Technology Innovation & Policy Forum 2016

Microgrids & Distributed Energy Is there a revolution in the making?

Council for Clean & Reliable Energy — transforming the way we think about power

WISE — Waterloo Institute for Sustainable Energy

University of Waterloo

Thursday November 24
University of Waterloo
Federation Hall

Innovation Showcase

The Technology Innovation and Policy Forum is pleased to present the Innovation Showcase featuring displays and projects, state-of-the-art products and information from institutional, corporate, government agencies and funding sources. Academia, entrepreneurs, innovators and industry representatives will be pleased to connect with you during the networking session times from: 8:30 to 9:30am, 12:30 to 1:30pm and 3:15 to 5:30pm. Auto industry representatives have electric vehicles on display and welcome the opportunity to showcase their products.

The University of Waterloo is investing heavily in the necessary infrastructure and development of human capital to maximize our capacity to support fundamental and applied research and development (R&D) for Smart Energy Networks (SENs). Our faculty members are working closely with utilities, industry and government to support the transition of the energy system and involved in providing feedback to the Ontario's Long Term Energy Plan (Ministry of Energy).

The Waterloo Institute for Sustainable Energy (WISE) was established at the University of Waterloo in 2008. The Institute comprises more than 100 faculty members with graduate students and postdoctoral fellows working as multi-disciplinary research teams across Engineering, Science, Mathematics, Arts and Environment. The Institute is the focal point at the University of Waterloo (UW) for research in energy studies. In collaboration with utilities, private sector partners, government agencies and civil society groups, the Institute's goal is to foster the development of innovative technologies and alternatives to existing energy production and delivery systems, and to promote energy efficiency and environmental sustainability. At WISE, we have 29 state-of-the-art labs that can be used for applied research, technological development, and equipment testing.

The Department of Electrical and Computer Engineering (ECE) is Waterloo's largest academic department, with over 2,500 students, 86 full-time faculty members, and more than 50 supportive staff. Our research activities cover a wide range of fields, from high-voltage engineering and sustainable energy to breakthroughs in wireless technology that will enhance communications across our global society.

The High Voltage Engineering, Electricity Market Simulation and Optimization, Smart Distribution Research, Power Electronics, Advanced Battery Technologies, Center for Advanced Photovoltaic Devices and Systems, Solar Thermal Research, Fuel Cell and Green Energy R&D, Wind Energy, Green and Intelligent Automotive, and Maglev Microrobotics research lab facilities have been actively pursuing R&D and commercialization initiatives in the discipline of smart grid electrical systems at the national and international level.

Thank you to our supporters

Council for Clean & Reliable Energy — transforming the way we think about power

WISE — Waterloo Institute for Sustainable Energy

University of Waterloo

Power Workers Union

Enbridge

Waterloo North Hydro Inc.

INSTITUTIONAL SHOWCASE

UNIVERSITY OF WATERLOO

P1 Design of Hydrogen Powered Micro grid for Grid Services and Back-Up Power

2016 Hydrogen Student Design Contest Winners

Mohammed Barbouti
Nidhi Juthani
Ushinik Mukherjee
Jonathan Ranisau
Aaron Trainor
Hadi El-shayeb

Abstract

A team from University of Waterloo was the Grand Prize Winner of the Hydrogen Education Foundation's 2016 Hydrogen Student Design Contest, announced at a session of the US Department of Energy's (DOE) Annual Merit Review in Washington, DC. The Contest required student teams to design a hydrogen powered microgrid with the capability of solely supporting a community, facility, or military base for two days on hydrogen, with the ability to handle at least 10% of peak demand with hydrogen while the macrogrid is active, as well as provide grid support during peak times. Teams from the United States, Canada, Great Britain, Japan, India, Indonesia, Peru, and South Africa participated in the Contest. The winning Waterloo team was mentored by Professor Michael Fowler and Dr. Azadeh Maroufmashat of Chemical Engineering.

