



Centre for Urban Energy

# ANNUAL REPORT

Empowering urban futures through  
research & innovation

RYERSON  
UNIVERSITY

Everyone Makes a Mark



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## Dean's Message

Ryerson University is a distinctly urban university, with the capacity to partner with industry and government in order to solve real-world problems. Measured by growth in external research funding, Ryerson has one of the fastest-growing research enterprises in Canada, and leads all Canadian universities in research publication growth over the past decade. Our research emphasis at Ryerson and in the Faculty of Engineering, Architecture and Science is on relevance, addressing the societal needs of today's world. In keeping with these objectives, the Centre for Urban Energy was launched thanks to significant support from its founding sponsors: Hydro One, Ontario Power Authority, and Toronto Hydro. Through academic, public and private sector collaborations, CUE researchers will light the way in developing and commercializing innovative solutions to urban energy issues. The future looks bright.



**Dr. Mohamed Lachemi, P.Eng., FCAE, FCSCE**  
**Dean,**  
**Faculty of Engineering, Architecture and Science**



## Director's Message



The Centre for Urban Energy (CUE) is a unique creation of Ryerson University and the Faculty of Engineering, Architecture and Science. Established in collaboration with founding sponsors Hydro One, Ontario Power Authority and Toronto Hydro, CUE comes at a time when we are seeing smart grid developments and renewable energy joining mainstream power systems. CUE is focused on identifying and solving urban energy challenges through research, development and demonstration.

In the first year, Ryerson invested \$1.5 million towards the creation of a physical space located at 147 Dalhousie Street. The Centre's infrastructure was conceptualized in August 2010, constructed over Fall 2010 and Winter 2011, and occupied in May 2011. The Centre has four labs for research in energy, with 11 office seats and 45 student seats.

The founding sponsors committed up to \$7 million for five years towards research, capacity building and student awards. After the Centre's announcement in September 2010, four externally funded projects from OCE, Lumentra, Innisfil Hydro and Ministry of Research and Innovation worth \$2 million were secured, in addition to 12 projects that are underway for the founding sponsors. Five Distinguished Fellows were hired and two administrative staff members joined the CUE team. In April 2011, Lynda O'Malley was hired as the administrative assistant, while Robert Hellier filled the manager position. CUE has also sponsored 23 student-led projects.

By investing in physical facilities dedicated to energy research, CUE creates synergies among faculty, students and industry partners that cannot happen in a virtual centre. Inspired by and working for industry, CUE boasts flexible Intellectual Property (IP) rights to lower barriers for industry collaboration with the university.

If we have not yet connected with you, we hope to connect now. Join CUE as we power up to solve the world's energy challenges and develop marketable products for global application.

**Dr. Bala Venkatesh, P.Eng.**  
Academic Director

## CUE Powers Innovation

CUE builds energy innovation into the urban grid, with great opportunities for students, faculty, and private and public sector partners to solve tomorrow's energy challenges today.

### CUE research focus



ENERGY STORAGE  
SMART BUILDING & NET-ZERO HOMES  
POWER GENERATION & TRANSMISSION SYSTEMS  
EFFICIENCY, CONSERVATION & DEMAND MANAGEMENT  
ENVIRONMENTAL, SOCIAL & ECONOMIC IMPACTS  
ELECTRIC VEHICLES & INFRASTRUCTURE  
POLICY & REGULATORY ISSUES  
RENEWABLE ENERGY  
SMART GRID

### CUE Vision

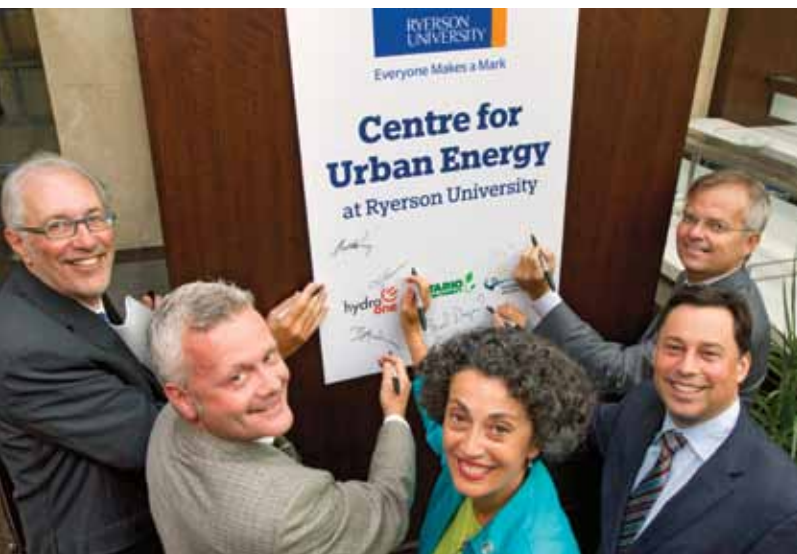
To be a world class research and innovation centre dedicated to solving urban energy challenges

