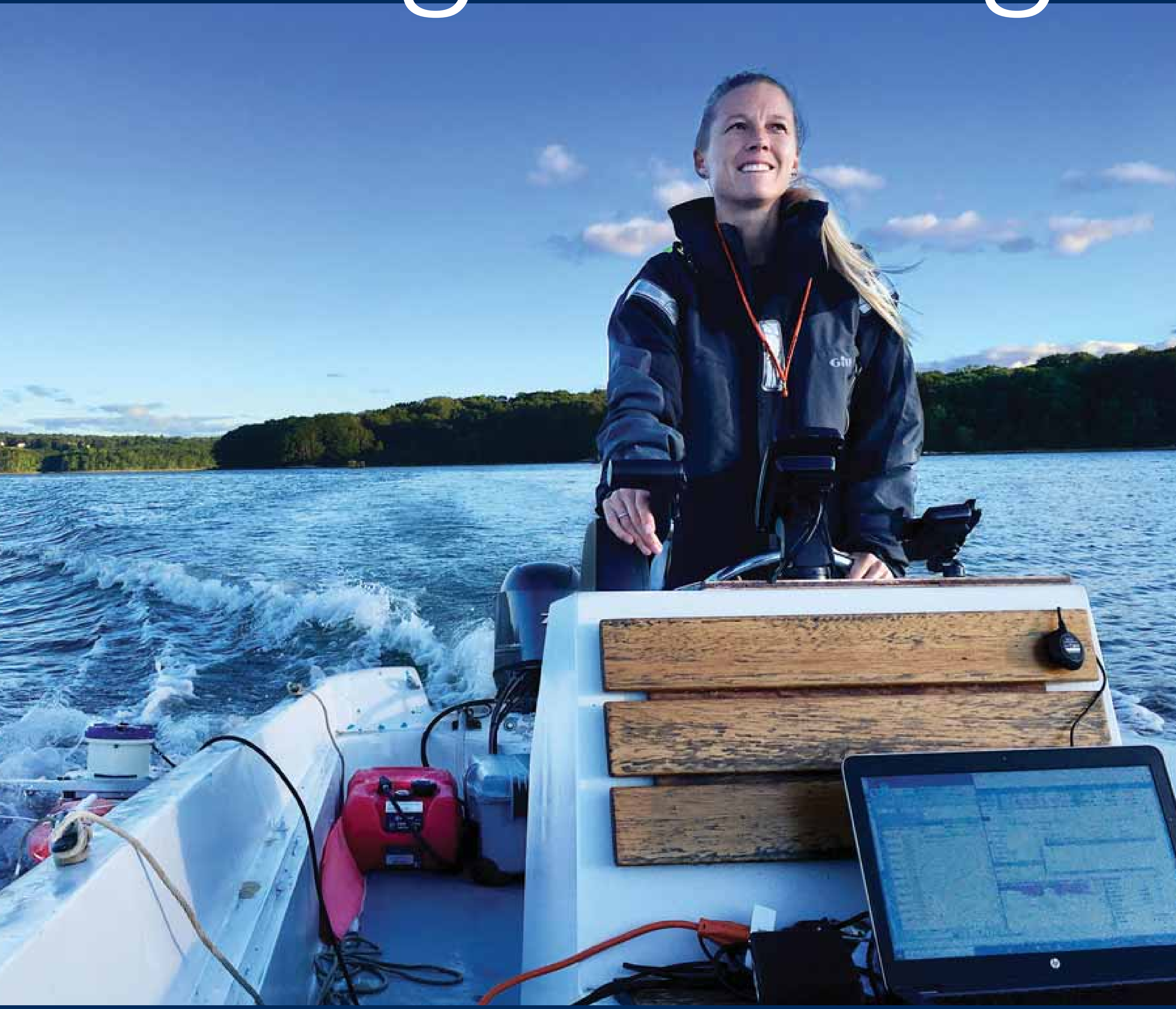
UMaine Engineering

2020/2021



ENGINEERING ADDRESSING CLIMATE CHANGE

Contributing to innovation, understanding, monitoring and mitigation

Features

Departments

Primary editorial content by Marcus Wolf, primary photography by Adam Küykendall, design by Val Ireland, editing by Margaret Nagle, Division of Marketing and Communications

Photographs of those not wearing masks were taken prior to the coronavirus pandemic or were socially distanced to allow showing an unmasked face. The University of Maine follows federal and state Centers for Disease Control and Prevention health and safety guidance, which includes social distancing and use of face coverings since the start of the 2020–21 academic year.

engineering.umaine.edu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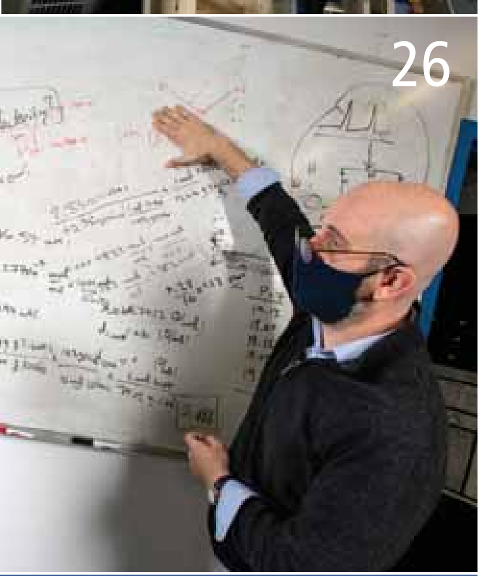
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The year 2020 will go down in the record books for UMaine engineering. In March, the engineering faculty accomplished the herculean task of shifting all their courses online in a matter of a week due to COVID-19. Our labs responded with a focus on developing personal protective equipment and producing hand sanitizer as highlighted in this issue. Despite these challenges, the college posted a record $35 million in funded research and industrial contracts. Much of this work focused on renewable energy sources and monitoring our environment as featured in several articles in this magazine. Finally, undergraduate enrollment is at record levels — for the first time over 1,900. Our fall 2020 incoming class of first-year students is 15% above last year.

The design team of WBRC and Ellenzweig completed the design of the $78 million Ferland Engineering Education and Design Center. Moreover, thanks to support from alumni, corporations and foundations, we reached our fundraising goal. In late April, we held a virtual groundbreaking. Since then, Consigli Construction has made steady progress. They are well along with the foundation work and they placed the first structural steel in late October. A point of pride is the number of UMaine engineers who are part of the design and construction teams, as showcased in this issue.

In October, the Harold Alfond Foundation announced an unprecedented $240 million pledge to transform the University of Maine System. This includes $75 million to create a statewide Maine College of Engineering, Computing and Information Science, led by UMaine. This needs to be matched 1:1 with private, state and federal funding so the total impact will be $150 million. Funding is included for expanded faculty and staff, student scholarships, and remodeling or replacement of Boardman, Barrows, Jenness and Crosby. This will propel our remarkable engineering heritage into the future. I predict that 2021 will be another great year for UMaine engineering.

Dana L. Humphrey

Dr. Dana Humphrey
Dean, College of Engineering
Saunders Professor of
Engineering Leadership and Management

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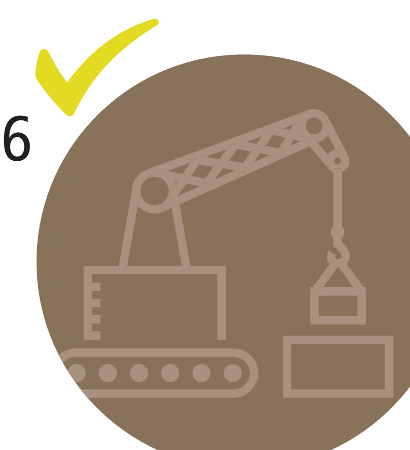
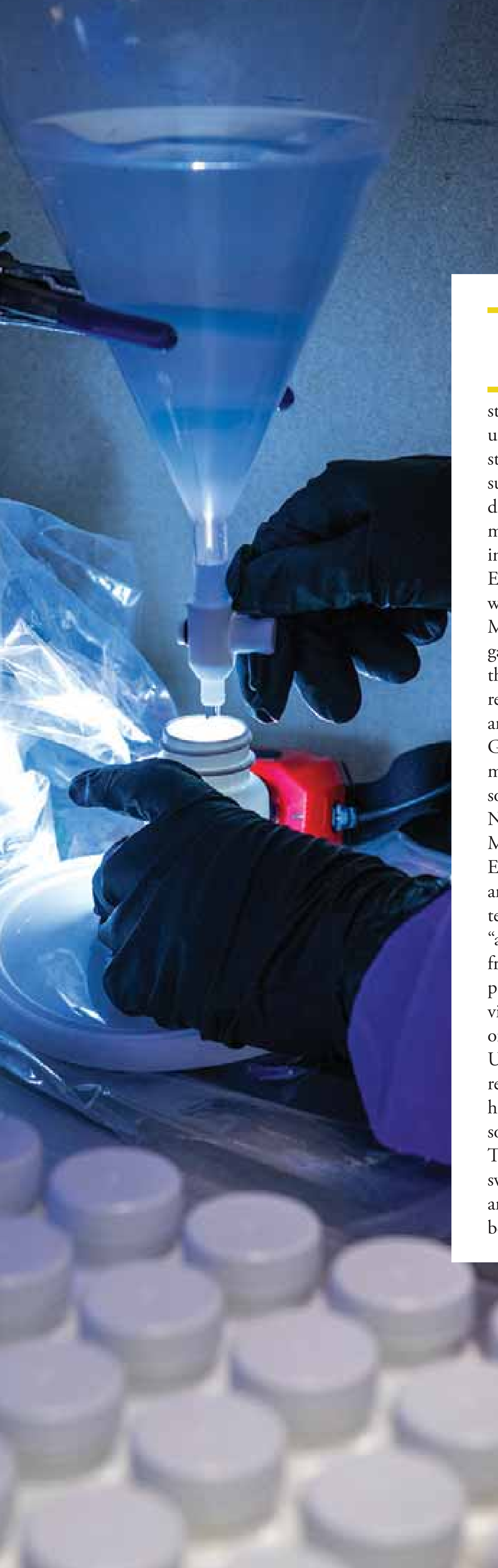


On the cover Extensive estuary closures can adversely affect the livelihoods of fishermen and aquaculture farmers for a whole season. To help them and state regulators, assistant professor of civil and environmental engineering Lauren Ross and faculty from the UMaine School of Earth and Climate Sciences are devising tools that will help predict pollutant travel in estuaries and enhance the scientific basis for shellfish closures in response to coastal runoff. Their assistance could possibly offer an alternative evaluation to the 2 inches of rainfall in 24 hours benchmark, opportunities for shorter closures and more insight into runoff pollution for fishermen and aquaculture farmers. Cover photo by Neil Fisher

COVID **response**

College of Engineering expertise key to UMaine helping address pandemic needs in Maine and beyond



In March when the pandemic hit Maine and University of Maine System campuses pivoted from in-person to remote learning, College of Engineering faculty, staff and students got to work to help the state's research university address COVID-19-related needs statewide and beyond. With hand sanitizer in short supply, UMaine partnered with the state's craft distillers and brewers to make more, led by team members in the Process Development Center and in the Department of Chemical and Biomedical Engineering. More than 3,000 gallons of sanitizer were distributed by UMaine to more than 50 Maine health care providers, with thousands of gallons more produced by distillers and brewers thanks to UMaine technical assistance. At the request of the Maine Center for Disease Control and Prevention, and for use by the Maine National Guard, the same chemical engineering team manufactured more than 2,200 bottles of testing solutions required to perform aerosol fit tests of N95 masks. In addition, teams from the Advanced Manufacturing Center and Maine Manufacturing Extension Partnership worked with hospitals and manufacturing partners in the state to build, test and start production of two variations of an "aerosol box." The boxes are designed to protect frontline medical staff as they intubate or transport patients who may be sick with the coronavirus. College of Engineering experts were part of a broad-based COVID-19 innovation team at UMaine that brought together multiple university research centers and representatives from Maine health care, manufacturing and government to solve emerging challenges related to the pandemic. The UMaine-led group tackled needs and worked swiftly to address problems the state was facing, and initiated collaborations that would reach far beyond UMaine's campus. ◆

Alumni on the Consigli Construction team leading the Ferland Engineering Education and Design Center project and other UMaine alums from the School of Engineering Technology: left to right, front row: Stacey Harris, B.S. CIE '11, Consigli superintendent; Will Manion, M.S. CIE '92, director of the School of Engineering Technology; second row: Bridget Cullen, B.S. CIE '19, Consigli project engineer; Pete Parizo, B.S. CET '02, project manager with Sargent Corp.; Joe Frazier, B.S. CET '18, foreman with Sargent Corp.; third row: Geoffry Nye B.S. MEE '17, mechanical, electrical and plumbing superintendent with Consigli; Adam Kapaldo, B.S. CET '15, project manager with Sargent Corp.; back row: Matthew Tonello, B.S. CIE '94, Consigli project executive. Photo by Adam Küykendall

It's personal

Alumni take special pride in returning to their alma mater to lead design and construction of the Ferland Engineering Education and Design Center

The WBRC team on the Ferland Engineering Education and Design Center project is led by alums, left to right, A. Ray Bolduc, B.S. CIE '90, principal-in-charge; Andrew Rudnicki, B.S. MET '05, senior mechanical engineer; Stephanie Laplant, B.S. EE '96, principal electrical engineer; Daniel Monroe, B.S. MET '94, principal mechanical engineer. Photo by Mark Wellman '72

University of Maine alumna Stacey Harris returns to campus annually for homecoming, but school spirit takes on a new meaning for her this year.

