utah ENGINEERING

KEUNHAN PARK
Converting heat to energy

THE UNIVERSITY OF UTAH • COLLEGE OF ENGINEERING NEWSLETTER

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A HOT IDEA

A lot of energy generated from everyday devices is wasted in the form of heat.

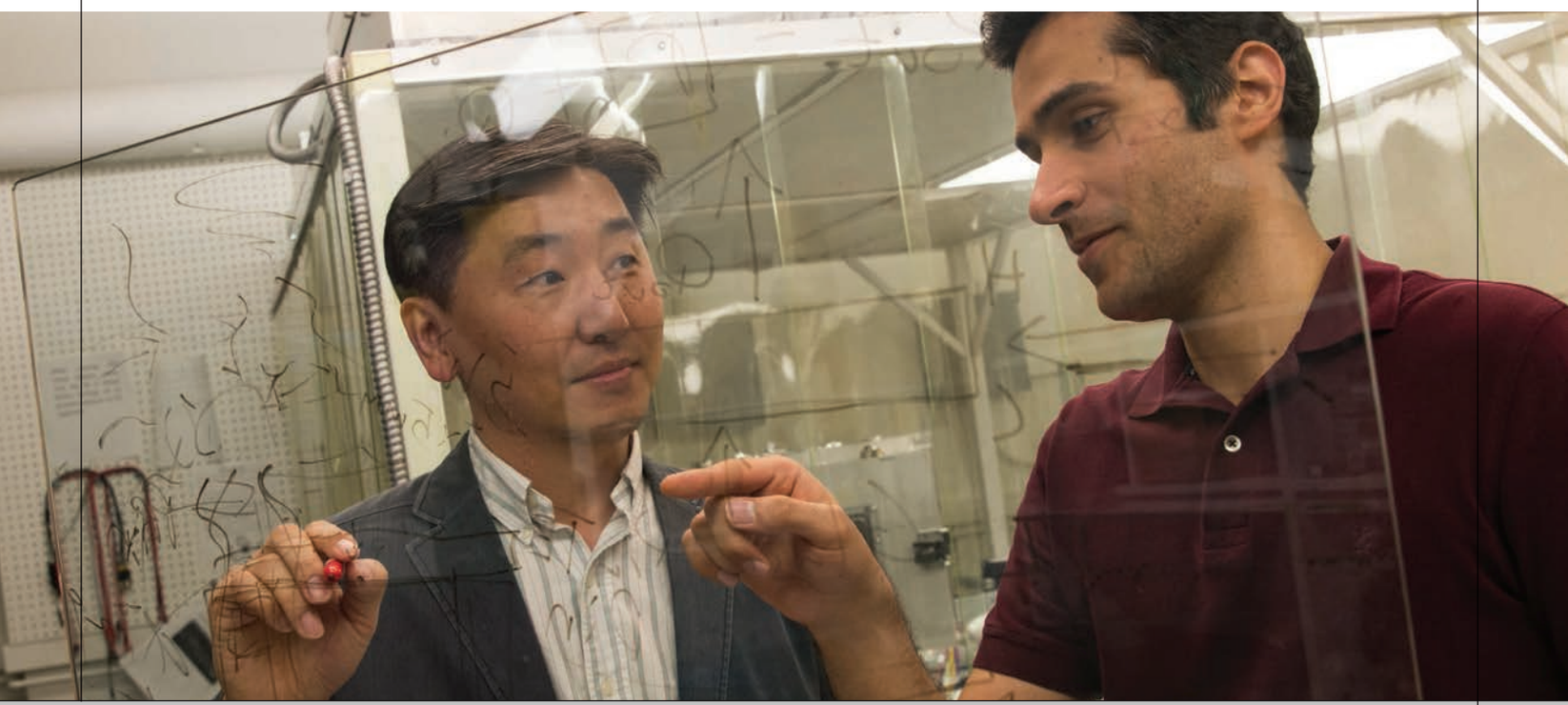
Whether it's a car engine, solar panels or the central processing units (CPUs) that run laptops or smartphones, these devices inevitably dissipate heat into the environment. As of 2017, more than 66 percent of energy resources consumed in the U.S. is wasted in the form of heat, said University of Utah mechanical engineering assistant professor Keunhan "Kay" Park. "If you were to recycle just a portion of waste heat into electricity, that would have a huge impact on every person's life," he added.