### CUE Mission

- Build academic, public and private sector partnerships
- Encourage multidisciplinary and collaborative approaches
- Conduct research, development and demonstration, leading to commercialization
- Provide scholarship and learning opportunities



## Launch



**From left:** Ryerson President Sheldon Levy, Ontario Power Authority CEO Colin Anderson, Hydro One President and CEO Laura Formosa, Ontario's Minister of Energy Brad Duguid, and Toronto Hydro President Anthony Haines.

On September 1, 2010, Ryerson University announced the creation of the Centre for Urban Energy (CUE), a unique research and technology demonstration centre devoted to the discovery and commercialization of innovative, practical solutions to urban energy issues.

CUE brings together industry and government partners, and top researchers from across Canada and around the world to undertake a collaborative, multidisciplinary approach to the study of urban energy. CUE combines engineering, science, environmental issues and infrastructure

management to tackle immediate challenges such as development of clean energy technologies; energy conservation and demand management; alternative local energy generation; energy storage; carbon footprint reduction; and smart/adaptable infrastructure.

The Centre for Urban Energy will receive up to \$7 million from three founding sponsors. Hydro One and Toronto Hydro Corporation have each committed \$2.5M over five years, while Ontario Power Authority will provide up to \$2M during that same period.

### CUE by Numbers

Funding	\$11 M
Projects — Faculty	16
Projects — Student	23
Students	38
Faculty	15
Fellows	5
Administrative Staff	2

### Partners

- Hydro One
- Ontario Power Authority
- Toronto Hydro
- Temporal Power
- Lumentra
- Ontario Centres of Excellence
- ISTP Canada
- Ministry of Research and Innovation
- Innisfil Hydro
- Fed Dev Ontario
- Electrovaya
- Natural Resources Canada
- Schneider Electric
- Anna University
- University of Waterloo
- University of Western Ontario
- University of Ontario Institute of Technology
- Indian Institute of Technology, Chennai
- University of Alberta
- Pollution Probe





# Research Projects

To date, 16 R&D and technology demonstration projects led by faculty members are underway

