UNIVERSITY OF WISCONSIN–MADISON
COLLEGE OF ENGINEERING

SPRING 2022 NEWSLETTER

CIVIL & ENVIRONMENTAL ENGINEERING

SELF-DIRECTED UNDERGRADS

With a societal focus

Greetings from beautiful Madison!

Spring has arrived, there is excitement in the air, and our department continues to grow and excel. I'm very pleased to announce that Dr. Sikai (Sky) Chen will be joining us as an assistant professor this fall. Sky has expertise in automated systems including connected and autonomous vehicles, unmanned aerial vehicles, artificial intelligence, and smart infrastructure. His hire supports the college's plans for strategic growth in the areas of automation, energy and advanced materials, and will accelerate outstanding efforts already underway in automated technologies, some of which you will read about in this issue.

Our new bachelor of science in environmental engineering (BSEnvE) degree is off to a great start. We are tremendously excited about the opportunities it brings to our students and the diversity it is already bringing to our community. Women comprise 80% of initial enrollment in the program, and we anticipate they will account for 50% to 70% of BSEnvE student enrollment long term. To all of our dedicated alumni and friends who have supported the program's launch, thank you so much. We look forward to its continued growth and development.

This issue highlights some of the advances that our students and faculty are making to address societal and environmental grand challenges and the emerging technologies that will help us get there. The Badger shuttle project, led by our Traffic Operations and Safety (TOPS) Laboratory and implemented in the City of Racine, is the first real-world application of autonomous vehicle technology at the municipal level in Wisconsin. The TOPS Lab has also created Wisconsin's first connected corridor along Park Street here in Madison, where short-range communication units have been installed to share information with vehicles that move along the corridor. At the student level, undergraduates from our department and across campus engaged in the CARLA project are moving connected and autonomous vehicle technology forward through simulation-based research of challenging driving scenarios, including inclement weather and construction zones. Meanwhile, Assistant Professor Hannah Blum is leading efforts to integrate virtual and augmented reality technology into the classroom that takes our structural engineering students "inside" buildings virtually to explore and test the structural components that they are learning to design.

In this issue, you will also learn about recent renovations to our fluid mechanics teaching laboratory made possible through the generous support of our alumni. We are thankful for the support and passion of our community. Every donation helps us better serve our students and the greater civil and environmental engineering community as a result. If you would like to support the department 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 from our corner of campus. 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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INTERPRO

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CIVIL AND ENVIRONMENTAL ENGINEERING
CEE ANNUAL
GOLF OUTING
UNIVERSITY OF WISCONSIN-MADISON

Registration Opens for 25th Golf Outing

The Civil and Environmental Engineering Department will host its 25th annual Golf Outing on Friday, Sep. 23. Gather with alumni, industry colleagues, faculty, staff, and students for a day of fun and fundraising in support of the department at Pleasant View Golf Course in Middleton, Wisconsin. For more info or to register, visit golf.cee.wisc.edu.

Collaboration drives advances in AV understanding

The city of Racine, Wisconsin, has a new shuttle that doesn't necessarily need a driver.

Dubbed the "Badger," the new shuttle is a flashy example of technological advances that have led to the emergence of autonomous vehicles—capable of driving themselves—over the past decade. It is also both the culmination of and a new starting point for years of research for the Traffic Operations and Safety (TOPS) Laboratory at UW-Madison.

Steven Parker, the lab's managing director, says faculty and staff who work in the TOPS Lab have researched connected and autonomous vehicles from various perspectives for years. Those years of work have led to the Badger, which is the first application of autonomous driving at the municipal level in Wisconsin.

The Badger is a smart vehicle capable of both predefined route-mapping and real-time environmental sensing to make adjustments as it drives. It's equipped with lidar sensors that researchers can use to recreate a point-by-point image of what the vehicle "sees" while traveling the roadways, in addition to traditional cameras for more human-ready imaging.

"Any time we take it out, there will be a TOPS Lab researcher in the vehicle ready to disengage, which means they can hit a button and take full control of the vehicle," Parker says. "In these autonomous vehicles, the safe driver is still a very active role. It requires a lot of attention—especially because in this case, everything we do will affect how the public perceives this."