Nine years after graduating with a bachelor's degree in civil and environmental engineering, Harris joins other alumni in helping erect a facility that will reshape the academic landscape for engineering majors for years to come: the Ferland Engineering Education and Design Center (Ferland EEDC).

"It's a career dream, " says Harris, who also serves on the UMaine Alumni Association Board of Directors. "Everybody wants to say 'Hey I got my degree here, and I built a building here.'"

The 108,000-square-foot center will serve as the new home for the Department of Mechanical Engineering and the Biomedical Engineering Program. It will feature teaching laboratories for the Mechanical Engineering Technology Program, spaces for all engineering majors to complete their senior capstone projects, and collaborative learning classrooms available to all UMaine students.

Crews from WBRC Architects Engineers and Consigli Construction, tasked with designing and building the three-story complex, respectively, include College of Engineering graduates who studied in Boardman and Barrows halls years ago. They will use the knowledge they acquired and skills they developed at UMaine to improve its academic offerings with a new, transformational asset.

Harris, a superintendent with Consigli, assists with on-site logistics and educational outreach for the project. She says when students look up the stairway of the building, they'll see the landing and pedestrian bridge on each floor, and the skylight at the top. The new laboratories and collaborative learning classrooms will provide more hands-on learning opportunities.

"I think it's going to really transform the UMaine campus and be able to expand the capacity of the engineering program," Harris says. "We don't pump out enough engineers. We need more, more and more."

Other alumni from Consigli involved with the project include Matthew Tonello, director of Maine operations, and Bert Kiesow, senior project manager.

Tonello, who graduated with a bachelor's degree in civil engineering in 1994, says he most looks forward to the capstone project spaces and welcome center, as "they are going to be incredibly flexible and valuable spaces."

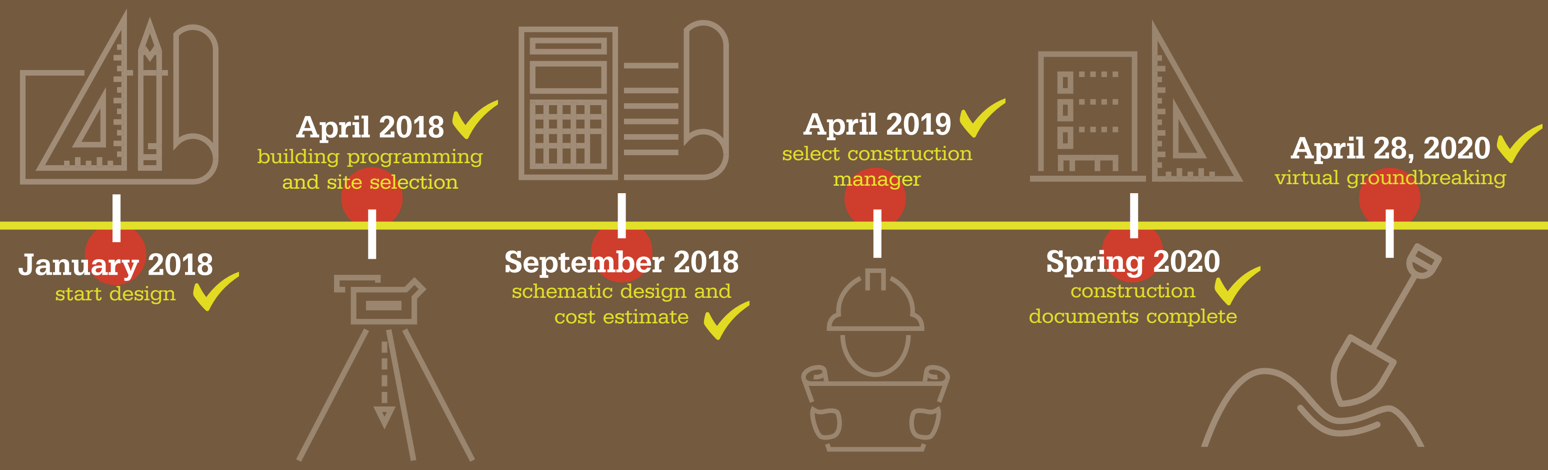
Kiesow says he believes it will produce graduates who can help Maine become a leader in the biomedical engineering field. He graduated from UMaine with a bachelor's degree in construction management and an associate degree in engineering technology in 1996, and notes that the ground-floor collaborative spaces will allow students to "experience success and failure, versus reading about it in textbooks."

The senior project manager from Consigli, who interfaces with the UMaine Facilities Management group and various project partners, complimented WBRC and university staff for how they designed the center. He highlighted the central corridor that will connect the main level to a new welcome and outreach center, the food service area with a two-story commons, and the "open feeling throughout the building."

"Being involved in the most significant addition to the engineering department in decades is exciting," Kiesow says. "Being able to make a permanent mark on my alma mater is also rewarding, but mostly, it is able to demonstrate to future construction management students that a UMaine engineering education allows you to build exciting, impressive, sustainable buildings, like the Ferland EEDC."

UMaine graduates from WBRC who participated in developing Ferland EEDC include A. Ray Bolduc, a firm principal and education studio director; Daniel Monroe, another firm principal and mechanical engineering department manager; and Stephanie Laplant, the electrical engineering department manager and firm principal.

Timeline for Ferland Engineering Education and Design Center



Laplant, who graduated from UMaine with a bachelor's degree in electrical engineering in 1996, serves as the engineer of record for the project, meaning she fields any questions about the design drawings and ensures construction workers understand and follow their directions.

"It will be an incredible recruitment tool for both students and faculty. To let prospective students know that this building was designed by alumni — what better way to say 'UMaine knows what they're doing!'" Laplant says.

These alumni demonstrate the deep and diverse expertise UMaine needs to bring the vision of the multifaceted Ferland Engineering Education and Design Center into reality.

After graduating from UMaine in 1996, Laplant began her engineering career working for R.G. Vanderweil Engineers, now called Vanderweil Engineers, in Boston. She then returned to Maine to work for WBRC in 1999. She became a firm associate in 2008, a senior associate and shareholder in 2016, a department leader in 2017 and a principal shareholder in 2020.

Kiesow's career encompasses roles that include surveyor, ironworker, project engineer, MEP engineer, or mechanical, electrical and plumbing engineer; project manager, area manager and senior project manager. His diverse portfolio of facilities and assets he helped erect include a bridge connecting Waterville to his hometown of Winslow "that forever changed the traffic flow in the adjacent communities," a biotech manufacturing facility, semiconductor plants, biomass heating plants and data centers.

"I have spent the majority of my career building world-class facilities for companies in medical research, development and production," he says.

Tonello began his career in 1994 as a civil engineer. He then secured a structural engineer position with Boston Building Consultants in 1996. He received a master's degree in structural engineering from UMass Lowell in 1998. Revit Technology, Waltham, Massachusetts, then hired Tonello as a product manager in 2000, and he worked for the firm for two years until he joined Consigli as a project manager in 2002. Tonello received his master's degree in business administration from Boston University in 2006.

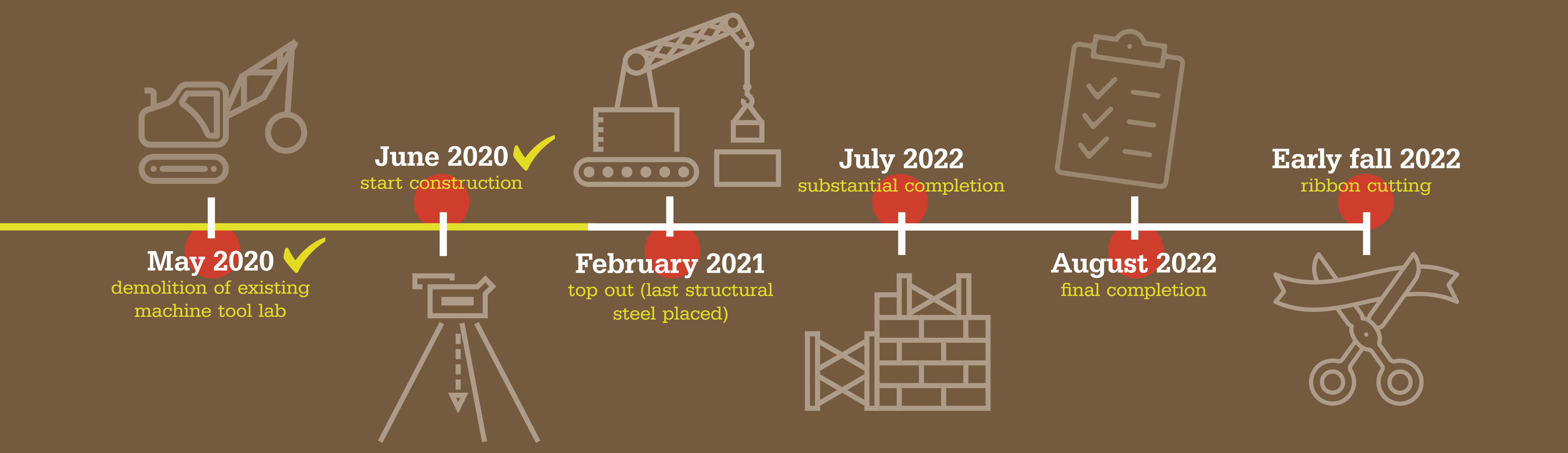
Harris earned her master's degree in global enterprise management from Rensselaer Polytechnic Institute, Troy, New York, in 2012, a year after graduating from UMaine. After studying abroad in Rome and Shanghai, and interning with IBM, Harris joined Turner Construction, Boston, in 2012 as a field engineer. She worked for the firm until joining Consigli's Maine bureau in 2016.

"Anyone who grows up in Maine and goes to school in Maine, they learn work ethic," Harris says. "If you work hard and be kind, it can go a long way in your career."

Despite several years passing from the time they worked in a classroom or lab, these alumni still cherish their memories of UMaine and their college careers. Recollections of hockey games, in particular, still excite them as if they were still in the stands cheering on the Black Bears.

Harris began attending UMaine hockey games as a child, and Laplant says she remembers watching matches when Shawn Walsh coached and Paul Kariya, who went on to play for the Anaheim Mighty Ducks, was on the UMaine team. Kiesow and Tonello say the excitement from the 1993 hockey season, which peaked when the Black Bears won the NCAA Hockey National Championship, still reverberates through their minds like cheers in Harold Alfond Sports Arena.

"I was a member of the newly formed Blue Line Club, which granted me a great seat to every home UMaine Hockey game. I didn't miss a single second of hockey that (1992–1993) season," Kiesow says. "The energy on campus that winter and the night



we won the title was something I can still remember."

Each alum interacted with the campus community in different ways, but all left with experiences worth reminiscing.

Joyful memories of participating in the Society of Women Engineers, joining Pi Beta Phi, munching on a Winslow (chicken caesar) wrap in the Boardman Hall student lounge, singing the "Stein Song" and meeting her husband, Brian, keeps Harris connected to her alma mater. Laplant says she enjoyed participating in Maine Hello.

"I love that the current students greet the new ones and give them a helping hand in getting settled," Laplant says.

Lessons from the College of Engineering remain with these alumni many years after graduation. Particular faculty helped mold them into the engineers who now participate in shaping the future of the university.

Habib Dagher's instruction and passion for wood structure design inspired Tonello to become a structural engineer. While teaching a design of wood structures class, Tonello says Dagher, founding executive director of the Advanced Structures and Composites Center, encouraged the class to "feel the beam" when calculating bending stresses and determining failure modes of different loading conditions. The professor of civil engineering also helped Tonello obtain his first construction internship.

"He and I worked during the spring semester on the design and shop drawings for a Howe Truss bridge constructed from eastern hemlock. Our presentation of the design of the structure to Galen Cole turned out to be my first engineering interview," Tonello says.

"Habib's urging of Mr. Cole to include me in the construction team got me my 1993 summer internship constructing the covered bridge at the Cole Land Transportation Museum in Bangor," he says.

Per Garder, a professor of civil and environmental engineering at UMaine, taught Harris leadership and management skills, and encouraged her to obtain an MBA, she says. Laplant says Fred Irons, former professor of electrical engineering, and Allison Whitney, a former lecturer in electrical engineering, broke down their subject matter in ways all students could understand. Professor Chuck Gould's incorporation of real-life experiences into his lectures provided an education that still influences Kiesow today.

