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interfaces

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Sustainability

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On the Cover
Wood fibre from Professor Emma Master's lab.
Photo by Ian Patterson.

"We also understand our responsibility to focus on sustainability in order to address global problems and work toward solutions"

Sustainability — Opportunity for Growth

THE WORLD IS FACING significant challenges, from climate change and associated severe weather events to crises in water, food and biodiversity, to depletion of our natural resources. Meeting these challenges and adapting to inevitable change in ways that avoid significant human conflict requires us to move to a more sustainable path.

Virtually all of these challenges involve chemical and biochemical systems, positioning our Department of Chemical Engineering & Applied Chemistry (ChemE) as one that can play a major role in developing solutions and in educating the people who will lead this positive change. This is why sustainability lies at the core of our vision: "Through leading-edge research and education, we integrate chemistry, biology, and engineering to drive solutions to global challenges in energy, the environment, and health."

Our faculty, researchers, alumni, partners, students, and staff recognize how fortunate we are to have access to a diverse network of expertise and knowledge, as well as cutting-edge research facilities and equipment. We also understand our responsibility to focus on sustainability in order to address global problems and work toward solutions.

In this edition of *Interfaces*, you will meet members of our ChemE community making noteworthy contributions to improving the global environment. Of course, this is just a sample of the many people who are making a difference. For example, Professor Yu-Ling Cheng and her team are reinventing the toilet to provide off-grid sanitation to the developing world. Professor Emma Master is turning wood fibre into plastic-like material to help reduce the billion tonnes of plastic thrown away each year. And our newest faculty members, such as Professor Ning Yan, who is leading the development of green chemicals and materials from renewable forest biomass in partnership with existing industries, and Assistant Professor Nikolai DeMartini who is working to enhance bioprocessing systems to maximize energy recovery and reduce our environmental footprint.

For ChemE, sustainability is more than just solving global challenges; it's about creating an environment where our members feel supported in their quest for growth, knowledge, creativity, and giving back. Positive change occurs through them.

I hope you enjoy this magazine and when you're done, please feel free to share it with others, join us on Facebook, Twitter, Linkedin, and now U of T Engineering Connect (uoftengineeringconnect.ca) – Skule's new alumni social networking platform. We welcome you to reconnect with us and discover how we can assist you on your sustainable journey.

D. Grant Allen (8T1, MASc 8T3)
Professor & Chair

by Peter Stevens

Photo by Ian Patterson

ChemE Alum Leads through Sustainable Action and Example

Engineering a Green Future

Opposite page: Andrew Hellebust in his Don Valley backyard where he is re-establishing native tree and plant species.

ANDREW HELLEBUST (9T0) admits to being something of an iconoclast. He speaks glowingly of his days as a U of T Chemical Engineering student, but also concedes that he "wasn't really into the engineering culture." He is equally forthright when asked about the environmental challenges posed by today's high-carbon economy. "Engineers have a lot to answer for," he asserts, "because they've created the infrastructure that we see today. But the good news is that engineers also are very well equipped to solve these problems."

After more than 20 years of designing sustainable wastewater treatment systems, Hellebust is a recognized expert in his field. Currently the President

"The dominant culture may not survive if we don't adopt some central tenets of indigenous beliefs"

of Toronto-based Rivercourt Engineering, he has served on numerous water-related committees for bodies such as the Canadian Standards Association and the Government of Ontario. His career reflects a passion for sustainability that Hellebust traces back to his youth. Growing up during the 1970s oil crisis, he developed a fascination with alternative energy that eventually led him to enrol in the Department of Chemical Engineering & Applied Chemistry, where he focused on thermodynamics. He later attended Princeton University to do graduate work in microbiology, expecting to become a scientist like his botany-professor father. Ultimately, however, Hellebust concluded that he preferred practical matters to the abstraction of academia. Upon completing his Master of Science degree in engineering in 1993, he returned to Toronto, eager to work on projects that used biological processes to solve engineering problems.

Hellebust soon became the Project Engineer at EcoWerks Technologies. There, he developed a system that reclaims wastewater by filtering effluent through a constructed wetland and then exposing it to ultraviolet light. The treated water is then suitable for non-potable uses, such as flushing toilets. Among the clients to install Hellebust's engineered wetlands were Body Shop Canada, the Kortright Centre for Conservation, and the Toronto Waldorf School, which uses the system to recycle one-million litres of water each year.

In 2007, Hellebust left EcoWerks to found Rivercourt. Since then, he has continued to refine his constructed wetlands system, collaborating with a Niagara Falls firm to build ecological wastewater systems for local wineries. He also has broadened his scope, designing on-site water, sewage, and landfill leachate systems at remote locations in northern Ontario. His focus widened again in 2016, when Rivercourt acquired Sustainable EDGE, a company that designs passive buildings, which depart from traditional architecture by using solar power, geothermal energy, and enhanced building envelopes. Hellebust's own home, which was retrofitted in accordance with these standards, won a 2015 Canadian Green Building Award.

Hellebust sees a natural progression to his expanding professional interests, since he believes that energy use, food production, water infrastructure, and waste management need to be regarded as parts of a single, integrated system. His vision for the future includes semi-autonomous buildings that harvest their own water and energy, and feed any surplus into centralized utility systems. He also imagines greater symbiosis between urban and rural areas, with farmers sending food to cities in exchange for nutrient-rich fertilizer in the form of treated human waste. Adopting this holistic approach to development would lead to significantly reduced greenhouse gas emissions, Hellebust says.

Projects with northern Ontario First Nations have given him opportunities to put his ideas into practice. Since many native communities are isolated, they require on-site systems to meet their food, water, and sewage needs. Fortuitously, Hellebust explains, the answers to these problems fit well with the broader native goal of self-determination: "One legacy of colonization is a large bureaucracy that First Nations people themselves do not control. Having a high degree of energy autonomy and food-production autonomy puts more power into their hands. As such, our goal as engineers is to find technical solutions that also meet their social needs."

