SUSTAINABILITY RESEARCH

UNIVERSITY OF TORONTO | Engineering

SUSTAINABILITY RESEARCH AT U of T ENGINEERING

Over the last century, technology has enabled standard-of-living improvements around the world. At the same time, thriving cities and growing populations take a toll: lakes, rivers and oceans have become polluted, air quality in major cities is poor and our climate is changing.

U of T Engineering researchers are at the forefront of sustainable alternative technologies that can mitigate these impacts. We are creating new ways to harvest energy from the sun and wind, and efficiently store it. We are developing cleaner, more efficient engines that can run on biofuels without compromising safety or reliability. And we are designing better ways to move people through cities in order to make our urban environments more livable.

Together with industrial partners in diverse sectors, our leading-edge research is helping companies make better use of resources and enabling access to new technologies for a cleaner, greener and more sustainable future.

SELECTED AREAS OF EXPERTISE IN SUSTAINABILITY RESEARCH AT U of T ENGINEERING

- Alternative Fuels
- Carbon Management
- Combustion
- Emissions Reduction
- Energy Policy
- Energy Storage
- Infrastructure Management
- Life Cycle Assessment
- Smart Grid
- Sustainable Aviation
- Sustainable Energy
- Transportation
- Urban Development

SPECIALIZED EDUCATIONAL OFFERINGS IN SUSTAINABILITY

Our Master of Engineering students can choose from technical specializations in Advanced Water Technologies, Sustainable Energy and Sustainable Aviation, where they access the expertise of our world-class professors and contribute to leading-edge research in these important areas. At the undergraduate level, students can pursue minors in Sustainable Energy and Environmental Engineering, and Engineering Science students can major in Energy Systems Engineering.

RESEARCH CENTRES & INSTITUTES

2015

CENTRE FOR POWER AND INFORMATION (CPI)

CPI is building the power grid of tomorrow. It includes experts in smart grids and focuses on issues such as the integration of renewable power, cyber security and demand response.

2013

CENTRE FOR RESEARCH IN SUSTAINABLE AVIATION (CRSA)

CRSA equips scientists and engineers with the interdisciplinary competencies required to develop future generations of environmentally sustainable aircraft. It includes experts in aerodynamics, propulsion, biofuels, life-cycle assessment and aviation policy.

2013

INSTITUTE FOR SUSTAINABLE ENERGY (ISE)

ISE brings together more than 50 principal investigators from U of T Engineering and the Faculty of Arts & Science to advance solutions in technologies including wind turbines, solar power, fuel cells and hydroelectricity.

