College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

FALL 2022 NEWSLETTER

CIVIL & ENVIRONMENTAL ENGINEERING

DRIVING INNOVATION

Greetings from beautiful Madison!

Much has happened over the past six months! We have fully launched our new bachelor's degree program in environmental engineering. This means that the department now offers three undergraduate degrees: civil engineering, environmental engineering, and geological engineering. This also means that we are growing. I am happy to share that the size of our incoming freshman class suggests greater growth than we anticipated; 160 new students are joining us this fall, which is double that of last year! This growth presents tremendous opportunities and challenges, but the department is poised to face them, and we welcome the excitement that these new students bring.

Our faculty also continue to thrive and impress. Pavana Prabhakar, Hiroki Sone and Dan Wright were promoted to associate professor and awarded tenure over the summer. Congratulations to these excellent scholars and colleagues. We have also made two exciting faculty hires with the addition of Sikai Chen and Xiaopeng Li, who you will learn a bit more about in this issue. These new professors bring critical mass to our already strong program in transportation engineering. Their presence elevates UW-Madison's place on the map as a world-class place to develop and learn about automated vehicles and smart infrastructure. We are very excited to welcome them aboard.

As you might imagine, the growth in our department, and more generally across the College of Engineering, is driving the need to expand our facilities. We hope that the Wisconsin legislature will include funding for our new engineering building project in its 2023-25 state budget, and we currently are raising funds for our portion of its cost.

We are thankful for the support and passion of our community, and every gift to our department helps us better serve our students. If you would like to support us in any way, please contact our director of development Rob Herrick (Rob.Herrick@supportuw.org) or me directly (likos@wisc.edu).

I hope you enjoy reading about the latest news and accomplishments of our community in this issue. As always, please feel free to come by whenever you are in Madison to meet our students, faculty and staff, and see firsthand all the great things we are doing.

On, Wisconsin!

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Engineers' Day Luncheon

Our department will host an Engineers' Day luncheon at 11:30 a.m. on Friday, Nov. 4 at Olbrich Botanical Gardens in Madison. Join us to celebrate Distinguished Achievement Award winner John Kissinger (president and CEO, GRAEF; MSCEE '87) and Early-Career Achievement Award winner Zak Koga, (owner, Karben4 Brewing; BSCE '08). Visit go.wisc.edu/cee-luncheon to register.

Support a STAR Scholar

Effective solutions to today's challenges arise when we bring the brightest people to the table. When you make a gift to our STAR Scholarship fund, you'll help our college recruit the nation's best students so that they can become tomorrow's problem-solvers and difference-makers. Thanks to a commitment from The Grainger Foundation, there's also matching support available—meaning that you can double the impact of your support.

We need your help growing this important scholarship fund. To make a gift, contact Kyle Buchmann, senior managing director of development, at kyle.buchman@supportuw.org or (608) 630-1679.

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Associate Professor James Tinjum's research team has worked on geothermal exchanges at Epic Systems in Verona for years. Now they're putting that expertise into a project to support the federal government's efforts to bolster energy efficiency. Submitted photo.

Going underground to heat and cool top-level facilities

James Tinjum

UW-Madison researchers are helping the U.S. government improve energy efficiency at an array of federal buildings. Associate Professor James Tinjum is leading a multi-institutional effort to expand deployment of geothermal heating and cooling exchanges at Department of Defense facilities. The Department of Energy's Office of Energy Efficiency and Renewable Energy is backing the project with up to $6 million in grant funding.

Geothermal exchange systems—also called geothermal heat pumps or geoexchange—use the earth like a battery, relying on the relatively constant temperature of the ground, which is warmer than the air above in winter, and cooler in the summer.

"We circulate liquid through a series of pipes that are typically about 500 feet underground," Tinjum says. "By doing that, we're transferring heat into the earth during the summer to provide cool air, and we are withdrawing heat in the winter to warm our buildings and heat our domestic hot water."