Working with native communities also has shaped how Rivercourt does business. "The dominant culture may not survive if we don't adopt some central tenets of indigenous beliefs," Hellebust argues. "We have this Cartesian idea that we're here and nature is over there. But we are not apart from nature; we are *part* of nature. So at Rivercourt, we want to figure out what it means to do engineering that is informed by the values of indigenous culture."

Belief in interconnectedness also keeps Hellebust optimistic, despite current worries over climate change. "We *are* headed for a dire future," he declares, "but we're also quite capable of changing our behaviour. There are much better ways of building our houses which don't merely use less energy but are actually healthier and more comfortable. Growing our own food based on organic fertilizer that's locally produced is not just solving an environmental problem; it's also healthier and tastier, and it means we have jobs locally. If we as a society make wise choices, the result will be happy lives and mutually assured abundance." i

Andrew Hellebust working from his house – the winning residential project of the 2015 Canadian Green Building Awards.

Photo by Ian Patterson

Photo by Mark Neil Balson

Photo by Andrew Hellebust

Top: Rivercourt provided consultation to Fogo Island Inn to ensure sustainable design/construction of its drinking water treatment system, thermal building envelope and mechanical systems.

Bottom: A wastewater treatment wetland at Redstone Winery Restaurant in Beamsville, Ontario, designed by Andrew Hellebust for Aqua Treatment Technologies.

Photo by Sean Caffrey

by Branden Wesseling

SUSTAINABILITY

A Collaborative Approach

Opposite page: Postdoctoral fellow Fei Luo sampling a vessel containing a microbial community that can remediate groundwater contaminated with benzene.

ENGINEERS ARE MOST KNOWN for being creative problem solvers, so it should come as no surprise that research engineers at the University of Toronto's Department of Chemical Engineering & Applied Chemistry (ChemE) – home to some of the best researchers in the world – are being drawn to one of the world's biggest and most challenging problems: helping to build a sustainable future. Global challenges necessitate far-reaching solutions, and ChemE is quickly becoming a hub for multi-disciplinary, national, and international cross-collaboration with partnerships across the Faculty of Applied Science & Engineering (FASE), universities across Canada and the globe, as well as with major industries. These partnerships are already beginning to yield exciting results that are helping the Department, and the world, move toward a sustainable future.

Just the Beginning

At less than a year old, Carbon Control for Climate Change Mitigation (C4M) – an initiative made possible through funding from the Faculty of Applied

"I think our work is helping to show that sustainable technologies can increase a company's social impact and benefit its bottom line"

Science & Engineering's Dean's Strategic Fund – is still in its infancy. "We launched C4M to better address the emerging needs of industry – that's the difference in our approach," says Professor **Ramin Farnood** who leads the group.

"We want to reduce greenhouse gasses through optimization, innovation of totally new processes, and capture and convert whatever we can't reduce," Farnood says. "Those are the three pillars of C4M."

The reduction of industrial carbon emissions is C4M's primary target, a strategy that's largely informed by increasingly stringent government regulations like Ontario's new Climate Change Action Plan which creates financial incentives for industry to lower emissions through a cap-and-trade system.

C4M hopes to begin addressing these new regulations with its first major collaboration with the food and beverage industry. C4M is currently in discussions with potential industry partners to help solve the problem of food waste that results during large-scale processing. "For instance, to ensure each bottle on a bottling line is filled to the top they're slightly overfilled and then capped, causing a lot of spillage," says **Raluca Ellis**, recently appointed Director of Strategic Relations for the initiative. Through new recovery processes being developed by C4M researchers, the goal is to retrieve and convert that waste into new usable materials. "The less waste that escapes the system, the lower the environmental impact," explains Ellis.

But this project is just the beginning. Long term, the goal for C4M is to bring multiple institutes from across the University of Toronto together for much larger projects, allowing for optimization of the full lifecycle of industrial processes. Bigger projects mean bigger savings, which should lead to even greater reductions in carbon emissions.

"We're interested in really high-level collaboration, pulling together expertise from many different disciplines in order to have the biggest impact possible," Ellis says. "To achieve sustainability we can't just be focused on one area or another. We need to see the big picture."

Part of C4M's mandate is to match its multidisciplinary team with real-world industry challenges. "The goal is to make U of T the go-to place for emission reduction, where industries come to have their carbon emission challenges solved. We're a bit like a match-making service," Ellis jokes. "U of T is Canada's largest research institute, and that means we have an opportunity to be a leader when it comes to creating a sustainable future."

Scaling Up

BioZone – a centre for applied bioscience and engineering based in the Department of Chemical Engineering & Applied Chemistry – is helping major resource industries in agriculture, energy, forestry, and mining reduce and repurpose the by-products of their processes through enzyme discovery and synthetic biology. "Enzymes and microorganisms have been used in chemical and industrial applications for a long time to help make reactions work and to reduce waste," explains **Sean Caffrey**, Executive Director of BioZone. "Enzymes are similar to chemical catalysts in many ways, except enzymes are typically more selective and the resulting processes can be more environmentally friendly."

The enzymes that BioZone is developing offer several benefits over traditional chemical synthesis pathways that are typically employed in industrial processes: "Enzymes can help to minimize wasteful side reactions, tend to operate at moderate temperatures and under moderate pressure, reduce energy requirements, and the enzymes themselves can be less toxic than the catalysts they are replacing," explains Caffrey. BioZone is also developing microbial processes to reduce energy consumption and waste production, and decrease the cost of water treatment in industrial processes.

Photo by Sean Caffrey

Enzymes produced in genetically modified yeast are examined in a gel for purity by research associate Thu Vuong before being used to transform plant-derived fibres into products traditionally made from petrochemicals.

Collaboration with industry is essential to how BioZone operates. The Industrial Biocatalysis Network (IBN), a five-year, $5-million initiative connecting researchers and industrial partners from across Canada and around the world, including many of BioZone's Principal Investigators, is working to address a variety of industry needs with the help of microorganisms. "We strive for a frequent flow of information back and forth with our industry partners to help facilitate collaboration," suggests Caffrey.