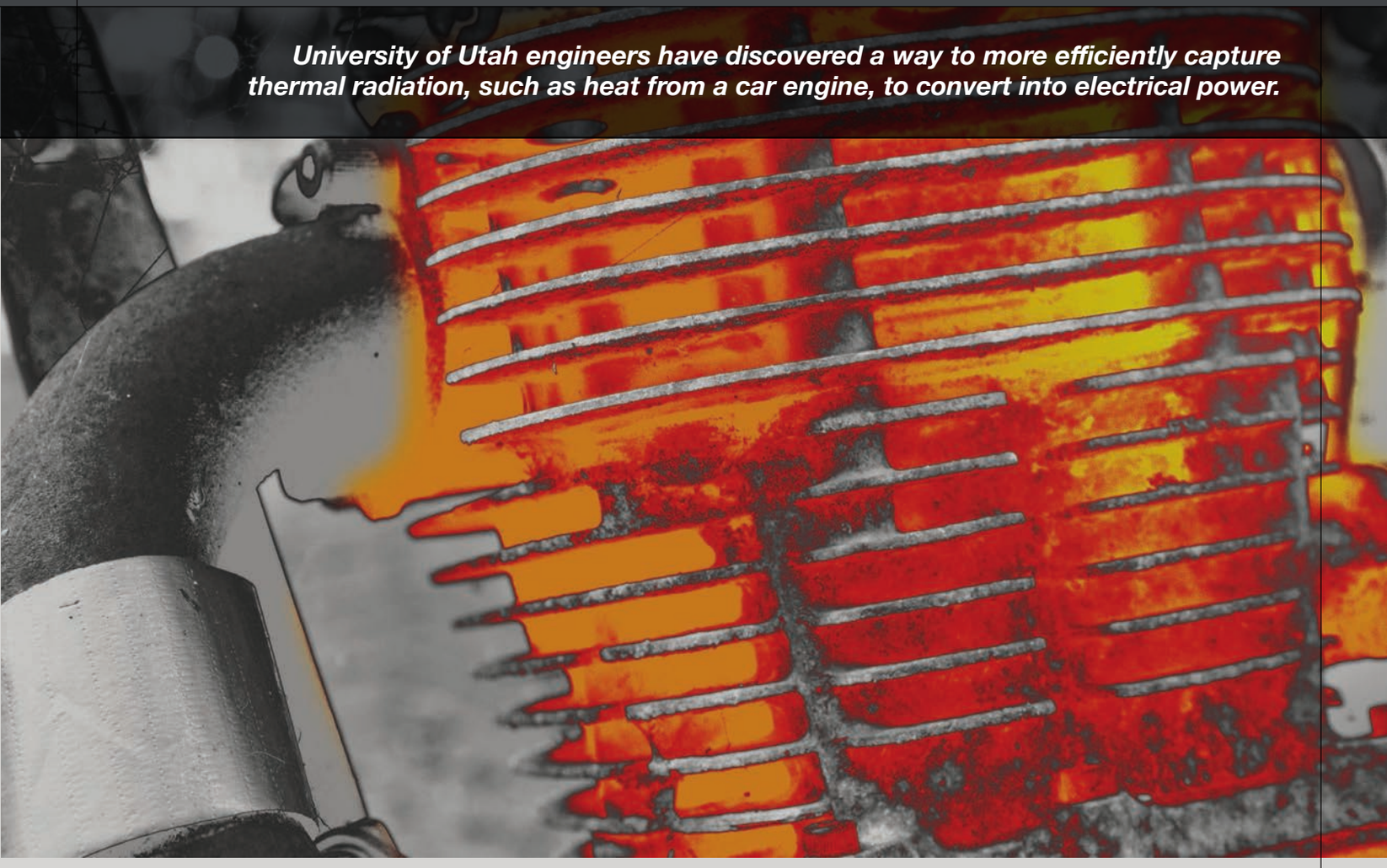
Park and his doctoral student Mohammad Ghashami may have a viable solution: Capture more of the thermal radiation emitted from a wasted heat source and convert it into electrical power using a low-bandgap photovoltaic cell. All hot surfaces release heat in the form of thermal radiation, whether it's from the sun at 5,500 degrees Celsius or from an incandescent light bulb. Within the thermal radiation spectrum, Park believes mid-infrared light can be used to capture more energy. The question is, how much energy can be captured from thermally-radiated infrared light?

