BUILDING A NET ZERO FUTURE

ANNUAL REPORT 2022

Toronto Metropolitan University

Centre for Urban Energy
Faculty of Engineering
& Architectural Science

A message from

the Dean and VPRI

The Centre for Urban Energy's (CUE's) innovative and collaborative research has been at the forefront of efforts to help Toronto, and the rest of the country, slow climate change and reach zero greenhouse gas emissions by 2050. Since its inception, CUE has been awarded over $35.6 million to fund initiatives that have secured its reputation as a world-class clean energy research centre.

Steven N. Liss

Tom Duever

This report summarizes CUE's major research and activities in 2022, including:

- **Natural Sciences and Engineering Research Council of Canada (NSERC) Synergy Award for Innovation**
- **Independent Electricity System Operator (IESO) Grid Innovation Fund with partner Toronto Hydro**
- **NSERC Alliance-Mitacs Accelerate grant with partner Hydro One**
- **NSERC Alliance-Mitacs Accelerate grant with partner Toronto Hydro**

In 2022, the launch of the Power Up Program in CUE's Clean Energy Zone (CEZ) to support the city's transition to a prosperous low-carbon economy was incredibly exciting! This program helps students and early-stage entrepreneurs with developing new visions and ideas for minimum viable products (MVPs) while gaining leadership experience, technical expertise, business acumen and communication skills. At the end of the year, CEZ incubated 55 startups and created 220 jobs.

The goal for the coming years is to expand our research horizons and develop solutions for energy transition using hydrogen and small modular reactors, and to pursue cybersecurity and deep learning technologies for the energy sector.

Tom Duever
Dean, Faculty of Engineering and Architectural Science

Steven N. Liss
Vice-President, Research and Innovation

A message from

the CUE team

CUE builds and delivers industry solutions through academic excellence, accelerating energy transition in Canada. CUE has played a crucial role in fulfilling Toronto Metropolitan University's (TMU's) 2020-2025 Strategic Research Plan by bringing together energy stakeholders and harnessing their respective expertise to break new ground.

The CUE team are researchers and much more. We connect, collaborate, enable and co-innovate with universities, utilities, government and the private sector, and the pan-Canadian NSERC Energy Storage Technology Network (NESTNet) is a prime example. We span the globe from South America, Europe and Asia through strong international partnerships, and work collaboratively and inclusively with an international group of experts to develop real-world, deployable clean energy solutions at home and around the world.

Our goals include academic research and more as we convene interdisciplinary stakeholders and students to innovate and work on global problems. We are motivated to address energy challenges and build solutions for affordable, secure and sustainable energy systems for generations to come.

Bala, Eleonora, Karen and Michelle

> **We're proud to work with CUE as we continue to modernize the grid and prepare for increasing electricity demand in the future. CUE's research helps Toronto Hydro develop practical solutions for building a smarter, more flexible and resilient energy grid.**

Elias Lyberogiannis,
Executive Vice-President, Planning and Chief Engineering and Modernization Officer, Toronto Hydro

Our vision

CUE was created to be a world-class research and innovation centre dedicated to solving our most pressing urban energy challenges.

Our model

CUE is an academic-industry partnership established to explore, develop and commercialize sustainable, innovative, cost-effective and practical clean energy solutions and technologies.

Our three pillars

Research, testing and consulting

Projects and reports are often completed in collaboration with — or sponsored by — government and industry partners.

Testing of products or prototypes takes place at a world-class university, using state-of-the-art equipment.

Consulting projects draw on our capacity for multidisciplinary collaborations between industry professionals and academic researchers, as well as access to our unique lab spaces.

Education

Professional development is offered through a formalized curriculum and an executive education seminar series.

Innovation

As part of TMU's Zone Learning ecosystem and housed in CUE, CEZ is a startup incubator focused on fostering innovative ideas and businesses in the clean and sustainable energy sector.

Our SRC activities

CUE's work and culture are guided by TMU's scholarly, research and creative (SRC) objectives. Our key performance indicators are listed later in this report under SRC Excellence.