The Badger's software maintains a running log of every event that happens while it's driving, and Parker says TOPS Lab researchers will review that information to inform safety decisions for it and even future vehicles. "We're taking the first step of changing transportation culture and what the future of transportation may look like in Wisconsin, the United States and, ultimately, the rest of the world," says David Noyce, the Arthur F. Hawnn Professor of CEE, executive associate dean for the College of Engineering and executive director for the TOPS Lab. "We'll all learn together what the next steps look like."

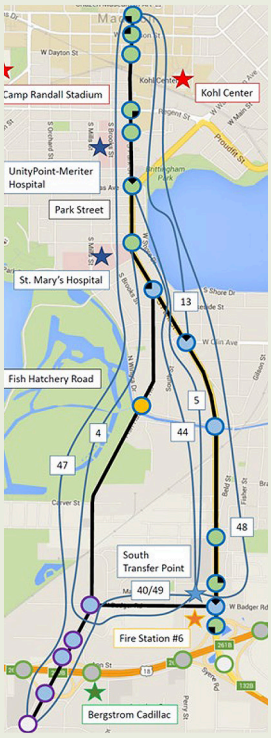
Award-winning connected corridor a preview of 'smart' travel in Madison

UW-Madison researchers are paving the way for intelligent or autonomous vehicles to communicate with the very infrastructure that lines our roadways.

The Traffic Operations and Safety (TOPS) Laboratory at UW-Madison, in partnership with the city of Madison and TAPCO, Brown Deer-based traffic safety equipment manufacturer and service provider, has created Wisconsin's first connected corridor along Park Street in Madison.

The Park Street connected corridor spans roughly four miles, from its intersection with University Avenue to its connection with the Madison Beltline (Highway 12/18). The route, which sees roughly 48,000 vehicles per day, serves as a major artery into and out of the university campus and Madison's downtown. The project team has equipped 15 intersections along the Park Street corridor with dedicated short-range communication roadside units that form the backbone of a smart, connected corridor.

Jon Riehl, a transportation systems management and operations engineer and researcher in the TOPS Lab, says the upgrades at these intersections build on Madison's fiber optic infrastructure and can allow the roadside units to "talk" to vehicles that have appropriate equipment as they move along the corridor.



"As the vehicles move, they transmit basic safety messages 10 times a second that give information about speed, location and heading," Riehl says. "The intersection is sending back information on signal phasing and timing. So if, for example, the signal is red, it informs the vehicle of this, as well as how soon the signal will turn green."

Connected roadside infrastructure systems also could interface with vehicles, as well as bicycles and pedestrians, to provide warnings about red lights or roadside hazards, and TOPS Lab researchers are determining the best way to convert that information into messages motorists can quickly and easily understand.

"We have a full-scale driving simulator that we're using for tests to see how drivers react to messages and how to best convey that information," Riehl says. "Messages can be sent in a variety of methods, such as audible warnings, haptic feedback, or visual cues, and the timing of messages is critical. We'll continue to work on research for those potential applications. The big question for us is this: Once we receive messages from vehicles and the infrastructure, how can we process them to best improve traffic mobility and safety?"

Through rain, snow and road construction, researchers across campus solve automated vehicle driving challenges

In the not-so-distant future, a city full of autonomous cars may have to weather a snowstorm.

It's a scenario that's not unusual in places like Madison, but it presents a unique challenge for automated vehicles that may rely on tools like cameras or lidar to see where they're going. Heavy snowstorms can be challenging for drivers; for automated vehicles, they could prove crippling as visibility drops or precipitation obscures their sensing devices.

Bin Ran, the Vilas Distinguished Achievement Professor in civil and environmental engineering at UW-Madison, is leading a years-long research effort to better understand how to "train" autonomous vehicles to navigate difficult road conditions. To aid their research, he and his students are using CARLA, an open-source simulator that allows them to create and study customized AV driving scenarios.

"Even with our current autonomous cars, drivers can still take over and drive in poor conditions," Ran says. "But in the future, if all cars are fully autonomous and there are situations where the cars can't understand what's going on, the cars would have to stop. It would be a disaster."

Ran works with UW-Madison's Traffic Operations and Safety Laboratory. The research team uses CARLA to input parameters to set conditions and simulate how an autonomous car might behave in certain circumstances. The project has focused on navigating inclement weather and driving through construction zones.

Ran sees an answer to these challenges by leveraging connected infrastructure, which uses "smart" technology to connect roadside infrastructure to vehicles. Such systems allow cars to "talk" to the roadside infrastructure and to each other to access more information than an individual vehicle could gather on its own.

