel Graphics and Visualization Institute
- Intermountain Industrial Assessment Center
- Manufacturing Extension Partnership
- NIH Center for Integrative Biomedical Computing
- NSF Center of Excellence for Large Facilities Cyberinfrastructure
- NVIDIA CUDA Center of Excellence
- Scientific Computing and Imaging Institute
- University of Utah Robotics Center
- Utah Center for Data Science
- Utah Center for Inclusive Computing
- Utah Center for Nanomedicine
- Utah Nanofab

LIFE IN UTAH

One glance at Utah's unmatched landscape and people are hooked. From the red rocks of Southern Utah to the picturesque Wasatch Mountains in the north, it's a glorious setting for work and play. Utah is the new center for computer science and engineering and is expected to have the greatest percentage growth in tech jobs of any state in the next decade, according to the Cyberstates 2021 report. Here is how Utah and Salt Lake City are ranked in a variety of categories in economic growth and recreation.

UTAH

#1 Best State Economy — WalletHub
#1 Best Economy — U.S. News & World Report
#1 Best Economic Outlook — Rich States Poor States
#1 Best Economy — 24/7 Wall St.
#1 Best State for Employment — U.S. News & World Report
#1 Best State for Entrepreneurs — Forbes
#1 Best Economic Outlook — Fox Business
#1 Happiest States in America — WalletHub
#2 Best States for Winter Activities — GoAllOutdoors.com
#3 Best Ski Resorts in the USA (Snowbird) — PlanetWare
#3 Best Ski Resorts in North America (Snowbird) — ZRankings
#4 Best Ski Resorts in the USA (Park City) — PlanetWare
#4 Best Ski Vacations in the USA — U.S. News & World Report

SALT LAKE CITY

#1 Best Place to Start a Career — WalletHub
#1 Most Fiscally Fit Cities — State Farm Insurance/Best Places
#2 Best Cities for Young Professionals — Rent.com
#2 Best Cities for Jobs — WalletHub
#3 Best Cities to Start a Career — Zippia
#4 Best-Performing Large Cities — Milken Institute

COLLEGE OF ENGINEERING
OFFICE OF THE DEAN
72 S. Central Campus Drive
Salt Lake City, UT 84112-9200

Non-Profit Org
US Postage Paid
Salt Lake City, UT
Permit No.571

Follow us:

@UtahCoE

facebook.com/UtahCOE

@UtahCoE

www.coe.utah.edu

THE UNIVERSITY OF UTAH