## Featured Project #1

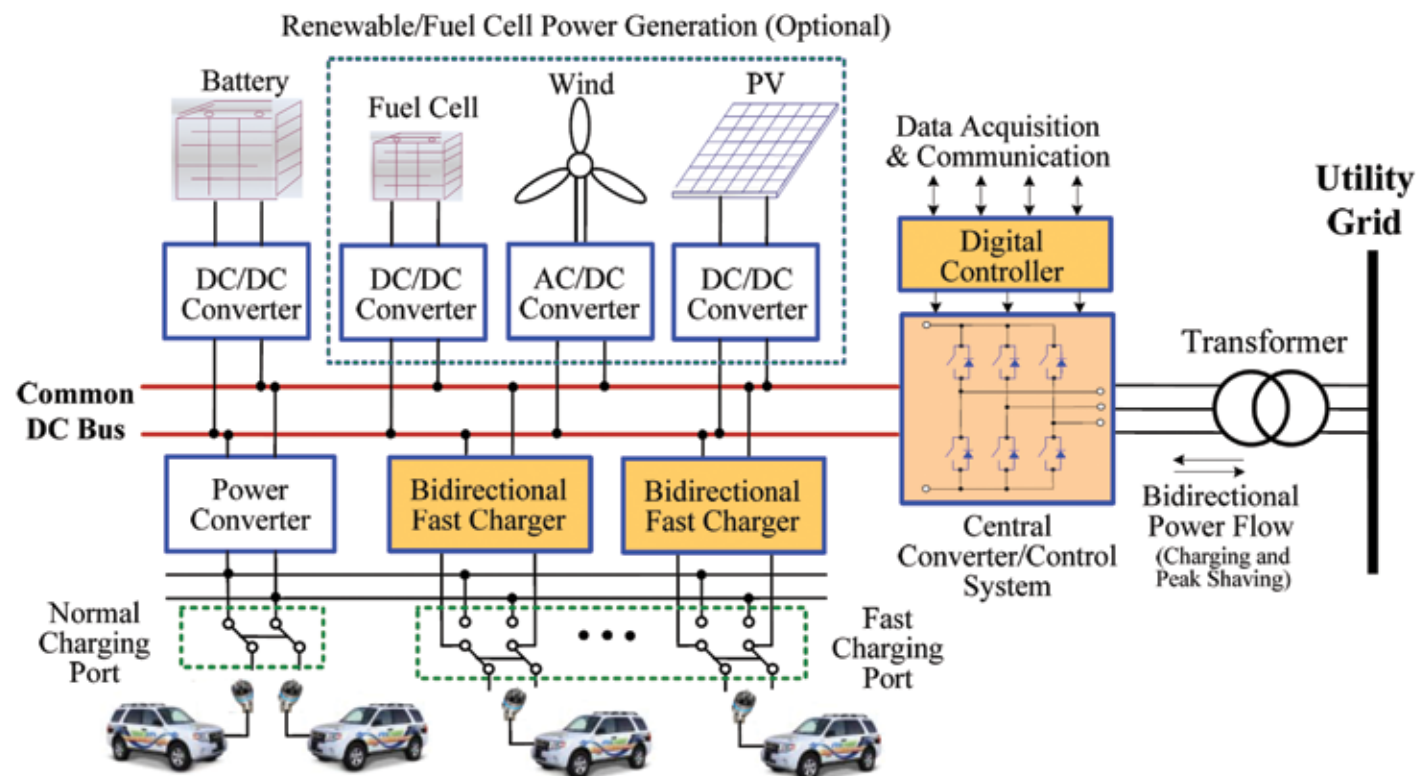
### Plug-in hybrid electric vehicle charging station for urban energy systems



**Dr. Bin Wu's** CUE project, Plug-in Hybrid Electric Vehicle Charging Station for Urban Energy Systems will help develop a novel charging station configuration employing common DC bus for plug-in hybrid electric vehicles (PHEV), with funding from Toronto Hydro (\$295,000). The charging station is equipped with a battery energy storage system and optional fuel cell power generation, and can integrate renewable energy, such as photovoltaic (PV) and wind energy, into the system. The station can also provide fast and normal charging to PHEVs that meets requirements set by the Society of Automobile Engineers. To develop the key technology, the research team will focus on a central converter/control system with optimal power management for PHEV charging stations, and high-efficiency cost-effective bidirectional fast chargers for PHEVs. Technologies

to be developed are intended to solve problems facing the urban energy system due to the coming widespread use of electric vehicles. The project will tackle the difficulties for high performance connection of highly dispersed micro sources in an urban environment, and deliver necessary technologies for the development of a smart urban distribution network to enable widespread use of clean/renewable energy and energy storage.