"You have to bring the road and the car together," Ran says. "If you want to do that, everything has to work as one system—otherwise the car will stop and there's nothing it can do."

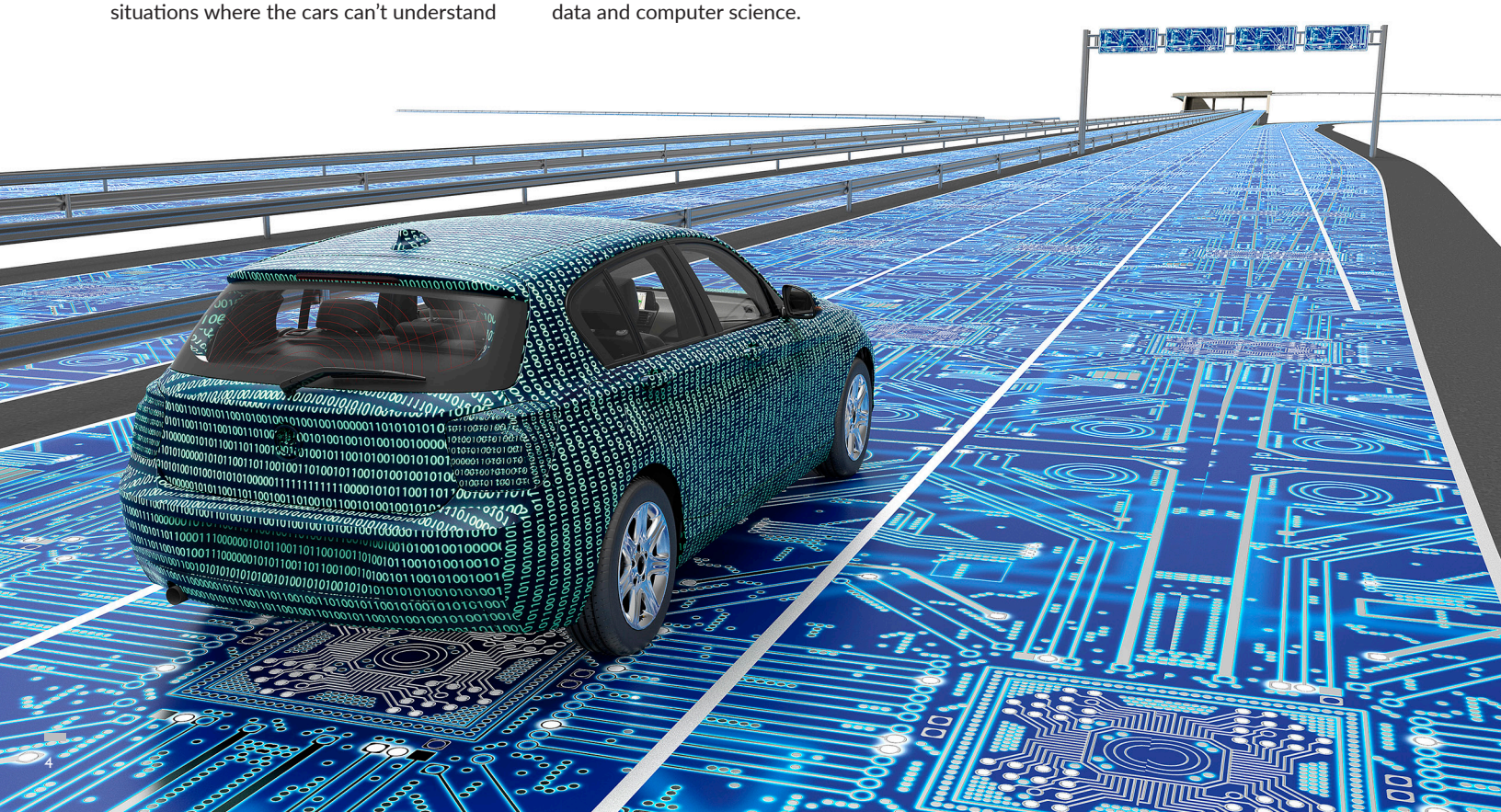
The CARLA project draws in undergraduate students not only from across the College of Engineering but from other disciplines at UW-Madison such as data and computer science.

Noah Leonard, a fifth-year CEE senior, joined the CARLA project for the spring 2022 semester.