"BP [one of the world's largest energy companies] just recently joined the IBN," says Caffrey, "so we're very excited to see the impact enzyme discovery can have on such an important industry on such a large scale." Other major BioZone projects include working with the agriculture and forestry sectors to design microbially-based processes that use waste materials to produce plastics, resins, paints, and other useful chemicals, simultaneously reducing the total amount of waste produced, recycling water and generating new income streams.

"Our researchers are taking ideas from bench to full-scale experiments to better enable the application of the technologies being developed to real-world problems," explains Professor **Elizabeth Edwards**, Director of BioZone. This includes evaluating the social and economic viability of these processes to make them more enticing to industries and acceptable to regulators. "I think our work is helping to show that sustainable technologies can increase a company's social impact and benefit its bottom line."

A Central Point of Contact

The Institute for Water Innovation (IWI) – a collection of 26 researchers with various water-related research interests from across the Faculty of Applied Science & Engineering (FASE) – was conceived as a vehicle for bringing together resources from across disciplines, and a central point of contact at the University for industry.

IWI associated researchers offer a breadth of expertise in water management, characterization, treatment, and remediation. With Department of Chemical Engineering & Applied Chemistry researchers active in all of these areas, the Department makes up more than half of IWI's membership.

So what does IWI do exactly? "Currently a key focus for us is educating industry partners about what is possible in terms of making industrial processes more sustainable. The familiarity of our research collective with chemical and industrial processes gives us an obvious strength in industrial

Photo by Ian Patterson

Opposite: Professor Vladimiros Papangelakis in his office located in the Wallberg Building.

water treatment," says Professor **Vladimiros Papangelakis**, Director of IWI.

Several major partnerships have already been formed by IWI during its short existence. Papangelakis is project lead for *Elements of Biomining* – a collaboration of 13 researchers from Laurentian University, the University of British Columbia, and Commonwealth Scientific and Industrial Research Organisation in Australia being funded by the Ontario Research Fund - based out of IWI. This team is seeking to develop sustainable ways to stabilize mine waste, and prevent metal leaching and acid mine drainage into nearby water bodies. "The goal is to mitigate environmental damage and in doing so, try to recover as much locked metal as possible to make a profit and offset the processing cost," Papanegelakis explains.

"We've only been around for two years. Over the next few years we see things shifting to the point where industry partners are approaching us for our expertise in solving specific problems they've identified," Pagangelakis suggests.

While IWI is still relatively new, some of its projects have been decades in the making. Professor **Elizabeth Edwards** is leading a group that has identified microbes capable of digesting BTEX chemicals – benzene, toluene, ethylbenzene and xylene – which are found in contaminated soils near industrial sites like mines and refineries, but also on urban sites like gas stations.

Over the course of 15 years Edwards and her team carefully selected microbes from several different sites based on their ability to breakdown the BTEX group. Recent funding by Genome Canada will help Edwards and her industrial partners bring the unique microbial culture to market.

Acting Locally, Thinking Globally

Rare earth elements are found in everything from our cellphones to our solar panels – products with increasing importance in our lives moving forward. Rare earth elements also pose significant environmental and economic problems – there is little that can be done with them once they are spent, and extraction is notoriously dirty and resource intensive. As our reliance on products made from rare earth elements continues to grow, the situation will only continue to get worse. Organic electronics may hold the key to solving these problems.

"Organic solar cells have far less impact on the environment compared with those made from silicon because the chemical process is so much more efficient," explains Professor **Tim Bender**, Principal Investigator of the Bender Lab. "Organic solar cells are also unique in that they can be recycled using current municipal systems. It's a tremendous advantage."

Organic light emitting diodes also present significant benefits over what's presently available. "LEDs are much more efficient and sustainable than standard light bulbs, but research is starting to show that the light LEDs emit can actually be harmful to us," Bender explains. "The light is fluorescent and harsh on the eyes. Not only are organic LEDs more efficient than standard ones and more sustainable to produce, but the light they give off is also more natural. They're better for us and the environment."

Canada doesn't currently have an industry for the base materials for solar cells or LEDs, and manufacturers for the end products are scarce. Bender sees an opportunity to change that. "The plan is to create a startup within the University so that we can retain the rights to the technology. It makes sense for us to do it ourselves – the company will produce the materials and the final products. Complete integration, and it will all happen inside of Canada."

Bender is excited about the benefits of a "Made in Canada" solution. "I think we're finding that outsourcing may not be the best for every technology. The cost of labour is only one factor. Quality control

> "We can move away from environmentally costly technologies that rely on rare earth elements and petrochemicals to those with minimal environmental impact"

and the ability to mitigate process variation is extremely important in these industries, and having the ability to be hands on throughout the process can lead to big rewards," Bender explains. "We can move away from environmentally costly technologies that rely on rare earth elements and petrochemicals to those with minimal environmental impact, and it can be done with resources available in Canada and done by Canadian manufacturing. The eventual idea is that Canada will be a world leader in these spaces."

The Future Is Bright

For the Department of Chemical Engineering & Applied Chemistry's newest researchers sustainability is key. "Environmental and social are the two most important facets of sustainability for me. As engineers, it's our duty to keep sustainability at the forefront of our problem solving. It doesn't make sense to solve one problem while creating an even bigger one," says Assistant Professor **Erin Bobicki**. "Right now we're using microwaves to reduce the viscosity of low-grade nickel ore slurries to enhance mineral separation. This is a very unique approach to the problem of clay minerals in nickel ore processing," Bobicki explains.

"All thrusts of my research are focused on addressing sustainability challenges," says Assistant Professor **Gisele Azimi**. "From recycling rare earth elements from industrial process residues, designing advanced materials that can significantly reduce energy consumption in power plants or desalination plants, to making novel technologies, every problem I'm focused on relates directly to helping to create a sustainable future." One current project has Azimi particularly excited. "We're developing a new generation of rechargeable batteries that is safer, more cost effective, and more efficient than our current lithium-ion batteries," she explains. "We envision that our new battery technology will find widespread applicability in various industrial sectors."