**Figure 1:** Proposed charging station configuration with common dc bus technology.



## Featured Project #2

### Reducing the carbon footprint at Hydro One

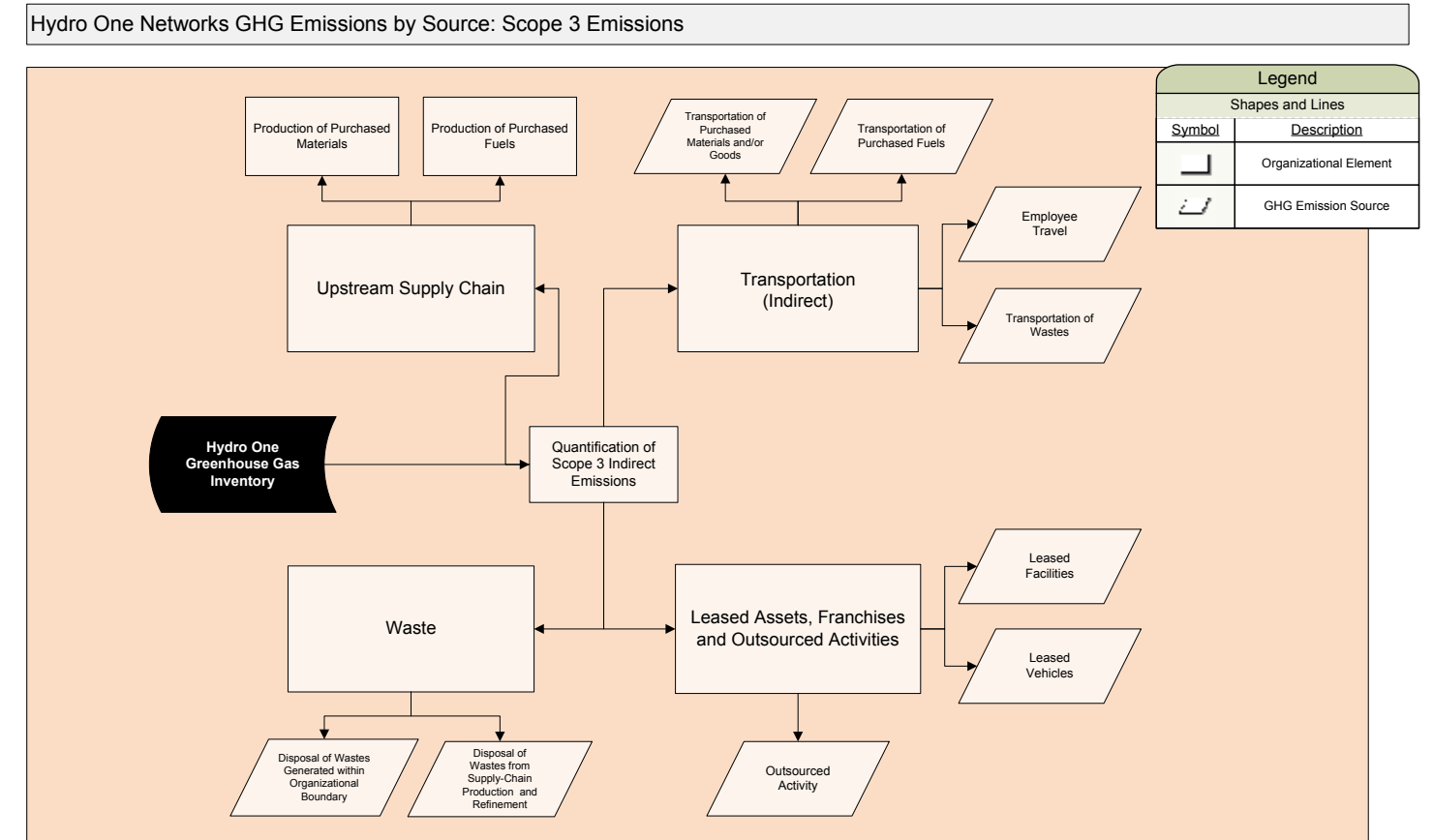
**Dr. Cory Searcy's** work at CUE on Reducing the Carbon Footprint at Hydro One, funded by Hydro One (\$50,000), recognizes that Canadian corporations are under increasing pressure to address the environmental implications of their activities. Many corporations have identified the re/reduction of their company's carbon footprint as a key priority but have struggled to develop scientifically sound models to reduce the carbon footprint of their operations. The goals of this research are to develop a baseline of greenhouse gas emission sources from Hydro One Networks Inc. (HONI) operations, to quantify and project its key emissions over the next ten years, and to develop practical options for HONI to consider reducing its organizational carbon footprint over the next decade. The research will therefore focus on the development of three

principal outputs:

1. process maps to help HONI systematically identify its current carbon footprint,
2. a scenario analysis to help HONI project its future carbon emissions over the next decade, and
3. a set of recommended actions to reduce carbon emissions over the next decade.



**Figure 2:** Preliminary Process Map: Hydro One Networks GHG Emissions by Source - Scope 3 Emissions





**Featured Project #3**

**Development of residential HVAC and air conditioning demand management and control systems**

Principal Investigator **Dr. Alan Fung** will research Development of Residential HVAC and Air Conditioning Demand Management and Control Systems, with funding from Toronto Hydro (\$112,500). Dr. Fung will work with Dr. Xavier Fernando and Dr. Janabi-Sharifi to respond to the housing sector for higher performance housing, addressing multiple issues, such as building codes versus energy consumption; time of use rates (TOU) and demand side management oppor-

tunities; energy saving heating, ventilation and air conditioning (HVAC) and domestic water heating (DHW) equipment; and solutions for homeowners to save on energy costs. Homes equipped with innovative, two-way communications-enabled HVAC and DHW equipment integrated with renewable energy sources will be key to meeting these objectives.

