College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

FALL 2024 NEWSLETTER

DEPARTMENT OF
CIVIL AND ENVIRONMENTAL ENGINEERING

Greetings from Madison!

If you took a project-oriented class from me as a student, you probably heard me say to use numbers in your communications instead of words like “large” or “small.” So, I’ll kick off this message with the number 800:—the approximate number of Badgers that make up our day-to-day community in the Department of Civil and Environmental Engineering.

Almost 700 of these Badgers are students in our undergraduate and graduate degree programs. The remaining 100 are faculty, teaching faculty, adjunct faculty, research scientists, academic staff, university staff, postdoctoral associates, and volunteers from the local community of engineering practice. Scan the QR code on the right to watch videos introducing some of our exceptional graduate students. These 800 collectively achieve our mission every day: to create, integrate and transfer knowledge and practice in the development of professionals, leaders and citizens. We couldn’t do it without them and you’ll see a fraction of them highlighted in this newsletter.

The number of our alumni and friends is well into the thousands, making our daily community of 800 look small. These Badgers offer their enthusiastic support, volunteering their time as mentors in senior capstone design, advisors on our Visiting Committee, organizers of fun events like our recent gathering in Milwaukee or this fall’s golf outing in Middleton, and so on. They hire our students as interns and our graduates as career professionals and serve as excellent ambassadors of ours at professional conferences and events. We couldn’t achieve our mission without them either.

Our profession is about making communities and environments better. We teach and practice engineering for the public good. Which leads me to another number: one. One community. The best. Nothing else like it. Thank you, Badgers, for making us better and one of the world leaders at what we do. With your continued enthusiasm and support, we will stay that way for years to come.

On, Wisconsin!

Gregory W Harrington

Gregory Harrington
Professor and Department Chair

Historic gift for new engineering building

A $75 million gift will fuel construction of a much-needed new building for the College of Engineering.

With their lead gift—the largest single gift in college history—brothers and UW-Madison L&S alumni Marvin and Jeffrey Levy are honoring the memory of their brother, Phil, who passed away in 2021. Phil earned an English degree from the university in 1964; the Levy family has a long history of involvement in and support for UW-Madison.

A stunning facility that marries intentional design with future-ready engineering flexibility, the Phillip A. Levy Engineering Center will be the new centerpiece of the College of Engineering campus. The transformative facility will inspire future engineering leaders, spark collaboration and yield breakthroughs that echo across generations. Enabling work for the building already has begun.

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On cover: Postdoctoral researcher Wissam Kontar and PhD student Erin Bulson created a calculator that converts carbon emissions to the equivalents produced in making a cheeseburger. Photo: Joel Hallberg.

A more digestible CO2 calculator swaps cheeseburgers for carbon

Photo: Joel Hallberg.

A new study introduces public audiences to the carbon dioxide (CO2) emission impact of different modes of transportation through a simple online calculator. To drive home the point, however, that calculator also translates pounds of CO2 into one of the nation's favorite foods: the cheeseburger.

The researchers, PhD student Erin Bulson and postdoctoral researcher Wissam Kontar and their colleagues, published their study in the May 2024 issue of the Nature journal *NPJ Sustainable Mobility and Transport.*

The two say one of the challenges of educating the public about various transportation modes' environmental impact is that it can be difficult to envision how much CO2 an individual trip might pump out. Adding to that complexity is the fact that it can be even more difficult for people to comprehend what a pound of CO2 emissions really means.

"We thought carbon emissions might not necessarily be intuitive to the public," Bulson says. "We wanted to use a different way to communicate this information, so we tested it out with cheeseburgers, which is unique and happens to be a culturally appropriate fit for Wisconsin."

The calculator's approach is simple: Enter a trip's distance and it shows the estimated carbon emissions for cars (gas, electric and hybrid), a bus ride, bicycling (regular and electric), and walking. Then, the calculator converts all of those pounds of CO2 into a cheeseburger equivalent (about 4 pounds of CO2 per burger). The research showed promising results: 46% of study participants reported having a better understanding of CO2 emissions after a three-month period of using the calculator. Additionally, their own travel mode changes typically resulted in fewer emissions.

It's not the first time burgers have made it big in research. For example, the Big Mac Index, created by *The Economist* in 1986, uses the Big Mac to illustrate differences in purchasing power parity across countries. Similarly, researchers have considered the carbon impact of a cheeseburger while studying how displaying carbon emissions affects customer decisions in restaurants.