"I still regularly tell stories about his teaching style, and the experiences (although I didn't know it at the time) he was teaching us would resonate through my entire career," Kiesow says.

Seniors from the Class of 2023 will be the first to complete their capstone projects in Ferland EEDC after construction concludes in 2022. The alumni tasked with helping build it have advice for those future seniors and all students who join the campus community.

Laplant says they should learn real-world applications by participating in hands-on learning. They should also "push the boundaries of (their) comfort zone(s)."

Kiesow says students should participate in as many opportunities the College of Engineering offers as possible, because they will refer back to their experiences throughout their careers.

Harris says students should remember that they will not know everything by the end of their college careers, and they should embrace learning how to learn.

Engineers, she says, should never "build a bridge from memory."

"Engineering is really problem-solving, and we're going to find problems and you have to know where to find answers. That's something you don't have to do from memory," she says.

The center was named after Skowhegan, Maine natives E. James "Jim" Ferland and Eileen P. Ferland, who gave $10 million toward the project.

The University of Maine Foundation raised $78 million in public and private donations for the facility. Ferland EEDC was part of UMaine's $200 million Vision for Tomorrow comprehensive campaign, led by the UMaine Foundation.

"There has been a tremendous amount of time spent in discussions with end users to really tailor this building for the future. I can't wait to see it in use and know that I had a part in it," Laplant says. ◆

Jordon Gregory. Photo by Adam Küykendall

Hands-on learning

JORDON GREGORY of Minot, Maine, hit the ground running on her path toward an engineering career in the pulp and paper industry.

The Pulp and Paper Foundation scholarship recipient secured internships at Verso Paper in Jay, and Solenis at ND Paper in Rumford. Solenis also offered her another internship to continue to learn about the industry, and gain hands-on experience running trials and improving the papermaking process.

Extracurricular activities also have opened engineering pathways for Gregory. The third-year student participates in the UMaine chapters of the American Institute for Chemical Engineering and the Technical Association of the Pulp and Paper Industry. She also is a member of Team Maine, the Campus Activities Board and Alternative Breaks.

"It is crazy to think that just in this small amount of time, this university has opened so many doors for me," she says. "Since coming to UMaine, I really have been able to catch a glimpse into what the future holds for me."

University faculty have fostered a welcoming and supportive atmosphere by answering any questions and helping her succeed, she says. College of Engineering Dean Dana Humphrey's Introduction to Engineering Leadership class stands out for teaching her leadership skills through real-world examples.

Gregory describes UMaine as "innovative" — from its nanocellulose research and the launch of the world's largest 3D printer to the pilot paper machine that provides hands-on learning for future pulp and paper industry leaders.

"The University of Maine engineering program is always on the search for new opportunities for students to help impact the world," she says.

When she graduates, Gregory says she plans to work as an engineer in the pulp and paper industry.

"I am very excited to see where my career in the industry is going to take me, whether it is working for a chemical supplier like Solenis or working for a manufacturer like Verso. The need now in the industry is for new engineers," Gregory says.◆

Two alums who changed our world

THE COLLEGE OF ENGINEERING ***is proud to have presented these outstanding Black Bears with the Edward T. Bryand Distinguished Engineer Award — Frank Woodard in 2001 and Chuck Peddle when he visited campus in April 2019.***

Chuck Peddle

CHUCK PEDDLE, a Maine native who graduated in 1959 with a degree in engineering physics, led the development of a revolutionary microprocessor — the 6502 — that ultimately made personal computers possible.

Peddle died Dec. 15, 2019 in California at the age of 82.

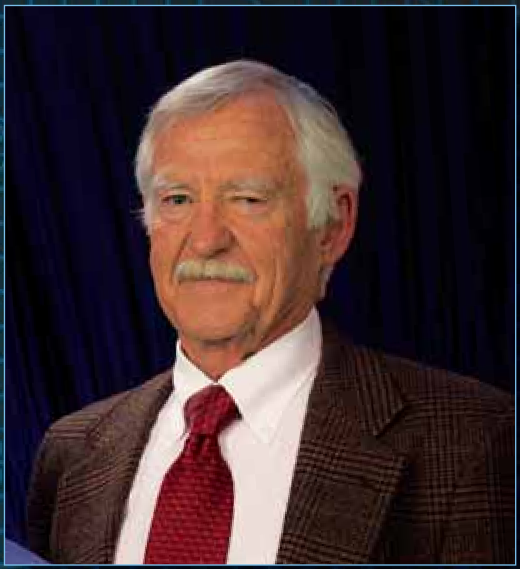
It was as a UMaine undergraduate that Peddle was introduced to "computer language" and its possibilities. "I was convinced computers were the future," he said in a 2019 interview. "I knew I wanted to do computers for the rest of my life."

After serving in the Marine Corps, Peddle worked 11 years for General Electric. He then joined Motorola and led the design of an early microprocessor, the 6800.

Peddle and a team of engineers were determined to make cost-effective microprocessors that consumers could afford. They created the 6502 at MOS Technologies, which was purchased soon after by Commodore Business Machines.

His vision and innovation launched the age of personal computing and gaming.

"We took an idea and created an industry — a big industry," said Peddle, whose microprocessor drove the most successful personal computers of the 1970s and early 1980s.



Frank Woodard

Alumnus and College of Engineering faculty member **FRANK WOODARD,** co-founder of Woodard & Curran, an environmental engineering consulting company, died in Maine on March 14, 2020, at the age of 80.

The Maine native graduated from UMaine in 1961 with a bachelor's degree in civil engineering and a master's two years later in environmental engineering. He also received a Ph.D. in environmental engineering from Purdue University.

The Franklin Woodard Environmental Engineering Laboratory in Boardman Hall is named in his honor.

After serving in the U.S. Army, Woodard taught for 12 years as a member of the UMaine engineering faculty. In 1979, he co-founded Woodard & Curran, which today has 100 locations nationwide.

Woodard wrote what is considered to be the seminal text on industrial waste treatment. He was a leader in the development of many of today's professional practices involving wastewater, water quality, hazardous waste, solid waste, air quality and permitting. ◆

Assistant professor of civil and environmental engineering Lauren Ross and her team are developing models to quantify residence times for particles in water in the Jordan and Medomak rivers. Based on stakeholder feedback, her research scope has expanded to model and sample the Union River, Sullivan estuary and other water bodies around Mount Desert Island.

Lauren Ross photo by Louise McGarry

Particle research tackles pollution longevity prediction in estuaries

Aiding **aquaculture**

Lauren Ross and her students spent 13 consecutive hours collecting data in the Jordan River on multiple occasions in the past couple of years. Half-day cruises in the five miles between Trenton and Lamoine allowed the assistant professor of civil and environmental engineering's team to gather water level and velocity data throughout the tidal cycle, along with salinity and temperature data.

The data validated a 3D numerical model that demonstrated how long water remains in the Jordan River before exchanging with adjacent coastal ocean or river flow. The model quantified the length of time it takes for a particle located in the estuary to exit, also known as residence time. This time scale is critical for understanding water quality, Ross says. Sohaib Alahmed, a Ph.D. student in coastal engineering, created the model so he, Ross and their team could help state officials improve their response to contamination threats in estuaries by providing enhanced predictions for how long pollutants could linger.

When a portion of an estuary experiences 2 or more inches of rain in 24 hours, the Maine Department of Marine Resources (DMR) typically shuts down shellfish harvesting in that area for two weeks or until it can be deemed clean through testing. Runoff can bring bacterial pollution from land into the water. Filter-feeding shellfish can ingest pollutants from runoff, and anyone who consumes those shellfish can become sick. Closures can last a couple of days or longer when heavy rainfall hits. Shellfish harvesting in some coastal water bodies stops when they experience 1 inch of rain in 24 hours.

Extensive closures can adversely affect the livelihoods of fishermen and aquaculture farmers for a whole season, Ross says. To help them and state regulators, she and UMaine faculty from the School of Earth and Climate Sciences are devising tools that will help predict pollutant travel in estuaries and enhance the scientific basis for shellfish closures in response to coastal runoff.

Their assistance could possibly offer an alternative evaluation to the 2 inches of rainfall in 24 hours benchmark, opportunities for shorter closures, and more insight into runoff pollution for fishermen and aquaculture farmers.

Building on previous studies from her colleagues, Ross and her team are quantifying residence times for particles in water in the Jordan and Medomak rivers and other estuaries. The project is supported by a $35,000 grant from the U.S. Geological Survey (USGS).

"We want to help stakeholders, aquaculture farmers and policymakers make decisions for how long farms should close due to pollution using science," Ross says.

Estuaries, like many bodies of water, are dynamic. How long water remains in one before flowing out can differ throughout the tidal cycle, seasons and levels of precipitation. Therefore, the models and data to validate them have to account for variations resulting from spring tide and neap tide, which involve relative positions of the sun and moon, low tide and high tide, which are affected by the moon's gravitational pull, salinity, and the wet and dry seasons, which affect changes in river flow.

Ross says she initially chose to study the Jordan and Medomak rivers because they have vastly different characteristics. The Jordan River has a "small nontidal watershed contributing freshwater flows to a straight rectangular channel," while the Medomak River, which begins in Liberty and flows into Muscongus Bay, has a "relatively large nontidal watershed of irregular shape with multiple subembayments that create more complicated hydraulic conditions," according to Ross.

Stakeholder feedback encouraged Ross to expand her scope to model and sample the Union River, Sullivan estuary and other water bodies around Mount Desert Island.

"It's really great that we are expanding our study area because of all of the different sizes, shapes and river flows found in the additional systems," Ross says. "It really gave us more of a wide variety of estuaries to consider."

Ross and her team began their research in 2018. When they started interacting with stakeholders, Alahmed began designing the model for the Jordan River and they began sampling data. Gwyneth Roberts, who wrote her Honors thesis with Ross, was awarded a UMaine Center for Undergraduate Research Summer Internship

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We want to help **stakeholders, aquaculture farmers and policymakers** make decisions for how long farms should close due to pollution using science."

Lauren Ross

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Clammers, aquaculture farmers, mussel fishermen, DMR officials and other **stakeholders reviewed the model and the team's findings.** Several aided Ross by identifying suitable testing locations, and speaking to them helped the UMaine scientist frame her research questions and discover the best way to share her findings with the public.

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Award to collect and analyze data collected from the Jordan River. Roberts, who was awarded Outstanding Undergraduate Student Contribution to Sustainability Research by the Senator George J. Mitchell Center for Sustainability Solutions, provided Alahmed with the processed data needed to validate his model.

Developing the 3D numerical model required several software programs, including TELEMAC, AutoCAD and others; existing data from the National Oceanic and Atmospheric Administration USGS and other repositories; and computing power from the computer cluster managed by the Advanced Computing Group at UMaine, Alahmed says.

The model for the Jordan River depicts the individual water particles moving through it. The particles in the model flow toward the mouth of the river connected to Frenchman Bay, moving back into the estuary when a theoretical tide pushes them, and looping through different sections as a result of the hydrodynamic forces at work and the complicated structure of the coastline.

Using the model, Alahmed, Ross and collaborating researchers can determine the residence time of particles in sections of the Jordan River. For instance, particles released from downstream near Crippens Brook during low tide and at low river discharge would remain in the river for about two days before entering Frenchman Bay. Therefore, a bacterial pollutant that enters the estuary around that location at those conditions would likely remain in the river for two days.

Their simulation also reveals flushing times, or the amount of time needed for the volume of water in an estuary to be completely renewed, for the Jordan River based on different moments in the tidal cycle and year. The model, for instance, found that only 20% of the particles released during low tide and low river discharge in the Jordan River remain in the system after approximately four days.

Alahmed also developed models for other estuaries, including the Sullivan estuary. The model for that estuary, which flows between the towns of Sullivan, Franklin and Hancock, allowed him and Ross to discern residence times for different quadrants and flushing times. This is useful in estuaries that have a complex shape, Ross says. For example, at the mid-reaches of the Sullivan estuary, there are reversing falls and the hydraulic conditions that change depending on whether someone is located upstream or downstream.

The portion of the estuary encompassing its mouth at Frenchman Bay, as an example, has a residence time of about five days at neap low tide and low river discharge. After nine days, about 80% of particles released in the Sullivan estuary exit into Frenchman Bay.

The model also reveals that some particles from the Sullivan estuary also flow into the Skillings River, which runs between the towns of Hancock and Lamoine. About 10% of the particles that flow out of the Sullivan estuary enter the Skillings River after about five days.

"I looked at how the actual particles and pollutants are transported through these estuaries," Alahmed says.

Once Alahmed crafted the models, he, Ross and her other students needed to determine their accuracy by sampling the estuaries they mimicked. If the salinity, water level and velocity of the water bodies mirrored that of the information used to create their models, they could advocate the residence and flushing time results from the models to stakeholders, Ross says.