"It's been really neat for me because I don't think a lot of undergraduate students have the chance for this type of exposure to the topic," Leonard says. "The really cool part has been figuring out how we integrate autonomous vehicles into our transportation systems and how we might one day phase out human drivers to go fully autonomous."

For Ran, the CARLA project offers a unique opportunity to expose the next generation of engineers to the challenges that will come with the slow transition toward autonomous vehicles. He hopes the exposure will help Badger engineers lead the charge in creating solutions for those challenges.

"Many of our undergraduates will go into industry when they finish here, and we have to train them to be prepared for that," Ran says. "There's a revolution coming in the automotive field, and I want them to know that they will be the champions of the effort."



In a real-life class, civil engineering undergrads learn in a virtual world

Hannah Blum is blending the virtual with what's real for students in her *Steel Structures 1* class.

Blum, an assistant professor and the Alain H. Peyrot Fellow of Structural Engineering, has been a trailblazer within the College of Engineering when it comes to using virtual reality for teaching her students. Now, she's using a blend of augmented and virtual reality learning tools to help students visualize—in striking detail—the sorts of work they'll do as structural engineers.

For one such learning tool, Blum is using Microsoft HoloLens. The HoloLens fits like a pair of futuristic glasses and projects a computer-rendered image over the wearer's field of vision. In one class period, Blum's students used the technology to view a bolted steel connection. Using the HoloLens controller, they could interact with the steel as if it were in front of them, and pull it apart to see what an actual fracture would look like.

"It's there in 3D; you can walk around and view it from different angles," Blum says. "You can virtually hold it, twist it, pull it apart and put it back together. This is so much better compared to looking at a book."

In another class session, Blum took students to the new Kohler Innovation Visualization Studio in the College of Engineering's makerspace. There, her students used Oculus virtual reality headsets to take a guided tour, narrated by the project's lead engineer, of the 51st floor of a recently completed skyscraper in Chicago. The tour was recorded while the building was under construction.

The narrator explained engineering concepts as students moved throughout the construction site, and there were various popups along the way for students to interact with for more information. It emulated the type of experience students could get on a field trip to a construction site.

The mixed reality sessions have been a hit with Blum's students. Abby Grant says the virtual tour reminded her of some of the construction sites she's worked on for the past two summers. She says some of the subjects that came up during the tour were ones they hadn't yet learned in class, but the experience served as a great introduction.

It's been a big undertaking, but Blum says it's worth the effort and hopes to see wider uptake of mixed reality learning within the college and beyond. She says it's important not only as a fun, hands-on way for students to learn but because it gives valuable preparation for when they move into their careers.

"Companies are starting to use this technology," she says. "They might have a virtual reality walkthrough for a client to show what a building looks like. Some construction software companies are using mixed reality to overlay models onto construction sites. We want students to be familiar with this technology so that they're prepared when they go out into the workforce."

What happens when microbes hitch a ride on microplastics in lakes

As the climate changes, dangerous algal blooms become more common in our lakes, threatening not only humans, but entire freshwater ecosystems.

Assistant Professor Nimish Pujara is studying how tiny plastic pieces might play a role in encouraging these blooms.

Pujara has received Wisconsin Idea Grant funding for a collaborative project with Erica Majumder, an assistant professor of bacteriology at UW-Madison. They'll work with UW Extension Lake Superior outreach specialists Erin Burkett and Chad Cook to study how microorganisms and microplastics influence algal bloom growth on Lake Superior.

Microplastics are plastic fragments smaller than 5 millimeters across. They can come in all sorts of densities and chemical compositions and are ubiquitous in the environment, including sources of drinking water, according to the World Health Organization.

Purjara's research focuses on fluid mechanics, and he's leveraging that expertise for the project. He says microbes might latch onto microplastics, which allows them to spread further in lakes than would otherwise be possible.

"Our hypothesis is that there might be a yo-yo effect," Pujara says. "A biofilm forms around the plastic, which makes it heavier so that it starts sinking. From field data we know that we recover a lot of heavy plastics from the surface of the water. So some biological process on the surface of that plastic—maybe some kind of gas formation—is making it buoyant so that it rises to the top again."

Pujara's team will work with the nearshore monitoring workgroup, part of the UW Extension's Lake Superior Collective, to collect water samples. Once the state's waterways thaw in spring 2022, Pujara's team will join the workgroup in collecting lake water samples for analysis.

