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

Technology and Innovation Policy Forum 2016 Report

April 2017

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ABOUT THE AUTHORS

Bronwyn Lazowski
Bronwyn Lazowski is a PhD Candidate in the Faculty of Environment at the University of Waterloo. Her research focuses on the social aspects of residential smart grid technology adoption. In particular, her mixed-methods research investigates the potential of smart grid engagement mechanisms (e.g., in-home displays, web portals, goal-setting and scheduling) to engage consumers with the smart grid and to shape energy practices in order to achieve conservation and demand management objectives.

Through her research, Bronwyn aims to bring insights on how to implement a consumer-centered approach to smart grid program and policy design for the development of effective policies and meaningful technological design and the achievement of a 'smart' and 'sustainable' energy culture at the residential scale. Bronwyn is a renewal recipient of the Energy Council of Canada Energy Policy Research Fellowship.

Dr. Jatin Nathwani
Professor Nathwani is the founding Executive Director, Waterloo Institute for Sustainable Energy (WISE) and holds the prestigious Ontario Research Chair in Public Policy for Sustainable Energy. Professor Nathwani is also the Co-Director, with Professor Joachim Knebel (Karlsruhe Institute of Technology, Germany), of the consortium 'Affordable Energy for Humanity (AE4H): A Global Change Initiative' comprising 110+ leading energy access researchers and practitioners from 30 institutions and 12 countries.

Prior to his appointment to the University of Waterloo in 2007, Professor Nathwani worked in a leadership capacity in the Canadian energy sector over a 30-year period. Professor Nathwani has over 100 publications related to energy and risk management, including seven books and is a Registered Professional Engineer (PEO) in the Province of Ontario, Canada.

FOREWARD

This report provides a summary of the highlights of the Technology Innovation & Policy Forum 2016 organized by the Council for Clean and Reliable Energy and the Waterloo Institute for Sustainable Energy entitled: "Microgrids & Distributed Energy: Is there a revolution in the making?" We would like to acknowledge the contribution of the expert speakers and panelists, the academic and industry innovators participating in the Innovation Showcase, and the advanced educators that provided tours of the Fuel Cell and Green Energy Lab, and the Centre for Advanced Photovoltaic Devices and Systems Lab.

Thank you to the University of Waterloo for hosting this first annual Forum on their campus in Waterloo, Ontario, Canada. We invite you to join technology developers and innovators, leading researchers and entrepreneurs, industry thought leaders, and policy makers for the Technology Innovation & Policy Forum 2017 to help shape next generation smart energy solutions.

INTRODUCTION

The 2016 Annual Technology and Innovation Policy Forum was held at the University of Waterloo on November 24, 2016. The Forum was hosted by the Council for Clean and Reliable Energy (CCRE) and the Waterloo Institute for Sustainable Energy (WISE).

The Forum focused on microgrids, distributed energy resources (DER) and their influence on the energy sector. The Forum addressed an urgent need to accelerate impactful integration of cost-effective solutions to help decarbonize the energy system. The proceedings concentrated on the technological developments, the associated financing, new business models and alignment of policy with regulations for an effective energy transition to a low carbon economy.

Two panel sessions brought together insights from academic, industry and policy experts to address key questions concerning the future of the energy system in light of microgrids and distributed energy developments. As emphasized by Dr. Jatin Nathwani in the opening of this event, the subject of microgrids and distributed energy are important to discuss, as there is a 'revolution in the making' driven by dramatic declines in cost reductions of renewable energy technologies.

Overall, the Forum aimed to achieve several objectives:

- To highlight and showcase state-of-the-art microgrid technologies for remote (off-grid) and networked operations;
- To highlight the revolutionary potential of electric mobility, energy storage and information and communication technology (ICT) to disrupt the existing utility distribution sector;
- To explore financing and investment barriers for technology developers and foster understanding of new business models for consumer benefits;
- To enhance collaborative research partnerships between universities and industry to strengthen the eco-system for innovation and entrepreneurship; fifth, to focus on integration of distributed energy systems to improve performance and resilience of the distributed network; and,
- To address regulation and policy changes needed for the emerging grid. This report provides a summary of the event proceedings and highlights key directions for the development of the Agenda for future Forums.

INTRODUCTORY MESSAGE FROM THE CCRE & FORUM CO-CHAIRS

On behalf of the Council for Clean & Reliable Energy and the Waterloo Institute for Sustainable Energy, thank you for taking this time to read the report on the first Annual Technology Innovation and Policy Forum. The purpose of this forum was to bring together technology developers and innovators, leading researchers and entrepreneurs, industry thought leaders, and policy makers annually to help shape next generation smart energy solutions.

The goal of the 2016 Forum was to shape the pathways of development for emerging disruptive technologies and to understand the impacts of microgrids embedded on a large-scale within the existing distribution networks. The forum discussed an urgent need to accelerate impactful integration of cost-effective solutions to decarbonize our energy system, and address the convergence of policy development with technology advances.

Through dialogue and extensive opportunities for network, collaboration and discussion, the Forum focused on establishing a common basis for accommodating divergent interests. We look forward to continuing this discussion with future Forums, and we appreciate the active participation of the registrants.