The team's design used Cornwall, ON, Canada, as the basis for the location of their renewable hydrogen-powered microgrid design. Hydrogen, generated by hydrogenics electrolyzers, is used as an energy storage medium to be converted back into electricity by Hydrogenics PEM (Polymer Electrolyte Membrane) fuel cells. The system is designed to supply hydrogen to 100 forklifts used at a food distribution centre and more than 30 commercially available fuel cell vehicles (FCEVs) used in the residential community. Wind, solar and hydrogen power continuously supply 10% of the energy demand of the community as well as the full demand for two days in the event of a blackout with the use of stored hydrogen. Key to meeting this criteria is the vehicle-to-grid concept used in the design, where FCEVs provide some of the hydrogen storage capacity and can be connected to charging stations to supply power back to the grid during peak demand or emergency scenarios.

UNIVERSITY OF WATERLOO

P2 Decarbonizing Transportation through the use of Power-to-Gas for Oil Refining Operations

Abdullah Al-Subaie

Abstract

Power-to-Gas is a technology that generates hydrogen by electrolysis. It can be used to provide a number of energy services including energy storage, ancillary services for the electrical grid, and the production of hydrogen for industrial processes and transportation fuel. Hydrogen has many industrial applications for example in oil refining where it is used primarily in hydrotreating and hydrocracking processes. The purpose of this paper is to provide an incentive for using power-to-gas technology for oil refining processes in an effort to reduce the carbon footprint in the refining industry and ultimately the transportation sector. It also highlights the optimal size and operation of the hydrogen production facility that includes polymer electrolyte membrane (PEM), electrolyzers to meet the proposed refinery demand. The economic calculations include a comparison of the cost of hydrogen ($ per kg) between electrolysis and steam methane reforming. The carbon pricing is also incorporated in the analysis to show its potential impact in the costing of both technologies.

UNIVERSITY OF WATERLOO

P3 Adaptive Energy Ecosystems: Improved Operability, Efficiency and Economics for Electricity and Gas Power to Gas Energy Storage

Azadeh Maroufmashat

Abstract

The convergence of the electrical grids with the natural gas distribution/storage infrastructure increases the flexibility for managing intermittent renewable supplies. Renewable Natural Gas, Power-to-Gas (PtG) and other gas-based energy storage solutions offer the ability to improve the economic and technical management of surplus off-peak power, and intermittent renewable energy. New adaptive infrastructure like electrolyzers allows simultaneous grid stabilization, seasonal storage of bulk power, geographic transmission of energy and dispatchable regeneration of distributed renewable energy. This is achieved by bridging the electricity and gas-pipeline infrastructure together. This has near-term potential because much of the existing energy infrastructure exists. Renewable gases, like PtG conversion of renewable power to hydrogen, is just optimizing the existing gas distribution and electricity network capabilities to limit waste and exports to harvest more renewable energy for Ontario. In this program, various models will be explored to size and site the key gas generation components, and assess the implications to the natural gas distribution system such as the resulting concentration of hydrogen a various points and times in the system. In addition to the economic and environmental benefits, optimizing existing infrastructure will result in public push-back on energy issues as pressure for new-build energy infrastructure is reduced.

UNIVERSITY OF WATERLOO

P4 Including Smart Loads for Optimal Demand Response in Integrated Energy Management Systems for Isolated Microgrids

Bharatkumar Solanki
Akash Raghurajan
Kankar Bhattacharya
Prof. Claudio A. Cañizares

Abstract

This poster presents a methodology to control smart loads in demand response scheme so that operating costs of the isolated microgrid can be optimized. A mathematical model of smart loads is developed with a neural network (NN) load estimator as a function of the ambient temperature, time of day, Time of Use (TOU) price, and the peak demand imposed by the microgrid operator. The realistic data from an actual Energy Hub Management System (EHMS) is used for supervised training to develop the NN-based smart load estimator. The load model is integrated in a novel Microgird Energy Management System (MEMS) framework which considers power flow and Unit Commitment (UC) constraints simultaneously to yield optimal dispatch decisions of dispatchable generators, energy storage system (ESS), and peak demand for controllable loads. Furthermore, to account for deviations in the forecast of demand and renewables based generation, a Model Predictive Control (MPC) approach is used in formulation of the proposed MEMS framework. The proposed methodology is validated and tested on a CIGRE benchmark system which includes distributed energy resources (DERs) and renewables based generation. The results show the feasibility and benefits of the proposed models and approach.