This project aims to demonstrate a control module that can both inform

homeowners of their energy consumption via a user-friendly display and automate system operation of equipment. The anticipated outcome of the project will be the demonstration of the ability of “smart” controls to reduce energy consumption and/or shift loads to off-peak times by optimizing the operation of innovative home HVAC, DHW and renewable energy equipment.

# Faculty Projects

Project	Researchers and Students
<b>Toronto Hydro</b>	
Dev. of Residential HVAC & Air-Con Demand Management & Control System	A. Fung, F. Sharifi, X. Fernando, M. E. Poulad & T. Sayed
Secure & Reliable Data Communications for Smart Grid	L. Guan, Y. He, J. Mistic, J. W. Ting, H. Khazaei & B. Guan
Transmission Supply Diversification Challenges -Toronto Central & Downtown	B. Venkatesh, I. Labricciosa, D. Cheng & A. Elksrawy
Plug-in Hybrid Electric Vehicle Chargers, Stations, Converter Interfaces, & Power Shaving	B. Wu, J. Wang, V. Liu, S. Andre & R. Iunnisi
<b>Hydro One</b>	
Electrical Impact-Transformer (Electric Vehicle)	B. Wu & B. Singh
System Integration of Large Scale Energy Storage System Using Lithium Batteries	D. Xu, B. Venkatesh & K. Masterifarahani
Carbon Footprint Reduction	C. Searcy
Electrical Impact-Transformer (Solar Panel)	B. Venkatesh, B. Singh & A.R. Haider
Intelligent Algorithms for Integrating Wind Power -Distribution System	B. Venkatesh, B. Singh, D. Cheng & C. Opathella
Control Interfaces for Urban Clean Energy Microgrid	B. Wu & Y. Li
Electrical Impact-Transformer Station (Storage)	D. Xu, B. Venkatesh & B. Singh
<b>Ontario Centres of Excellence</b>	
Energy on Time	B. Venkatesh, D. Xu, Kamran Masterifarahani & S. Simon
<b>Innisfil Hydro</b>	
Analysis of Innisfil Hydro System	B. Venkatesh, D. Cheng & S. Patel
<b>Ministry of Research &amp; Innovation</b>	
Future Urban Electric System	B. Venkatesh, M. Salama, T. Venetsanopoulos, L. Guan, J. Mistic, Y. He, B. Wu, V. Sood & D. Xu
<b>Lumentra</b>	
Development of quality system for NVLAP accreditation for photometric lab	B. Venkatesh, V. Venkatraranam & Rui Li

Total value of the projects currently underway: \$ 3.4 Million



Jennifer Hiscock receives her CUE Student Research Award from Toronto Hydro's Vice President, Ivano Labriciossa.

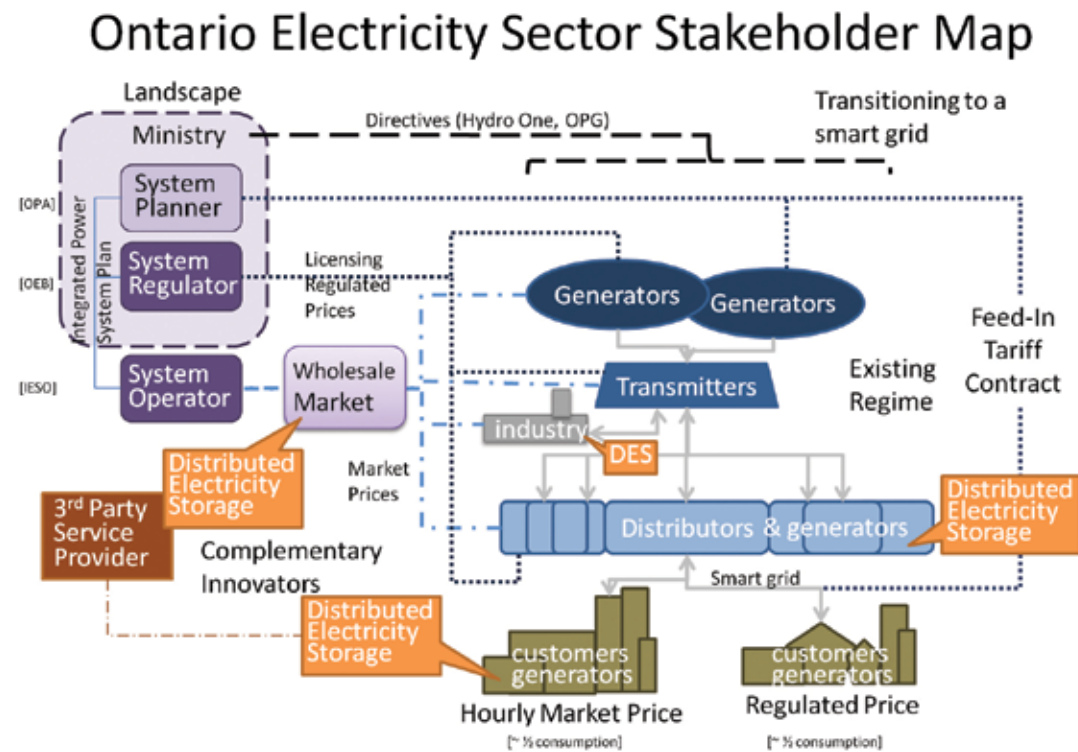
To date, 23 student-led projects have been completed, three of which are highlighted below