Geothermal exchange systems can generate tremendous efficiency improvements because mechanical heating and cooling systems don't have to work as hard to provide conditioned air. For example, on a 90-degree day, a typical air conditioning unit has to work hard to lower the temperature of the ambient air it draws in. With a geothermal exchange system, the unit circulates liquid that's already been cooled through circulation within the earth that is at a relatively constant 55 degrees, drastically reducing the amount of energy needed to produce a comfortable indoor temperature.

Because space conditioning accounts for so much energy usage in the United States (Tinjum says it consumes about 40% to 60% of energy in businesses and homes), lowering the amount of energy we dedicate to heating and cooling could have big ramifications for sustainability efforts across the country. That's especially true for the federal government, which consumes nearly 1% of all end-use energy in the United States, making it the largest single energy consumer in the country.

And these efficiencies are ones that the UW-Madison team has seen firsthand. Epic Systems in Verona, Wisconsin, has a geothermal exchange field with thousands of wells in it. Tinjum and his research group have worked with Epic for a decade to monitor its geothermal network using a fiber-optic system they developed to collect distributed temperature measurements across district-scale geothermal exchange fields.

"At Epic, the system operates at an incredible coefficient of performance of 10, which means that only one unit of input energy is needed for 10 units of heating/cooling," Tinjum says. "That project really put us at the forefront of the industry, with some of the papers we've prepared and presentations we've given—some of which led directly to our current project with the Department of Energy."

A quest to learn

Baraka and Liow create educational African card game

Joel Baraka hopes his newest game can take its players on an educational quest across the African continent.

Baraka is working with his friend and fellow CEE graduate student Anson Liow to design and test the new game, called Your African Quest. It's inspired by their first creation, the 5 STAZ board game, which they designed for elementary students in Ugandan refugee settlements.

Your African Quest is an educational card game focused on the nature, people, countries, culture and food of the African continent. Baraka and Liow say the game is currently in production and have recently made it available for pre orders. They'll use all proceeds from Your African Quest to continue supporting the 5 STAZ.

5 STAZ was a knockout fund-raising success. Baraka says a supportive community sprang up around the game, and he and Liow wanted to repay that kindness.

"People wanted to support us, but also wanted to get a copy of the game," Baraka says. "The challenge is that the 5 STAZ was geared toward Ugandan students and might not be suitable for a general audience in the United States. But people supported us, and we didn't want to continue asking for donations when we're not able to give our supporters anything."

Baraka and Liow, like any good engineers faced with a challenge, decided to create a solution. By spring 2021, they created a rough prototype of their new game. Since then, they've collaborated with the UW-Madison African Studies Program on it, and conducted beta testing with friends, family and students in the Madison Metropolitan School District.

"We wanted to make this a product that's accessible to everyone, whether they're a college student or a family wanting to try out a new game," Liow says. "It's a game that we want diverse groups of people to be able to play."

Graduate students Joel Baraka (right) and Anson Liow (left) created Your African Quest as a fun card game that can be used to learn about Africa. Submitted photo.

Baraka and Liow have designed Your African Quest to be a game people can use to learn about the many diverse peoples and cultures of the African continent. Both students say designing the game has been a humbling, eye-opening experience as they themselves realized how much there is to learn about Africa, and hope the game provides the same opportunities for others.

Max Beal (second from right) has taken lessons learned on Lake Mendota abroad on an NSF-funded research trip to Lake Victoria in Kenya. Submitted photo.

Analyzing an 'Erie' algae similarity with Kenya's Kisumu Bay

When spring comes around, freeing Lake Mendota in Madison, Wisconsin, from its annual deep freeze, environmental engineer Paul Block and his students study the season's climate conditions to predict what summer has in store for the lake.

Max Beal, a CEE PhD student, is part of that group—and he's taken lessons learned in his hometown of Madison to a similar lake more than 7,800 miles away. Beal went to Kisumu Bay, on the Kenyan side of Lake Victoria in Africa, under a National Science Foundation-funded advanced studies program. Beal was one of 11 students from the United States, Canada and the United Kingdom participating in the program.