Glenn Wright
Chairman
Council for Clean & Reliable Energy

Jatin Nathwani
Forum Co-Chair
Executive Director, Waterloo Institute for Sustainable Energy

David McFadden
Forum Co-Chair
Counsel, Gowling WLG (Canada) LLP

SYNOPSIS OF THE KEYNOTE ADDRESS BY BRUCE CAMPBELL:

INNOVATION IN ONTARIO'S ELECTRICITY SECTOR

Bruce Campbell is the President and Chief Executive Officer of the Ontario Independent Electricity System Operator (IESO). As the Forum's Keynote Speaker, Mr. Campbell discussed the integration of emerging technologies, microgrids and distributed generation in the IESO's operation and planning of the Ontario electricity sector and how he sees these trends evolving in the future. The following section provides a brief synopsis of the keynote address.

Understanding the influence of innovations on the development of energy policies and infrastructure is becoming increasingly important. The University of Waterloo, and its reputation for innovation, provides an opportune venue for discussing these trends. In light of emerging trends, the current market needs to be rebuilt to establish a foundation for energy transactions and a capacity market. This will provide an improved platform for integrating emerging innovations in the energy sector such as storage, increased renewables and distributed resources.

A significant shift in the supply mix towards a larger share of renewable generation is one key element of change. A standard for renewable integration has been built and set in Ontario by the IESO. The challenges and management of variable, intermittent generation resources will translate into a shift in the planning, design and operation of the infrastructure of the electricity grid. By 2025, we expect nearly 50% of the generation capacity to be renewable resources.

The search is underway for local, and innovative solutions for demand response and conservation and demand management. Utilizing data-driven solutions is crucial for better decision-making. A critical change for distribution systems involves collaboration with key stakeholders at the local-level to understand the current and future needs of the community.

Provincial and federal regulations are a significant influence on electricity grid transitions, with climate change policies and related programs being a significant factor. This is expected to continue and is highlighted in the four energy demand outlooks identified in the IESO's Ontario Planning Outlook: low demand, flat demand and two high demand outlooks. In particular, the two high demand outlooks are influenced by different amounts of electrification to reduce carbon emissions and to align with climate change policies. In order to meet demand forecasts and climate goals, aggressive action plans are required.

Another significant transition for the electricity grid is the establishment of a capacity market to enable renewables. The IESO is investigating platforms to support transactions for the establishment of a dynamic marketplace and the integration of multiple actors in the sector. The central focus of this type of market is not just about meeting an end price; it is about the coordination of resources. As resources become more available, coordination becomes more important to maximize efficiencies and opportunities. The creation of a capacity market for enabling renewable generation will create new value for customers. Additionally, it will prepare the grid to service a different future, where the influence of microgeneration will increase as a result of the proliferation of 'prosumers.' This system will be dynamic and needs to take advantage of past experiences to move beyond challenges, which include: the improvement of energy scheduling, the implementation of day-ahead marketing pricing and design, and the incorporation of real-time information for consumers.

Making changes to the system now will provide substantial efficiency improvements in the electricity system in the future. The transition of the electricity grid will involve the improved management of system capacity, an effective role for stakeholders and LDCs, the increased penetration of renewables and involvement of the technology sector driving the next generation of distributed technologies. New innovations (e.g., block chain technology) bring forward a strong influence on the business-side of the electricity grid. The keynote ended with a final thought: in this era of transformation and innovations in technology, markets and policy, need to be closely aligned to help deliver value to the customer.

PANEL 1: TECHNOLOGY AND DISRUPTIVE INNOVATION

Moderator: **Dr. Jatin Nathwani**, Executive Director, WISE; Member, CCRE
Panellists: **Josipa Petrunic**, Executive Director and CEO, Canadian Urban Transit Research and Innovation Consortium (CUTRIC)
Mark Henderson, EVP, Asset Management and COO, PowerStream
Hartmut Schmeck, Professor of Applied Informatics, Karlsruhe Institute of Technology (KIT), University of Karlsruhe, Germany
David Teichroeb, Business Development, Emerging Technology, Enbridge Gas Distribution

The challenge posed by the declining cost structure of distributed energy resources (e.g., solar, electric vehicles, storage, and microgrids) on the utility distribution network was assessed during the first Forum panel. In particular, this panel aimed to discuss the following questions: will prosumers proliferate? Is the state of technology mature enough for a massive exodus of customers and is there a real threat of stranded assets?

Moderated by Dr. Jatin Nathwani, the panellists were further driven to answer whether they could imagine the transition to a real-time market, and to classify the drivers for this technological development (e.g., technology or costs). Additionally, panellists were asked to identify the shift in roles for operators, distributors and consumers and how this advancement in technology will change the 'texture' of our energy system.

PRESENTATION 1: Josipa Petrunic
Pan-Ontario Electric Bus Presentation and Integration Trial: Phase I (2017-2020)

The Canadian Urban Transit Research & Innovation Consortium (CUTRIC) focuses on five key areas of transportation innovation. Bringing insights and experiences for electrifying public transportation sector, Josipa Petrunic's presentation highlighted the challenges and opportunities for transitions within this sector and how developments in microgrid technologies can aid this transition.