Assistant Professor **Elodie Passeport** is building and testing innovative water treatment systems that could eliminate wastewater and industrial pollution from the environment. Taking her inspiration from nature, Passeport is investigating the potential of wetlands – both natural and engineered – to decrease pollution from raw and partially treated wastewater. "Wetlands are known for their water treatment capacities of common pollutants such as nitrogen and phosphorus, but very little is known about their potential to control less traditional pollutants" Passeport explains. "We are currently attempting to mitigate pollution and contamination from emerging contaminants such as pharmaceuticals and personal care products, which are becoming a major problem." Passeport uses tools from radio and stable isotope chemistry to better characterize the fate of such contaminants in the environment. "The goal is to develop sustainable water treatment systems that are cleaner than current systems, have minimal impact on aquatic life, and actually maintain their treatment efficiency over time."

"In its most basic sense, we are fabricating nanoparticles that allow new chemistry to happen for producing clean fuels, energies, and chemicals," explains Associate Professor **Cathy Chin** of her team's work at the Multidisciplinary Laboratory for Innovative Catalytic Science. "We're developing a range of nanoparticles – what we call 'catalyst materials' – that can convert methane and carbon dioxide into 'syngas'," says Chin. "This syngas is a fuel-gas mixture that can be used to generate energy or make agricultural fertilizers." The project will make use of the Faculty of Applied Science & Engineering's microscopic and spectroscopic tools in the new Ontario Centre for Characterisation of Advanced Materials (OCCAM), the first of its kind in Canada. i

by Andrew Connolly

Photo by Ian Patterson

ChemE Alum Starts Company to Recycle Lithium-ion Batteries

Selling the Power of Sustainability

Opposite page: Ajay Kochhar during a visit to the Wallberg Building in September 2017.

AS BATTERY POWERED VEHICLES become more common, the world is faced with a new environmental challenge: what happens to batteries when they are no longer useful?

Right now, lithium-ion batteries are popular for vehicles, consumer electronics, and stationary energy storage. Lithium is light weight and provides the largest energy density for weight. Furthermore, the cost of lithium-ion batteries has dropped dramatically in the past 20 years. The result is that an estimated 11 million tonnes of lithium-ion batteries will reach the end of their useful lives between 2017

"U of T embedded the core concepts of sustainability in my approach to business and life"

and 2030. The best recycling technology recovers up to 30% of the materials contained in those batteries. That still leaves a lot of waste, and a serious environmental problem. That's where Li-Cycle comes in.

Li-Cycle is a new company based in Mississauga and led by CEO, **Ajay Kochhar** (1T3). "We are on a mission to solve the global lithium-ion battery waste problem and meet the rapidly growing demand for critical battery materials," explains Kochhar.

The company has already developed a proprietary and validated process to improve the recycling process. Li-Cycle Technology™ recovers more than 90% of the mass from used lithium-ion batteries. "We strive to ensure that electric vehicles have a truly positive environmental impact over their entire life cycle," says Kochhar. "Sustainability is at the core of what we do."

Li-Cycle's scale-up facility located in Kingston, Ontario.

Photos on this spread courtesy Li-Cycle

Training Sustainable Leaders at U of T

Kochhar's experience in the University of Toronto's Department of Chemical Engineering & Applied Chemistry had a profound influence on him. "U of T embedded the core concepts of sustainability in my approach to business and life," he says. "It rooted my ideas about sustainability in practicality."

U of T provided Kochhar a chance to work with people who had experience developing sustainable solutions, as well as helped him understand the vital link between sustainability and industry, a link that is evident when he talks about sustainability.

"Sustainability means leaving a positive world for future generations to live in. Environmental, societal, and economic vitality are all important," explains Kochhar. That makes working toward sustainability complex. It means ensuring that natural resources are replenished and that waste is reduced; it means ensuring that everyone has access to basic rights and necessities; and it means making sure those goals work within the current financial context.

One of the major challenges is convincing business owners that environmentally sustainable options are also economically sustainable. "Businesses often associate 'green' practices with increased costs," says Kochhar. "They need the financial returns and other benefits quantified."

Kochhar explains that sustainable technology needs to be developed in a way that is marketable, and that companies need to work to convince businesses and consumers to change their habits.

Li-Cycle Technology™ has been validated to recover up to 100% of cobalt, lithium, and other key materials from spent lithium-ion batteries.

"Changing typical consumer behaviour to improve sustainability can be a daunting task, but it is achievable through persistent and relatable communication that clearly articulates the value of sustainable practices."

Kochhar's nuanced understanding of sustainability is reflected in his current business endeavours, and is a direct result of his education at U of T. "U of T's culture and opportunities are critical to creating the future generations of sustainability leaders," says Kochhar.

Simple, Marketable Sustainability

Kochhar initially began discussing the idea for Li-Cycle with his colleague, Tim Johnston. They then brought the idea to their friends and family. "The initial discussions were encouraging, so we decided to put together a simple presentation to organize our thoughts and plans."

Kochhar and Johnston soon began looking for investors on the project. They quickly learned that they needed to refine their pitch. "One of the early discussions was with a contact from an investment group," recalls Kochhar. "My contact was extremely encouraging, but did not hold back with feedback. Our printed investor presentation was full of red-line markups and reorganized or eliminated pages after the meeting." The team learned how to simplify their message in a way that was appealing to investors and potential partners. "This can be a challenge for complex topics like sustainable chemistry, but is extremely important to get traction. It turned out to be a really pivotal moment for us."

Kochhar and Johnston have found success with their pitch, and now they are looking to grow their team. "We are looking to onboard engineering and supply chain talent that share our passion for Li-Cycle's mission." That mission combines environmental and financial sustainability through commercializing new technology. i

Photo by Ian Patterson

by Jennifer Hsu and Tyler Irving (MASc 1T0)

ChemE Researchers

Take on Air Pollution

Opposite Page: Cuilian Fang and Peter Murphy reading particulate matter counts from downtown Toronto, street-level samplers.

AIR QUALITY HAS INCREASINGLY become a major concern. According to a 2015 World Health Organization study, over 3 million people die prematurely each year from prolonged exposure to air pollution. By 2050, it could be 6.6 million premature deaths annually. To help combat this worrying trend, University of Toronto researchers from the Department of Chemical Engineering & Applied Chemistry are finding new ways to investigate air quality across the country. Through the use of this pinpoint analysis of areas where poor air quality exists, we'll be able to make more informed health decisions and have the tools to implement bigger societal changes to improve the quality of our air.