## Featured Project #1 Market Receptiveness of Urban Energy Storage Technologies in the Greater Toronto

**Jennifer Hiscock**

This project addresses the question: "What factors influence market demand and absorptive potential for urban energy storage technology in the Greater Toronto Area?" To investigate these market factors, Jennifer adopts an inductive approach, using a qualitative analysis to discover the critical factors, and a deductive analysis to determine their level of influence on market receptivity. Specifically this research will comment on the strategies of technology-push and market-pull, and identify elements of each of these strategies that could be applied based on the insights into the absorptive capacity of the market, and sensitivity to other factors that emerge in the findings that influence demand.

Figure 3: Ontario Electricity Sector Stakeholder Map

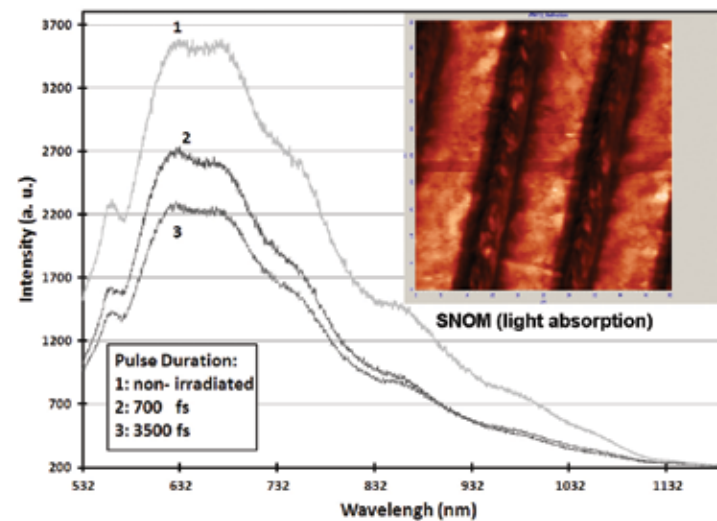


## Featured Project #2 Enhancement of optical absorption of amorphorized/oxidized Si layer for solar cell fabrication

**Amirkianoosh Kiani**

Rising energy prices are making alternative energy sources, such as solar energy, increasingly more attractive. A major drawback of semiconductor-based solar cells, however, is their low efficiency. Amirkianoosh has recently demonstrated a new method for generating an amorphorized/oxidized layer of silicon on silicon substrate which can reduce the reflectance of the surfaces. This project focuses on converting the property of crystalline silicon wafer from crystalline to amorphorized

silicon or oxidized silicon, using megahertz frequency femtosecond laser pulses. This results in an increase in the absorption of incident light which can be used in photovoltaic or other light energy conversion applications. This method can lead to promising solutions for solar cell fabrication.



Amirkianoosh Kiani receives his CUE Student Research Award from Toronto Hydro's Vice President, Ivano Labriciossa.

Figure 4: Scanning Near-field Optical Microscopy (SNOM) and light spectroscopy of amorphorized area induced by laser pulses with different pulse duration. The light absorption of amorphorized area increases by increasing laser pulse duration.