They started with the estuary that inspired this project: the Jordan River. Ross' team attempts to obtain as many samples as possible to validate any model.

"It's so time intensive because we have to be on the boat for 13 hours at a time," she says. "We can't do that everywhere at all times, which is why the model results are so important. They allow us to extrapolate the data to a larger spatial domain."

Ross and her students dipped a Sontek Castaway conductivity temperature depth (CTD) profiler to collect temperature and salinity data from the Jordan River. The devices gather information from the surface to the bottom of the river, and throughout the tidal cycle. The red and orange bobbles, which resemble plump fishing lures, collected data during both high and low tide in the wet season in the spring and dry season in the fall.

Solinst Levelogger pressure sensors, shaped like long thermometers, were used to measure water levels and their variation throughout the tidal cycle. Measuring the velocity of the Jordan River required extra ingenuity from Ross and her students aboard the vessel. They used a Teledyne RDI Acoustic Doppler Current Profiler (ADCP), a cylindrical device, and towed it back and forth in a small red boat.

"I love it. It's my passion, really. It's why I went into this field," Ross says.

When compared with the samples Ross' team collected from the Jordan River, she and Alahmed found that his model was 99% accurate. Ross says the finding gave her confidence in the accuracy of the simulation. Alahmed was elated, saying he then knew the clammers, oyster farmers and other stakeholders would have a trustworthy tool.

"These people rely on these data. Giving people untrustworthy simulations is the last thing we want to do," Alahmed says.

Preliminary findings also supported Ross' conclusion that estuary geometry and forcing mechanisms influence residence time. For example, residence time in the Jordan River, a shallow, narrow and short water body, varies depending on the tidal phase, whether it experiences spring or neap tide, and the rate of discharge. On the other hand, the residence time for the Sullivan estuary, a long and narrow water body with complicated geometry, depends primarily on whether it experiences the spring or neap tide. The Union River, a wide and deep system, was found to completely depend on freshwater inflow.

"Every estuary is different, and they're all beautiful in their own ways," Ross says.

Clammers, aquaculture farmers, mussel fishermen, DMR officials and other stakeholders reviewed the model and the team's findings. Several aided Ross by identifying suitable testing locations, and speaking to them helped the UMaine scientist frame her research questions and discover the best way to share her findings with the public.

While Ross and her team presented their models as a tool for enhancing responses to bacterial pollution, some stakeholders found alternative uses for them. Officials from DMR believe the models could help plan mitigation efforts for harmful algal blooms, which can cause amnesic shellfish poisoning, and aquaculture farmers claim they could help them expand their operations, Ross says.

"It felt rewarding," Alahmed says. "I love seeing my work put into practice. This is our currency as scientists."

Fiona de Koning, co-owner of Acadia Aqua Farms in Trenton, says the research from Ross' group helped her and her husband, Theo, evaluate a new site for their farm. The mussel farming couple, who lent Ross and her students the boat they used to collect samples from the Jordan River, wanted to lease a new plot along the Mount Desert Narrows where they could install a collection system for mussel seed, but wanted to ensure the site would be suitable. The simulations helped the de Konings predict how mussel seed might travel in the narrows, and showed that their prospective site would support their collection system, Fiona de Koning says.

"I'm really grateful; really super grateful to work alongside (Ross)," she says. "If you've got the data to make decisions scientifically, you can avoid expensive trial and error."

Ross says she and her students must validate their other estuary models as they did with the Jordan River, including simulations for the Sullivan estuary, Union and Skillings rivers, through sampling. They recently worked with stakeholder, Graham Platner, owner and operator of Waukeag Neck Oyster farm in Sullivan to deploy an ADCP near his location to collect velocity data for a little more than a month. These and other similar data will be used to gain confidence in the model for a larger domain, Ross says.

Ross and her team will continue their work as part of a larger USGS project, funded at $249,985, to model harmful algal bloom (HAB) transport in the waterways and estuaries surrounding Mount Desert Island. Her research builds on the New England Sustainability Consortium's (NEST) Safe Beaches and Shellfish project, which shared the goal of providing tools that would help officials make science-based decisions when determining whether to close shellfish harvesting in response to bacterial pollution in estuaries.

One objective of the three-year project, executed by scientists from Maine and New Hampshire between 2013 and 2016, involved developing a bacterial pollution vulnerability analysis for more than 500 coastal water bodies by investigating and quantifying the pollution sources, deliveries and residence times. The analysis now includes about 2,000 locations along the coast as a result of ongoing development. NEST scientists also developed a decision support system with datasets and analytical tools to help natural resource managers and other officials make scientific-based decisions when responding to pollution in coastal waters.

UMaine NEST team member Sean Smith, an associate professor of the School of Earth and Climate Sciences, says Ross' work was "a game changer" for the ongoing research that arose from the Safe Beaches and Shellfish Project. Smith, who worked with Ross on her research, says she further enhanced quantifications for residence time in coastal estuaries, particularly by factoring in circulation and salinity. The models produced and tested by Ross, Alahmed and their colleagues could help advance both NEST's bacterial pollution vulnerability analysis for coastal water bodies and decision support systems.

"Lauren made the first thorough, consistent effort to quantify estuary dynamics while plugging in the residence time category," Smith says. "Lauren and Sohaib really helped us understand how that part of the story plays out." ◆

A clean, green focus

Ameresco founder George Sakellaris an energy industry leader

George Sakellaris '69, president and CEO of Ameresco, anticipates significant technological improvement in the efficiency of solar panels in the next decade. Pictured here with Ameresco's MassDOT project. Photo courtesy of Ameresco

GEORGE SAKELLARIS is the president and chief executive officer, and board chair of Ameresco Inc., a leading North American energy efficiency and renewable energy company headquartered in Framingham, Massachusetts.

Sakellaris earned a bachelor's degree in electrical engineering from the University of Maine in 1969, and received an honorary doctorate from his alma mater in 2012. He also holds an MBA and master's in electrical engineering from Northeastern University.

Sakellaris lives in Milford, Massachusetts with his wife, Catarina Papoulias Sakellaris. Their daughter, Christina, attends Stanford University and has been working full time for Ameresco while studying remotely; their son, Peter, attends Virginia Tech, where he is on the baseball team.

For nearly 40 years, Sakellaris has been a leader in the energy industry. He founded Ameresco in 2000 as a product-neutral and supplier-independent energy company. The company went public in 2010, and continued to focus on providing energy-efficient, renewable solutions to organizations it serves, all in pursuit of a sustainable future with the development of clean, green energy sources. Today, his company is leading nearly 200 projects nationwide.

We asked Sakellaris to talk about his company's approach to renewable energy and green technology, and how engineers are addressing climate change-related challenges.

In the past decade, what have been three of the most pivotal drivers in the renewable energy industry?

What made climate change-impacting initiatives move primarily was what I would call "enabling legislation" on the federal and state levels. You can see more solar plants or wind farms with the help of renewable energy credits, tax credits and other incentives. At Ameresco, we have been lobbying at the federal and state levels to be able to promote these initiatives and programs.

Secondly, the technological evolution we have seen for the last one or two decades has been important, resulting in improvements in technical and economic efficiency. Take the wind power industry, with improved technology in turbines, blades and more. Similarly with solar, we've come to a point that in many parts of the country, it can compete with electric rates.

Another piece of the puzzle: improvements in battery storage and other effective storage. Ten years down the road, advanced batteries might be one of the ways you store energy. And there will be many others. It might be hydrogen, it might be the flywheel. Or somebody might come up with some better idea. But ultimately, I think the puzzle is going to be put together by having an effective and economic way of storing electricity.

Let's also be clear: consumer demand also has made climate change-impacting initiatives occur. They have become more environmentally aware. And as a result, you see more and more companies developing plans to go carbon free by 2050, or 50% reduction of their carbon footprint by a certain number of years. When Ameresco started out, we were talking to consumers about energy efficiency, but few paid too much attention. Now everyone has come to realize that it's important for them and for the planet.

What are some of your company's most recent points of pride?

This summer, our project at the United States Marine Corps Recruit Depot (MCRD) Parris Island received a Top Project of the Year Award in the Environment + Energy Leader Awards program. The MCRD Parris Island project was cited as a leading example of the innovative work being done today in the fields of energy and environmental management. In June 2019, Ameresco completed a comprehensive energy resiliency project at MCRD Parris Island, which included the development of distributed generation, energy storage and secure microgrid controls.

Also this summer, Ameresco received Frost & Sullivan's 2020 Global Company of the Year Award as a leader in the global distributed energy resources (DER) market. Ameresco has implemented a large, diverse number of DER installations across North America and Europe.

In Phoenix, we built the largest green gas — RNG or renewable natural gas — as part of a sewage treatment plant. Also this year, that project received an honorable mention in Fast Company's 2020 World Changing Ideas Awards in the energy category. The awards honor businesses, policies, projects and concepts that are actively engaged and deeply committed to solving the climate crisis, social injustice and economic inequality. The facility is the largest wastewater treatment biogas-to-RNG facility of its kind in the country.

What's next?

Many of the gas utilities want to decarbonize their pipelines. The only way they can do it is with green renewable gas. It's the next evolution we expect to see in renewable technologies. We built the plant in Phoenix and now have six more planned. Tremendous, tremendous potential there.

We're also working with a couple of universities to help get them to 100% carbon neutral. I think those are great, great projects. We're talking to other universities about being their energy provider. It's a new concept, known as Energy as a Service, or EaaS, providing for their energy needs, operating and maintaining their HVAC system, combined heat and power.

And at Fort Bragg, we're developing a floating solar plant on a lake.

In the next 10 years, we will see a big technological improvement in the efficiency of the solar industry. There will be more distributed generation, more localized, smaller-sized solar plants, and smaller-sized combined heat and power plants. More distributed, local power. And some kind of mega storage.

What is your advice to students who are beginning their engineering careers at the University of Maine today?

Get involved in the climate change-remediation initiatives. Participate in one of the biggest transformations in the electric industry and the same with the gas distribution industry. It will be a huge transformation, comparable to what happened to the internet and telecommunications.

The next revolution will happen to the electric industry. Smart buildings, nanotechnologies, whether it is the communication back to a central location or the smart cities or battery storage, hydrogen. So many things that happen in that space will keep them very, very interested, rather than building transmission lines to the central power plant, which was back 10 years ago. Now you're building smaller, remote units. Now they have to communicate with each other.

It's a great time to be a student in this field where electrical engineering, mechanical engineering and communications will merge, because you need them all. ◆

Evergreen AI

Developing new wireless sensor networks to monitor, forecast dynamics of New England's forests

New technology to enhance scientists' understanding of the complex yet highly dynamic Northern New England forests began its first trial in a flowerpot.

Ali Abedi, a professor of electrical and computer engineering at the University of Maine, tasked his new wireless sensor with gathering soil moisture data and sending it to a computer in his lab in mid-April, one of multiple tests for the prototype. The device, with rubber-coated wires connecting a red converter and two metal prongs, and its development will lay the groundwork for a multi-institutional effort to assess and forecast changes in 26 million acres of New England forestland.

Researchers from UMaine, the University of New Hampshire and the University of Vermont have joined forces to create a digital framework capable of gathering near real-time data about the forests spanning the northern portions of their respective states and New York — the Northern Forest Region. The digital framework will consist of many small networks of wireless sensors spread across the region. Governed by artificial intelligence, the sensors will collect data about soil moisture, soil temperature, ambient temperature, carbon dioxide, sunlight exposure and other characteristics; and communicate with each other to create a cohesive, regulated and self-monitoring network.

Abedi, who also serves as associate vice president for research and director of UMaine's Center for Undergraduate Research, leads development of the new sensor technology that serves as the first phase of the multiyear interuniversity

Electrical and computer engineering professors Bruce Segee, left, and Ali Abedi are leading the development of new sensor technology in the first phase of a multiyear project — Intelligent Informatics and Smart Data for Improved Understanding of Northern Forest Ecosystem Resilience (INSPIRES). The initiative, funded by a $6 million award from the National Science Foundation, involves networks of wireless sensors collecting data on the Northern forest region. Photo by Adam Küykendall

project, Leveraging Intelligent Informatics and Smart Data for Improved Understanding of Northern Forest Ecosystem Resilience (INSPIRES), which was awarded a $6 million National Science Foundation grant in 2019. Aaron Weiskittel, UMaine professor of forest biometrics and modeling, and Irving Chair of Forest Ecosystem Management, is the principal investigator.

The Advanced Computing Group, directed by UMaine electrical and computer engineering professor Bruce Segee, will work with Abedi to connect the wireless sensor network to the University of Maine System computer cluster in Neville Hall, which will serve as a data repository. A team from WiSe-Net, which Abedi directs, will help develop the sensor networks. Members include Sonia Naderi, a Ph.D. student and project manager for the network design, and Kenneth Bundy, a former master's student, now at University of Maine at Augusta, who are helping create machine learning algorithms.