UNIVERSITY OF WATERLOO

P5 Microgrid Load Balancing and Energy Storage via CO2 conversion into Renewable Natural Gas

Duo Sun
David S. A. Simakov

Abstract

Microgirds are well suitable for renewables and enable communities to generate their own power independently of the main grid. However, daily fluctuation in wind and solar energy make it difficult to guarantee a stable supply. Fluctuations in energy supply can be compensated by storing off-peak power in batteries but this approach has limitations of energy density, cost, and scalability. An alternative route is to store the surplus electricity in the form of chemical energy. In the suggested Power-to-Gas concept, an electrolyzer is used to generate hydrogen using renewable electricity. This hydrogen is then reacted with CO2 (from biogas, flue gas, fermentation etc.) to make renewable natural gas (RNG) via thermo-catalytic process of CO2 methanation. The resulted RNG can be injected into the existing natural gas infrastructure which provides storage and transportation capacities. It is a scalable technology. To realize the potential of this approach, a number of technological challenges have to be resolved, including the removal of heat produced by the highly exothermic methanation reaction. A simulation-based study of a heat-exchanger type packed bed reactor with internal cooling by a molten salt was performed in order to optimize the removal of heat, while maximizing CO2 conversion and RNG production. A preliminary techno-economic evaluation predicts RNG production costs below 20 $/GJ using multiple reactors and the optimized cooling rate and reactor throughput. Up to 80% of the renewable electricity initially stored in H2 is recovered as the RNG energy content and co-generated electricity.

UNIVERSITY OF WATERLOO

P6 Renewable Energy Deployment in Canadian Arctic: Pre-Feasibility Studies for Nunavut

Dr. Indrajit Das
Prof. Claudio A. Cañizares

Abstract

Environmental degradation in the arctic, caused by climate change, is posing a threat to the wildlife present there by destroying their habitat. Though the arctic is mostly uninhabited, there are nearly 50 communities in the Canadian arctic, and a good portion of them use diesel generators as the only means to generate electricity. This not only adds to the carbon footprint, but also endangers the environment by elevating the risk of oil spills while transporting diesel to and storing it in these communities. In addition to the environmental risks, the cost of fossil fuel dependency is an economic problem in the North, as governments have to subsidize this fuel.

There are environmentally friendly and economic sources of energy for the arctic communities, which should help reduce their fossil fuel dependency. Thus, the Waterloo Institute of Sustainable Energy (WISE) of the University of Waterloo has been involved in a consortium [1], led by World Wildlife Fund (WWF) Canada, to perform studies, funded by WWF-Canada, on the communities of Nunavut to integrate Renewable Energy (RE) sources in their grids. The task is focused on selecting 5 of the 25 communities from Nunavut for detailed feasibility studies for deployment of RE sources in some of these selected communities.

A two-step procedure has been adopted to determine the communities suitable for feasibility studies. In the first step, a preselection of 13 out of 25 communities in Nunavut is made based on information regarding community population, transportation routing for diesel, equipment and personnel, load profile, diesel generation availability, and high level data on solar and wind resources. In the second step, the HOMER software is used to simulate RE deployment in the pre-selected communities, based on various assumptions and considerations available. The simulation results are ranked based on various predefined criteria, such as maximum Operation & Maintenance (O&M) savings and emission reductions, at minimum cost.