Bulson and Kontar used the Greenhouse Gases Regulated Emissions and Energy Use in Technologies (GREET) model created by Argonne National Laboratory to assess the life cycles of the different transportation modes to determine their emissions.

The researchers conducted a study with 49 participants in Madison, who each used the calculator for at least 20 trips. Before the study began, the team conducted a survey that collected basic demographic data, information about travel habits, and an assessment of participants' environmental awareness. Throughout the study, participants kept track of their intended transportation mode for each trip and whether checking its CO2 emissions with the calculator changed their transportation plans.

Almost half the study's participants reported changing transportation modes at least once. Sixteen percent of the total trips involved a shift, with the most frequent being gasoline car to bus, bus to walking, and gasoline car to walking. Overall, participants recorded about 544 pounds fewer CO2 emissions due to travel mode changes. That's about 130 cheeseburgers.

"Overall, the net result from these changes was a positive environmental implication, which means a reduction in emissions," Kontar says. "From a socio-economic perspective, we saw that income, trip distance and a person's environmental awareness were the best predictors of whether someone would change transportation modes."

Inspired by UW-Madison methods, FEMA's new floodplain forecast looks clear

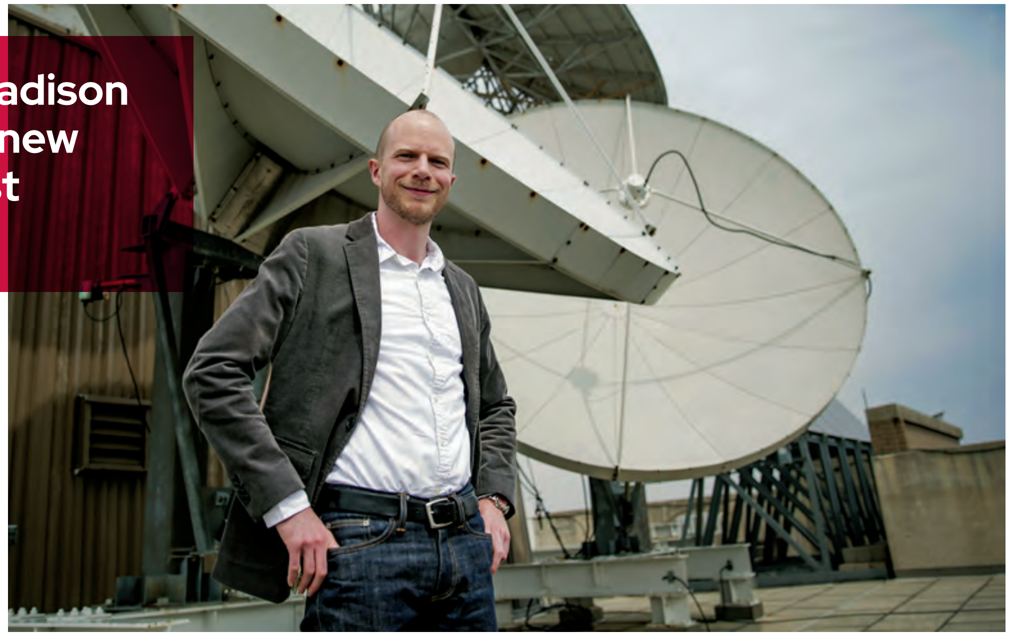


Photo: Renee Meiller.

For an expansive effort to remap floodplains across the United States, the Federal Emergency Management Agency and U.S. Army Corps of Engineers are drawing on a UW-Madison engineer's flood modeling research as the backbone of the project.

Daniel Wright, an associate professor, developed the RainyDay software, which uses a method called stochastic storm transposition to calculate rain impacts on different areas. Storm transposition is, essentially, moving a storm from its original location to observe its effects in a different environment.

Stochastic storm transposition ramps that idea up by orders of magnitude, allowing researchers to identify hundreds of storms across decades and move them around more or less infinitely. "That lets us see possible outcomes that could happen for a particular river or location that we're interested in," Wright says. "We can look at things like 100-year storms, run those through flood simulation models, and get data that can be used to map out floodplains."

FEMA is responsible for developing and maintaining maps of floodplains across the United States that are also the basis of the federally administered National Flood Insurance Program. The Army Corps of Engineers is using its hydrologic modeling software in partnership with FEMA, and drawing on Wright's RainyDay methodology, to improve the nation's floodplain maps.