Undergraduate students also will help craft the system hardware and power management technology, says Abedi, co-principal investigator for INSPIRES.

"I think it's exciting because it's close to home here in Maine," he says. "We live in the forests. It's important to understand what we have."

Current technology used to capture near real-time and high-resolution data for forests at broad spatial and temporal scales can vary in quality and availability, according to researchers participating in INSPIRES. The information obtained can also lack the specificity desired by scientists, land managers and policymakers.

Furthermore, the tools can prove costly, Abedi says. For example, one sensor unit station in the Northern Forest Region that collects research data costs hundreds of thousands of dollars, and the extent of information provided from it is limited. Abedi, therefore, aspires to develop wireless sensors with hardware and software that cost only a few hundred dollars. Deploying several small wireless sensor networks, which Abedi says he hopes researchers could use anywhere, would help capture and encode more data than possible with existing technology.

The Advanced Computing Group has already begun creating the digital infrastructure needed for sensors to transmit data to the UMS computer cluster. With 20 years of operation and updates, propelled by the formal creation of the Advanced Computing Group in 2013, Segee says the cluster should suit the needs of archiving and processing forest data. One challenge the computing group and colleagues in INSPIRES will have to overcome involves transmitting data to the cluster from remote areas with few or no overhead wires, cell towers, or other telecommunications infrastructure.

"The idea of a small, low-cost battery-operated wireless sensor communication is pretty darn cool," Segee says. "It is really a question of 'what can we do at this scale in a reasonable way?' Ideally, to understand the forest ecosystem, you want as many data points as possible. If the infrastructure costs $50,000 apiece, it's just not going to be deployed at a scale that is useful."

The prototype sensor contains a 12-bit analog to digital converter, features a resolution of 4.88 millivolts and consumes a few milliamperes of power. It generates electrical signals through chemical reactions that carry the ecological and geological data every hour. Sensor nodes digitize the information, code it in binary and send it to the microprocessor, which communicates with a radio to transmit data. The microprocessor determines the optimal time for data delivery.

Solar energy powers Abedi's wireless sensors. Some will possess their own solar-powered batteries, while others will connect to and share a photovoltaic panel that provides electricity.

In the spring, WiSe-Net students conducted initial tests for the prototype sensor. The first test involved gathering soil moisture data from a potted plant. The student team then

Tapping into **expertise in data science, ecology, electrical engineering, computer programming and communications from three institutions,** INSPIRES will help track and predict how the Northern Forest Region evolves.

evaluated the accuracy of the samples gathered from wet soil and dry soil.

They conducted a range test involving tracking the signal strength of a sensor in the forest that communicated with a laptop serving as base station. The test, Abedi says, allowed the team to determine whether the existing hardware and software were suitable, or whether a different antenna, amplifier or any other component was needed.

The student team found that signal strength between the sensor and the laptop remained suitable as far as 175 feet with no external antenna.

The students also tested the power system in his sensor in mid-April, and how it varied based on different weather conditions. They found that from April 9–14, which exhibited shifts between sunny and cloudy weather, rain and light snow, the sensor had an average power range of 2.5–4.6 watts.

"The experiments conducted by students demonstrated promising results, guiding us to develop a functional system in the near future," Abedi says.

INSPIRES researchers will place the sensors at different heights in forests, from the ground to the canopy, as well as at different soil depths. Abedi says his team will determine how to adjust wireless channel models for sending data based on sensor height. The models also will help predict when and how sensors transmit information.

"It's a big deal, the ability to tie the physical world into computers in real time, or near real time," Segee says. "The notion that you would be able to ingest live data from a large number of sources has implications for understanding the forests, understanding the weather, understanding ocean ecosystems."

Abedi says his students also plan to develop an AI program that will operate and oversee the wireless sensor networks. AI would monitor network performance and stability, the communication channels used to transmit data, sensors' battery levels and other system components.

Machine learning will determine when the sensors collect and transmit data, and when to halt information gathering to conserve battery life and help researchers make sense of the data, Abedi says. For example, they should be able to slow data collection during inclement weather, or reduce the number of times they transmit information to whenever they will have enough sunlight. They should also be able to adjust data transmission behavior to prevent any interference with each other.

"We need to be smart in terms of how we coordinate the network in data collection," Abedi says.

Researchers will next test the efficacy of Abedi's sensor against existing, more expensive technology. They also will perform lab fit tests and field tests in Old Town, the Howland Research Forest and other areas across Maine, New Hampshire and Vermont. According to Abedi, the multi-institutional team hopes to begin mass producing the sensors next year, deploying them across Northern New England the following year and begin collecting data the year after.

"This is a great example of interstate, interuniversity collaboration," Segee says.

Climate change and other shifting environmental conditions, natural disturbances such as the pending spruce budworm outbreak, and differences in land ownership and management make New England's forests dynamic and diverse. Communities across the region rely on forestland to support their economies, biodiversity and recreation. Understanding how forests change over time helps policymakers, land owners and scientists take actions that ensure their viability.

Tapping into expertise in data science, ecology, electrical engineering, computer programming and communications from three institutions, INSPIRES will help track and predict how the Northern Forest Region evolves. The digital framework it creates using emerging computational, monitoring, remote sensing and visualization technologies, such as Abedi's wireless sensor networks, will yield critical real-time data vital for analyzing the integrity and resilience of New England forests.

The data collected from wireless sensors will support the development and enhancement of forest models from the Center for Research on Sustainable Forests, like the ecological models PnET-II and the Forest Vegetation Simulator, used to forecast the effects of climate change, deforestation and other stressors.

Segee says the ability to use large data acquired in near real time for predictive modeling is "revolutionary."

"It would be interesting to know all the temperatures over the course of a day at some particular point on Earth. You may want to know the temperatures of different places at different points in time," Segee says. "Combine all that and you begin to understand how a forest is working."

Wireless sensors offer a variety of applications, Abedi says, and participating in the INSPIRES initiative means evaluating a new use for them. During 15 years of research and development at UMaine, the engineering professor created sensors used in a medical device that measures sleep movement patterns to detect brain injury, created a leak detection system with wireless sensors that the International Space Station uses, and developed other new tools with sensor technology.

Abedi says for several years he discussed the prospect of using wireless sensor technology for forest research with Weiskittel. With INSPIRES under way, Abedi says he is eager to contribute to Maine's rural economy and environment.

"Forests vary dramatically over space and time, particularly in New England. These new sensors will greatly improve our ability to understand them at relevant scales and I am very excited that they may lead to new avenues of research," says Weiskittel, who is leading INSPIRES. ◆

Harnessing offshore wind power

Engineering faculty lead global advances in efficiency, cost-effectiveness of floating turbine technology

A 20-meter — 65-foot — tall floating wind turbine off the coast of Castine harnessed gusts blowing across Penobscot Bay to generate electricity between 2013 and 2014. The turbine, sitting atop a floating concrete hull anchored to the bay floor about 20 meters deep sent power to the electric grid through an undersea cable for 18 months, even during storms and other inclement weather.

Led by Habib Dagher, engineers from the University of Maine's Advanced Structures and Composites Center developed the floating turbine hull, known as the VolturnUS. The 1:8 scale model deployed off Castine was the first grid-connected offshore wind turbine in the Americas. The success of the VolturnUS propelled the Composites Center's ongoing efforts to enhance floating offshore-wind technology and reduce the cost of offshore wind.

The National Renewable Energy Laboratory (NREL) found in 2018 that Maine has the seventh largest offshore wind resource in the nation. It can generate enough electricity to meet the state's entire power needs, and supply extra electricity to New Hampshire and Massachusetts. The most economically viable offshore wind resource, however, exists in waters deeper than 60 meters, or 197 feet; too deep for fixed-bottom offshore wind towers, according to NREL. Wind turbines, mounted on floating hulls anchored to the seabed can harness those winds far from the coast.

Andrew Goupee says the question of how to harness the state's offshore wind resource in deep waters drives his research and projects from faculty from the Composites Center and College of Engineering. The associate professor of mechanical engineering worked on the VolturnUS and other projects at the Composites Center for 10 years, primarily in modeling and validation.

Offshore wind offers a clean, renewable, cost-effective energy source that could foster energy independence for Maine, offset transmission costs and provide opportunities for economic development, says Goupee, a Composites Center cooperating faculty member. While Goupee says many advancements will need to occur to make floating offshore wind technology viable, Composites Center and other UMaine researchers have several projects lined up to provide a few of them.

"For Maine, it's really starting to hit home that we consume a lot of energy per capita, and a lot of it is heating homes," Goupee says. "(Offshore wind is an) opportunity to create a huge dent covering the energy consumption we have in Maine."

Changes in the wind and waves, as well as other natural

VolturnUS is UMaine's patented floating concrete hull technology that has been awarded 43 patents in the U.S. and abroad. In August, it was announced that the University of Maine will collaborate with New England Aqua Ventus, LLC (NEAV), a joint venture between Diamond Offshore Wind, a subsidiary of the Mitsubishi Corporation, and RWE Renewables, the second-largest company in offshore wind globally, to develop UMaine's floating offshore wind technology demonstration project off the coast of Maine.

forces, can inhibit floating turbines from generating energy by moving their platforms around, bending the towers and overtaxing the rotors and blades. Even if turbines can capture an extensive wind resource, complications from external or internal forces, or loads, can reduce overall performance and power production.

Developers strive to balance the needs for wind capture and managing stress from loads to achieve efficient electricity generation and cost effectiveness, Goupee says. Researchers from the Composites Center, and cooperating faculty like Goupee, explore technical enhancements that can better manage high-speed winds, rocky waves, mechanical limitations, gravity and other stressors.

Goupee, Eben Lenfest, who was the 2019 Outstanding Graduating Student in the College of Engineering, and colleagues from NREL researched a strategy for minimizing platform movement last summer that designers could apply to a broad variety of turbine and platform configurations. They focused on improving the turbine controller, a computer system that gathers environmental and machine performance data, and regulates turbine operations like blade angle and rotation. The controller must balance the need to produce power while managing fatigue from external and internal forces, according to the researchers.

The UMaine and NREL team found that incorporating velocity feedback gain from the nacelle, the oval hub at the top of the tower that houses several turbine components, including the controller, could help turbines negate the disrupting force of undulating waters, wind shear and other disturbances. Goupee's group tuned the controller to incorporate nacelle movement in its operational decision making.

The strategy helped the controller stabilize the turbines as they faced different stressors during testing, preventing a loss in power generation. UMaine engineers are exploring stabilization tactics used in onshore wind turbines like this one to determine whether they apply to floating offshore wind turbines, Goupee says.

"This controller strategy builds on previous research and opens another avenue to optimize the performance of floating wind turbines," Lenfest says.

Goupee, Lenfest and their colleagues presented the findings from their research, funded by a $96,000 award from the National Science Foundation, in a conference paper incorporated in the proceedings for the 2020 International Conference on Ocean, Offshore, and Arctic Engineering, held virtually in August.

In addition to applying existing tactics in new ways, Composites Center researchers explore new technology to help increase the stability of floating turbines. One project, awarded $1.4 million in grant funding, involves incorporating equipment developed by NASA. Anthony Viselli, manager of offshore model testing and structural design at the Composites Center, serves as principal investigator and Chris Allen, a senior research engineer at the Composites Center, serves as a co-principal investigator.

UMaine researchers will develop a turbine that will use motion mitigation equipment created by NASA that decreases rocket vibrations. The technology should reduce floating turbine movement, which could help make turbines more efficient, permit the use of lighter platforms and decrease the levelized cost of energy, or cost to produce a single unit of energy.

Goupee says the NASA motion mitigation technology can help create a lighter and more cost-effective system in an unconventional way, and help make the U.S. more competitive in the world market for offshore wind development. UMaine researchers, however, will "have to get creative" when determining how the controls will interact with the overall system, Goupee says.

"There are new possibilities, but also new challenges," he says. "We're trying to find the best way to leverage this damping technology."

Platform technology plays a crucial role in stabilizing floating turbines and ensuring optimal energy production. UMaine engineers have studied methods for developing and improving platforms since they created VolturnUS.

In an effort to reduce the footprint and improve the efficiency of an upcoming floating offshore wind demonstration project, Composites Center researchers will develop a newer, larger platform to support it. The 10–12 megawatt project, planned for deployment near Monhegan Island, previously included two floating substructures to support two turbines. After receiving a $5.9 million grant from the U.S. Department of Energy, Composites Center researchers

For associate professor of mechanical engineering Andrew Goupee, left, and graduate student Eben Lenfest, developing new technology to help increase the stability of floating turbines is key to helping harness the state's offshore wind resource. Photo by Adam Küykendall

The NASA motion mitigation technology can **help create a lighter and more cost-effective system in an unconventional way and help make the U.S. more competitive** in the world market for offshore wind development.

can now explore methods for supporting a single, larger turbine on one platform that would feature a similar output as the two earlier models.