The result of this pre-feasibility study, available in [2], indicates that substantial reduction in CO2 emission can be achieved at a relatively low initial investment costs, and at least 35% RE penetration can be achieved for all the top 5 communities in Nunavut at a minimum cost of 7.8 M$, except for Baker Lake (7.1%, 2.99 M$), while avoiding the purchase of a new diesel generator.

[1] WWF-Canada, News and Reports, http://www.wwf.ca/newsroom/?20583/New-alliance-to-bring-renewable-energy-to-remote-communities-in-Canadas-Arctic-WWF-Canada-announces
[2] Fueling Change in the Arctic, WWF-Canada, May 2016. http://awsassets.wwf.ca/downloads/summary_and_prefeasibility_report.pdf

UNIVERSITY OF WATERLOO

P7 A Voltage-based Frequency Controller for Inverter-Based Systems in Microgrids

Kankar Bhattacharya
Mostafa Farrokhabadi
Prof. Claudio A. Cañizares

Abstract

This poster presents a novel voltage-based controller for frequency control in inverter-based isolated microgrids through load voltage regulation. The proposed controller makes use of the load sensitivity to operating voltage to regulate load consumption. The performance of the controller is evaluated and validated through simulation studies on PSCAD/EMTDC based on a medium voltage distribution network benchmark. The controller offers two significant advantages:

1. It decreases the system dependency on energy storage systems; and,
2. Allows for higher penetration of renewable energy and hence less fuel consumption.

The controller only requires a local feedback signal, and hence no extra communication infrastructure is needed.

START-UP VENTURE

University of Waterloo Showcase

T13 Masood Energy Corporation
Scaling up High Precision Battery Testing Protocol

Muaaz Masood, Chief Executive Officer

Abstract

Masood Energy Corporation is developing a high precision battery testing protocol to estimate battery capacity and predict future life using less time and energy than existing battery testing methods. The gold standard of capacity estimation involves no faster than 1C charges/discharges which is a significant time.

For battery testing we have identified three key areas where we can reduce cost:

1. Time horizon to test one cell;
2. Overall energy cost to test one cell; and,
3. Cost of equipment to test cells.

CORPORATE SHOWCASE

utilismart CORPORATION

T1 Utilismart Corporation
ODS Program 2.0 Paradigm with Advanced Information Exchange Platform

John Avdoulos, President

Abstract

Utilismart Corporation provides an Advanced Information Exchange Platform that enables utilities to unlock Smart Grid Technologies and facilitates a 21st Century Energy Management and Services Platform. Utilismart unlocks the ability for Internet Connected Devices to interact with other utility applications by unifying all data and creating a holistic, centralized data set. This enables Power System Flexibility, Adaptive Infrastructure and Customer Control. All of this is offered through a friendly Cloud based technology and has the highest level of Security designed in to the solution and exhibited through our ISO 27001:2013 Certification.

T2 Holeshot1
Graphene Micro Super-capacitor Battery

Doug Mochrie, President

Abstract

Holeshot1 a local tri-cities tech company is partnering with the University of Waterloo and the Waterloo Institute for Sustainable Energy to help usher in the Revolution of Batteries. The Graphene Micro Super-capacitor will enable devices that can charge and discharge a thousand times faster than standard batteries. Also prolonged life of batteries with a new nanowire process by 400 times are the two keys to a hybrid battery that will be world changing.

The applications are vast to many industries - Solar PV and EV are just a few industries that will be forever changed.

Interest and excitement is very high throughout the world in regards to this research, and Holeshot1 aims to help bring this to fruition with the University of Waterloo and WISE for a vast array of solutions for Solar PV, EV and the battery industry.

T3 Green Sun Rising Inc.
Solar Systems: Solar PV and Solar Thermal

Klaus Dohring, President

Abstract

Green Sun Rising Inc. is a Windsor Ontario based company focusing on developing and supplying solar systems, both solar PV for clean electricity, and solar thermal for clean heat energy. To date we have implemented successfully over 250 solar projects across Canada, including the Arctic.