In a recently published paper in *Physical Review Letters*, his team has experimentally verified that if they reduce the gap between two plates — one a hot plate that emits thermal radiation and the other a cold plate that absorbs it — they can greatly increase the amount of radiative energy transfer.

"Traditionally, we used to believe thermal radiation had nothing to do with the distance in the gap," Park said, "But we've now learned that as the distance gets smaller we can boost that thermal radiation by orders of magnitude. This means we can also boost the amount of electricity generated if the cold plate is replaced by a low-bandgap photovoltaic cell."

There are some additional obstacles, however. The gap has to be about 100 nanometers, or about several hundred times thinner than a human hair, to make this energy conversion attractive for waste heat recovery.





University of Utah engineers have discovered a way to more efficiently capture thermal radiation, such as heat from a car engine, to convert into electrical power.

While researchers are still looking for more efficient methods of converting that mid-range spectrum of thermal radiation into electricity, Park believes that within 10 years, prototype devices can be invented to generate electricity from thermally-radiated waste heat. This means devices such as a cellphone or laptop could run longer by recycling the heat from their main computer chips to recharge batteries. Park also imagines cars that could store additional electrical power by capturing the heat from the engine block.

“How can we optimize that power generation? How can we design and make a device that can be used for applications? Each of these steps could have barriers,” Park said. “But we are trying hard to make it happen.”

Park’s research is focused on the energy transport and conversion at micro/nanoscales for various applications, particularly for renewable energy. He received his bachelor’s and master’s degrees in mechanical engineering from Seoul National University in Korea and a doctorate in mechanical engineering from the Georgia Institute of Technology. He began studying the effects of thermal radiation at nanoscales because he believes there is great potential in learning more in this area, especially in energy applications.

“As an engineering professor, I really want to impact society, particularly in sustainability. That’s my big goal,” he said. “The population is growing so fast and energy consumption is growing even faster — not only in the U.S. but also in developing countries. So now the question is will we have enough energy resources to sustain all the human beings on the globe?”

WIRELESS 'LIVING LABORATORY'

For millions of mobile phone users, it can be a frustrating dilemma: Your service too often cuts out during a conversation. It not only happens to everyone, it can happen more than once a day.

University of Utah School of Computing associate professor Kobus Van der Merwe and his associates in the FLUX Research Group are building a research test bed to help carriers like AT&T and Verizon figure out ways to mitigate problems with call quality, reliability and speed. To do that, he's going to turn all of the U campus and part of downtown Salt Lake City into a "living laboratory."

Van der Merwe and his fellow researchers were chosen in April to be one of the first two research institutions to build such a platform in the United States. Salt Lake City's Platform for Open Wireless Data-driven Experimental Research (POWDER) 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 tech companies to create city-wide testing platforms for research on wireless communication and networking technologies. Rutgers University, Columbia University and New York University will build a second complementary platform in New York City.

"Mobile and wireless is where it's at," Van der Merwe said. "We have 5G coming. We have multiple radio technologies and different applications coming. All of those things need platforms to experiment on, to prototype on, to explore."

The test bed will involve installing "nodes" or wireless network base stations on the University of Utah campus and along a two-mile corridor of downtown Salt Lake City. These nodes will also be installed on 60 vehicles including some U commuter buses and Salt Lake City vehicles such as street sweepers.

The platform will use "software-defined radios," network boxes that can add or change features by just reprogramming the software, a popular concept because they can change network features without swapping out expensive hardware.

"We want to build it so that one day it looks like a cellular network, then tomorrow it looks like an autonomous-vehicle network, and the day after that it can look like something a military wireless system might use," said Van der Merwe. "You need that flexibility built into the infrastructure."

With this laboratory, companies from Comcast to Nokia and Intel, along with defense contractors, research universities and government labs can test their technologies on an open, real-world wireless network as opposed to in computer simulations. With it, scientists can improve the speed, efficiency, reliability and security of their technologies as well as develop new applications, services and privacy features.