Goupee will provide a supportive role for the project. UMaine deploys large teams of researchers to advance offshore wind technology, he says, but they consist of recurring participants who have worked together for years.

"It's sort of an all hands on deck effort," Goupee says. "We're a big team, and as a result, we've been very successful in doing big projects."

Engineers rely on detailed, extensive data sets and simulation tools to develop offshore wind energy facilities. The Composites Center and cooperating UMaine faculty endeavor to enhance both through a couple of other upcoming projects.

Goupee and Lenfest plan to develop updates for the offshore wind farm open-source computer-aided-engineering simulation tool FAST.Farm. Enhancements to the online tool, developed by NREL, would allow offshore wind developers to simulate advanced control system methodologies for turbines.

"Wind turbines have all kinds of control systems," Goupee says. "It's all about power management."

Control systems help prevent turbines from overloading as they generate electricity, Goupee says. The updates to FAST.Farm would allow developers to simulate novel active turbine blade pitches, generator torque, nacelle yaw and fluid structure coupling control architectures. FAST.Farm provides simulations for whole wind farm systems.

Goupee says performing controls across an entire wind farm, particularly through schemes like wake steering, can mitigate energy losses from downstream turbines running in the wakes of upstream turbines. He also wants designers to be able to simulate control systems for each individual floating turbine in a system.

He and Lenfest will travel to NREL's National Wind Technology Center, Boulder, Colorado, to work on the project in summer 2021.

"FAST.Farm provides a very holistic view of offshore wind projects, so it's really neat to be able to help refine this tool and give wind turbine designers a better idea of how things will work in the real world," Lenfest says.

UMaine Composite Center researchers, including Viselli, Goupee, Matt Fowler and Rich Kimball, and NREL also will create the first public floating offshore wind turbine scale-model datasets to feature advanced turbine controls, floating hull load mitigation technology and hull flexibility. The endeavor, known as the Floating Offshore-wind and Controls Advanced Laboratory (FOCAL) experimental program,will produce data sets involving controls, flexibility and load mitigation in four model-scale campaigns, with a model that will replicate a 15-megawatt floating offshore wind turbine, in the Alfond W^2 Ocean Engineering Lab. Viselli serves as principal investigator for the project.

"This has never been done," Goupee says. "If we can do it, and do it well, we can generate a high-quality data set coming out of UMaine."

Research projects and the facilities at the Composites Center, including the Alfond W^2 Ocean Engineering Lab, the reaction wall for wind blade testing and Hastest Solutions Environmental Test Chamber, also for wind turbine blades, provide ample opportunities for hands-on learning. Goupee says his graduate students, some who eventually become center staff, perform simulations, crunch test data and complete other tasks to support UMaine development projects as they learn.

"Probably the most enjoyable aspect (of my role) is working with young folk who are excited about research," Goupee says, "and helping them get where they want to go."

Efforts to improve the efficiency and cost effectiveness of floating offshore wind technology requires engineers' entire arsenal of knowledge — from introductory lessons learned in freshman-level curricula to insight gathered through graduate and doctoral research, Goupee says. Basic principles he teaches in freshman and sophomore engineering classes, such as equilibrium, the need for balance across all forces; relative motion analysis, the energy of work and simple thermodynamics, play crucial roles in his research and development.

"There's lots of just really low-level, fundamental physics ideas that are super helpful day in and day out," he says. "You're kind of using your whole toolkit as an engineer."

When former Gov. John Baldacci and his Maine Ocean Energy Task Force in 2009 called for the state to work toward installing 5 gigawatts of offshore wind facilities by the end of 2030, and most recently, when Gov. Janet Mills asked, the Composites Center answered. The work of its researchers and cooperating faculty from the college helps advance an industry with untapped potential and assists the state in reaching its long-term renewable energy goals. ◆

University of Maine Climate Change Institute researchers, left to right, Mariusz Potocki, Paul Mayewski and Heather Clifford with an ice core retrieved on Mount Everest in 2019 with the help of ice core drill technology retrofitted by engineers in the Advanced Manufacturing Center on campus. Photo by Adam Küykendall

Core strength

Scientists in the University of Maine Climate Change Institute (CCI) are conducting some of the world's most important research about our planet's past to better inform our future.

And for at least two decades, UMaine engineers in the Advanced Manufacturing Center (AMC) have been among their key collaborators, retrofitting ice core drills that have been used on glaciers and ice sheets worldwide, as well as other field equipment.

"They are a valuable and necessary partner," says Daniel Dixon, a CCI research assistant professor who has been working with AMC engineers since 2000.

"They work on some aspect of our field equipment at least once or twice a year — doing modifications to cutting heads and teeth, core dogs, in addition to the other sampling equipment. And they're in the labs more than that — from building melt heads to an ICP-MS laser system that can sample cores at the highest resolution in the world. And the list goes on.

"It's a full-on collaboration, brainstorming what in an ideal world we want (and need), and them telling us from an engineering perspective what's possible," Dixon says. "Without them, we would not have access to the level of expertise we need."

That engineering innovation achieved great heights last year as part of the National Geographic and Rolex Perpetual Planet Everest Expedition, led by CCI director and internationally recognized explorer Paul Mayewski.

CCI researchers needed ice coring equipment light enough to be carried up Mount Everest. It also had to be rugged enough to endure severe conditions and work in a variety of snow and ice conditions.

In preparation for the expedition, the climate change researchers trialed an off-the-shelf ice core drill in Iceland, then returned to campus to talk to AMC project managers Kyle Forsythe and Forest Wentworth about the modifications needed — and the expected outcomes of the equipment.

Forsythe and Wentworth have retrofitted CCI ice-coring systems before. In this case, they made three off-the-shelf ice-coring systems lighter, altered the drill heads and made holes in the barrels to preclude ice chip jams.

One system was used at base camp, and the climbing team took two up the mountain. Each 33-pound system included extensions, drills of various sizes and shapes, toolkits and batteries.

CCI glaciochemist Mariusz Potocki said the revamped equipment performed perfectly as he collected the highest ice core in the world on South Col at 26,321 feet.

Wentworth, who majored in mechanical engineering technology at UMaine, says the expedition's success reminded him of how special his job is.

Forsythe, who earned a degree in engineering physics in Orono, says he's gratified to have had a hand in the consequential project.

The innovation projects for CCI continue to grow in complexity, Dixon says, including the thermal drill now under development for use on temperate glaciers — "when there's water everywhere and when things can get difficult."

AMC provides an invaluable service, he says.

"Some of our research would not have taken place if not for access to that facility and that expertise," says Dixon. ◆

Early lead

IN FALL 2020, Zoe Vittum of Brewer, Maine, enrolled at the University of Maine as a full-time undergraduate. And a sophomore in biomedical engineering.

Vittum's participation in UMaine's Early College program resulted in earning more than 50 credit hours by the time she graduated from Brewer High School. She focused on her general education requirements in engineering — from physics and calculus to English 101 — so she could jump right into her biomedical engineering coursework, which she describes as "more hands-on than almost every other college that offers biomedical engineering as an undergraduate degree."

She also continues her work as a student researcher at UMaine's Advanced Manufacturing Center in her long-held passion for robotics. Vittum is a member of Black Bear Robotics and the NASA Robotics Mining Challenge teams. And she is on the outreach committee of the UMaine chapter of the Society of Women Engineers.

Summer 2021, Vittum will be doing a research internship at Jackson Laboratory.

When asked to describe the UMaine student engineering experience in one word, she said: individual.

There's so much going on in the College of Engineering and students have so many experiential learning opportunities that can make their UMaine experiences different, Vittum says.

"There are so many opportunities within UMaine engineering, from research, to clubs, to courses, to minor options that no two people have taken advantage of the same ones," she says. "This allows every student to focus on what they want and make their knowledge base unique to what they want to do and who they are, which is really important when trying to stand out to future employers or schools."

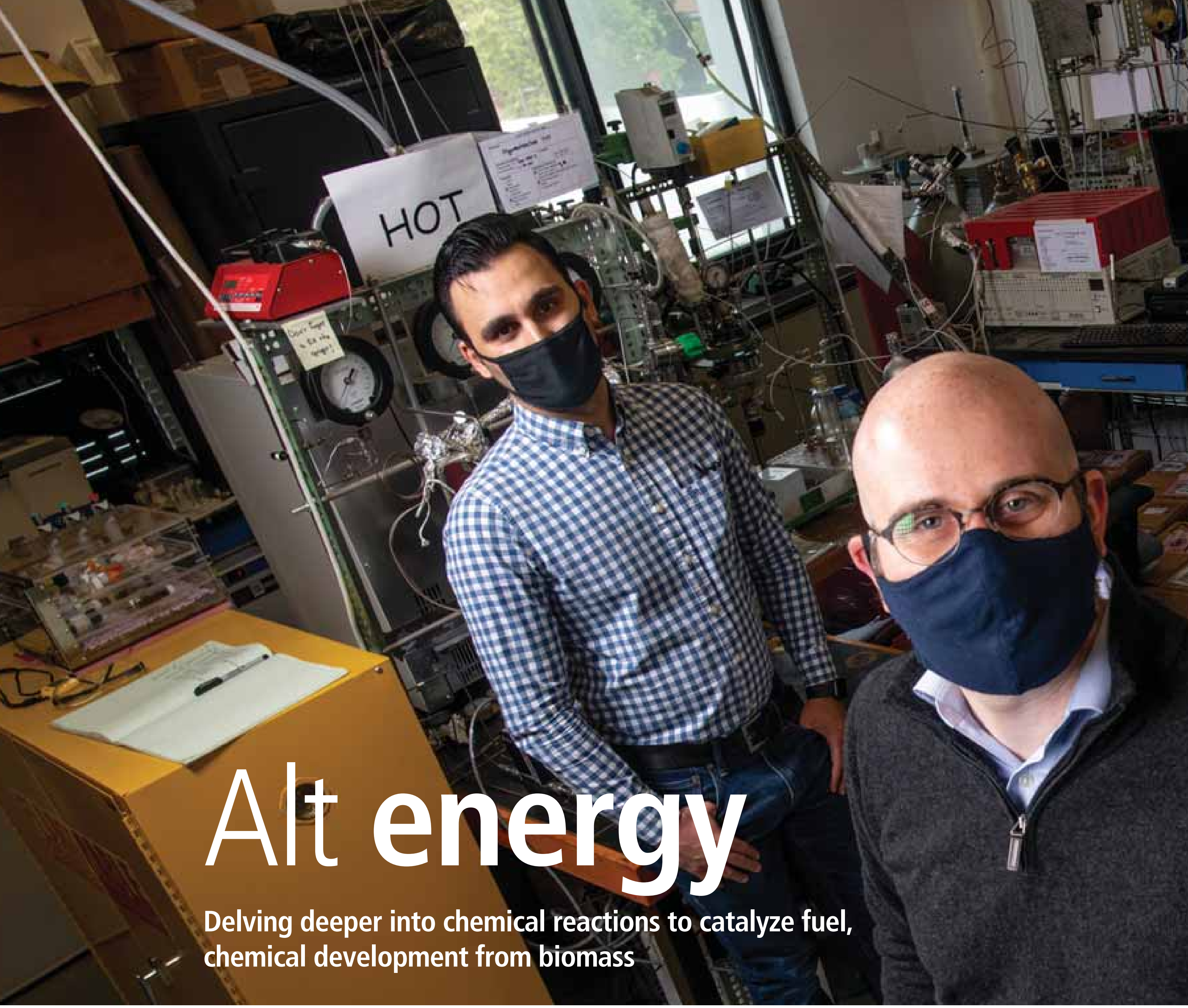
Her favorite classes so far? Calculus I–III with lecturer Paul Van Steenberghe. "Having a strong understanding of math is absolutely vital in engineering and Steenberghe did an amazing job teaching us not only how to do the math, but how to use the math and how we will see it used in our futures," she says.

The academic atmosphere at UMaine is very hands-on and real-world preparation-based, says Vittum. It's clear that the UMaine undergraduate engineering curricula and professors have this in mind when designing and structuring classes. It also is evident in the number of opportunities for undergraduate research on campus.

"UMaine's academic atmosphere and the opportunities for undergraduate research are some of the biggest reasons why I and many other students have chosen UMaine," Vittum says. "UMaine has given me opportunities to challenge myself academically and excel in what I enjoy learning about."

Early College opportunities while still in high school "allowed me to design that path to best fit my needs and capabilities," she says. "UMaine is giving students a way to make progress toward their future, which makes a huge difference in the lives of students like me." ◆

Zoe Vittum. Photo by Adam Küykendall



Alt **energy**

Delving deeper into chemical reactions to catalyze fuel, chemical development from biomass

Another international oil crisis had peaked when Thomas Schwartz enrolled at the University of Maine in 2006. The critical lack of supply to meet demand during that time stands out in his mind as he pursues research to advance the transition away from using fossil resources as feedstocks for plastics, fuels and chemicals, even after the oil and gas industry discovered new methods for extracting the finite resource.