The current maps, Wright says, employ hard boundaries based on outdated computer modeling that doesn't properly account for the uncertainty that should be inherent in predicting floods. So for example, a resident could live just inside of a 100-year floodplain boundary for a flood that has a 1% chance of happening in any given year, and traverse that boundary with a single step.

"In reality, the quality of the models we have right now is nowhere near the level that would allow you to set a boundary with that degree of certainty," Wright says. "That's very much an artificial line. So we should—and can, using more modern data and methods—quantify the amount of confidence we have in how these maps are drawn."

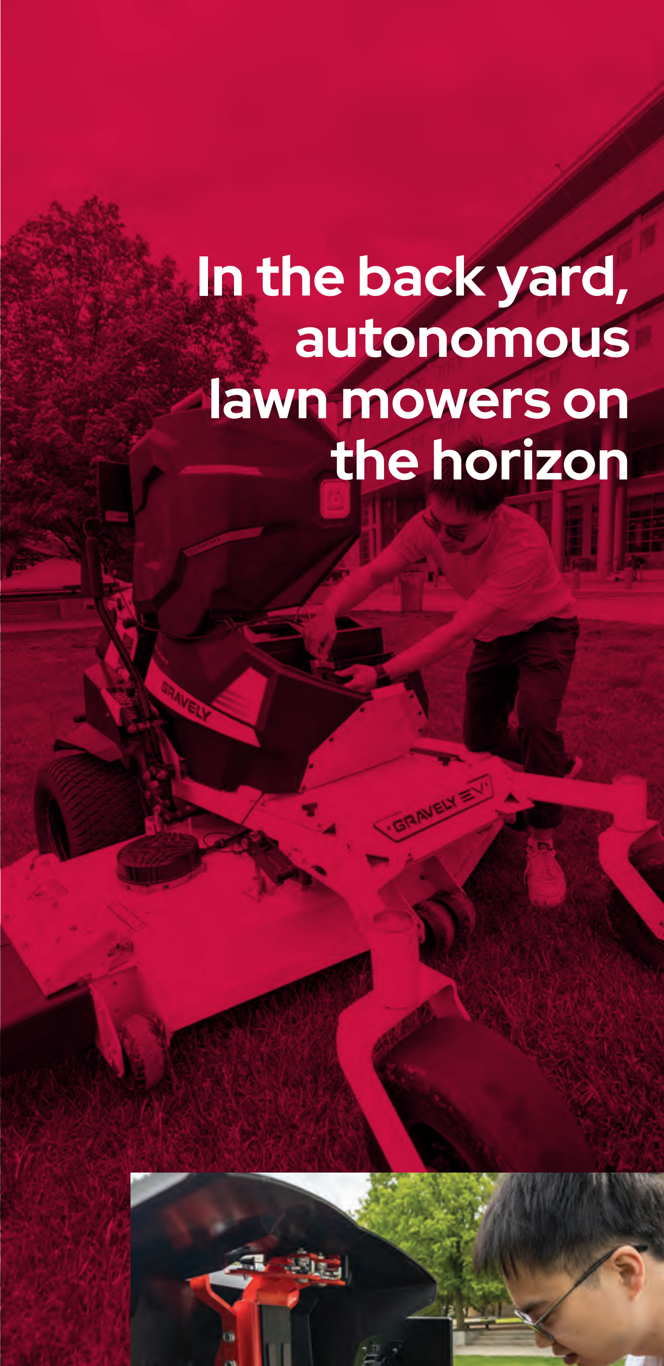
FEMA is overhauling its mapping from the ground up and including simulations of what happens when rainfall hits the ground. The hope is that, with a more holistic approach and modern data, FEMA can not only create better floodplain maps, but also more accurately reflect uncertainty in areas that are at risk of flooding.

Wright and his students now are updating RainyDay as FEMA broadens its use of the methodology beyond the original target environments. "When I started developing this during my PhD, the idea was that it would work for small watersheds, small river systems, and relatively flat terrain," Wright says. "FEMA needs to be able to apply it across the entire United States, including to mountainous areas and very large watersheds."

One way Wright and his students are adapting their methodology is to incorporate snow melt in mountainous and northern watersheds where spring thaws can trigger flooding. They're also trying to determine how to handle differing rainfall data quality, which can vary based on where and when it was collected.