AirSENCE, a technology developed by Professor **Greg Evans** (8T2, MASc 8T4, PhD 8T9) and Adjunct Professor **Jeffrey Brook**, collects data on the Air Quality Heath Index (AQHI) and on estimated

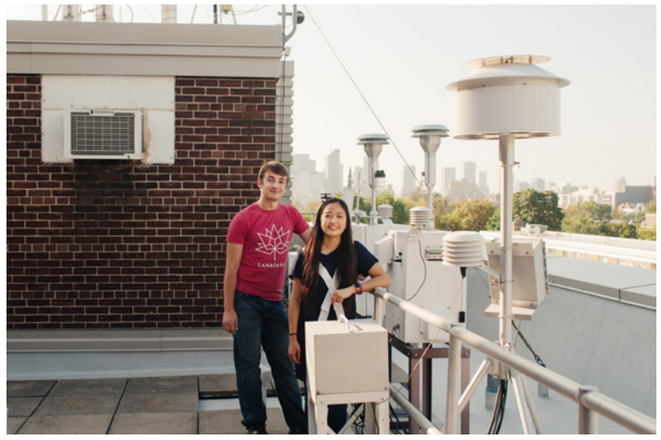

Photo by Ian Patterson

Peter Murphy and Cuilian Fang next to ambient air-quality monitoring equipment housed on top of the Wallberg Building.

concentrations of five air pollutants: nitrogen oxides, ozone, particulate matter, carbon monoxide, and carbon dioxide.

Supported by AllerGen NCE research funding and first deployed for mainstream use during the 2015 Pan Am games in Toronto, AirSENCE helped Pan Am visitors – especially those with allergies, asthma, and other respiratory conditions – plot the timing and location of their activities based on data made available on the AirSENCE website (www.airsensors.ca). Even the athletes may have benefitted, tailoring their training schedules based on air quality alerts.

"This compact and inexpensive device can be placed anywhere and allows people to monitor air pollution in real time," explains **Peter Murphy** (1T5 + PEY), a MASc candidate from the Southern Ontario Centre for Atmospheric Aerosol Research (SOCAAR) helping to expand the use of the technology through the Greater Toronto Area. By Fall 2017, AirSENCE devices should be installed along the King Street and Yonge Street corridors in Toronto, and in the neighbouring cities of Guelph and Mississauga on lamp posts and utility poles.

The data collected will help to evaluate everything from the effect of idling cars in school drop-off locations to the impact transit prioritization has on pollution levels in local project areas. AirSENCE has worldwide potential by enabling users to make better-informed choices to manage their exposure to outdoor or indoor pollutants, reducing both the risk of exacerbations of pre-existing health conditions, like asthma, and of development of chorionic disease through long-term exposure.

Working alongside Murphy is **Cuilian Fang** (1T9) who spent all summer collecting and analyzing data across downtown Toronto for SOCAAR. Fang's investigations involve the effects of traffic on air quality. Her work may help reveal traffic patterns, the types of cars causing the most pollution, as well as assist in recommending new running trails and bike lanes.

"Air quality measurements can be great indicators for how the things we use in society impact the environment," says Fang. "I'm excited to see how the data I've collected over the summer will make a positive impression on the air we breathe in Toronto. It is each of our responsibility to protect and preserve this precious resource."

Assistant Professor **Arthur Chan** and his research group are also working hard to help improve air quality. Under the supervision of Chan, postdoctoral researcher **Lukas Kohl** and EngSci undergraduate student **Cynthia Jing** spent their summer vacuuming the homes of complete strangers in northern Alberta. But they didn't travel all that way to lend a hand with the chores; they were looking for evidence of long-term human health impacts arising from last summer's devastating wildfire.

"This compact and inexpensive device can be placed anywhere and allows people to monitor air pollution in real time"

That fire, which raged through northern Alberta one year ago, is already estimated to be the costliest natural disaster in Canada's history, destroying approximately 2,400 homes and forcing the evacuation of nearly 90,000 people. But the burned buildings only account for a part of the damage. "Smoke and ash can contain many different compounds, including organic compounds, heavy metals, black carbon, and more," says Chan. "Some of these are suspected to be carcinogens or are linked to other negative health outcomes," which will last long after the flames are extinguished.

Chan and his team, using advanced analytical chemistry techniques, can detect everything from heavy metals such as lead, a potential neurotoxin, to organic chemicals such as polycyclic aromatic hydrocarbons (PAHs), which have been associated with cancer.

In their current project – dubbed Fire Ash Characterization and Evaluation of Toxicity (FACET) – Chan's team collected house dust from dwellings in Fort McMurray, Alberta, and other communities affected by the wildfire. While much of the outdoor ash has been either shipped away from town or immobilized by spraying it with a glue-like substance known as tackifier, the ash found in the community's remaining homes has proved more difficult to treat.

"This is the ash that is closest to people's bodies, and because we spend most of our time indoors, it has the biggest impact on people's health," says Kohl. "Indoor pollution is not well understood, so this research is bringing a new perspective on forest fires."

Kohl and Jing used a variety of techniques to collect ash samples from the homes, including a modified vacuum cleaner that collects dust into small vials and by wiping surfaces with a wet, disposable cloth.

"We wanted to make sure we sampled a variety of locations within the house," says Kohl. "For example, we wanted to examine spaces that people clean often, like a living room, and compare them to spaces that people use much less, like an attic, where dust containing a lot of fire ashes would likely be found."

Initially, the team was concerned with the challenge of arranging house visits. "When we're sitting in Toronto, it can be hard to reach out to people who live hundreds of kilometres away," says Kohl. But after a few short days, the team was overwhelmed by the response from willing participants.

"We reached out to Facebook groups used by people in Fort McMurray, as well as local media," says Jing. "Within two days, we had more than 60 interested people contacting us about the study."