Josipa presented several examples of working examples of the Pan-Ontario Electric Bus Demonstration Trial, which incorporates energy delivery, storage and optimal pricing for electrified heavy-duty vehicle systems. New technologies linked to strategy options for electric bus solutions included the Nova Bus and the New Flyer. Those technologies linked to charging options for electric bus solutions included ABB group and Siemens.

A central challenge raised during this presentation, was the lack of working relationships between transit agencies and utilities. Another major issue with electrifying the transit industry is the source of funding for development. Since the public transportation sector is not a private industry, how can innovations be made when there is no direct relation to profits? An opportunity highlighted was the collaboration with federal agencies and local distribution companies, which can initiate a potential business model based on energy consumption.

The challenges and opportunities highlighted during this presentation offer insights to the barriers faced by this industry for making innovative advancements in technological adoption, while identifying how innovative models and partnerships can help bridge the gap and incorporate these technologies.

PRESENTATION 2: Mark Henderson
The PowerStream Journey and Perspective So Far

Mark Henderson brought insights from PowerStream's transition towards a 'next generation utility.' At the core of PowerStream's developments is the belief that a revolution in micgrogrid and distributed energy generation is in progress; thus utilities play a significant role to move swiftly with these advancements. As a leading energy company,

and the second-largest municipally-owned LDC in Ontario, PowerStream's innovations offer critical examples of services provided by the 'utility of the future.'

Inspiration for PowerStream's developments was an outcome from a visit to Nissan's offices in Japan, where the conference room was powered by a Nissan Leaf. Additionally, PowerStream is out to prove against the 'death spiral of utilities' model. As value migrates from the core business, there is a need for identifying new areas for business development.

Mark Henderson highlighted that PowerStream is involved with seven advancements for alternative energy solutions: RPP (OEB Pricing Pilot), microgrid, smart home technologies, demand response, residential nanogrid, commercial microgrid and electric vehicle integration. Three key developments were discussed in depth during Mark Henderson's panel discussion. Firstly, PowerStream has also made their offices into a commercial-scale microgrid 'living lab'. This microgrid 'living lab' demonstrates to consumers how renewables, storage and control work together, and how to advance this strategy. Solar, wind, natural gas generation, storage technologies, electric vehicle (EV) charging and a solar carport are integrated in this living lab.

Secondly, PowerStream has developed a utility-scale microgrid in Penetanguishine, Ontario through a partnership with Korea Electric Power Corporation (KEPCO), which integrates inter connected feeders, storage, autonomous microgrid control and distribution automation functions. A MiDAS micgrogrid solution is also included in this development. The existing grid is reinforced by this microgrid through increased resiliency and operational flexibility.

Thirdly, PowerStream has introduced a residential-scale microgrid program entitled 'Power House.' Rooftop solar installation and Net Metering are involved in this program. The 'Power House' program is geared towards early adopters, and those fascinated with smart home technologies.

Mark Henderson's presentation ended with a final thought, "the world is moving so fast today that those who say it can't be done are usually interrupted by those doing it." This highlights PowerStream's key message on innovation and 'leading by doing' through their integration of microgrid and distributed energy projects.

PRESENTATION 3: Hartmut Schmeck
Lessons from European-German Energy Transition: Is the Disruption Potential Real

Dr. Schmeck's presentation entitled 'Lessons from the European/German energy transition: is the disruption potential real?' provided insights on the challenges, consequences and opportunities faced by the Europe's energy transition. Key takeaways for upcoming energy transitions within Ontario and other provinces were highlighted.

Europe's recent history of energy transition began with March 2007's Strategic Energy Technology Plan 20-20-20, which involved a 20% reduction of GHG emissions, a 20% share of renewables, and a 20% increase in energy efficiency by 2020. In 2010, Germany set more ambitious goals, resulting in "Energiewende" in 2011, with the objective of fast replacement of nuclear power with renewables by 2022.

However, in the transition to renewables, three major challenges exist for the electricity grid, including:

1. The volatility of daily energy demand and renewable energy generation. Consequently, storage, flexibility and demand-side-management (DSM) is integral.
2. The uncertainty of renewable energy generation capabilities. Although day-ahead predictions are available, they might not be achieved.
3. Decentralization presents new stability problems in the distribution grid. In particular, increases in low voltage grid due to PV, as well as voltage increases due to EVs.

Dr. Schmeck addressed the consequences for the energy grid and energy management. As the grid develops, increased flows of communication need to take place alongside flows of energy. Additionally, the transition of the energy grid will no longer be configured in a top-down distribution system; thus, the distribution grid is not an accurate name for the energy network. These developments present a need for an energy information network with distributed system intelligence. With this proliferation of data, only necessary data should be used, with decisions made at decentralized levels. Changes for energy management are also prevalent in this energy transition. In the new future system, there is a potential reversal of power flow, where demand follows supply, which requires more flexibility.

Flexibility within the energy system, in terms of supply and demand, can be seen in multiple avenues, including smart homes and businesses. Utilizing charging opportunities from EVs can present a potential for increased grid flexibility through Vehicle-to-Grid (V2G) operations. Additionally, at the industrial, level there are opportunities to utilize flexibility potential without reducing productivity (e.g., using HVAC for power system services).