Ultimately, the researchers' task comes down to finding (and then pushing) the limits of stochastic storm transposition. "You probably can't move most storms from one side of the Rocky Mountains to the other, because the mountains themselves change the meteorology," Wright says. "So how do you do this in different places in a way that respects the real physics of how storms occur, but also in a way that you can repeat for 500 watersheds all around the country? That's what we're going to be working on."

FEMA is funding Wright and collaborator Antonia Sebastian, an assistant professor of earth, marine and environmental sciences at the University of North Carolina at Chapel Hill, $500,000 in 2024-25 to support the project, with additional funding possible in following years.



In the back yard, autonomous lawn mowers on the horizon

Set it and forget it. That's the wish of every homeowner who's trying to fit mowing the lawn into an already busy weekend. It's also the logic driving autonomous lawn mower technology under development at UW-Madison.

The researchers, led by Professor Xiaopeng Li, have translated their expertise in autonomous vehicles to a riding lawnmower. Li and his students are accustomed to working with full-size vehicles like cars—so creating a module to control the mower took a little bit of reverse-engineering, as well as adapting some of the systems they've previously used on autonomous cars.

The module is essentially the mower's brain; the researchers can use it to program routes using GPS coordinates that the mower then follows. The team solved lots of little challenges along the way—for example, controlling turns. "Most of the time for four-wheeled vehicles, we use the turning ratio (moving a steering wheel by some amount turns a vehicle's wheels by a corresponding amount) for moving left and right," says Zhaohui Liang, a PhD student in Li's group. "But this mower is different. It turns based on the speed differential between its left and right wheels. That's a dynamic function that's very different from other vehicles we've worked with—and we had to develop new code for it."

That work paid off. In March 2024, Liang and fellow PhD student Peng Zhang successfully tested the mower, which followed a prescribed route without additional input from a human driver. With continued testing to verify the mower can navigate simple routes on its own, the team will next focus on how it will traverse more complicated paths and terrain.

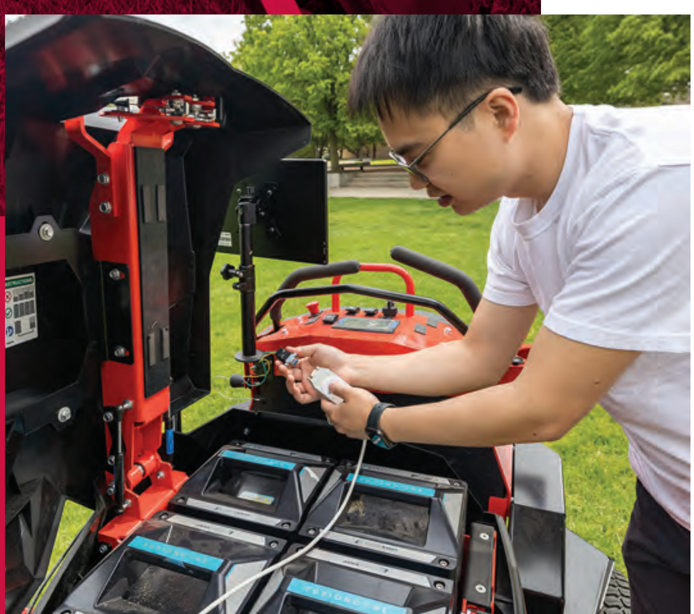
"The first phase of this project was to prove that this concept could work at all," Li says. "We've completed that phase and have the mower autonomously operating. For the next phase, we're focusing on coming up with good algorithms to help it navigate not only on flat terrain but to go through hilly areas and to deal with different obstacles to be able to do its job."

Li has long researched connected and autonomous vehicles and the roles they might play in our lives as technology matures. While traditional cars and trucks most often grab headlines for autonomous vehicle development, Li says this project demonstrates how the technology will proliferate into vehicles like lawn mowers or snow plows.

"Cars are usually the first vehicles to get advances in autonomy, and then those developed technologies filter to vehicles in different areas," Liang says. "Once those technologies that help with things like perception, localization and control are developed for cars, it's easier to move them down into things like this mower."

Ultimately, work on this project may carry over to autonomous vehicle categories, just as it already has drawn on experience working with autonomous cars. For example, Li's lab group also is focusing on autonomous pavement crack-filling machines. "That's another device that's quite similar to the mower," Zhang says. "So we might be able to migrate this module we've developed to a new machine and see how well it works for different tasks. That's a really exciting concept, to me."