## Featured Project #3 The Effect of Community Involvement on the Adoption of Energy Efficient Behaviours

**Craig Brown**

Energy efficiency in high-rise residential buildings often utilizes technical approaches. Behavioural programs, on the other hand, seek to increase energy efficiency by encouraging certain behaviours, including those related to electricity, gas

and water consumption, as well as transportation and purchasing decisions. This pilot study will provide much needed data about community-driven behavioural programs in Toronto. Rental populations must be engaged effectively if positive societal change is to occur.



Craig Brown receives his CUE Student Research Award from Hydro One's Bob Singh.



# Student Projects – A Comprehensive Inventory

Name	Title
Derek Roeleveld	Models for optimization of high-performance fenestration
Abdallah Elsayed	Development of carbon-based grain refiners for magnesium alloy components in auto parts
Craig Brown	The effect of community involvement on the adoption of energy efficient behaviours
Peng Yu	LMP simulation considering approximate stochastic model of wind electric generators
Nejad Saman Shaban	Application of novel phase change materials (PCM) in solar/net-zero energy building designs
Runa Das	Perceptions of household energy consumption
Reza Ghaffari	New option-influenced methods for wind turbines' integration in unit commitment process
Dahai Zhang	Development of monitoring system for archetype sustainable house
Hayes Zirnheld	Residential passive solar design for Canadian cities
Aya Dembo	Least cost analysis for Ontario new housing
Mohammed Ebrahim Poulad	Design and manufacturing of a Thermal Diode Panel (TDP) fitted for Toronto climate conditions
Amirkianoosh Kiani	Enhancement of optical absorption of amorphorized/oxidized Si layer for solar cell fabrication
Chandrabhanu Opathella Ganeshi Kankanamalage	Intelligent algorithms for integrating wind power to the distribution system
Houman Mortazavi	Stimulating demand for "EcoEnergy Retrofit" programs by Financing Opportunity for SMEs
Venkata Yaramasu	Model predictive control of four-leg inverters for grids-connected PV/wind hybrid systems
Milad Arouni	Ontario/OPA microFIT feasibility study for residential and commercial customers
Kathryn Atwell	Evaluation of trajectory type efficiency in reciprocating load driving
Jennifer Hiscock	Market receptiveness of urban energy storage technologies in the greater Toronto area
John O'Neill	Assessing opportunities for siting anaerobic digesters in urban areas
Nae Kyung Seong	The determinants of household renewable energy use

## Research Fellows

Through funding provisions from Hydro One and Toronto Hydro, CUE attracts renowned scholars and industry players to partner in its growth.



CUE's first Hydro One Distinguished Research Fellow **Dr. Magdy Salama** joined CUE in January 2011. During his 12-month term, Dr. Salama has been using his intimate knowledge of Hydro One Networks to research the opportunities and challenges of Smart Grid implementation. Dr. Salama specializes in energy systems research in a number of areas, including power quality analysis, smart grid analysis, renewable energy analysis, power system asset management and risk analysis, grounding system analysis, and distribution system analysis.



CUE's second Hydro One Distinguished Research Fellow **Peter Love** joined CUE in March 2011. During his 12-month term, he has been using his background as Energy Conversation Officer for the province of Ontario, as well as his many years as an environmentalist, to engage in research related to energy conservation and efficiency. Mr. Love's leadership and experience in Canadian energy conservation policy and programs will be a significant advantage for CUE as it continues to develop innovative solutions to the challenges facing cities in the future.



**Dr. Dan McGillivray** brings over 30 years of experience to CUE, having worked as managing director of two centres at the Ontario Centres of Excellence – the Centre for Energy and the Centre for Earth and Environmental Technologies. He joined CUE in August 2011 as a Toronto Hydro Distinguished Fellow. Dan's research will focus on energy, innovation and entrepreneurship. He will be creating an accelerator program for new energy businesses; developing a master's program and a certificate program in energy, management and innovation; and creating a new centre for water innovation.

Other research fellows and post-doctoral fellows include: Dr. Stanislav Pejovic, Dr. S. S. Murthy, Dr. Tianqi Xu, Dr. Daniel Cheng and Dr. Alex Nassif.





# ISTP India Workshop

## International Collaboration on Urban Energy



**From left:** Dr. Bala Venkatesh, Dr. Mohamed Lachemi, Dr. Mannar Jawahar, Jayendra Parikh

In January 2011, the Centre for Urban Energy (CUE) undertook one of its first urban energy projects in Chennai, India, thanks in part to a grant it received

from International Science and Technology Partnerships (ISTP) Canada, the national organization responsible for promoting international, collaborative research and technology-based partnerships.