For each home, the team plans on making two more visits, one in the fall and one over winter, to minimize anomalies and compare any changes in hazard levels over time.

"Of course, our hope is that we won't find anything," says Chan. "But if we do, we can inform people of their risk, and suggest adjustments to their cleaning habits. We want to understand the impacts before people start to suffer from them, and provide guidelines to minimize exposure."

This knowledge will not only help develop recovery plans for Fort McMurray, but also assist other fire-affected areas across the globe to ensure that people can live their lives feeling safe after these catastrophic events.

Similarly, AirSENCE has worldwide potential by enabling users to make better-informed choices to manage their exposure to outdoor or indoor pollutants, reducing both the risk of exacerbations of pre-existing health conditions, like asthma, and of development of chorionic disease through long-term exposure. i

Photo by Rémi Thériault

 by Andrew Connolly

Promoting a Sustainable Future

How Members of ChemE's Board of Advisors are Working Toward Sustainability

Opposite page: Jeanette Southwood in Ottawa attending Engineers Canada's Board meetings in September 2017.

U OF T CHEMICAL ENGINEERING Board of Advisors member **Jeanette Southwood** (8T6, MASc 8T8) is matter of fact when it comes to 'sustainability.' "By its definition, without sustainability there is no future," she says.

Southwood draws on established definitions of sustainability, including the definition in Engineers Canada's 2016 National guideline on sustainable development and environmental stewardship for professional engineers. The document defines sustainability as the "ability to meet the needs of the present without compromising the ability of future generations to meet their own needs, through the balanced application of integrated planning and the combination of environmental, social, and economic decision-making processes."

That definition is largely based on the UN's Brundtland Commission, published in 1987. The commission established what is often referred to as the three pillars of sustainability: environment, society, and economy. Southwood isn't simply reciting abstract definitions. She has built her career on these principles and actively works to promote sustainability.

Presently, Southwood is the Vice-President, Strategy and Partnerships at Engineers Canada. Sustainable Development is part of her portfolio, where she works closely with fellow U of T

"ChemE, and my fellow alumni have made significant and impactful contributions to sustainability"

Engineering alum, David Lapp (GeoE 7T8) in his role as Practice Lead for Globalization and Sustainable Development. Lapp led the team that established the aforementioned national guideline on sustainable development and environmental stewardship.

An international version was produced by Engineers Canada for the World Federation of Engineering Organizations and its national engineering organization members from over 90 countries. Engineers Canada has now embarked on developing a Massive Open On-Line Course (MOOC) on the national guideline to inform and educate engineers on the principles and their application in practice. This MOOC will be offered for the first time in April 2018.

Before accepting this position with Engineers Canada in 2015, Southwood worked as the Global Sustainable Cities Leader at Golder and Associates, a global consulting firm. In that position, she led a team that worked with private and public clients around the world and across sectors to ensure that urban development proceeded in a way that kept with the core principles of sustainability. Her team consisted of experts in transportation, energy and power, real estate, finance, insurance, legal, land development, manufacturing, and infrastructure. All of them working to help cities develop in sustainable ways.

Southwood's commitment to sustainability began while she was still a student at the University of Toronto. "When I was a student, the terms 'sustainability' and 'sustainable development' were relatively new, however, the concepts were alive and well and evolving," recalls Southwood. She says working with professors like Donald Mackay, Phil Byer, and Doug Reeve helped her develop an understanding of the importance of sustainability.

Now as a member of the Board of Advisors for the University of Toronto's Department of Chemical Engineering & Applied Chemistry (ChemE), she hopes to pass both that understanding and commitment on to current students. This means making sure that course content continues to include an emphasis on sustainability, and that students are encouraged to take advantage of U of T's broad range of experience.

"Sustainability, by its very nature, is multidisciplinary," she explains. Southwood isn't on her own in this endeavour. The Board of Advisors features many members who have extensive experience in sustainable development. For example, **Daryl Wilson** (8T2) is the Chair of the Board of Advisors. He has been the Chief Executive Officer and President at Hydrogenics Corporation of Algonquin Power & Utilities Corp. since December 2006.

Under Wilson's guidance, Hydrogenics has signed a deal to deliver 1,000 fuel cell units to a company in China. These fuel cells are integrated into zero-emission electric buses, helping to reduce pollution and promote sustainability. Hydrogenics is also an important member of the international Power-to-Gas Project, HyBalance. This project explores the multiple uses of hydrogen, including clean transportation.

"ChemE, and my fellow alumni have made significant and impactful contributions to sustainability," says Southwood, "not only in Canada but globally." That contribution isn't finished yet. Southwood is calling on her fellow alumni to continue supporting future engineers in their pursuit of sustainability.

"Students of today will make significant and impactful advances in sustainability," says Southwood. "We can provide the intellectual, financial, and mentorship underpinnings for them to do that."

With the guidance of the Board of Advisors and the support of alumni, the Department of Chemical Engineering & Applied Chemistry will continue to be a leader in promoting and enabling sustainability. i

In Memoriam

It is with regret that we have learned of the passing of the following ChemE graduates since the last issue of *Interfaces* in Fall 2016.