The challenges presented by disruptive technologies on the existing network were also highlighted. Specific examples included: the increase of rooftop generation, the faster-than-expected decline of battery cost, and the upcoming and strong decentralization of power generation. Consequently, EVs will become more prevalent, increasing opportunities for grid flexibility. Additionally, the reduction of costs for local generation and storage will result in the proliferation of prosumers and the potential for grid independence.

The state of technology is not currently mature enough for systemic change; however, remote communities and small-scale developments applications are realistic with current advancements. Large-scale developments need to ensure stability and security of the power grid. For small-scale developments, the cost of batteries and technologies are affordable for private homes and commercial businesses. In combination with home and building energy management systems, there are strong capabilities for small-scale microgrid development.

Dr. Schmeck also highlighted the threat of stranded assets and the importance of developing new business models, as no clear role for central transmission systems is evident in the future grid. The Karlsruhe Institute of Technology has several research groups and projects focusing on the development and future of the energy grid. Closing his presentation, Dr. Schmeck highlighted the importance for a strong collaboration between multiple disciplines for investigating the future energy grid.

PRESENTATION 4: David Teichroeb
Technology and Disruptive Innovation in the Natural Gas Sector

With a presentation entitled, 'Technology and disruptive innovation in the natural gas sector,' David Teichroeb highlighted opportunities for natural gas in distributed microgrids, through Enbridge's recent developments.

David Teichroeb discussed the opportunities presented by Natural Gas through 'Net Zero Ready' policy and construction. Currently, homes produce an estimated 3.3 tonnes of GHG emissions per year, whereas homes that are 'Net Zero Ready' can result in reduction of two-thirds of GHG emissions for mixed fuels. Establishing a stronger building code can enable the development of Net Zero Ready, and can improve diversity and affordability through site and source options. Currently, gas is supplied to 3.6 million consumers in Ontario with 270 TWh. Bringing flexibility will help in the achievement of Net Zero guidelines.

Additionally, the expansion of renewable gas was discussed. This power-to-gas energy storage technology converts off-peak and surplus electricity to green hydrogen, which can provide a grid reliability service and bulk power management. This support can increase renewable power generation on the electricity grid while supplying green hydrogen for pipelines, power generation and vehicles. Enbridge has a 2MW energy storage project on schedule for operation in early 2017.

The 'home of the future' provides flexibility for net zero developments. Microcombined heat and power alongside storage at the household level can provide affordability and accessibility for Net Zero, and green gas becomes a flexible resource. Opportunities exist to integrate gas and eclectic thermal solutions into a hot water micro grid as new demand response services for LCD/IESO. The emergence of disruptive technologies is facilitating the capability for hybrid heating and thermal microgrids (e.g., hot water air handlers, mCHP, natural gas heat pumps, indirect water heaters, etc.,). The additional emergence of advanced gas technologies hold a significant role in retrofit and new construction. David Teichroeb also emphasized the opportunities available for academic and industry collaboration on the development of supply-side technology developments.

SUMMARY OF THE AUDIENCE QUESTIONS AND RESPECTIVE REPONSES

QUESTION 1: Combining of car and transit charging through infrastructure
The first question asked whether an infrastructure facilitating a combination of bus and car charging was possible.

Response from Josipa Petrunic: Although it is worthwhile at the next stages of development to integrate storage and charging for aggregate loads, it is a challenge to integrate both elements together. This is a two-fold issue, one is the hardware itself cannot be integrated; the other is the logistics and location of the charging stations.

QUESTION 2: The concern about the rate of adoption of smart homes and electric vehicles in comparison to solar panels
The second question asked whether there is a concern about the slow adoption of smart homes and electric vehicles in comparison solar panels for developments in the energy transition.

Response from Dr. Schmeck: The largest challenge is getting the involvement of residents of the home in order to offer demand flexibility. There is a need to develop new kinds of business models to achieve this level of engagement. The opportunity has to be given to the customer to specify the degree of freedom before the integration of control. This is related to the integration of energy management systems (EMS) and to the control and optimization of EV charging, appliance use and load shifting within the home. How can the flexibility be discovered? The preference of the local consumer needs to be integrated into the energy management system.

QUESTION 3: Demand flexibility and the role of information science
The third question developed the point of demand flexibility and asked: what role do you see for informatics and information science – to get info to consumer to interact with system to make more useful?

Response from Dr. Schmeck: There are tasks that we have to do that we cannot do with standard energy technologies. There is a need for EMS to visualize the consumption and normative feedback, and information technologies are needed to fulfil that function. Consequently, there is a need to identify the available data and how it can be utilized; however, this can only be completed through information technology and with the participation of computer scientists. There is also a need to identify what is the most useful information to utilize.

Response from Josipa Petrunic: There is an important role for information science in the efficiency planning for the transit system. In the transit system, there are opportunities for significant savings to use the EV power available for charging and recharging busses and connecting to the grid. It is important to establish IT development to further understand when EV capacity is available to 'borrow' via a flexible subscription service to grid. These developments could result in lower transit fares; therefore, an increased social benefit. This would be an interesting development in information science and technology.

QUESTION 4: Challenges for integrating natural gas renewable grid as district energy
The fourth question asked about the challenges for integrating this natural gas renewable as district energy.