Because microplastics are so widespread in the environment and because algal blooms are so common, the project has potential for big impact. Algal blooms can sicken or kill humans and wildlife, create "dead zones" in water, make water treatment more expensive, and damage industries that rely on clean water. Pujara says scientific communities are increasingly seeing microplastics as an urgent focal point as we learn more about just how common they are in the world.

"This is a pollutant that we don't really know the full impacts of," he says. "So it's important to continue encouraging further studies so we can gain a better understanding of how it moves within and impacts our environment."

For undergrads, there's an undercurrent of excitement in renovated fluid mechanics lab

Upgrades in CEE's fluids teaching lab are bringing in new state-of-the-art learning tools for undergraduate engineering students.

The Kenneth R. & Ruth M. Wright Fluid Mechanics and Water Resources Teaching Collaboratory has long served as a place where students can learn how physics drive an array of interactions in fluids. The facility is a combined classroom and laboratory space, and recent renovations includes the classroom portion.

Nimish Pujara, an assistant professor who specializes in fluid mechanics, says those upgrades paved the way for modernizing the lab's equipment, too.

The lab now has a new system of lighting and high-speed cameras that will allow students to conduct particle image velocimetry (PIV) experiments. PIV is used broadly for fluid mechanics research and is particularly helpful for understanding how flow speed varies in space via tracking of small particles within the flow.

"We can have physical demonstrations of fluid viscosity, which can be a difficult concept to explain," Pujara says. "Previously, we might have demonstrated it indirectly by dropping balls in a fluid. Now, we can see it by taking measurements of flow over a region of space. It's a very direct visualization."

The lab also has new flow meters, thanks to alumnus David Benett (BSCEE '78, MSCEE '80), who has worked with industry contacts at Badger Meter and Teledyne ISCO to secure the new equipment. These flow meters are used to measure the flow you can't directly see—for example, within a building's pipes.

Undergraduate student Allie Stephens and CEE faculty associate Jacob Zeuske designed and built a new wavemaker for the lab using the College of Engineering's makerspace and TEAM Lab. Zeuske also designed a rig that will allow in-lab hydraulic jump demonstrations.

All of these upgrades will help the instructors who teach in the lab to explain

the sometimes-esoteric fluid mechanics concepts to students. And Pujara says better instruction will benefit everyone.

"One of the things that can help make education more equitable is if you have good experiments where students visualize the concepts they're learning," Pujara says. "Even if they don't come in knowing the right theoretical language that we use in lectures, having good laboratory facilities can help fill those gaps, especially for those who come from underrepresented backgrounds or without much prior exposure to these ideas."

The lab's upgrades were made possible in large part through a grant from the College of Engineering's fund for education innovation.

Undergrads invent innovative roof for when natural disasters strike

In 2017, Hurricane Maria devastated the island of Puerto Rico.

The storm unleashed untold destruction as it raked across the northern Caribbean. In Puerto Rico, it destroyed or damaged more than 60,000 roofs, according to FEMA. In the storm's wake, the agency implemented a temporary housing program, known as the Blue Roof program. Now, a team of our undergraduate students is working on a project that might make affordable, strong, temporary roofs available for use in the aftermath of natural disasters like Hurricane Maria.

Jordyn Benn, Anna Cardinal, Claire Steines and Caitlin Piotrowski are designing and testing a concept that employs carbon fiber reinforced with resin and silicon joins. Their hope is that these structures could be easily produced, collapsed for easy transport, unfolded on-site, and collapsed again afterward for reuse at a later time.

Together, the team—dubbed the STEMinists—is one of several undergraduate groups competing in the department's annual Innovation in CEE Competition. The competition, sponsored by The Boldt Company, focuses on developing new materials, technologies and solutions for today's evolving civil and environmental engineering challenges.

The STEMinists met in one of Charles G. Salmon Assistant Professor Pavana Prabhakar's structural engineering classes. They drew inspiration from Prabhakar's lessons for their project.

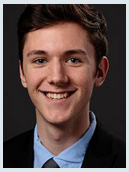
"We knew we wanted to do something with structures," Benn says. "We all came up with the idea of doing something related to natural disasters because it's an interesting way to figure out how structures work and hold up during natural disasters. Professor Prabhakar helped us reach the idea of something that could be used after natural disasters."