2011

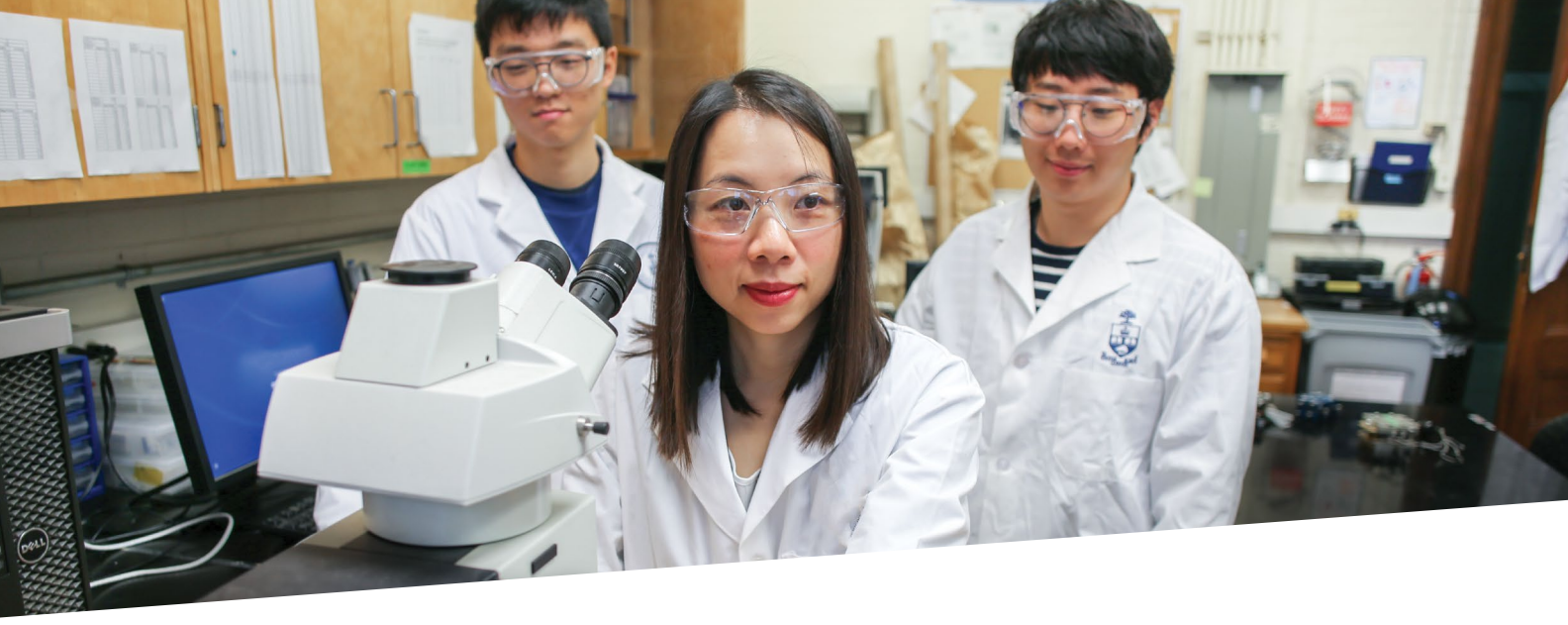
BIOZONE

BioZone leverages recent advances in molecular biology and genomics to address engineering challenges in a number of sectors, including environmental bioremediation, energy and human health. Solutions include enriched microbial cultures that can degrade hazardous compounds, bio-derived fuels and other commodity chemicals, and large-scale production of protein-based medical products.

2009

CENTRE FOR GLOBAL ENGINEERING (CGEN)

Through courses, co-curricular activities and research, CGEN facilitates creative solutions to global challenges in sanitation, alternative energy, health care and clean water.



RESEARCH IMPACT

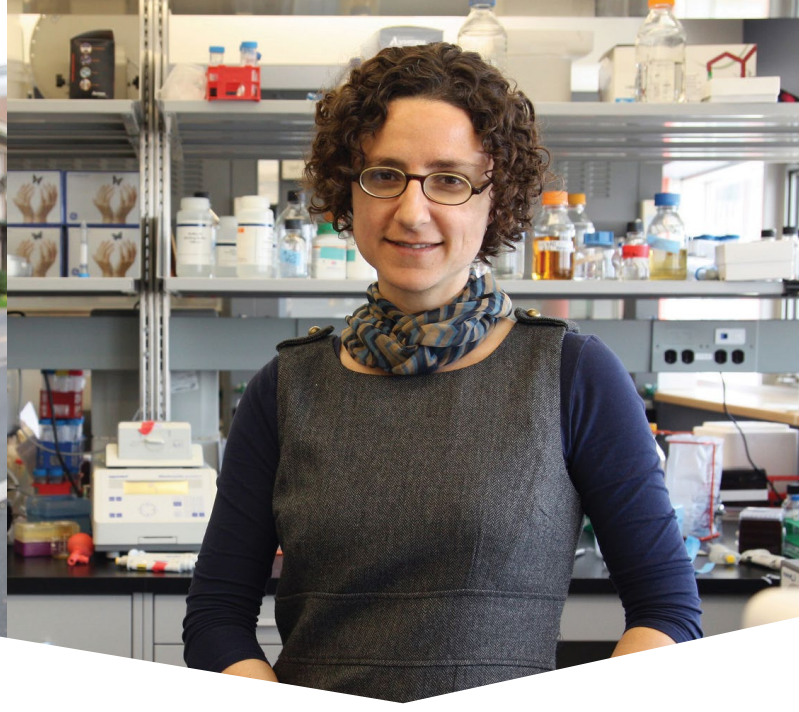
"Every day our students are taking intellectual risks and asking exciting questions in sustainability. What I love is connecting those minds with companies who have an interesting idea, and helping them realize their visions together."

PROFESSOR AIMY BAZYLAK
Canada Research Chair in Thermofluidics for Clean Energy; Director, Institute for Sustainable Energy

CLEANER ENERGY THROUGH HYDROGEN

Solar and wind installations provide clean power, but storing that energy for days when conditions are cloudy with no wind is still a major challenge. One solution is to use electrolyzers, which take renewable electricity and use it to split water into hydrogen and oxygen gas. The hydrogen can later be used in a fuel cell that reverses the process, recombining H_2 and O_2 to produce electricity and water.

Mechanical engineering professor and director of the Institute for Sustainable Energy **AIMY BAZYLAK** (middle) holds the Canada Research Chair in Thermofluidics for Clean Energy, and leads a team of experts specializing in polymer electrolyte membrane (PEM) fuel cells and electrolyzers. By designing new materials and formulations for electrochemical energy conversion, Bazylak and her team are improving the efficiency and reliability of fuel cells and electrolyzers while keeping costs low. Better electrolyzers and fuel cells could enable efficient, long-term storage of renewable power.



SMART CITIES ARE SUSTAINABLE CITIES

Over half the world's population now lives in cities. By centralizing resources, urbanization has the potential to greatly reduce per capita environmental impact. But it can also lead to gridlock, air pollution and other challenges that threaten our health.