Response from David Teichroeb: The costs are a significant challenge to implementation. Clusters can develop and make it economic and to allow gas, electric and, overall, to facilitate hybrid implementation. Density is required for district energy. Peer collaboration is integral to understand the costs.

QUESTION 5: Clarity for the "Energiewende" movement
The fifth question posed that the truth behind "Energiewende" is not as good as it seems. Some see it as a harmful approach, since coal often replaces closed nuclear operations, whereas others see it as positive for renewable development. Some clarity behind the motivations behind "Energiewende" was requested.

Response from Dr. Schmeck: There were two main reasons that Germany did not want to use nuclear: due to risk of nuclear risk of catastrophe, and due to the inability to responsibly deal with nuclear waste. If you look at long-term and lifecycle costs for nuclear, there are significant costs involved. Additionally, there are many benefits for renewables, for example, there is no need to import fuels and it provides a more sustainable option for future development.

QUESTION 6: Efficiencies, costs and the current distribution model
The sixth question asked whether there is an efficiency and cost point where the current distribution model makes sense in comparison to distributed models.

Response from Mark Henderson: There has been limited investigation on this issue; however, due to consumer reliance on the system, distributed systems are not possible in the near future.

Response from Dr. Jatin Nathwani: There is enormous value when providing a connected energy system and that the value of connectedness is not going to disappear no matter how it is approached.

Response from Dr. Schmeck: There is value in connectedness; however, there are still people who see value in independence, which can be seen in the mobility sector. Consequently, this will result in a distributed, rather than a top-down energy structure. The market is there, but there are still associated risks.

QUESTION 7: Autonomous vehicles – an opportunity or a challenge for transit?
The seventh question asked whether autonomous vehicles pose a challenge or a solution to transit efficiency and planning.

Response from Josipa Petrunic: Autonomous vehicle development brings benefits to the transportation network. It has the potential to increase efficiencies through smaller shuttle-sized operations. Additionally, it can result in a convergence between transit in the automobile-side and the transit side. This can result in on-demand shuttles where partnerships between private shuttles and transit can take place. Overall, autonomous vehicles increase efficiencies for charging and automation.

QUESTION 8: Creative methods for funding natural gas and energy
The eighth question asked for insights on creative ways of funding in natural gas and energy.

Response from Josipa Petrunic: The Smart Grid Fund allows for large-scale and long-term funding.

Response from David Teichroeb: Enbridge provides funding for some projects.

PANEL 2: FINANCING: BUSINESS MODELS; AND, REGULATORY CONSTRUCT: POLICY ALIGNMENT

Moderator: **David McFadden**, Counsel, Gowling WLG (Canada) LLP; Member, CCRE
Panellists: **Colin Andersen**, Chair, Energy Council of Canada
Brian Poth, Partner, Power and Utilities, PricewaterhouseCoopers
Paul Murphy, Board Chair, Advanced Energy Centre
Vicky Sharpe, Corporate Director and founding President and CEO, Sustainable Development Technology Canada (SDTC)

The second panel focused on new financing and business models and the role for new regulations in the light of these new energy innovations. With the advancements in energy technologies, the texture of the energy system is changing from a traditional model of 'cost recovery' and 'one-way' information and energy flows, to new models. The aim of this session was to identify whether the introduction of energy resources, high penetration of variable generation and ICT-enabled consumers undermine the existing business model of the distribution utilities.

David McFadden was the moderator of this panel and identified the significance of this event for the CCRE, as the first event hosted by this organization on microgrids and distributed energy. The results of this Forum have both provincial and global implications; thus it is important to have a wide-range of perspectives regarding these opportunities.

PRESENTATION 1: Colin Andersen
Financing, Regulatory and Policy Alignment

As the Chair of the Energy Council of Canada, Colin Andersen provided insights into issues, opportunities for developments, as well as emerging trends in the Canadian energy industry.

The World Energy Council provides a World Energy Issues Monitor annually, where issues are raised based on their level of uncertainty and impact. For 2016, the top issues for Canadian energy, respectively, were: commodity prices, climate framework, liquefied natural gas, China-India, regional connections, U.S. policy, renewable energies, trade barriers, and talent. The retiring energy sector is a crucial element of the talent issue for the energy sector, where there is a need to focus on younger talent in the industry.

Canada's energy future does not mirror Canada's energy past. For the first 100 years, Canada's electricity industry stayed the same; however, there are large changes to be seen in Canada's energy future. Canada's energy past was centered on passive consumers, utility-scale grids, central planning, single fuel projects and geographic monopolies.

Canada's energy future is driven by technological change, and it needs to be enabled by policy. Several elements are driving this change, including: new types of markets, the development of prosumers, local engagement at the early stages of development, and low-carbon energy access. Additionally, there is a strong development towards the 'roaming' customer through the utilization of EV battery storage. Other advances are certain with the expansion of home energy management and the potential integration of energy, security and IT. Furthermore, the procurement of resources has changed drastically and will continue to change.

Colin Andersen emphasized the positive influence of sub-national advancements, driven by climate change, on Canada's current energy transition. Specific trends include: decarbonisation and carbon pricing, rate reform, engaged consumers, and utility transformations. The prudent phase-in of energy projects and the importance of community partnership were highlighted as lessons learned for future transitions. A large challenge for Canada's energy future is to find new solutions and transition pathways amid challenges, for a successful and sustainable energy transition.