Acknowledgments

Founding Sponsors

2022 Partners and Sponsors

Elocity
Celestica
Halton Hills Hydro
Hydro One
Mitacs
NSERC
Opus One
Peak Power
Tata Power
TCHC
Toronto Hydro
Alectra
Magna International

Advisory Board

Thomas Duever
Dean, Faculty of Engineering and Architectural Science, Toronto Metropolitan University (Chair)

Matthieu Bureau
Vice-President, Power Systems Canada, Schneider Electric

Tom Chapman
Senior Manager, Market Development and Strategy, Independent Electricity System Operator (IESO)

Martin Huang
Vice-President, System Operations, Hydro One

Steven N. Liss
Vice-President, Research and Innovation, Toronto Metropolitan University

Elias Lyberogiannis
Executive Vice-President, Planning and Chief Engineering and Modernization Officer, Toronto Hydro

Neetika Sathe
Vice-President, Green Energy and Technology (GRE&T) Centre, Alectra

Thomas Timmins
Leader, Energy Sector Group, Gowling WLG

Bala Venkatesh
Academic Director, Centre for Urban Energy

Focus

areas

CUE's focus areas are climate change, microgrids, demand management, efficiency, electricity planning, hydrogen, conservation, electric vehicles, net zero buildings, policy and regulation, renewables, smart grids, storage, transmission and distribution, and transactive energy.

activities

CUE combines the perspectives of engineering, science, environmental studies, business, social sciences, public policy, law and infrastructure management.

advantages

- World-class urban energy researchers, technologies and facilities
- Multidisciplinary collaborations under one roof
- Integration of research and commercialization
- Research and cost-effective testing for real-world applications
- Objective, academically driven innovation
- Evidence-driven approach to big-picture issues
- Sustained commitment to supporting incubation and entrepreneurship

> **As a hub for research, collaboration and innovation, CUE brings together industry, government and top researchers to explore today's most pressing urban energy challenges. The work done by CUE is critical to long-term sustainability of our cities and major centres. I am very proud of the work done by our researchers and the positive impact they are making on the future of our province and country.**

Mohamed Lachemi,
President and Vice-Chancellor, Toronto Metropolitan University

Addressing

your needs

YOU

- Have a pressing energy problem to solve
- Need access to pioneering research and innovative development
- Have a grid-scale prototype or project to test under real-world conditions
- Want customized energy education for professional development
- Would like to sponsor research, mentor a student or support awards

CUE

- Has world-class researchers with urban-energy expertise
- Collaborates across disciplines and industries to develop energy solutions
- Merges research, innovation and commercialization
- Is nonpartisan, objective and evidence-based
- Generates and demonstrates real-world impact

How our model applies to

different stakeholders

Utilities benefit from access to cost-effective research, testing and innovation.

Governments benefit from policy and technical implementation, white papers, reports and a vision for whole energy systems.

Industries benefit from a pool of highly qualified personnel.

Students benefit from working and/or training directly with industry partners.

Society benefits from efficient, accessible electricity and a cleaner environment.

> Hydro One is committed to energizing life in Ontario by ensuring clean, safe and reliable power is available for customers now and into the future. We are proud to support the work being done to advance Distributed Energy Resources (DERs). The development of new technologies will help support our operations today and into the future as we plan for our clean energy future.

Spencer Gill,
Vice-President, Planning, Hydro One

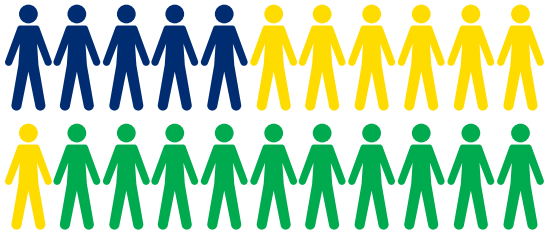
Resources

People

Administration

4 employees

Researchers



5 research fellows

7 visiting researchers

10 principal investigators

Facilities

736 m²
(7,922 ft²)

6 labs
including the Schneider Electric Smart Grid Lab

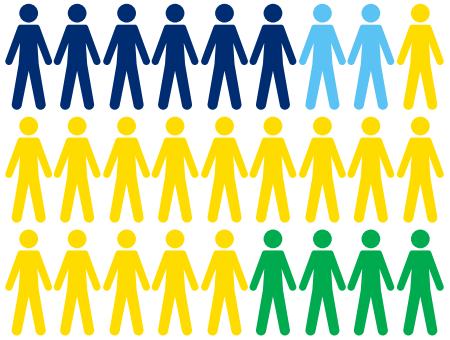
TEDS showcase

SRC excellence

SRC commitments

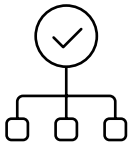
- Increase international student enrolment
- Continue to engage students
- Continue to create global connections
- Push towards equitable energy research using an interdisciplinary approach
- Promote integration of EDI-related considerations in research practices and team formation
- Foster an equitable, inclusive and accessible research work environment for team members