Professor **ERIC MILLER** is the director of the University of Toronto Transportation Research Institute (UTTRI) in the Department of Civil & Mineral Engineering, which helps cities grow in a more sustainable way. UTTRI brings together more than two dozen experts from engineering, economics, policy, urban geography and computer science. Through data gathering, analysis and modelling, UTTRI researchers provide system-wide, evidence-based policy analysis and decision support.

Ongoing projects include analysis of the effectiveness of new bike lanes installed on Toronto's Bloor Street and using artificial intelligence and machine learning to optimize the most efficient timing of traffic lights through an intersection. By working with urban governments, city planners and companies in the transportation sector including Miovision, IBM Canada and Esri Canada, UTTRI is ushering in a new era of smarter, greener cities.

FROM PLANTS TO PLASTICS

In Canada, the forest is our largest bio-based feedstock. Yet despite the increasing demand for greener materials and the abundance of this renewable resource, many of the products we use on a daily basis are still made from non-renewable fossil fuels. Even for paper products, only a tiny fraction of the raw wood material makes it into the final product.

Designing reproducible and cost-effective processes for transforming wood into marketable products is technically challenging. Hemicellulose and lignin — which together make up more than half of the wood in a tree — are usually wasted, burned for power generation or discarded. Chemical engineering professor **EMMA MASTER** is leading a national Genome Canada initiative called SYNBIOMICS aimed at developing processes to create value-added products from this underutilized forest biomass.

Master and her colleagues are designing biocatalysts to upgrade rather than degrade cellulose, hemicellulose and lignin. Upgrading bypasses the challenges involved in breaking down these structures and builds on the unique qualities of each polymer for targeted applications. These applications include resins, coatings, bioplastics and adhesives for lightweight biocomposites. Working with several industry partners across the value-chain such as Canfor and Dupont, SYNBIOMICS aims to meet the precise specifications and consistency the market requires while reducing reliance on fossil fuels and revitalizing Canada's forestry sector.

SPRAY-ON SOLAR POWER

Today, virtually all commercial solar cells are made from thin slices of crystalline silicon which must be processed to a very high purity. It's an energy-intensive process, requiring temperatures higher than 1,000 degrees Celsius and large volumes of hazardous solvents.

However, silicon isn't the only path to solar power. Electrical and computer engineering professor **TED SARGENT**, Canada Research Chair in Nanotechnology, and his team are working on alternative technologies, from perovskite crystals to nanoparticles known as quantum dots. Both of these technologies enable the active ingredient to be mixed into a liquid, creating a kind of "solar ink." Eventually, this material could be sprayed onto surfaces such as urban rooftops or used in traditional inkjet printing equipment to create solar cells at a fraction of current costs.

The team has also demonstrated the ability to combine a layer of quantum dots with a traditional silicon photovoltaic cell, creating a tandem device that harvests more of the solar spectrum than silicon alone. Sargent and his collaborators founded a spinoff company, QD Solar, to commercialize this technology. Their customers include leading solar manufacturers who want to give their products a boost at minimal cost.

THE FUTURE OF SUSTAINABLE RESEARCH

ALGAE FOR FOOD AND FUEL

Algae are among the fastest-growing photosynthetic organisms on the planet, but they could also be the most useful. In addition to absorbing climate-warming CO_2, some species of algae accumulate fats and oils that could be turned into biofuels and biochemicals, while others produce nutritious molecules that could be used to feed fish, animals and even humans.

Professors **GRANT ALLEN** in Chemical Engineering and Stewart Aitchison in Electrical and Computer Engineering have developed an efficient tool to pipe light into algal biofilms. Working with partners such as the National Research Council, Pond Biofuels, Biox Corp and Mara Renewables, they are investigating whether algae grown on an industrial scale could simultaneously clean wastewater, reduce air emissions and produce value-added products.

BLUE SKIES AHEAD

Every day, commercial flights burn over 100,000 litres of fuel, leading to significant harmful carbon dioxide emissions. Aerospace engineering professor **DAVID ZINGG** is the U of T Distinguished Professor of Computational Aerodynamics and Sustainable Aviation, and the founding director of the Centre for Research in Sustainable Aviation. In partnership with major aircraft manufacturers such as Bombardier and Airbus, Zingg and his colleagues are investigating novel aircraft configurations, stronger and lighter materials, and friction-reducing actuators to substantially improve aircraft fuel efficiency.

CLEANER COMBUSTION

Combustion powers our society, yet it also contributes to climate change and generates other emissions that impact local air quality. Leading a national network that includes industry partners such as Ford, Rolls-Royce and Pratt & Whitney, mechanical engineering professor **MURRAY THOMSON** and his collaborators are training a new generation of combustion experts who will redesign engines to lower emissions, improve fuel efficiency and enable the adoption of biofuels.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

LEADING INNOVATION STARTS HERE

Connect with us to discuss how a partnership with U of T Engineering can benefit your organization:

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STATEMENT OF ACKNOWLEDGEMENT OF TRADITIONAL LAND
We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people and we are grateful to have the opportunity to work on this land.

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