The team is working through the spring semester to develop its idea, with the ultimate goal of producing a small-scale model that members can demonstrate at the end of the semester. Along the way, members will experiment with different materials and methods to determine how they can best realize their vision. For example, they started out comparing glass fiber and carbon fiber as potential base materials before settling on carbon fiber and silicon residue.

Regardless of the competition's ultimate outcome, the STEMinists are excited about their project—they hope similar concepts could have applications in everything from temporary housing to space travel—and the opportunities it's providing to learn about different materials and structural design ideas. The team enjoys the freedom to pick their own project and figure things out as they go.

"This is unlike anything I've learned in any class, which is really cool," Steines says. "It gives you a different perspective on what we're doing. I haven't used this material before, so it's been great to get this experience."

STUDENT NEWS



Master's student Riley Hale won a 2021 UW-Madison teaching assistant award. Hale won the Early Excellence in Teaching Award, which recognizes outstanding and inspirational performance on the part of teaching assistants with less than four semesters of teaching experience.

Graduate students Haotian Feng, Sabarinathan Pushparaj Subramaniyan, Hridyesh Raj Tewani and Guanjin Yan, all from Associate Professor Pavana Prabhakar's research group, won first prize at the American Society for Composites simulation for their project, "Machine learning application to design co-cure processing of energy-efficient honeycomb sandwich composite structures."

ALUMNI AND FACULTY NEWS

Associate Professor Andrea Hicks won the college's Benjamin Smith Reynolds Award for Excellence in Teaching. The award is presented annually to a faculty member who makes exceptional contributions to the outstanding instruction of engineering students.

Steven Parker, managing director and IT program director at the Wisconsin Traffic Operations and Safety (TOPS) Laboratory, won the college's Bollinger Academic Staff Distinguished Achievement Award for Research Excellence. The award recognizes outstanding contributions to the College of Engineering's operations, research and teaching efforts made by members of the academic staff.

Associate Professor Christy Remucal won the college's Ragnar E. Onstad Service to Society Award. This award recognizes researchers in the College of Engineering who inspire or demonstrate the use of innovation and engineering principles to benefit humanity.

David Noyce, executive associate dean for the College of Engineering, director of the TOPS Laboratory and Arthur F. Hawn Professor of CEE, has been elected to serve as president of the Transportation and Development Institute of the American Society of Civil Engineers for fiscal year 2021-22.

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Hicks explores whether the climate is right for turning CO_2 into plastic

Associate Professor Andrea Hicks has received a Scialog Negative Emissions Science Team Award to study how plastic could help reduce the amount of carbon dioxide in the atmosphere.

The NES Team Awards, backed by the Research Corporation for Science, bring teams of early career researchers together in high-risk, high-reward projects focused on tackling some of the biggest challenges driving climate change. The Scialog grants are geared, in particular, toward finding scalable solutions that could draw greenhouse gases from the atmosphere to help slow the pace of climate change.

Hicks' project will focus on converting carbon dioxide to bioplastics, which can be either based on biomass materials, rather than petroleum, or biodegradable. She'll collaborate with researchers at the University of California, Los Angeles, and Rice University.

Hicks is an expert in using life cycle assessment to determine the overall environmental impact of products or processes. She'll contribute that expertise to understanding whether drawing carbon dioxide from the atmosphere creates a net-negative or positive impact. She'll also help determine how environmental impact and economic feasibility may change from lab-scale systems to commercial production-scale systems.

Carbon capture and use—the process of removing carbon dioxide from the atmosphere and using it for products or services—is a growing field, even in surprising ways. Hicks says some companies have used carbon dioxide to make vodka, for example. However, she says products like vodka have a short shelf life (meaning they're used comparatively quickly), and part of the project's challenge will lie in finding long-term-use applications for bioplastics.

"With plastics, the life cycle really depends on the use," Hicks says. "Some applications, like water bottles, have short shelf lives. Others, like decking, have longer shelf lives. So the question is, can we use these in ways that will gravitate toward longer use lives, and how do we dispose of these at end of life?"

Each NES Team Award recipient receives a $55,000 grant, so Hicks' team has $165,000 for its project. This is Hicks' second Scialog grant, and she's previously been named a Negative Emissions Science Fellow.

"This is a wonderful opportunity," Hicks says. "Climate change caused by excess carbon dioxide in the atmosphere is a very important area of research, so I'm excited to be able to contribute to projects like this."