Students



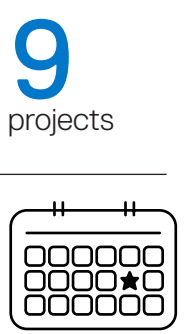
- 6 undergrad
- 2 MASc
- 15 PhD
- 4 research assistants

Student engagement

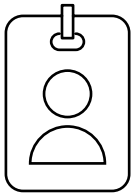


9 projects

25 events



4 awards



6 internships

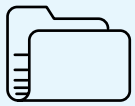
Partners

11 industry

2 government

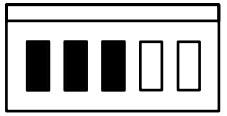
Projects

86 total



77 completed

9 in progress

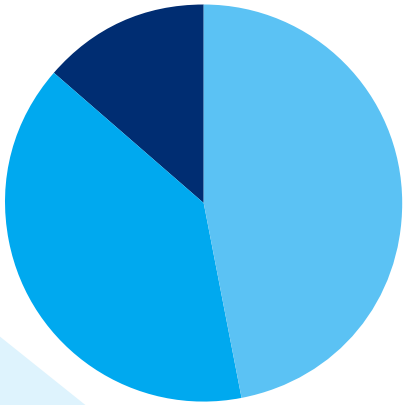


Funding

$35.62M total funding from 2010

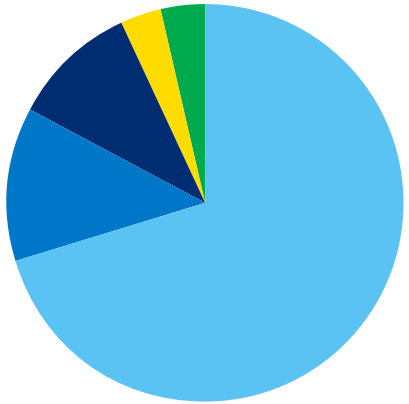
2022 funding **$3.79M**

2010 2012 2014 2016 2018 2020 2022



Sources of funding

- 47.2% industry
- 39.2% government
- 13.6% university



Funding distribution

- 70.5% research
- 12.5% operations
- 10.2% research fellows
- 3.2% student awards
- 3.6% Clean Energy Zone

Impact

Journal publications	Technical reports	Conference publications	Patents
20 in 2022	28 in 2022	5 in 2022	3 since 2015
125 since 2015	74 since 2015	45 since 2015	

Global partnerships

- 2 Brazil
- 1 India
- 1 Malaysia
- 1 Scotland
- 1 England
- 1 USA

Featured

projects

Celestica

As the demand for electrical vehicle (EV) chargers continues to rise, so does the need for testing and evaluation of solutions to assist original equipment manufacturers and other suppliers in designing and creating innovative products and solutions that improve reliability and performance while meeting specific technical, developmental or regulatory needs. Under the co-supervision of professors Reza Arani and Bala Venkatesh, CUE and Celestica will continue their partnership to produce a wide range of testing solutions unique to EV chargers.

Hydro One + NSERC and Mitacs

Distributed energy resources (DERs) are playing an increased role in the way electricity is generated and delivered, providing a pathway to a zero carbon 2050 future. As with most emerging technologies, DERs can also present new challenges to existing infrastructures and practices.

Under the supervision of professors Bala Venkatesh and Reza Arani, CUE will provide the tools, frameworks and expertise to support Hydro One in seamlessly integrating tens of thousands of DERs into their system to improve electricity reliability and resiliency. The project is supported by funds from the joint NSERC Alliance-Mitacs Accelerate grant and Hydro One.

IESO + Toronto Hydro + Power Advisory LLC

With the goal of building a resilient infrastructure, promoting sustainability and fostering innovation, CUE is pleased to partner with Toronto Hydro and Power Advisory LLC, with support from the IESO Grid Innovation Fund and the Ontario Energy Board's (OEB) Innovation Sandbox, to identify solutions that will allow the utility to use the same demand response resources simultaneously to meet the capacity needs of both local and provincial grids.

NSERC

In recognition of the outstanding R&D collaboration between CUE and Toronto Hydro, professor Bala Venkatesh received NSERC Synergy Award for Innovation. The monetary award will be used to continue the research with Toronto Hydro to develop new strategic solutions for distribution system operations.