Schwartz, now a UMaine assistant professor of chemical engineering, has turned to biomass as an alternative to finite petroleum and natural gas, a view shared by several manufacturers and other researchers. Biomass, including wood and forest waste, sugarcane bagasse and switchgrass, is renewable and can decompose, which can reduce the influx of waste piling up in landfills, Schwartz says.

Despite the production of goods from carbon-based feedstocks like biomass and petroleum for more than a century, scientists are still learning more about these chemical processes on a molecular level. Schwartz's research delves deeper into these processes, unraveling the inner workings of the chemical reactions that help create chemicals and fuels from petroleum, natural gas and biomass. Learning every step in these chemical reactions will help Schwartz discover enhanced methods for creating products from biomass.

Assistant professor Thomas Schwartz, head of the UMaine Catalysis Group, studies the production of chemicals and fuels from biomass. His group primarily delves into the inner workings of the chemical reactions involved in making these products, typically manufactured using fossil fuels. By understanding the processes involved in making these goods on a detailed level, focusing on catalysts in the chemical reactions, scientists can find better ways to make these goods with biomass. Team members with Schwartz, foreground, are, left to right, Hussein Abdulrazzaq, Elnaz Jamalzade and Chayton Boucher.
Photo by Adam Küykendall

The chemical engineering professor founded the UMaine Catalysis Group to explore the intricacies of catalysts and the roles they play in chemical reactions involved in making fuels and chemicals from carbon-based feedstocks. The team, which includes undergraduate and graduate students, strives to ascertain at a molecular level the processes that occur on catalytic surfaces during conversion. They delve into heterogeneous catalysis, when the catalyst and reactants differ in phase of matter; reaction kinetics, the rate at which reactions occur; why a reaction occurs and "how chemical bonds between atoms are broken or formed."

"If you understand that and why a catalyst works the way it does, you can sort of rationally design improved catalysts" and materials, says Schwartz, who also works with the Frontier Institute of Research in Sensor Technologies (FIRST). “None of these reactions happen by themselves. They all require a catalyst.”

While manufacturers have created gasoline, diesel, lubricants, fuel additives and plastics from petroleum and natural gas for decades, the chemical structures of these carbon-based feedstocks have limitations that biomass can overcome.

Fossil fuels possess only hydrogen and carbon atoms, yet manufacturers require other elements, particularly oxygen and nitrogen, to make plastics and high-value chemicals, Schwartz says. Oxygen can be incorporated into the chemical structures of fossil fuel feedstocks, but only under very carefully controlled conditions to avoid burning away the essential hydrocarbons. Despite possessing plentiful energy, crude oil, natural gas and other fossil resources are less reactive than other carbon-based feedstocks like biomass, and converting them to plastic can be challenging.

Biomass contains an abundance of oxygen, an essential element for manufacturing several staple products, and other useful components. Creating plastics like polyethylene and polyurethane for cars from fossil fuels, for example, can be challenging because they lack oxygen and require additives, but biomass contains an ample supply. Selectively removing excess oxygen from biomass to create products remains a critical obstacle for scientists and serves as a major research thrust for the UMaine Catalysis Group.

Companies have been exploring replacing fossil fuel-derived products with goods manufactured with biomass, like an alternative to polyethylene terephthalate (PET), which is used to make plastic soda bottles. The replacement, polyethylene furanoate (PEF), can better hold carbon dioxide, thus improving the shelf life of a bottle of soda while also consisting of bio-based, renewable materials, Schwartz says.

“We’re looking at ways to take some of the chemical structure inherent in biomass and use that to our advantage,” he says. The goal is to find alternatives to traditional petroleum-derived resources in an economically viable way.

Schwartz earned bachelor’s degrees in both chemical and biological engineering from UMaine in 2010, and a Ph.D. in chemical engineering from the University of Wisconsin in 2015. He has conducted several studies over the years into the intricacies of chemical reactions that produce fuels and chemicals, with a focus on catalysis, discovering and designing improved catalysts and determining how to use them for biomass products.

Schwartz partners with other researchers from UMaine and beyond, including M. Clayton Wheeler, associate director of the Forest Bioproducts Research Institute (FBRI) and professor of chemical engineering, and Brian Frederick, an associate professor of chemistry who also works with FBRI and FIRST. While some help Schwartz enhance the knowledge of the inner workings of chemical reactions, others use his research for product development with biomass.

Catalytic reactions used in making fuels and chemicals from carbon-based feedstocks occur primarily in the gaseous phase, but reactions involved in biomass occur in the liquid phase, Schwartz says. Last year, he and collaborators at the University of Florida explored how reactions work in the liquid phase on a molecular level, particularly by researching the etherification of the very reactive molecule 5-hydroxymethylfurfural (HMF) and ethanol to create a crucial component for biodiesel fuel, ethoxymethylfurfural.

The team discovered through a combination of experimental kinetics measurements and computational catalysis that HMF and ethanol cross-etherify in one step instead of two steps by HMF protonating and dehydrating to form a methoxyfurfural carbocation. The process provides higher selectivity and yield than the previous state-of-the-art etherification of HMF and ethanol, Schwartz says.

The research team’s findings were published in ACS Catalysis.

Graduate students from the Department of Chemical and Biomedical Engineering, Department of Chemistry, FBRI and FIRST led a recent project exploring how to obtain butadiene from biomass-derived ethanol. Butadiene is used to create synthetic rubber for car tires and other products.

Harnessing butadiene from shale gas can be challenging, which has led to recent price increases as a result of declines in crude oil production, Schwartz says. Obtaining butadiene from ethanol requires a seven-step chemical reaction, and relies on a magnesia-silica mixed oxide catalyst. Despite being a common conversion process, Schwartz says little research has been conducted in understanding the process on a molecular level.

The UMaine researchers focused on studying the reaction kinetics of the first step in the process for obtaining butadiene from ethanol: converting ethanol to acetaldehyde and ethylene using magnesia-silica as a catalyst. Understanding the chemical reactions behind the process will help scientists develop improved methods for producing butadiene from biomass.

By facilitating catalysis using a model catalyst with a uniform, well-defined surface structure, Schwartz says the research team, led by graduate student Hussein Abdulrazzaq, was able to measure the rate of ethanol conversion and pinpoint the mechanism that allows ethanol to convert to acetaldehyde and ethylene.

“We’re the first to report (also in ACS Catalysis) on the mechanism for that reaction,” Schwartz says.

Abdulrazzaq, who recently defended his Ph.D. in chemical engineering, says converting ethanol to butadiene through a series of reactions known as the Lebedev

Chemistry Ph.D. student Elnaz Jamalzade joined the UMaine Catalysis Group in 2017. In her research, she has been developing catalysis used to convert Maine's forest biomass to bio-jet fuel.

process can be "very complicated, with many inconsistent mechanisms describing the reaction pathway of butadiene." The research project he led should broaden how chemists and engineers understand the process, particularly the mechanistic pathways for key reaction steps.

"Finding out that my research paper was going to be published in ACS Catalysis was a dream come true. I truly felt that I had contributed valuable time and knowledge to the industry, and it is an honor to have all of my hard work be recognized," says Abdulrazzaq.

The oil and gas industry has discovered new tactics for increasing access to their feedstocks since Schwartz studied at UMaine, including hydrofracking and horizontal drilling. These methods have helped increase the supply of oil, ending the most recent oil crisis, and igniting the shale gas booms in Pennsylvania, Texas and North Dakota, Schwartz says.

While processors and companies maintain access to an ample supply, crude oil and natural gas will diminish in the long-term. Much of what scientists know about catalysis has evolved from research for the fossil fuels and automotive emissions industries, Schwartz says.

The finite nature of fossil fuels, however, motivates Schwartz to continue his research. He says he would like to shift towards producing fuels and chemicals from renewable biomass, which could reduce plastic waste and carbon dioxide emissions by generating energy using waste biomass from goods production.

"We can't keep using all of this fossil-based carbon," Schwartz says. "While these are finite resources and we should be cognizant of that, the bigger problem is no longer just that we're running out of oil, it's that we can't use all of the oil we've found without destroying the planet." ◆

Aiding the **pandemic response**

UMAINE ALUMNA JULIA HOLMES O'NEILL '81 recently joined Moderna Therapeutics in Cambridge, Massachusetts as a Distinguished Fellow. She is leading the integration of statistical sciences throughout chemistry, manufacturing and control (CMC) functions, and serving as a member of the Technical Development Leadership and Management Team.

Her "dream job" brought together her chemical engineering education from UMaine; master of science in statistics from the University of Wisconsin – Madison; and her career expertise as a former director of engineering at Merck with the opportunity to address the global pandemic. O'Neill is contributing to readying the Moderna COVID vaccine for full-scale manufacturing and distribution at facilities in Massachusetts, New Hampshire and other sites, and helping to build systems for the pipeline of mRNA products. She is the founder and principal consultant of Direxa Consulting LLC. She lives with her husband, Joseph O'Neill, in Glenside, Pennsylvania and East Machias, Maine, and worked this past summer from her family cottage on Gardner Lake. ◆

Optimizing reliability

Nolan and Andrew McCullough. Photo by Adam Küykendall

ANDREW "ANDY" MCCULLOUGH '92, B.S. in mechanical engineering technology, is the facilities engineering and requested services manager at Texas Instruments' Maine FAB in South Portland. In this role, he works with teams focused on construction, capacity assignments, expansions and optimization activities, with strong attention to reliability. McCullough also serves on the Industrial Advisory Board for UMaine's Mechanical Engineering Technology program. When he's not working, McCullough enjoys spending time with son, Nolan, and wife, Joan McClure Smith '89, often at their camp Down East. McCullough, his father and Nolan are all proud Eagle Scouts. Sharing many of his father's interests, Nolan is a first-year student in mechanical engineering at UMaine. ◆


Maine Woods Group


Hatch Hill Group

UMaine researchers help New England organizations in adopting combined heat and power


Members of the New England Combined Heat and Power Technical Assistance Partnership team include, left to right, Jacob Foss, Kyle Rooney, Michael Desgrosseilliers and Steven Hogan.

Minimizing outages, **improving efficiency**

When storms cause power outages in and around Bangor, Northern Light Eastern Maine Medical Center maintains its energy thanks to its combined heat and power (CHP) system in its central heating plant. The hospital obtains 95% of its electricity, as well as steam for heating and cooling, from the CHP system. The CHP system has the ability to disconnect from the electric grid, allowing the medical center to maintain full electrical operation during events causing power outages.

CHP, also known as co-generation, uses a single fuel source to generate electricity and thermal energy simultaneously at the end-user's facility. There are many different fuel sources available for a CHP system, including natural gas, biomass, biogas and more. Equipped with various prime movers like gas turbines, reciprocating engines and fuel cells, CHP systems capture heat emitted from electricity generation for thermal applications, such as space heating; process steam, water or heat; dehumidification; or even to be used by an absorption chiller for cooling purposes, according to the U.S. Department of Energy (DOE).

The system at Eastern Maine Medical Center's central heating plant consists of a 4.6 megawatt turbine generator coupled to a 24,000 pound-per-hour heat recovery steam generator. The turbine generates the electricity, and the exhaust from the turbine helps create high-pressure steam for heating, sterilization, cooking and laundry. Excess steam is routed to a 500-ton absorption chiller, as well as a cooling tower, to cool the hospital during summers. Cianbro Corp., Pittsfield, installed the 411-bed medical center's CHP system in 2006, and the facility has since increased its power resilience, reduced its energy costs, decreased its fuel use, and shrunk its carbon footprint.

University of Maine mechanical engineering technology professor David Dvorak uses the benefits the medical center received from its CHP system to showcase the technology to prospective end-users through the New England Combined Heat and Power Technical Assistance Partnership (CHPTAP).

The partnership, one of 10 in the nation overseen by DOE, supports CHP integration by providing technical assistance and advocacy through stakeholder interactions and promotional materials, like the online project profile for the system at Eastern Maine Medical Center.

"CHP systems are the most efficient use of a fuel if you use both the electricity and heat from the energy conversion process," says Dvorak, director of New England CHPTAP. "We as a society can use our existing fuel more efficiently."

New England CHPTAP, located at UMaine, includes researchers at the University of New Hampshire and the University of Massachusetts Amherst, all helping to serve six states. It was established in 2017 with a $2.5 million, five-year DOE grant.

Each CHPTAP provides prospective end-users, such as businesses, medical facilities, academic institutions and more, complimentary screenings to help determine whether a CHP feasibility study is merited. Dvorak and assistant director Kyle Rooney, with help from undergraduate and graduate research assistants, incorporate a year's worth of energy bills, or projected usage, into a spreadsheet, yielding a preliminary analysis that shows the difference between operational costs from their current functions and operational costs from implementing CHP.

Once a facility decides to move forward with installing a CHP system, the CHPTAP can support them through the entire process — from initial screening to installation and commissioning, including reviews of investment grade analyses, bid proposals and other services.