To enable future transitions, innovations are needed at various levels. This involves policy, financing, markets, regulations, contracting, technology, utilities/providers, and politics. An interesting element is in green banks and the investigation of the long-term asset resiliency.

At the closure of his presentation, Colin Andersen emphasized the importance of sustainable, accessible, reliable and affordable energy for all. There are many communities in Canada, and abroad, that do not have access to clean or reliable energy. Colin Andersen works with the Affordable Energy for Humanity project with the Waterloo Institute for Sustainable Energy. The presentation was closed with an engaging quote by UN Secretary, General Ban Ki-Moon, "energy is the golden thread that connects economic growth, social equity and environmental sustainability."

PRESENTATION 2: Vicky Sharpe
Summary of Presentation

Vicky Sharpe brought insights into the financing of innovations and the funding of clean technologies. At the root of her presentation, Vicky Sharpe mentioned that innovation has no value unless it falls into the hands of the market, and that to see the value of these investments in clean technology developments, the 'diffusion of innovation' needs to take place.

In the current scenario for project financing and investments, software innovations are less capitally intensive, and easily funded. On the other hand, the funding opportunities for hardware venture capitals, which are highly capital intensive, are extremely limited because of the risk associated with these investments. As a result, it is difficult to raise capital for these innovations and takes time for the development of these projects. As the electricity sector is fairly hardware intensive, this could be large barrier to the development of innovation in this sector to achieve infrastructure-level advancements in technology.

One key model for financing these capitally intensive projects is through green banks. This is a heterogeneous model for the financing of renewable or clean energy technologies and can be involved in the development of a singular innovation or multiple projects. Green Banks provide a path to market project financing and low risk areas and there is a need to move in this direction for financing.

At the closure of her presentation, Vicky Sharpe emphasized the necessity for a green infrastructure bank at the federal level for financing these projects. This would put money towards the current needs for distributed energy. Additionally, there is currently no capacity for LDCs to become involved in risky investments associated with the development of these technologies. Overall, more financing is necessary to spur the development of these energy innovations and clean technologies; thus, more innovative financing solutions are required for utilities to remain innovative.

PRESENTATION 3: Brian Poth
Opportunity Amidst Disruption: Energy Transformation in Canada

Brian Poth of PwC provided insights on PwC's work on strategizing and predicting Canada's energy future, envisioning Canada's decentralized energy future through Delphi scenarios, and identifying implications and considerations for utility business models.

To gain further understanding of current energy transitions in Canada, PwC developed two national surveys. The first survey gauged the insights from 44 energy executives on trends, challenges, opportunities for growth and drivers of the transformation. The second survey gauged insights from 1504 consumers on the customer's role in the energy transformation, relationships with providers, and the challenges consumers face in the energy industry. Additionally, 6 in-depth interviews took place with internal and external subject experts.

This work identified four significant forces transforming the energy landscape:

1. Customers – The expectations and needs of customers are changing and are becoming more flexible. These elements need to be considered and met. Opportunities exist to provide different products and bundles to costumers.
2. Technology – There is an emergence of disruptive technologies that no one can control (e.g., block chain technology). This is changing the dynamic of the market and introducing new competitors.
3. Innovation – The introduction of new technologies, policies and modes of thinking needs to be incorporated into new business models and structure of operation.
4. Policy – The movement of innovation and disruptive technologies is moving faster than it can be addressed by policies and regulations. The energy 'trilemma' issue is often driving policy innovation.

Furthermore, it was identified that 43% of respondents believe current business models are not sustainable with energy industry innovations. The majority of energy executives surveyed identified that Canadian governments should prioritize their initiatives based on affordability (82%), followed by encouraging innovation or disruptive technology (68%). However, most of the executives surveyed said that they feel constrained, particularly by the regulator, due to misaligned priorities. Additionally, a majority of the executives surveyed (68%) identified that their company's business models are evolving at a pace consistent with energy transformation.

The development of new energy technologies will change the long-term operation of the energy market, including: generation, due to increased solar; transmission via distributed generation technologies; distribution, as a result of new storage technologies; and retail, through the proliferation of electric vehicles and other smart home technologies.

The second segment of Brian Poth's presentation highlighted the outcomes of PwC's project entitled 'Delphi Energy Future of 2040.' A survey of 350 global utility experts identified the probability of different future energy scenarios by 2040. The main outcome of this survey emphasized the centralized future of the energy system and the need for new types of governance and markets to assist this shift. Those jurisdictions likely to develop these transitions are Europe, Germany and North America, respectively.

Brian Poth emphasized that across the energy value chain, control is shifting 'downstream,' fuelled by the expansion in advanced metering infrastructure and 'behind-the-connection' technologies (e.g., distributed generation, storage, energy management services, smart home technologies and demand response). The transformation of markets stems from new models of financing and pricing seen in on-demand services, as well as 'bundled' service packages. Outcomes from the PwC Delphi survey suggest key developments will take place in this market transformation. Examples of these future developments were highlighted, including: community energy funds will drive the decentralization of the energy systems; customers will pay flat rate fees; and uninterrupted availability of energy supply will not be a standard service in 2040. Overall, these transformations have the potential to change the business model for distributors. Drivers of change are taking place at different paces; thus a combination of incumbents and new players will be involved as different actors embrace these changes in markets and technologies.