Schneider Electric

CUE's Smart Building Analytics Living Lab (SBALL), anticipated to open in 2023, is the result of a long-standing, collaborative relationship between Schneider Electric and TMU. It provides the tools to develop, test and optimize modern technologies and approaches as well as demonstrates savings in energy consumption, capital and operating expenses for buildings of all sizes. Under the supervision of professor Jenn McArthur, the lab will present opportunities for TMU students to "do cutting-edge, advanced research, and form the next generation of highly skilled personnel in the field."

Toronto Hydro + NSERC + Mitacs

CUE will leverage funds from the joint NSERC Alliance-Mitacs Accelerate grant to conduct research and advise Toronto Hydro as it modernizes its energy grid. With the rapid evolution of the energy landscape, CUE's work will include determining the optimum size of energy storage and improving scheduling, dispatching and utilization of energy resources, and in general, will help achieve sustainable growth.

Recently completed

projects

Opus One Solutions

PROJECT 1

CUE forecasted the growth of the EV and photovoltaic markets from 2021 to 2030 to determine the proportional relationship between population and EV chargers. CUE leveraged Opus One's GridOS Integrated Distribution Planning (IDP) software to analyze the impact of EV growth on a New Delhi utility distribution feeder, which resulted in the design and delivery of viable solutions such as energy storage to mitigate overloading conditions.

PROJECT 2

CUE designed and developed the world's first pole-mounted energy storage system and provided conceptual designs for three service areas within Canada and India. Benefits of this system include storing energy to be released as needed, which increases reliability and reduces strain on the local transformer.

Toronto Community Housing Corporation (TCHC)

Energy costs contribute substantially to the overall financial burden of housing. As a first step to improving the energy efficiency of TCHC buildings, CUE identified and recommended affordable, technological solutions that can offset the energy-cost burden and disruption to TCHC tenants as well as help reduce greenhouse gas emissions and power consumption.

Our programs

Professional Master's Diploma in Energy and Innovation

The Professional Master's Diploma in Energy and Innovation (part-time) program aims to equip participants with the knowledge and skills required to function competently as operators, officers, administrators, managers, technicians, analysts, policy advisors and other key occupations in the fast-growing, rapidly evolving, dynamic Canadian Canadian energy sector.

Electrical Engineering 101

The Electrical Engineering 101 seminar series introduces the fundamental concepts of electrical engineering to those without an engineering background looking to advance their career or break into a new one.

Customized Executive Education Programs

CUE delivers seminars and workshops developed for the unique needs of Canadian organizations and international groups. Optional daytime and evening networking events give participants an exclusive opportunity to connect with Ontario's energy leaders and policymakers.

Featured

companies

CLEAN ENERGY zone

Cence Power (formerly Argentum Electronics)

Cence Power builds touch-safe, high voltage direct current (DC) power distribution systems that increase service as well as energy efficiency of LED lighting by up to 40%. Cofounders Bolis Ibrahim and Sagar Jaiswal were named in the Forbes 30 Under 30 list in the category of Manufacturing & Industry.

Their 2022 achievements include:

- Awarded 1st place in **VentureLab's HardTech Pitch Competition**
- Acquired by Cence Power
- **i.d.e.a. Fund** recipient

Cleanair.ai

Based in Toronto, CleanAir.ai develops technology that provides transformational air to homes and buildings, and establishes a new standard for HVAC air infiltration. This tech startup's ALVI CleanAir Safety System delivers better-than-HEPA air quality, reduces energy consumption of HVAC systems, and has IoT wireless monitoring that allows filter status and indoor air quality events to be monitored at all times.

Their 2022 achievements include:

- Winner of an **International Sustainability Award** from one of the largest developers in the Asia-Pacific region
- Successful installation of the **ALVI CleanAir Safety System** in high profile Canadian government buildings in Ottawa
- Recently received a contract with **Mattamy Homes** to outfit a complete development

Innowind

Innowind is a wind energy innovation startup that is building an airborne wind energy system to provide renewable alternatives to remote, rural and Indigenous communities in Canada and around the world.