Glen Bower, a mechanical engineering scientist and teaching faculty member, assisted with the project.



Zhaohui Liang, a civil and environmental engineering PhD student in Professor Xiaopeng Li's research group, works on a control unit his team implemented into a lawnmower to enable autonomous driving. The research group has translated some of its work on autonomous cars to testing on a lawnmower. Photos Joel Hallberg.

Finding PFAS: New center of excellence will amplify ability to detect and identify 'forever chemicals'

Photo: Joel Hallberg.

UW-Madison is broadening its ability to study potentially harmful "forever chemicals" that are infiltrating our soil and water.

Professor Christy Remucal says nearly $1 million in federal funding will support establishing a PFAS center of excellence at the university. It will fund a major equipment upgrade in the Water Science and Engineering Laboratory that will bolster cross-campus efforts to study per- and polyfluoroalkyl (PFAS) chemicals.

Remucal, who also is interim director of the UW-Madison Aquatic Sciences Center, is leading the new center.

PFAS are a class of widely used chemicals found in everything from consumer products like popcorn bags and nonstick cookware to certain firefighting foams. Some PFAS chemicals break down very slowly, which means if they get into the natural environment, they remain there for years. They're also mobile, meaning they can move through the ground or bodies of water. For example, in late 2022, Remucal's research group published a study about a PFAS plume that moved into Green Bay and Lake Michigan through groundwater.

"There are more than 9,000 different PFAS chemicals," Remucal says. "We don't actually know exactly how many there are yet. With the current instrumentation we have on campus, we can measure about 40 different PFAS chemicals, and of course, 40 out of 9,000 is not a lot. This new high-resolution instrumentation will allow us to detect many more, including new PFAS that have not been studied yet."

A new high-resolution mass spectrometer is headlining the new batch of equipment coming to the center. Using the new spectrometer, researchers will be able to measure the chemical makeup of samples precisely to help identify PFAS materials they don't yet know or have exact chemical standards for.

That's important because it will allow researchers to essentially be PFAS forensic scientists. For example, with the equipment currently available on campus, they might be able to confirm that PFAS chemicals are present in a lake. With the more sensitive equipment, they could identify PFAS chemicals unique to different sources like firefighting foam or leachate from a landfill. While it's difficult to remove PFAS chemicals from the environment once they're there, identifying their sources is vital for curtailing further contamination.

The new instrumentation will be housed within the Water Science and Engineering Laboratory's core facility for advanced water analysis. "Our model for this core facility is both to advance research and to train graduate students, postdocs and even undergraduate researchers," says Remucal. "We want people to come in and learn how to process their samples and analyze data, so this new equipment will be available to everyone on campus who wants to get trained and learn to use it for their research."

With a strong foundation, new steel consortium at UW-Madison blends sustainability with structural integrity


Photo: Alex Holloway.

A new consortium at UW-Madison leverages structural engineering research excellence and the applied experience of industrial partners.

Associate Professor Hannah Blum is the director of the new Consortium for Holistic Steel Systems. The partnership brings together experienced engineers with researchers at UW-Madison, drawing on the strengths of both to tackle challenges facing the steel industry.

"In academia, we know how to design and conduct complex research projects," Blum says. "We know how to mentor students who will be the future of the field. But we should always want to be sure that what we're doing impacts the community for the better. The best way to do that is by integrating and working with experienced design engineers who can make sure that we're on the right path while contributing the wealth of knowledge they've obtained from years of working in the industry."

The consortium launched June 1, 2024, and focuses on enhancing steel's use in three key areas: reliability, robustness and responsibility. Reliability deals with the long-term integrity of steel structures and systems, while robustness includes their ability to withstand adverse conditions such as earthquakes or storms.

Thomas Sputo, technical director of the Steel Deck Institute and a consortium member through his consulting firm, says how people look at reliability and robustness varies based on location. In Florida, that might have to do with water from hurricane storm surges. In Australia, that might be based around bushfires.

Responsibility looks at steel's environmental impact from raw materials to finished products, including any recycled products that might extend its life cycle. Typically, structural integrity and environmental impact considerations are considered separately in the steel industry. Blum says the consortium (which will include Associate Professor Andrea Hicks, a leader in life cycle assessment research), will be a leader in looking at the bigger picture of steel.