While in Kenya, the group spent a week on a research vessel in the gulf taking samples for algae abundance, cyanobacteria toxins, and nutrients including phosphorus and nitrogen, which can cause cyanobacteria blooms. Such blooms can produce toxins that are dangerous to humans and animals, and Beal says it's vital to be able to communicate where and when they're happening to people who live around the lake.

"Blue-green algae, or cyanobacteria, is what we're really concerned about from a public health standpoint," Beal says. "Excess nutrients in the water can exacerbate their growth, and it's important for us to understand exactly why these blooms show up in the water. These cyanobacteria are capable of producing toxins, and a lot of people use Lake Victoria for recreation and drinking water."

Lake Victoria also faces some of the same challenges as Lake Erie here in the United States, and the students will conduct a comparative study between the two lakes. Beal says lots of agricultural nutrients flow into Lake Victoria, as is also the case with Lake Erie. However, there are notable differences, such as climate and the mixture of nutrient sources that come into the lakes.

"One of the major differences between Lake Erie and Kisumu Bay is that Lake Erie's algal blooms are primarily fed by agricultural runoff," Beal says. "There's a big issue in terms of nutrient-rich agricultural runoff flowing into the water. When nutrients like phosphorus and nitrogen are abundant in lakes, we tend to see increased cyanobacteria growth. We have that happening in Madison with Lake Mendota. Professor Block and I use several drivers of nutrient runoff to forecast cyanobacteria on Lake Mendota, and it's possible we might see similar drivers of cyanobacteria growth in Lake Victoria."

FOCUS ON NEW FACULTY

Xiaopeng Li looks to shape the future of automated vehicles

When Xiaopeng Li considers the potential smart vehicles could have on our world, he points to another, ubiquitous device: the smartphone.

Smartphones took off after the launch of the iPhone in late 2007. Now it's the exception to see someone using a phone that isn't smart. The devices have revolutionized our lives and the way we interact with each other, and Li, who joined CEE as an associate professor in fall 2022, thinks smart vehicles—those capable of interfacing and communicating with other vehicles and smart roadside infrastructure—could have a similarly titanic impact on our society.

Li's research focuses on emerging technologies within the connected and automated vehicle space. He's especially interested in understanding and influencing how new connected vehicle technology develops as the era of the smart car begins.

"Most research in our field is based on modeling and simulation using third-party data," Li says. "It tends to view connected and automated vehicles as an external factor, to see how that technology impacts our transportation systems. My group wants to be more proactive—not just viewing connected and automated vehicles as exogenous factors, but also trying to participate in the process of new technological development."

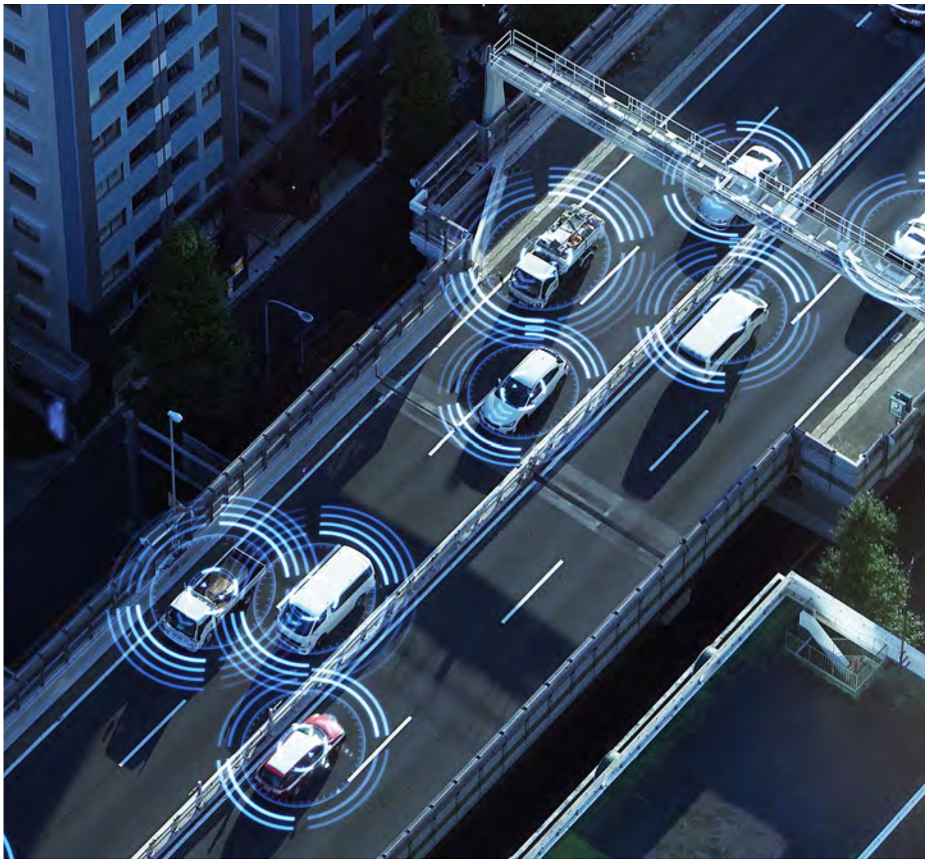
Connected vehicles are a maturing technology—and as such technologies do, will endure growing pains. Li says automakers might not be primarily concerned with system benefits and the type of impact connected and automated vehicles have on our transportation networks—instead, focusing on making the vehicles enticing enough for consumers to buy.