William Arabey (6T3)
Sep 24, 1939 – Jun 2, 2017

W. P. Barker (5T4)
Unknown – Mar 31, 2017

George A. Buck (5T5)
Oct 21, 1933 – May 20, 2017

Albert P. Budra (5T7)
Jun 10, 1934 – Aug 9, 2017

Douglas Cattran (6T1)
Jan 3, 1939 – Mar 28, 2017

Edward Chung (4T6)
May 20, 1925 – May 2, 2017

Gerard C. Frost (5T1)
Jan 11, 1921 – Feb 15, 2017

Carl E. Gall (5T5)
Dec 17, 1931 – Mar 20, 2017

Kenneth A. Hoole (5T1)
Jan 21, 1924 – Jul 13, 2017

Alvin D. Huffman (4T9)
May 2, 1924 – Jan 30, 2017

George Kosta (9T0)
Jun 30, 1966 – Feb 10, 2017

Gordon T. Leaist (5T1)
Oct 16, 1927 – Mar 31, 2017

Gordon K. Martin Sr (5T4)
Oct 14, 1931 – May 14, 2017

Hans F. Mogensen (5T7)
May 19, 1927 – Oct 12, 2016

Douglas S. Montgomery (3T9)
Nov 11, 1916 – Oct 4, 2016

John Noble (4T4)
Jul 22, 1922 – Dec 9, 2016

Ralph Noble (5T0)
Jan 3, 1939 – Aug 6, 2017

Edward B. Potter (4T0)
Nov 5, 1916 – Oct 11, 2016

Edward G. F. Rosengren (3T6)
Mar 19, 1915 – Dec 8, 2016

Stephen Schweinsberg (8T1)
Jun 18, 1957 – Aug 6, 2017

Mike A. Sheedy (8T3, MASc 8T5)
Nov 11, 1960 – Mar 30, 2017

Raymond J. F. Sherk (5T2)
Mar 20, 1922 – Dec 2, 2016

Steve Shuper (6T6)
Dec 13, 1943 – Jan 11, 2017

David A. W. Sime (5T2)
Dec 19, 1929 – Nov 22, 2016

John G. Smale (5T4)
Nov 6, 1930 – Aug 28, 2016

Robert F. Smith (4T8)
Jan 15, 1926 – Dec 16, 2016

Robert F. Sullivan (5T5)
Apr 18, 1930 – Mar 2, 2017

Sinnathurai Vijayakumar (MASc 8T0, PhD 0T5)
May 17, 1953 – Mar 31, 2017

John R. Whitehead (4T1)
Feb 14, 1919 – Feb 9, 2017

Joseph Young (4T7)
Jan 26, 1924 – Oct 1, 2016

Selected Honours & Awards

Members of the Department of Chemical Engineering & Applied Chemistry at U of T help set us apart from the rest.

We are extremely proud of the number of awards and acknowledgements received by our alumni, faculty and students since Fall 2016. Congratulations to each of them on their major achievements.

Alumni

APEGA, Community Service Award
2017 — Tracey Stock (8T2)

CSChE, Award in Design and Industrial Practice
2017 — David Beckman (MASc 8T1)

EC, Gold Medal
2017 — Larry Seeley (6T6, MASc 6T8, PhD 7T2)

House of Commons, Carillon Compsition Competition, Open Category, 1st place
2017 — Scott Orr (1T4)

Order of Canada, Member
2017 — Bert Wasmund (PhD 6T6)

U of T, Arbor Award
2017 — Joseph (Charles) De La Riviere (7T2)
Tom Latta (8T0)
John Lo (9T2)
Tony Pan Chung Tsui (0T7)

UOIT, Honorary Doctorate
2017 — Jeanette Southwood (8T6, MASc 8T8)

Donor-Sponsored ChemE Student Awards

The Class of 5T9 Leaders of Tomorrow Award
2017 — Rosten Role (1T8+PEY)

The Class of 8T2 Emerging Leaders Award in Chemical Engineering
2017 — Allan Cheung (1T9)

Colcleugh Family Award
2017 — Roham Dorakhan (1T8)
Man Bun Martin Li (2T0)
Shabbir Mustafa (1T7+PEY)

Diran Basmadjian Graduate Scholarship in Chemical Engineering & Applied Chemistry
2017 — Suraj Borkar (PhD candidate)

Eco-Tec Founder's Fellowship
2017 — Esmeralda Bukuroshi (PhD candidate)
Stephane Liegey (PhD candidate)

Edward Jarvis Tyrrell Fellowship
2017 — Darren Rodenhizer (1T3, PhD candidate)
Katie Sampson (PhD candidate)

The ERCO Worldwide Leaders of Tomorrow Award
2017 — Haroon Dawood (1T7)

Frank Howard Guest Bursary
2017 — Guangyu Song (MEng 1T7)

Helen L. Cross Memorial Graduate Scholarship
2017 — Olivia Molenda (PhD candidate)
Mahbod Hajighasemi (PhD candidate)

Irving O. Shoichet Graduate Scholarship
2017 — Nimalan Thavandiran (MASc 1T2, PhD candidate)

The Professor Douglas Reeve Leaders of Tomorrow Award
2017 — Miles Montgomery (PhD candidate)
Kylie O'Donnell (MASc 1T4, PhD candidate)

The Professor James W. Smith Leaders of Tomorrow Award
2017 — Natalie Tleel (1T9)

Professor William F. Graydon Memorial Graduate Fellowship
2017 — Jacyln Obermeyer (PhD candidate)

R. E. Jervis Award
2017 — Antione Boyer (MASc candidate)

R. W. Missen Memorial Prize in Thermodynamics
2017 — Ali Emam (1T7+PEY)
Shi Miao Yu (1T8)

The Troost Family Leaders of Tomorrow Award
2017 — Madhushan Perera (1T6+PEY)

W. H. Rapson Memorial Award
2017 — Alisha Giglio (MASc candidate)
Ezzat Jaroudi (PhD candidate)
Jason Ya (MASc candidate)

William J. Dowkes Graduate Bursary
2017 — Sable Reid (MASc candidate)

Faculty

BEJ, Young Investigator Award
2017 — Krishna Mahadevan

CCA, Killam Prize
2017 — Molly Shoichet

ChemE, Bill Burgess Teacher of the Year Award for Large Classes
2017 — Arthur Chan

ChemE, Diran Basmadjian Teacher of the Year Award for Small Classes
2017 — Emma Master

CIC/SCI, Kalev Pugi Award
2016 — Molly Shoichet

Connaught Fund, McLean Award
2017 — Alison McGuigan (PhD 0T5)

CRC, Tier 2 (Renewal)
2017 — Milica Radisic

CSChE, Canadian Journal of Chemical Engineering Lectureship Award
2017 — Alison McGuigan (PhD 0T5)

CSChE, Hatch Innovation Award
2017 — Alison McGuigan (PhD 0T5)

EC, Fellow
2017 — Levente Diosady (6T6, PhD 7T2)

FASE, Hart Teaching Innovation Professorship
2017 — Graeme Norval (8T3, MASc 8T5, PhD 8T9)