John Klein, a CEE professor of practice and longtime structural engineer, and Luca Mastropasqua, a mechanical engineering assistant professor, will also join the consortium. Blum is the Alain H. Peyrot Fellow in Structural Engineering. Hicks is the Nosbusch Professor and Hanson Family Fellow in Sustainability.

Prabhakar named Fulbright Scholar

Pavana Prabhakar, the Charles G. Salmon Associate Professor, has been named a 2024-25 Fulbright Scholar.

Prabhakar is a leader in engineering composite materials. She'll spend nine months in Chennai, India, beginning in September 2024, to conduct fundamental research to enable sustainable next-generation composite materials, especially fiber-reinforced polymer composites.

Fiber-reinforced polymers are composite materials that use fibers such as glass or carbon to strengthen the base polymer. These materials are being used more frequently in the aerospace and wind-energy industries, yet are piling up in landfills and scrap yards around the world—including in India—at the end of their use lives. Prabhakar's project will look for solutions to create natural and sustainable types of fiber-reinforced polymer composites, with the goal of accelerating their widespread use and durability.

Fulbright Scholar awards are prestigious, competitive fellowships that provide opportunities for scholars to teach and conduct research abroad. These scholars also play a critical role in U.S. public diplomacy by engaging and establishing long-term relationships between people and nations.

Wang redefines construction co-work

Groundbreaking research on human-robot collaboration in construction spearheaded by PhD graduate Xin Wang captured industry attention and a best paper award from among more than 400 submissions.

Construction robots and autonomous machines have shown transformational potential for years—yet haven't been widely adopted on construction sites. Wang used first-person vision and contextual information to improve gesture interaction efficiency and conducted a series of tests on different construction sites.

"We believe an intuitive and accurate human-robot interface can help contribute to resolving these barriers," Wang says. "Such an interface can greatly enhance the operability of robots in dynamic construction environments. It can also help to build a safe environment for worker-robot collaboration."

Wang presented his research at the Construction Institute and Construction Research Congress Conference at Iowa State University. The biennial conference allows researchers, academics and industry professionals exchange insights, advances and best practices.

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Focus on alumni

Houde hot on the trail of new geothermal extraction method

Matthew Houde's career led him to the forefront of groundbreaking geothermal energy technology at Quaise Energy, a startup company he co-founded. Houde received a College of Engineering Early Career Achievement Award in 2024.

Professor James Tinjum sparked Houde's interest in environmental engineering applications while Houde was a UW-Madison student. Later, during an internship, Houde came across superhot rock geothermal—a relatively new idea in the geothermal energy world. With boreholes deeper than 10 kilometers into the earth, this type of geothermal taps temperature in excess of 750 degrees. Water becomes supercritical at those high temperatures, and very dense with potential energy.

Today, Quaise is developing technologies to meet the engineering challenges that come with drilling deep into the earth's crust. Among those is a drill that uses millimeter-wave directed energy to dig deeper and handle more extreme temperatures than traditional equipment can.

"If we're able to drill down 10 to 20 kilometers, it makes geothermal a source of energy that's viable in locations without a favorable geothermal gradient, like Wisconsin," he says. "I think that's critical if we want geothermal energy to be a key player in the renewable energy transition."

Jorgensen finds success leading Boise Cascade

Nate Jorgensen's first week at the helm of Boise Cascade was one to remember.

He was the company's new chief executive after three promotions in five years. That was March 2020, when swaths of society shut down as COVID-19 exploded around the world.

"There wasn't a script out there that said, 'Here's what you do in a global pandemic,'" Jorgensen says. "We had to rely on our values as an organization to emphasize our priorities: first, making sure of the health of our associates each and every day, and then making sure the company continued to exist in an uncertain environment."

Four years later, Boise Cascade, a multibillion-dollar company with thousands of employees, continues to thrive under Jorgensen's leadership. In recognition of his career accomplishments, Jorgensen received a College of Engineering Distinguished Achievement Award in 2024.

Jorgensen credits his successes in his various roles to lessons learned in UW-Madison's engineering classes.

"Beyond the technical engineering skills, my engineering classes taught me things like collaboration and gave me confidence in what I was doing and in seeing what was possible to do," he says. "Engineering requires a lot of attention to detail and planning, and that's a skill that's served me throughout my career."