Their 2022 achievements include:

- Winner of the **Slaight New Venture Competition 2022**
- Winner of the **Quantum Valley Investments Problem Pitch**
- Finalist of the **UpStart Program** competition under Velocity Incubator

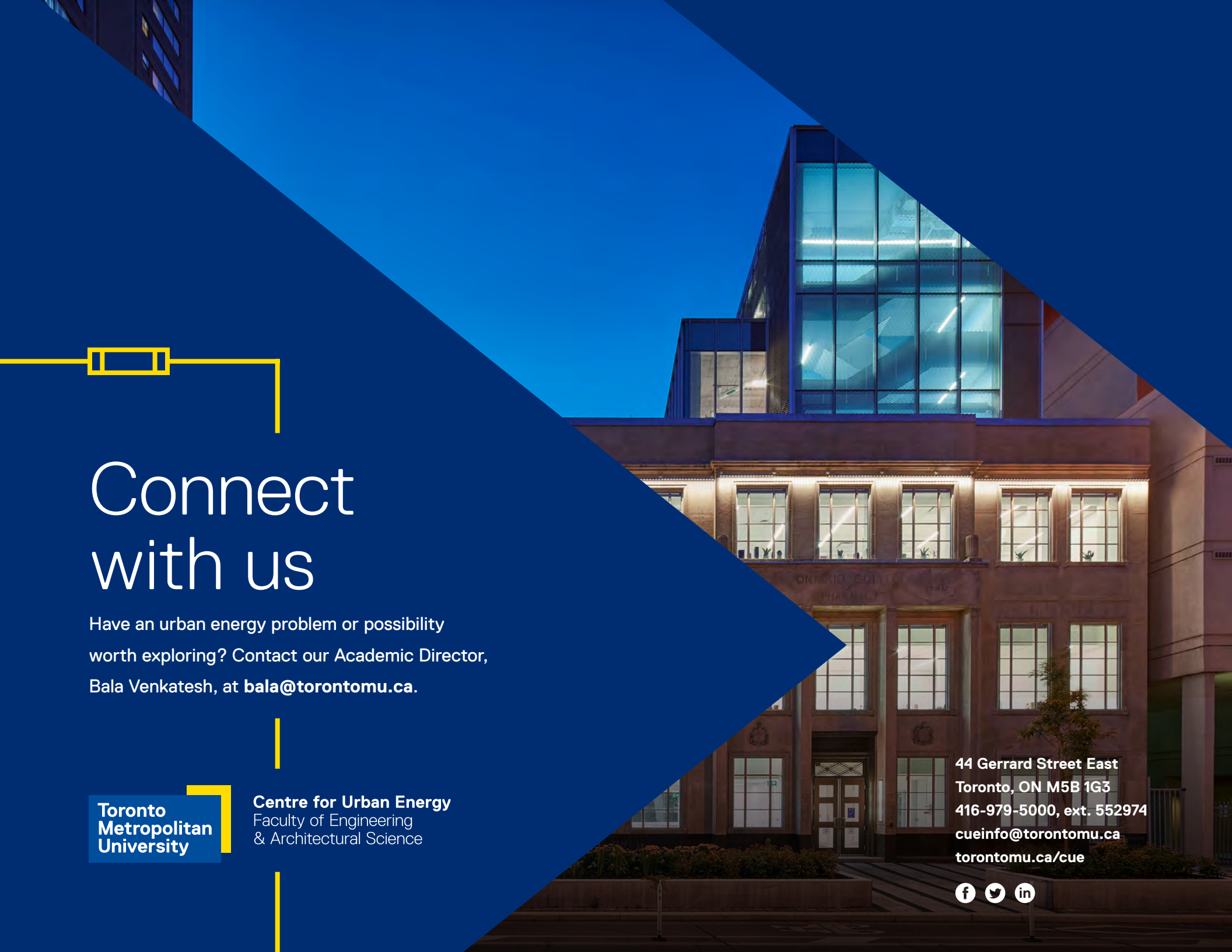
Have an idea for an urban energy startup?

The Clean Energy Zone (CEZ) is an industry-leading, campus-based incubator located at CUE. Since its inception, 55 startups have passed through CEZ, including million-dollar companies such as Peak Power and SWTCH.

Learn more at **torontomu.ca/cue/cez**.

Connect with us

Have an urban energy problem or possibility worth exploring? Contact our Academic Director, Bala Venkatesh, at **bala@torontomu.ca**.



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Centre for Urban Energy
Faculty of Engineering
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44 Gerrard Street East
Toronto, ON M5B 1G3
416-979-5000, ext. 552974
cueinfo@torontomu.ca
torontomu.ca/cue