PRESENTATION 4: Paul Murphy
The Future of Microgrids in Ontario

Paul Murphy brought insights into the directions taken within the MARS Advanced Energy Centre. At the root of the Advanced Energy Centre is the Mission to foster the adoption of innovative energy technologies in Ontario and Canada and to leverage those successes and experiences into international energy markets. The work completed within the Advanced Energy Center investigates community energy, energy data access, utility transformation and international energy transitions.

Within the work for community energy, two components are necessary: building energy efficiency and the development of microgrids. To understand utility transformations, the Advanced Energy Centre utilized the Newtonian Shift Simulation. This gaming simulation is used to help utilities understand the pace of change in the energy sector, and inform intentional decisions to capture the value and opportunities in a changing world. During the simulation at MARS, a unique outcome seen in Ontario was how much we depend and look towards the regulators for rules. This is a different experience compared to simulations in other jurisdictions. Ultimately, this exercise helps with strategic foresight for utility transformation and helps utilities to make informed and intentional decisions to effectively obtain value from changes in the energy landscape.

The second phase of Paul Murphy's presentation highlighted the results of a Navigant report on the future of microgrids in Ontario. The first profile and use case was at the residential scale and consisted of solar generation, battery storage as well as a controller and switchgear for both TOU shifting and run-through resiliency. Findings indicated it was not economic in the short-term for a residential consumer to establish a residential-based microgrid. It was not until the long-term (2035), where the customer could see a net benefit. The net benefit seen in 2035 was approximately $400 annually.

The second profile and use case of the Navigant report consisted of a community microgrid. In this scenario, the community profile consisted of solar generation and battery storage for reducing peak load and demand response for local distribution peak. In the short-term, community-based projects face a value gap of $0.2M, whereas in 2025 community-based projects face a net benefit of $1.2M and $1.9M in 2035. This shows large opportunities for benefits in the system. Overall, based on a desired payback of 10 years, the economics of community microgrids may not be positive today but are strong in the near- and long-term.

The third phase of Paul Murphy's presentation highlighted the results of a survey to envision the LDCs of the future. A majority of LDCs executives surveyed indicated their readiness for the future and that innovation is their driving principles, and that the LDC of the future will need to be high-tech and innovative. However, the main point was raised: if LDCs say they are ready for the future, how come they are not doing more? The survey results further indicated that LDCs are ready to embrace microgrids, encouraged by the driving forces of EVs, energy storage and battery technologies. LDCs also would prefer to keep microgrid initiatives within the utility. Additionally, LDCs indicated that the market should be rate-based for the inclusion of these initiatives. LDCs further indicated that a more supportive regulatory environment is needed for their increased involvement in these initiatives. Paul Murphy indicated that this finding is inconsistent with the finding of LDCs being prepared for the future and the integration of microgrids. This final finding highlighted an interesting point for further discussion during the Forum.

Overall, Paul Murphy highlighted insights obtained through the MARS advanced energy center, including the foresight strategic planning techniques for utility transformations, the economic feasibility of both residential and community-based microgrid projects, as well as the opinions of LDCs on the future of the grid and integration of microgrid technologies.

SUMMARY OF THE AUDIENCE QUESTIONS AND RESPECTIVE REPONSES

QUESTION 1: Renewable energy systems

Question 1 asked, in carbon-based systems 70% of costs are associated with energy delivery, whereas in clean renewable energy systems, 90% is spent on capacity. Energy is practically free in a clean system. Do you think changing the way we price of electricity will help speed-up the transformation process, if we went to a capacity-based system with a very small fee for energy?

Response from Brian Poth: This is a true dilemma and the German model provides a good example. In Ontario, sometimes there is too much energy available during certain times of the day, and what do we do with that? Since capacity and energy are different, there is a need to fundamentally rethink how to pay for the assets used for the generation of reliable power, and then fundamentally rethink different models of how to pay for the energy. The low long-term operational costs associated with renewables shows why they are so attractive to investors; once they are built, there are almost no marginal operation costs. This is very attractive and driving a lot of global adoption. As long as we can find a way to price the right things, such as carbon, then the adoption will grow accordantly.

Response from Vicki Sharp: In looking at institutionally driven change, we still have a big problem because the asset class we are looking at are not being recognized. When dealing with an investment fund, they do not have a team that looks at innovation and technologies in the energy sector. Another problem being faced involves the scale of funding needed versus the scale of funding these institutions want to provide. Although newer techs are looking for significant capital, it is not significant compared to what other funds are investigating. Often, projects under $500 million are not ideal. Human behaviour and performance is at the root of this, since investors are rewarded by making large investments and are less inclined to invest in smaller projects with large levels of risk.

Response from Colin Andersen: Institutional investors are not looking investments that are not built and do not have a proven, anticipated revenue stream. Thus, institutional investors are not interested in looking at investments until their anticipated revenue stream matches their actual revenue stream. Larger investments are more attractive to large investment funds.