"The no-cost technical assistance helps reduce upfront expenses and risks associated with investigating the feasibility of installing CHP systems," says Rooney, who is working toward a professional science and master's degree for business and engineering.

In the past two years since the partnership launched in 2018, Dvorak and his team have aided roughly 65 businesses and institutions in evaluating their ability to incorporate CHP.

"Our investment in this work is actually getting to the point where we're seeing additional CHP coming into Maine, as well as the other New England states," he says.

New England CHPTAP also provides outreach and education, Dvorak says, promoting benefits such as the prospects to achieve increased energy resilience, localized energy generation, and cost and waste reduction. Unlike on-site CHP systems, power plants generally do not recover the heat energy they generate when producing electricity, resulting in wasted heat.

"A lot of energy goes up the exhaust stack, or people use cooling towers to eliminate the heat, but that waste heat is lost," Dvorak says.

New England CHPTAP promotes CHP's benefits and technologies at professional and community events. The partnership also works with the Governor's Energy Office, Efficiency Maine, utilities such as National Grid and Eversource, and others to help eliminate barriers for CHP.

"We work with entities and organizations that can assist potential users in having successful CHP projects," Dvorak says. "We focus on outreach and engagement, offering unbiased and fact-based information and technical assistance to prospective end-users at facilities which might benefit from CHP."

Undergraduate and graduate research assistants receive financial support, including a tuition waiver for master's students if they continue working for CHPTAP, Rooney says. These benefits incentivized Rooney, graduate research assistants Michael Desgrosseilliers and Jacob Foss, and undergraduate research assistant Steven Hogan to join CHPTAP.

"We work with entities and organizations that can **assist potential users in having successful CHP projects."**

David Dvorak

The partnership also provides experiential learning opportunities for undergraduate and graduate students, and fosters teamwork and collaboration among them. They help conduct preliminary screenings, participate in facility tours, and write up project and policy profiles on grants and incentives that help fund CHP systems. Project and policy profiles are submitted to and shared by the DOE in an online database.

Students serving as research assistants for New England CHPTAP participated in a tour of Maine Woods Pellets Co., Athens, last year. They examined the facility's 8-megawatt, biomass-fueled Turboden Organic Rankine Cycle CHP system, which, according to CHPTAP's profile about this system, "was the largest Turboden turbogenerator of its type in the world" when installed in 2016. The system, which replaced a steam turbine CHP system, provided Maine Woods Pellets operating cost and wasted energy reductions, and improved efficiency.

New England CHPTAP staff also toured and wrote profiles about the Lewiston-Auburn Water Pollution Control Authority, a wastewater treatment facility that powers a 460-kilowatt CHP system through anaerobic digestion of wastes and other organic material; the Hatch Hill Landfill in Augusta, which utilizes a 550-kilowatt reciprocating engine powered by methane gas generated and collected from the landfill; St. Mary's d'Youville Pavilion and Residences in Lewiston, equipped with a 150-kilowatt CHP system with a reciprocating engine providing electricity and hot water, and other facilities in Maine and New England.

"We take frequent road trips," Dvorak says. "It's an opportunity for students to actually see these operations and talk with the plant engineers who make it work."

By the end of 2019, the U.S. had 80.7 gigawatts of installed CHP systems across 4,608 locations, according to DOE. Maine had 42 sites with CHP installed that had a combined capacity of 669 megawatts, or 0.669 gigawatts, at that time.

This is a long-term effort, says Dvorak.

"It will take years to cultivate strong relationships among state and regional entities and organizations, as well as potential sites, with the ultimate goal of increasing use of CHP in New England," he says. ◆


Liping Yu

Designing **new materials** for energy applications

Two University of Maine researchers will use artificial intelligence-aided design to develop new materials for improved batteries and supercapacitors.

The research initiative led by Liping Yu, assistant professor of physics, and Yingchao Yang, assistant professor of mechanical engineering, "Artificial-Intelligence Aided Design and Synthesis of Novel Layered 2D Multi-Principal Element Materials for Energy Storage," is one of 31 projects awarded a total of $21 million from the U.S. Department of Energy (DOE) through the federal Established Program to Stimulate Competitive Research (EPSCoR).

"Existing energy storage devices experience limitations such as inadequate power, capacity, efficiency, life span and cost effectiveness," says Yu, principal investigator of the project that was awarded $750,000 in DOE funding. "To overcome such limits, new electrode materials are critically needed."

The goal of their research is to predict, synthesize and characterize a new class of 2D materials for active electrodes in batteries and supercapacitors. These 2D materials will comprise four or more chemical elements in nearly equal concentrations; distinct from both traditional 2D materials, which consist only of two or three elements, and conventional alloys, which contain relatively small amounts of secondary elements added to a primary element.

"The new materials, if successfully predicted and experimentally validated, will have the capability to accommodate significant lattice strains and the potential to yield a huge improvement in electrode performance," says Yang, co-investigator on the project. "Such materials could also be interesting for many other important applications, including catalysts, hydrogen storage, sensors, quantum information and flexible electronics."

Yu's research focuses on the theoretical and computational prediction of new materials with properties suitable for sustainable clean energy and electronic applications, such as solar cells, supercapacitors and catalysts. His research methods include high-throughput computations, quantum mechanical electronic structure theory and materials informatics, such as machine learning.

"Traditionally, materials are discovered by serendipity or trial-and-error methods. From discovery to application, it takes about 20 years on average," Yu says. "The research in my group aims to significantly accelerate the pace of new materials discovery using high-performance computers."

Yang's research encompasses fabrication-property-application of novel materials, which includes synthesizing 1D and 2D nanomaterials through chemical vapor deposition, hydrothermal thermal reaction and other means; mechanics of nanomaterials in situ and ex situ investigated with micromechanical devices; and application of nanomaterials in energy harvest, energy storage and water treatment.

"With the guidance of theoretical prediction, we are able to precisely control the growth parameters to get crystals and films with various sizes and targeted performance," Yang says. "The mission of my research group is to conceive new materials, unveil their fundamental characteristics and achieve promising applications to serve us."

The DOE-funded research project will support one postdoctoral scientist and one graduate student at UMaine, who along with Yu and Yang will partner with Oak Ridge National Laboratory (ORNL) to collaboratively design new materials for energy storage applications.

"They will have the opportunity to visit ORNL several times a year, and work in close contact with research staff taking advantage of advanced computing resources and state-of-the-art experimental resources at ORNL," Yu says.

Both Yu and Yang are associate members of the Frontier Institute for Research in Sensor Technologies (FIRST) at UMaine. FIRST is providing support for an additional graduate student to work on the project. A closed interactive feedback loop between theory and experiment is being established that leverages both the DOE-user facilities at ORNL and materials synthesis and characterization capabilities within FIRST and other laboratories at UMaine. ◆

Abram Karam

2020 Outstanding Graduating Students

ABRAM KARAM, the Outstanding Graduating Student in the College of Engineering, received a bachelor's degree in civil engineering and a bachelor's degree in mathematics. The 2016 Bangor High School valedictorian is a UMaine Presidential Scholar and multiple scholarship recipient. He received a 2019–20 Center for Undergraduate Research Fellowship for the project, "Second-order derivatives of nonsmooth functions with applications in engineering." He was a student research assistant at UMaine's Advanced Structures and Composites Center and an engineering intern in the Office of Facilities Management on campus. Abram is pursuing a master's degree in mathematics at UMaine.

Ines Khiyara

INES KHIYARA of Crisnée, Belgium, is the Outstanding Graduating International Student in the College of Engineering. Khiyara received a bachelor's degree in biomedical engineering, and has a minor in environmental engineering. A member of the women's swim team for three years, Khiyara received multiple scholar-athlete awards and was on the America East Honor Roll. She also received an International Presidential Scholarship and the Richard E. Durst Scholarship. Khiyara served as a peer tutor, and a youth and adult swim coach. Her undergraduate research experience included work on the Duchenne muscular dystrophy zebrafish model using label-free microscopy tools to characterize sarcomere length. She is pursuing a master's degree in biomedical engineering at UMaine.

2020 Presidential Award Recipient

Jean MacRae

JEAN MACRAE is the founding faculty adviser to the UMaine student chapter of Engineers Without Borders USA (EWB-USA), which is dedicated to building a better world through engineering projects that empower communities to meet basic human needs and equip leaders to solve the world's most pressing challenges, according to the national organization's website. The UMaine chapter was established five years after the national organization formed in 2002. Since then, hundreds of UMaine students — both engineering and nonengineering majors — have been involved in EWB and contributed to design and fundraising, including dozens who have traveled to partner communities.

EWB-UMaine focuses on sustainably solving engineering dilemmas in developing countries through partnerships with local communities. The chapter has conducted service-learning projects in Honduras and Ecuador, where UMaine students collaborate with local professional engineers to develop sanitation infrastructure and propose solutions to providing clean drinking water. Often, these initiatives are undertaken in areas where conventional resources, including electricity and construction equipment, are unavailable.

The initiatives make a difference in public health and quality of life for the community members. The students gain an international perspective and real-world understanding of what it takes to undertake and succeed in such projects.

Prior to implementation, successful EWB-UMaine projects require relationship-building, planning and fundraising over multiple years. And that requires continuity of leadership and active engagement of student cohorts. "MacRae is the constant that makes this happen," one nominator noted. She also lends her technical expertise as an engineer and a researcher with a focus on microbial processes that affect pollutant and nutrient cycling, and issues related to sustainability issues, water quality and sanitation. MacRae's contributions are global and local. ◆

"Enrollment in the College of Engineering must continue to grow to meet the demand for talented engineering professionals to move our economy forward. Let's keep the momentum going. Please join me in giving to the College of Engineering Infrastructure Fund to take UMaine engineering to the next level."

Beth L. Sturtevant '82

CATALYZING GROWTH

Thanks to the combined $78 million investments from 500+ alumni, friends, corporations, foundations and the state of Maine, construction of the Ferland Engineering Education and Design Center is well underway, attracting more and more top students to UMaine.

Gifts to the University of Maine Foundation for the new College of Engineering Infrastructure Fund may be used for equipment, furnishings, moving expenses, personnel and start-up expenses for the Ferland Engineering Education and Design Center. Architectural and engineering studies, contracting and construction expenses for renovations of existing College of Engineering buildings also may be supported, as well as new construction as approved by the UMS Board of Trustees.

For more information about giving to the College of Engineering, please call Diane Woodworth or Pat Cummings at the University of Maine Foundation, **800.982.8503 or 207.581.5100.**

To make a gift: our.umaine.edu/infrastructurefund

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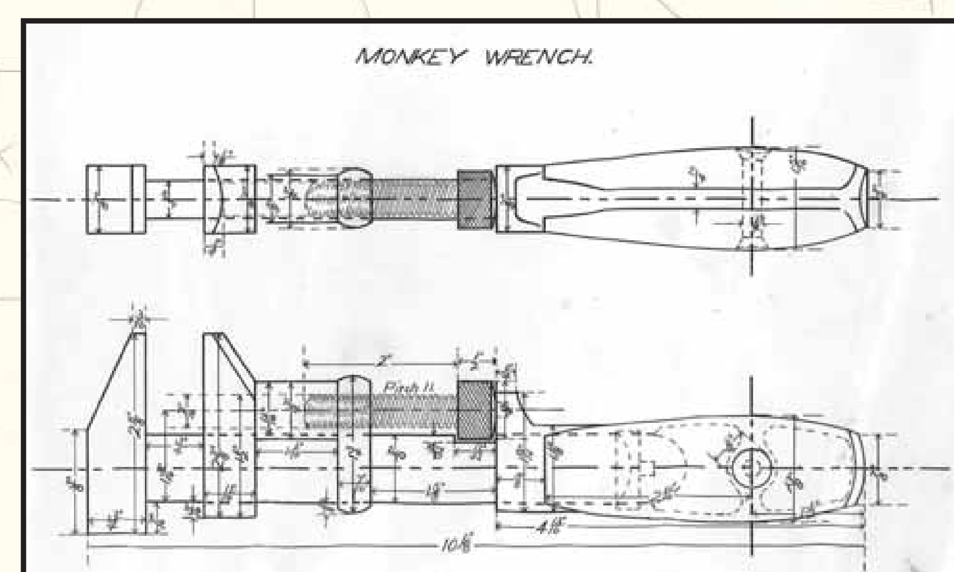

EARLY ENGINEERING

In September, University of Maine alumnus Peter Weston of Scarborough, Maine, MEE '78, donated dozens of recently discovered drawings from his family's engineering past. Peter Weston is a descendant of two students — engineers Benjamin F. Gould and George O. Weston — who were in UMaine's first graduating class in 1872. George O. Weston, who created the earliest drawings in 1871, graduated a year later. Another series of documents was created by Peter's grandfather, Wallace A. Weston, who graduated in 1900. The archival documents are housed in Special Collections of UMaine's Raymond H. Fogler Library. ◆