Our products represent state-of-the-art solar technology, and we are supported by leading European and German solar companies. Our products are mainly made by industry recognized partners. Our engineering and designs represent best-practices based on decades of solar know-how.

We offer premium products and services with intelligent solutions at a competitive market price. We strive to provide the best value, and excellent support..

T4 GeoSmart Energy Inc.
Renewable Geothermal Energy Heating and Cooling Solutions

Stan Marco, Chief Executive Officer

Abstract

GeoSmart Energy was established in 2005 by co-founders Chad Brezynskie and the Marco family - Cheryl, Stan and Stephen. We have since risen to the top of the renewable energy market by combining innovative and people-friendly practices with premium, cost-effective, energy efficient and renewable geothermal energy heating and cooling solutions for both home and business.

Our formula for success is deeply rooted in the belief that we're not just selling a geothermal energy product, but rather a 'system' that is supported by a customer first mentality, a comprehensive education and training program, a savvy and knowledgeable network of Renewable Energy specialists and a highly trained team of installers.

Our high performance product line is designed to meet every home or business need and offers everything from industry first PE100 geothermal pipe, intelligent thermostats and forced air and hydronic heating and cooling systems.

We excel at product innovation by constantly exploring opportunities to further improve existing geothermal energy technology. This passion for innovation ensures the best products for the dealers who sell them, the contractors who install them and ultimately, for the customers who invest in them.

P8 Orbit Solar Technology for Off-Grid Electrification

Michael Sinclair, Founder

Abstract

Orbit is developing the uniquely affordable solar home systems for the 1.2 billion people who lack access to electricity. We design high quality products that provide the features that off-grid customers want most: mobile phone charging, lighting, and radio. Our systems are made affordable by a unique Pay-As-You-Go (PAYG) micropayment system which leverages existing telecommunications infrastructure to create an interface that is familiar to customers and easy to use.

T5 Forbes Motors Inc.

Manni Birhanu, Sales and Leasing Consultant

Abstract

The Forbes family has been a part of the automotive history since the beginning with the involvement of Russell Arthur Forbes. Russell served as Henry Ford's personal secretary, and later held the position of business manager for Mr. Ford's newspaper, the Dearborn Independent.

Forbes Motors is a 68-year-old family operated General Motors dealership. We represent the Chevrolet, Buick, Cadillac and GMC nameplates as well as GM Optimum vehicle brands.

Forbes Motors was started by Russell Arthur Forbes in the 1940s, and then run by his sons, Jack and Ralph. Today, the business is run by Russell Forbes Sr., Ralph's son, along with Russell's son, Russ Forbes Jr., who is in charge of the GM dealership. Russell's daughter, Leigh Forbes, is the company's online marketing co-ordinator.

T14 Borealis Wind

Daniela Roeper, Founder

Abstract

Below 2°C wind turbine blades develop ice. Once there is ice on the blades, the wind turbine must be shut down, as the ice possess significant hazards during operation. Currently the wind turbines remain shut down until the ice sheds naturally. This downtime results in $100 Million in annual revenue loss in Canada alone. Borealis Wind offers a simple blade heating retrofit, which can be installed in any wind turbine. The heating system melts the ice off the blades, reducing the time that the wind turbine is shut down. We are currently in the process of field verification.

T15 Electrefy
EV Charging Solution: Chameleon Charger

Joseph Tam, CBDO

Abstract

Electrefy Inc. is an EV charging solutions provider introducing the first low-power DC fast charging system for public spaces. Existing solutions are either too slow to attract visitors, or unjustifiably expensive to install. As a result, few public fast chargers are currently available. Electrefy's Chameleon Charger provides fast charging without added infrastructure and installation costs. It is the first step towards making fast-charging affordable and accessible to everyone, everywhere.

T7 FleetCarma
A Division of Cross Chasm Technologies Inc.