ALUMNUS SPOTLIGHT
JOHN WILLIAMS

John A. Williams is always looking for solutions. An interest in finding solutions motivated his decision to study science and engineering as a student, and he has built his career on doing that.

Williams, who received his master's and doctorate degrees from the University of Utah in chemical and fuels engineering, enjoyed chemistry in high school because it explained natural phenomena. "I've always been interested in how things work and how to improve them," he said. "Engineering was about developing solutions in the sciences."

He lived through the energy crisis of the 1970s — a time when motorists were forming long lines at the gas pumps — and it sparked his curiosity about energy issues. "That's when I saw the need for a better understanding of our nation's energy picture and the technologies that could meet our needs," he said.

Williams attended the University of Utah because of its reputation in fuels engineering (a former research area that would later merge into the Department of Chemical Engineering at the U). "Nothing was close to the U in what it offered in fuels engineering, and what I learned would dovetail into what I wanted to do in industry," he said.

"It was very educational and very insightful and very demanding, but it was also very enjoyable," he said about his time at the U. "Faculty members were just tremendous in their ability to educate."

During and after receiving his doctorate in 1990, Williams worked as an engineer and senior scientist at Babcock & Wilcox, Monsanto Corp. and Bayer Corp. where he worked in technology assessments, research and development, optimization and retrofits for energy and chemical plants. That led to founding his own consulting firm, Environmental and Production Solutions, LLC (EPS), based in South Bend, Indiana, in 1995. EPS is an engineering, procurement, and construction management company for oil and gas, chemicals, biotech, waste-to-energy, and power generation facilities.

The success of his business has been based largely on one simple credo: "I believe 'better' does not

automatically translate to 'more expensive,' nor does it necessarily mean 'more complicated' or 'more impressive.'" In fact, he added, "creating a better design often means just the opposite — developing the simplest, most efficient, and highest-yielding solution possible."

Today, Williams' passion for his work and research now extends to the need to give back to the university that helped launch his life's work.

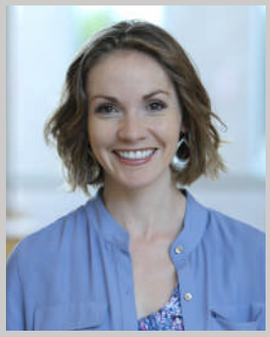
He is a member of the University of Utah's Chemical Engineering's Industrial Advisory Board as well as the Engineering National Advisory Council for the U's College of Engineering. He was awarded the Distinguished Alumni Award for the Department of Chemical Engineering in 2015 and was honored with the College of Engineering's Outstanding Service Award during the 2018 convocation. He and his wife, Amy, have been generous benefactors for the College, helping fund the building of the chemical engineering department's new Innovation Lab as well as the department's new high-tech conference room in the Merrill Engineering Building. They also contribute to scholarships for two undergraduate students each year.

"It's an easy thing to do," he said about giving back to the University of Utah, "It's just a small gesture of return from me. The University of Utah provided me with a very solid foundation in engineering and science that enabled me to become successful."

IN BRIEF

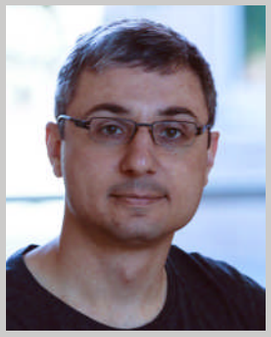
NSF CAREER AWARD RECIPIENTS

Five associate professors from the University of Utah's College of Engineering received this year's National Science Foundation CAREER Award. The grants are given to faculty "who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization." This year's recipients are:



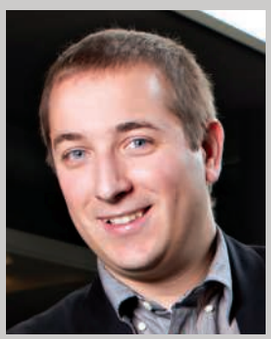
ASHLEY SPEAR (Mechanical Engineering)
Prof. Spear is working to understand the sources of failure in additively manufactured (AM), or 3D-printed, metal parts in hopes of better predicting their failure. These materials can be used in things such as aircraft and biomedical implants. Spear will employ sophisticated materials characterization tools along with computational modeling to recreate and visualize the failure process in three dimensions, starting at microscopic-length scales.