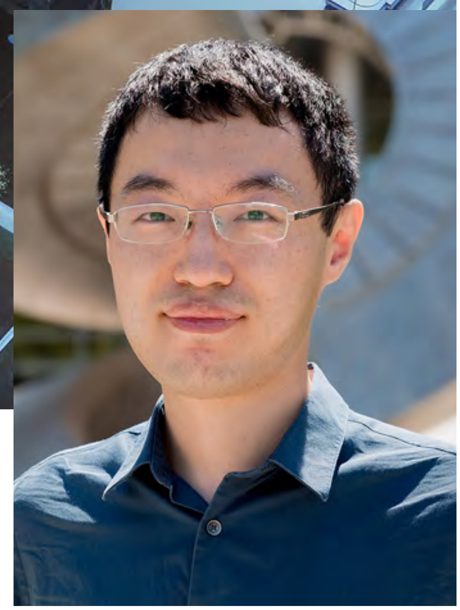
Li brings plenty of experience in the automated vehicle research space to UW-Madison. He's coming from the University of South Florida, where he was an associate professor of civil and environmental engineering and director of the Connected and Autonomous Transportation Systems Laboratory. He's also served as the director of the National Institute for Congestion Reduction, a multi-institution collaboration headed at USF and one of seven National University Transportation Centers.

As he settles into his new role at UW-Madison, Li intends to continue work on several major research projects he's already initiated. One, a multimillion-dollar project funded by the U.S. Department of Energy, focuses on low-cost technologies for connected and automated vehicles.

Li's also working on two National Science Foundation-funded projects. One looks at creating more physically connected platooning—when vehicles travel close together in a "train"—for connected and automated vehicles. The other is a collaboration with the Federal Highway Administration to help develop CARMA, which is the administration's system for enabling connected vehicles to cooperate with each other and with roadside infrastructure.

"One hurdle against the wide deployment of connected and automated vehicle technologies, especially from the infrastructure side, is the high cost requirement for new technologies," Li says. "We're looking at new methods to utilize existing infrastructure and equipment that is already out there to enable some of these connected functions."





FOCUS ON NEW FACULTY

Sikai Chen aims to drive safety, efficiency improvements with automated vehicles

When Sikai Chen thinks about "smart" connected driving in the world of tomorrow, three factors come to mind.

Chen focuses his research on connected and automated transportation, smart infrastructure, and human-vehicle interactions. After serving since fall 2021 as a visiting assistant professor at Purdue University, he joined CEE as an assistant professor in fall 2022.

He takes inspiration from Vision Zero—a global effort to eliminate traffic fatalities and serious injuries. Every year, more than 42,000 people across the United States are killed in crashes. Globally, more than a million people die on the road every year.