Bringing together Canadian and Indian academic and industry leaders, CUE organized a two-day workshop on the sustainability of urban electric systems. Engineering, Architecture and Science Dean Mohamed Lachemi and CUE Academic Director Bala Venkatesh were joined by colleagues from the Electrical and Computer Engineering, and

Mechanical and Industrial Engineering Departments. Hosted at Chennai's Anna University, the workshop's industry partners included Hydro One and Schneider Electric, as well as participants from the University of Western Ontario, the University of Ontario Institute of Technology, Indian electricity boards and representatives from the hydro and automotive industries. During the visit to India, Dean Lachemi also met senior administrators from Anna University and the Indian Institute of Technology Madras to discuss additional areas of potential research collaboration.

# International Collaboration on Urban Energy



## The Centre for Urban Energy at Anna University

Under the leadership of Ryerson President Sheldon Levy, an agreement was signed in August 2011.

The Centre at Anna University shall engage in research, consulting projects for industries, large scale energy project demonstrations and exchange of students and faculty members.



## Moving Forward

### New Partnerships

Moving forward, CUE continues to seek new partners and ideas. Relationships with Schneider Electric, General Electric, Cogeco, Union Gas and Natural Resources Canada are currently under development. Further, CUE aims for expansion in all research focus areas.

### CUE Innovation Accelerator

A key development underway is the CUE Innovation Accelerator. Spearheaded by CUE's Toronto Hydro Distinguished Fellow Dan McGillivray, CUE's Innovation Accelerator is a workplace focused on rapidly transforming great ideas into commercial products, services and enterprises for the energy sector. The CUE Innovation Accelerator is focused on:

- Energy entrepreneurship and the development of start-up businesses;
- Energy "intrapreneurship" and the development of new technologies and services to support established companies;
- Applied research, development and demonstration leading to commercialization in the energy sector;
- Preparation of students to assume leadership and management roles within established energy companies, or to create new innovative businesses in the energy domain; and
- Integration innovation literacy into the curriculum and developing a culture of innovation for our graduates.

### New Programs

CUE is also championing a certificate program and a possible Master's program to serve the energy sector.

## CUE partnership opportunities

Join our founding partners:

Hydro One, Ontario Power Authority and Toronto Hydro

- Private and public sector
- Global networks
- Research centres
- Academic institutions
- Venture capital and investors



# Centre for Urban Energy



## Location

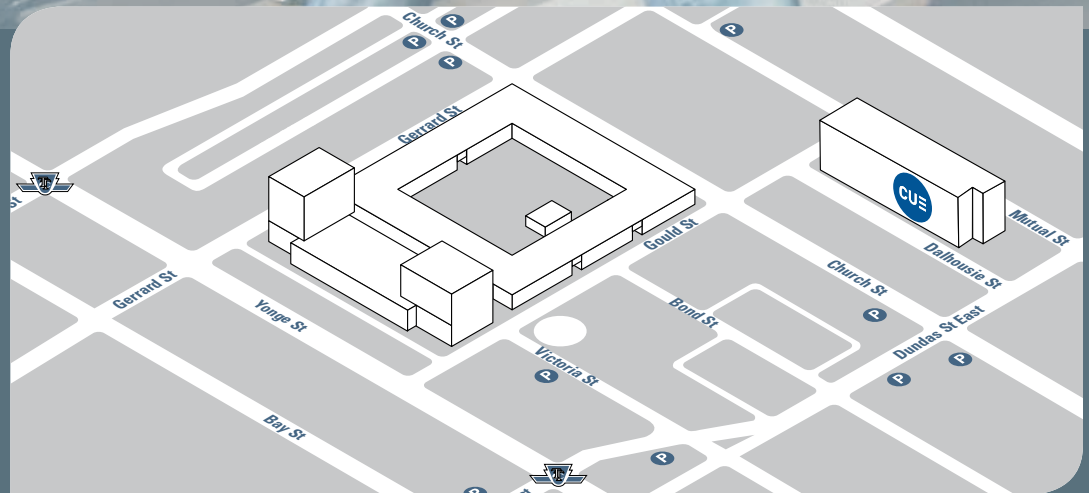
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