WENDA TAN (Mechanical Engineering)
Prof. Tan is exploring a new process of laser welding known as Vibration-Assisted Laser Keyhole Welding (V-LKW). In this process, a laser is used to melt the components at the contacting position, but it can suffer from several problems that reduce the strength of the joint. Tan's research looks at how the vibration of the laser will help solve these problems.



RYAN STUTSMAN (School of Computing)
Prof. Stutsman wants to reimagine the common approach to cloud-based databases. His new method could analyze much bigger data sets and produce results more quickly. He is trying to come up with a way to share massive amounts of data in cloud systems without having to shift the data from server to server as much. This could be valuable for services such as Facebook, which deal with massive amounts of data every day in real time.

ALEXANDER LEX (School of Computing)
Prof. Lex is developing software that will capture the decision-making process of doctors (specifically those who work with cancer diagnostics and those studying the genetic causes of suicide) by using algorithms and human-computer interaction methods. Lex will develop a software system so experts can validate their decision-making.



PIERRE-EMMANUEL GAILLARDON (Electrical and Computer Engineering)
Prof. Gaillardon is developing high-energy-efficiency computing systems by making novel transistors that have greater functionality in addition to being faster and smaller. The project will focus on using standard manufacturing processes to fabricate the new devices so that their use can cost-effectively produce circuits with a higher performance/power ratio.

DEAN RECEIVES ROSENBLATT PRIZE

University of Utah College of Engineering Dean Richard B. Brown was honored with the Rosenblatt Prize for Excellence, the U's highest faculty accolade. The $50,000 cash award is presented annually to a faculty member who transcends ordinary teaching, research and administrative efforts.

"I am pleased to honor professor Brown with the University of Utah's pinnacle faculty recognition," said university President Ruth V. Watkins. "He is internationally respected for his pioneering research and exceptional leadership as dean. He is also beloved by his students, faculty and peers, and acclaimed by legislators and governors of Utah."

Since Brown's arrival as dean of the College of Engineering in 2004, research expenditures have grown from $34 million to $82 million per year, the number of graduates has more than doubled from 484 to 1,011, and the number of freshmen coming into the College has grown from 7 percent to 20 percent of the U's total freshman class.

COMMERCIALIZATION WORKSHOP

The University of Utah College of Engineering announces a one-day workshop on Commercializing Engineering Research.

Thursday, June 28,
In Salt Lake City
For more information and to register, go to
www.coe.utah.edu/commercialization

the strongest form of new knowledge dissemination

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STUDENT LIFE

TOBI YOON

The notoriously uncomfortable prep associated with a colonoscopy is about the last thing you'd think a teenager would obsess over. But it's what currently drives Tobi Yoon, a student in the University of Utah's biomedical engineering program.

Yoon may have just finished her first year in the College of Engineering, but she already has launched her first company developing a prep kit that is much easier to tolerate than the normal bowel-cleaning procedure.

"I worked for a gastroenterologist one summer and got to observe a lot of colonoscopies," said Yoon, who graduated from Rowland Hall in Salt Lake City. "The doctor wished patients would comply with the preparations but she understood how awful it was."

That is what ignited the idea that there must be a better way to prepare a patient. With the help of local gastroenterologists and other researchers, Yoon created the kit, which is comprised of 20 magnesium citrate laxative pills, anti-nausea medication should the patient experience discomfort, and a recipe book for meals that leave little residue in the colon.

Normally, a patient has to consume a huge jug of water mixed with a laxative that leads to many uncomfortable trips to the bathroom. Yoon says her kit just involves taking pills over a two-day period combined with eating the right foods in the cookbook for a less-uncomfortable experience.

Yoon so far has won the grand prize at the Lassonde Institute's High School Utah Entrepreneurship Challenge and was one of the top 20 projects named in the recent collegiate-level Utah Entrepreneurship Challenge. She hopes to have a final product on store shelves in several years.

Meanwhile, Yoon says she will enroll in the College's new Engineering Entrepreneurship Certificate, which provides engineering students business, law and communications knowledge that will be helpful should they launch a new venture.

"I find myself really challenged by the engineering program," she said about attending the University of Utah. "I don't know if I would have the same opportunity at another university to be exposed to the kind of biomedical research and classes I have here."