Julie Hunter

Abstract

Established in 2007, FleetCarma is an award-winning clean technology company providing programs and services to the electric utility and fleet industry to advance transportation electrification initiatives to help combat climate change and achieve a sustainable transportation and low carbon energy future. Through the deployment of its world-leading electric vehicle (EV) connected car platform, FleetCarma is committed to supporting electric utilities and fleets in delivering innovative transportation solutions focused on accelerating plug-in EV adoption, optimizing EV fleet management practices, and facilitating EV load management programs. FleetCarma provides three core programs and services through its EV connected car platform: Fleet EV Suitability Assessment Program, Fleet EV Management System, and EV Load Management Programs, to effectively increase wide-scale EV adoption and smart grid integration. FleetCarma will exhibit its C2 connected car device and cloud-based software system at this event which is used to propel each of the aforementioned programs and services.

T9 Waterloo Nissan

Asmat Ullah, Sales and Leasing Consultant

Abstract

ELECTRIFY YOUR drive with all energy, no exhaust. Wake up fully charged, and get where you're going with swift power out of the gate. Change course: Take the scenic route, stay out longer with confidence. Embrace the future in the world's best-selling fully electric car. The 2016 Nissan LEAF.® A whole new outlook on LIFE.

Nissan LEAF®'s compact lithium-ion battery is twice as powerful and half the weight of nickel-metal hydride batteries used in traditional hybrid cars. Its arrangement in the floor of the vehicle means interior roominess and plenty of cargo space. Every time you slow down, the regenerative braking system stores that energy in the Nissan LEAF® battery. That means your car charges anytime you brake. Nissan LEAF® is aerodynamically designed to keep wind resistance down and efficiency up. A drag coefficient of 0.28 is something to celebrate. Low-resistance rolling tires also come standard, and reduce the vehicle's energy output. Available LED low-beam headlights use half as much energy as traditional headlights. Plus, they're aerodynamically designed to maximize efficiency.

Waterloo Nissan dealership on Northfield Drive comes fully loaded with a tonne of great, ecologically-minded features.

Among the green initiatives at Waterloo Nissan is a smart lighting system called LightBoss, a Canadian-made intelligent lighting system headquartered in Milton. LightBoss controls the dealership's lighting indoors and out, saving on hydro and using energy more efficiently than traditional lighting. The construction of the facility used recycled,

highly-rated environmentally friendly building materials like recycled porcelain tiles for the showroom flooring and aluminum composite paneling on the exterior - which is from recycled materials, and can again be recycled.

Low emissivity windows were installed to reduce energy consumption for heating and cooling. The glass in each window has a special coating to prevent Ultra-Violet light from passing through into the building; this has the added bonus of preventing sun-fading inside the showroom. Between the panes of glass themselves is a special inert gas that drastically reduces the amount of heat transfer between the indoor and outdoor environments, providing greater efficiency for a controlled climate in the spacious showroom.

ASSOCIATIONS AND GROUPS SHOWCASE

T6 Waterloo Region Voltec

Mark Coughlan, WISE Member

Abstract

Waterloo Region Voltec (WRVoltec) is a group of Chevrolet Volt owners and enthusiasts in the Waterloo Region and Beyond.

GOVERNMENTAL FUNDING AGENCIES SHOWCASE

T10 Natural Sciences and Engineering Research Council (NSERC) of Canada

Maja Bracovic, Research Partnerships Promotion Officer, Ontario Regional Office

Abstract

The Natural Sciences and Engineering Research Council (NSERC) of Canada invests in scientific discovery and people for the benefit of Canada – science and engineering at the frontier of knowledge. NSERC ensures businesses are first to know – use discoveries to accelerated R&D. We provide the feedback loops from industry to academia to optimize technologies and inform future discovery research.

NSERC aims to make Canada a country of discoverers and innovators for the benefit of all Canadians. The agency supports university students in their advanced studies, promotes and supports discovery research, and fosters innovation by encouraging Canadian companies to participate and invest in postsecondary research projects. NSERC researchers are on the vanguard of science, building on Canada's long tradition of scientific excellence.