Although traffic congestion often takes the limelight, transportation safety is where Chen sees the most work to be done. With advances in connected and automated vehicles, he believes that fixing the former problem also enables him to tackle the latter.

For example, a road that narrows from three or four lanes to two creates a bottleneck where regular, non-connected vehicles may back up as drivers all attempt to move into the narrower space at once. With even a few connected or automated vehicles, Chen says, we might be able to mitigate congestion in those areas as the vehicles communicate with one another and the smart infrastructure, change lanes earlier, and keep traffic flowing. When traffic flows more smoothly, it reduces the potential for crashes, making the roads safer.

In another scenario, he says connected and automated vehicles with sensors that detect other vehicles may be able to work together to avoid a collision if a human-driven car makes a hard shift from one lane to another without warning.

"That's called cooperative driving automation," Chen says. "That allows the vehicles to talk to one another and to smart infrastructure so they can work together to improve safety, efficiency and energy consumption. We can't solve all of these problems we face on the road with automated vehicles alone, but we can help try to lessen the problems' impact. That's something I've been working on and will continue to research at UW-Madison."

Of course, automated vehicles come with their own unique challenges. In the future, cars may be capable of navigating roads without drivers. That might introduce new conflict points, particularly in places like crosswalks, where pedestrians and vehicles interact. Chen says it's natural for pedestrians to look at a vehicle to be sure the driver sees them. In the absence of a human driver, engineers will have to find ways for pedestrians to know they're safe.

"We'll have to be able to effectively communicate to pedestrians that the automated vehicle sees them," he says. "That could be something like a blinking light in the window or some sort of display on the windshield. We don't want it to be overwhelming so pedestrians have to stand there and stare at the screen."

Building on a solid process, Wang pours resources into making carbon-negative cement

Year in and year out, cement production is one of the biggest contributors to humanity's carbon emissions.

Making portland cement, the most frequently used cement around the world and a key component in concrete, releases about three billion metric tons of carbon dioxide per year. That's roughly 8% of all emissions that arise from human activity.

A UW-Madison-led team is embarking on a project to not only slow that environmental impact—but, in fact, reverse it. The project is led by Rob Annex, a professor of biological systems engineering in the College of Agricultural and Life Sciences, and Bu Wang, a CEE assistant professor.

The team's work builds upon a direct-capture system Wang and Anex developed that removes carbon dioxide from the air through a simple chemical reaction with hydroxide. This creates carbonate ions, which, when combined with coal ash, can be turned into limestone and activated silica particles for use in cement.

Through this new process, Wang says the team hopes to replace portland cement with a new, more environmentally friendly mixture that combines this innovative air capture system with upcycled industrial waste products.

"Portland cement today is produced using raw materials like limestone, clay and sand," Wang says. "In our new cement, one of the key ingredients is waste materials—like coal ash, slag from steel and iron production, or cement kiln dust."

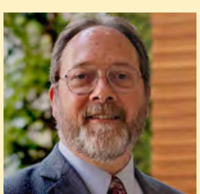
The team's technique incorporates water-based reactions for processing waste materials for use. Focusing on using waste alleviates the need to extract those raw materials from the earth and allows the team tap into materials that are already available for use, thanks to earlier production.

Wang has long researched sustainable concrete and cement production. He says one of the biggest hurdles to reaching that goal is the way we currently use concrete, which often is transported to a job site as a mix, then poured and set during construction. While there have been efforts to make concrete that captures carbon, such mixtures haven't been suitable for casting and setting on-site—nor have they captured much carbon.

"With this new capture technology, we may finally have a way to put the carbon dioxide into the material before it's manufactured," he says. "When we make the concrete, the carbon dioxide is already there, so all we'd have to do is pour it like normal and allow it to harden by itself."

Bill, Parker move into new TOPS Lab leadership roles

Andi Bill



Steven T. Parker

The Traffic Operations and Safety (TOPS) Laboratory has named two longtime staff members to key leadership roles within the organization. TOPS Lab deputy director and information technology program manager Steven T. Parker will become the lab's managing director, while Andrea (Andi) Bill will extend her traffic safety engineer research program manager role into the lab's associate director position.