FASE, Research Leader Award
2017 — Greg Evans (8T2, MASc 8T4, PhD 8T9)

FASE, Sustained Excellence in Teaching Award
2017 — Will Cluett

FASE, Technology Enhanced Active Learning (TEAL) Fellows
2017 — Tim Bender
Erin Bobicki
Will Cluett
Greg Evans (8T2, MASc 8T4, PhD 8T9)
Jennifer Farmer
Ramin Farnood (PhD 9T5)
Alison McGuigan (PhD 0T5)
Graeme Norval (8T3, MASc 8T5, PhD 8T9)
Elodie Passeport

RSC, Fellow
2017 — Milica Radisic

STLHE, 3M National Teaching Fellowship
2017 — Greg Evans (8T2, MASc 8T4, PhD 8T9)

TAPPI, Gunnar Nicholson Gold Medal Award
2016 — Honghi Tran (PhD 8T2)

U of T, Sports Hall of Fame
2017 — Levente Diosady (6T6, PhD 7T2)

UTAA, Faculty Award
2017 — Elizabeth Edwards

Staff

FASE, Innovation Award
2017 — Pauline Martini

FASE, Quality of Student Experience Award
2017 — Engang (Susie) Susilawati

Other Student Awards

CAGS, Distinguished Dissertation Award, Engineering/Medical Science/Natural Science Category
2017 — Boyang Zhang (PhD candidate)

CEMF, Rona Hatt Chemical Engineering Ambassador Award
2017 — Olga Misic (1T9)

ChemE, ChemE Exhibition Poster Competition, Energy Category, 1st place
2017 — Amirhossein Foroozan Ebrahimy (MASc candidate)
2nd place
2017 — Suraj Borkar (PhD candidate)

ChemE, ChemE Exhibition Poster Competition, Environmental Category, 1st place
2017 — Jonathan Wang (MASc 1T2, PhD candidate)
2nd place
2017 — Ezzat Jaroudi (PhD candidate)

ChemE, ChemE Exhibition Poster Competition, Health Category, 1st place
2017 — Alison Traub (MASc candidate)
2nd place
2017 — Anastasia Korolj (1T5, PhD candidate)

ChemE, Chemical Engineering Plant Design Award
2017 — Danielle Appavoo (1T7)
Lynn Li (1T7)
Frank Maka (1T7)
Ekamjit Singh Deol (1T7)
Krithika Sugavanam (1T7)

ChemE, Environmental Engineering Plant Design Award
2017 — Cullen Hunter Adam (1T7)
Shannon Goulden (1T7)
Tong Li (1T7)
Lucas Pereira (1T7)
Surya Rana (1T7)
Saloni Sabharwal (1T7)

ChemE, Graduate Student Life Catalyst Award
2017 — Sofia Bonilla (PhD 1T7)
Jennifer Logie (PhD 1T7)

ChemE, Sustainable Engineering Plant Design Award
2017 — Mohammed Ali (1T7)
Krishelle Calilung (1T7)
Ruhi Choudhary (1T7)
Raghav Goswami (1T7)
Matthew Matys (1T7)
Alexander Wong (1T7)

ChemE, Undergraduate Student Life Catalyst Award
2017 — Neha Bhasin (1T7)
Katherine Dritsas (1T7)
Andrew Kostruba (1T6+PEY)
Kayla Musalem (1T7)
Kenny Wei (1T6+PEY)

CSA, Academic Challenge
2017 — Katherine Dritsas (1T7)
Andrew Kostruba (1T6+PEY)
Kayla Musalem (1T7)
Kenny Wei (1T6+PEY)

CSChE, Minerva Canada/ CIAC Case Competition, 2nd place medal
2016 — Katherine Dritsas (1T7)
Andrew Kostruba (1T6+PEY)
Kayla Musalem (1T7)
Kenny Wei (1T6+PEY)

CSChE, Robert G. Auld Student Paper Competition, 1st place medal
2016 — Ziyu Bao (1T8)

FASE, Hatchery Demo Day, Lacavera Prize
2017 — Bowen Li (1T7)
as part of Team Genecis

Minerva Canada, James Ham Safe Design Award
2017 — Katherine Dritsas (1T7)
Andrew Kostruba (1T6+PEY)
Kayla Musalem (1T7)
Kenny Wei (1T6+PEY)

Ontario Engineering Competition, Communications Category, 1st place
2017 — Neha Bhasin (1T7)
Anne Nasato (1T7)

MetSoc of CIM, Hydrometallurgy Undergraduate Scholarship
2017 — Chenbo (Sophie) Xu (1T8)

MetSoc of CIM, Ernest Peters Master's Award
2017 — Eric Shum
(1T5, MASc candidate)

MetSoc of CIM, Lucy Rosato Undergraduate Scholarship in Science and Engineering
2017 — Sahar Ayaz (1T7)

OPEFE, Scholarship
2017 — Enakshi Shah (1T7+PEY)

RBC, Prize for Innovation and Entrepreneurship
2017 — Bowen Le (1T7)

U of T, Gordon Cressy Leadership Award
2017 — Stephanie Gaglione (1T7)
Andrew Kostruba (1T6+PEY)
Natalia Mykhaylova (PhD 1T7)
Madhushan Perera (1T6+PEY)
Nimalan Thavandiran
(MASc 1T2, PhD candidate)

U of T, Lester B. Pearson International Scholarship
2017 — Deborah Emilia Solomon
(2T1)

UnERD, Chemical Engineering Poster Competition, 1st place medal
2017 — Chenbo (Sophie) Xu (1T8)

University of Oxford, Rhodes Scholarship
2017 — Stephanie Gaglione (1T7)

Save the Date!

The **2nd annual ChemE Exhibition** and **33rd ChemE Dinner** will take place on Friday, March 23, 2018.

These two "must-attend" events brings together alumni, industry friends, students, faculty, and staff.

We will be sending out email invitations within the next few months. If you wish to attend, please make sure we have your current email address on file by sending a message to address.update@utoronto.ca.

Hope to see you then!

Upcoming Events

For information on upcoming events visit chem-eng.utoronto.ca.