T11 Ontario Centres of Excellence (OCE)

Ivette Vera-Perez, Business Development Manager

Abstract

Ontario Centres of Excellence (OCE) drives the development of Ontario's economy by helping create new jobs, products, services, technologies and businesses.

In partnership with industry, OCE co-invests to commercialize innovation originating in the province's publicly funded colleges, universities and research hospitals. We also support and invest in early-stage projects, where the probability of commercial success and potential total return on innovation are substantial. Another expanding focus for OCE is the development of the next generation of innovators through our entrepreneurship fellowships and programs for students and youth across Ontario.

Our efforts are focused on sectors of the economy with the greatest potential to drive Ontario's future prosperity and global competitiveness: energy and environment (including water); advanced manufacturing; advanced health technologies; and information, communications technologies and digital media.

A trusted partner of government in program delivery, we are committed to advancing a whole-of-government approach as a means of streamlining funding application processes for companies and entrepreneurs.

T12 Mitacs

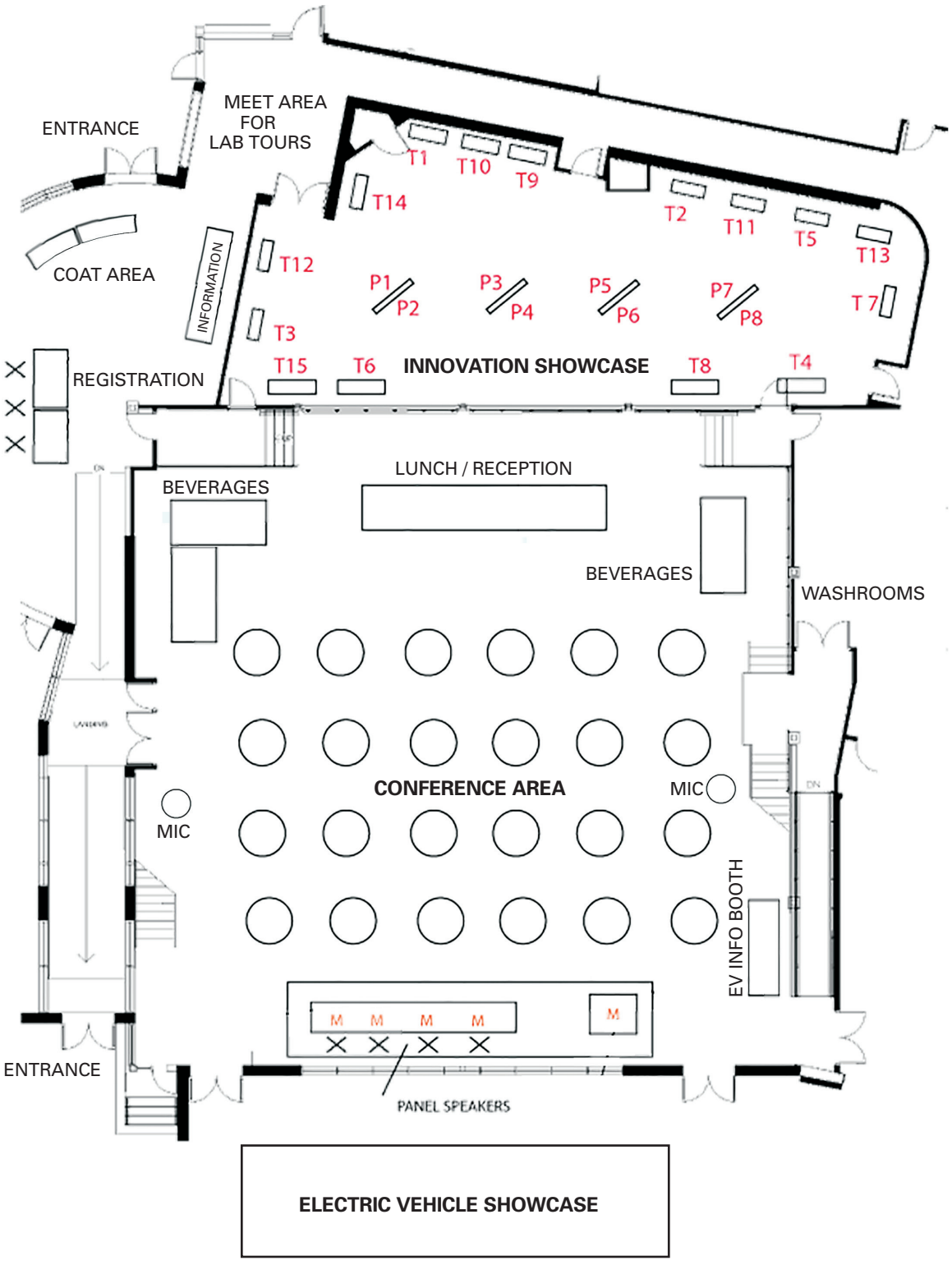
Fiona Cunningham, Director, Business Development