In his new role, Parker will manage the TOPS Lab's day-to-day operations. He also will manage the lab's research partnership with the Wisconsin Department of Transportation. He will continue to lead his nationally recognized efforts in safety and operations data management, the WisTransPortal data management system, and his role as IT program manager.

In her new role, Bill will lead the transportation safety and traffic operations research areas of the TOPS Lab. She also will collaborate with the other TOPS Lab directors in overall leadership of the lab, and will continue as the traffic safety engineer research program manager.

Hanna is outstanding academic

Awad Hanna

The Construction Industry Institute (CII) awarded Boldt Company Professor in Construction and Engineering Management Awad Hanna its Outstanding Academic Award. Hanna is a nationally recognized thought leader in the fields of productivity, risk management, construction readiness, out-of-sequence work, project delivery, and construction claims. He has been a primary investigator on seven major CII projects and serves as the academic advisor for the organization's Downstream and Chemical Sector Committee. He's been instrumental in translating innovative research into accessible reports and tools that permit CII member companies to apply these findings to their own businesses.

Hicks named Fulbright Scholar

Andrea Hicks

Associate Professor Andrea Hicks is a 2022-23 Fulbright Scholar. She's a leading expert in using life-cycle assessments to determine the overall environmental impact of products or processes, and she applies her expertise to study challenges ranging from sustainable aquaponics methods and filling gaps in personal protective equipment supplies in the early days of the COVID-19 pandemic to the feasibility of using carbon dioxide in the atmosphere to create more environmentally friendly plastics.

The prestigious, competitive Fulbright Scholar award enables Hicks to teach and conduct research abroad. She'll also play a critical role in U.S. public diplomacy by engaging and establishing long-term relationships between people and nations.

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Assistant professors Mohan Qin and Haoran Wei work with Ziyan Wu (foreground) as she pours water for testing. Qin and Wei are leading a project to study the presence of microplastics in the Great Lakes.

Unhealthy obsession

There's a proliferation of tiny plastics in our environment. We're studying how these micro menaces travel through the Great Lakes, and beyond.

The thought of pollution tends to conjure images of some fairly tangible threats: tall stacks spewing dark smoke into the sky, smoggy cityscapes, beaches slicked with oil, animals stuck in plastic bags or six-pack rings. The list of pollutants extends well into the less-visible range, and among those "hidden" pollutants of concern is a group known collectively as microplastics. These tiny contaminants are no larger than 5 millimeters long and are often much smaller. They've been found everywhere from soil to rain and even our bodies.

Microplastics also pervade the Great Lakes—the largest group of freshwater lakes on Earth—and two environmental engineers are studying how they proliferate in these big and important bodies of water.

Haoran Wei and Mohan Qin, both CEE assistant professors, are focusing on incredibly small microplastics less than 50 micrometers across.

"There's a real need to study this in the Great Lakes," Wei says. "We know that there are 22 million tons of plastic flowing through the Great Lakes every year. They release a lot of invisible plastic particles, and we currently don't know how much of that stuff there is."

To do this, they'll create and use specialized membranes to separate microplastics of differing sizes for observation. Then, they'll use surface-enhanced Raman spectroscopy—which uses scattered light to detect and identify materials—to detect the plastics.

"We'll collect water samples from Lake Michigan and Madison's Lake Mendota and put them in a rooftop tank along with some consumer-grade plastic products," Wei says. "We'll leave that out to study how sunlight and radiation promote the release of microplastic particles."

Qin and Wei hope to refine their technique to reliably detect microplastics and also to shed light on how they proliferate, and build a standardized technique that researchers or environmental agencies in other locales can use to monitor water-borne microplastics.

That's all the more important because there's a lot we still don't know about microplastics. The U.S. EPA has noted a "critical need" to develop methods to determine the contaminants' environmental and human health risks.

"We can detect this in human blood or even in the poop of babies, so these plastics are getting into children before they're even born," Qin says. "There's no study yet that definitively shows how they impact human health, but they're everywhere, so we need to know more about them."