Abstract

Mitacs is a national, not-for-profit organization that has designed and delivered research and training programs in Canada for 15 years. Working with 60 universities, thousands of companies, and both federal and provincial governments, we build partnerships that support industrial and social innovation in Canada. Mitacs builds partnerships between academia, industry, and the world – to create a more innovative Canada.

Mitacs was founded in 1999 as a Canadian Network of the Centres of Excellence, dedicated to supporting applied and industrial research in mathematical sciences and associated disciplines. In 2003, we launched a research internship program designed to increase deployment of highly educated graduates into the private sector. Open to all disciplines since 2007, Mitacs has expanded in response to industrial and university needs, including programs in R&D management, professional skills development, and international research training. Fully independent since 2011, Mitacs remains committed to its core vision of supporting research-based innovation and continues to work closely with its partners in industry, academia, and government.

INNOVATION SHOWCASE



Innovation Showcase Participants

Poster board Presentations

P1 – Design of Hydrogen Powered Microgrid for Grid Services and Back-up Power

P2 – Decarbonizing Transportation through the use of Power-to-Gas for Oil Refining Operations

P3 – Adaptive Energy Ecosystems: Improved Operability, Efficiency and Economics for Electricity and Gas Power to Gas Energy Storage

P4 – Including Smart Loads for Optimal Demand Response in Integrated Energy Management Systems for Isolated Microgrids

P5 – Microgrid Load Balancing and Energy Storage via CO2 conversion into Renewable Natural Gas

P6 – Renewable Energy Deployment in Canadian Arctic: Pre-Feasibility Studies for Nunavut

P7 – A Voltage-based Frequency Controller for Inverter-Based Systems in Microgrids

P8 – Orbit Solar Technology for Off-Grid Electrification

Table Presentations

T1 - Utilismart Corporation
ODS Program 2.0 Paradigm with Advanced Informaton Exchange Platform

T2 - Holeshot1
Graphene Micro Super-capacitor Battery

T3 - Green Sun Rising Inc.
Solar Systems: Solar PV and Solar Thermal

T4 - GeoSmart Energy Inc.
Renewable Geothermal Energy Heating and Cooling Solutions

T5 - Forbes Motors Inc.

T6 - Waterloo Region Voltec

T7 – FleetCarma

T9 – Nissan Waterloo

T10 – Natural Sciences and Engineering Research Council (NSERC) of Canada

T11 – Ontario Centres of Excellence

T12 - Mitacs

T13 - Masood Energy Corporation
Scaling up High Precision Battery Testing Protocol

T14 - Borealis Wind

T15 – Electrefy

Thank you to our event supporters

Council for Clean & Reliable Energy — transforming the way we think about power
WISE — Waterloo Institute for Sustainable Energy
University of Waterloo
Power Workers Union
Enbridge
Waterloo North Hydro Inc.