Response from Vicky Sharpe: There are input and output risks associated with investments in energy development. It's just not a mix in which they are likely to get involved.

QUESTION 2: Energy access

The second question reflected on Colin Andersen's last presentation slide regarding energy access and asked: what opportunities do you see for Canadians to serve these developing world markets?

Response from Colin Andersen: Certainly we are seeing that it is more difficult to adopt mircogrids to existing neighbourhoods, but there is a real opportunity to get them developed in new neighbourhoods. There are significant opportunities in the developing markets as well. We also have 'people grids,' where social interactions are a large driver for renewable energy and microcredit projects in the developing world. For example, you can have a $500 project involving solar panels, and once you attach a cell phone charger to it, a business model is envisioned through selling charges to neighbours. Suddenly the consumer is making more money from their investment and able to pay-off their investment faster. What has really been key to this project is the marriage between technologies that are enabling substantive change, resulting in more leapfrogged effects rather than moving stepwise. Those countries won't be building large grids; they will skip right over it. There are some innovative companies that are already working in the space. The Waterloo Institute for Sustainable Energy is involved in the Affordable Energy for All Initiative. In the spring of 2016, 130 different organizations, academics, participants were in Waterloo for the Energy Access event, where a lot of work was done on this topic. There are lots of opportunities available in this area.

Response from Paul Murphy: We have some of these applications here in our own country. There are remote communities within Northern Canada that do not have access to clean or reliable energy. Consequently, we have a testing ground for these technologies and we have a need. Together with the opportunities seen throughout the world, there is a strong reason to move forward with these developments.

QUESTION 3: Scale of solar system used in residential scenario

Question three was directed towards Paul Murphy from MARS. Looking at the actual consumption of the residential system (18,00kWh), the residential solar PV installed was undersized and there were opportunities for energy efficiency within the home. Why was a 5KW system used when low costs for solar PVs can motivate installations utilizing east-south-west systems and up to 15KW in size? Utilizing this kind of system, even without storage, the cost outcome could be significantly different than shown, even under today's economic scenario.

Response from Paul Murphy: A large house was chosen for a couple of reasons. Firstly, so that there was enough energy consumption to make it worthwhile and, secondly, owners of large houses may have more money to spend on a solar panel system whereas lower-income consumers and smaller houses may not have available income to spend on a solar panel project. Since Paul Murphy was not involved the calculation and decision to choose the size of home, he could not directly respond as to why this system was chosen; however, he can further investigate whether all aspects were considered for this situation.

Response from Brian Poth: There is very little connection within consumers' minds between the business case and the purchase decision and that is something we cannot lose sight of. The engineering answer might not be the answer that sells. This can be seen in California, where Tesla cars are predominantly driven and houses are 'hooked up' with smart home devices. When discussing the rational for adoption, it not an economic conversation; it is a cutting-edge technology conversation. This is something we need to consider going forward. Brian Poth shared that his children enjoy driving their friends in their family vehicle, the Chevy Volt, even though it is not the 'fanciest' car at school, but because it is 'cool' now. The current consumer market is different and this should be considered going forward, especially when the engineering answer might not be the most accepted or ideal answer for the consumer.

Response from Paul Murphy: The Navigant report describes these aspects and comments on the non-measurable benefits associated with residential micro-grid technologies. Whether the consumers are motivated by environmental or technological concerns, these elements will also influence purchase decision.

Response from Colin Andersen: There is a convenience element associated with this development through 'end-to-end' services. To install these devices, a lot of barriers exist, such as identifying the rebates and fulfilling the audits for incentivized programs. As a result, many consumers give up in their pursuit of these installations.

QUESTION 4: Influencing policy through innovation

Within Ontario's energy system, chemicals are being reduced or eliminated in order to meet carbon reduction goals. The main question asked how to influence policy development for carbon capture and trade, as well as carbon taxes, to recognize benefits associated with certain technological innovations in this realm.

Response from Vicky Sharpe: A clear vision with some economic values, such as job numbers, associated with this technology that is associated needs to be shared with the constituency of your champion political person.

The question was further refined to ask how to make an impact when the innovations are associated with productivity gains, rather than job growth and how to gain support from local constituencies with this policy issue.

Response from Vicky Sharpe: This is an issue when investigating initial financing opportunities, however, a large amount of innovation is coming from the private sector, which would be responsive to productivity gain parameters. Baselines are important for providing strategic support for these types of developments.

Response from Colin Andersen: Two examples were highlighted as examples. The first was an equivalency agreement in Nova Scotia between the federal and provincial governments. The drivers for this decision was that coal facilities would not be closed after 2030, as long as additional initiatives were taking place. If they had to close those

coal plants, they would build gas plants. It came down to an issue of affordability for meeting their carbon goals. Therefore, the affordability scenario is also a very strong argument for politicians. The recent carbon policy umbrella provides a great opportunity for presenting these innovations and getting support, however these need to be presented in 'people-friendly' terms (e.g., pricing and jobs).

Response from Paul Murphy: Something MARS has been working with, involves envisioning the idealized outcome and then laying out particular incentives for this to take place, rather than identifying particular actions. There are cheaper methods for reducing carbon emissions. If we want to provide different methods to achieve idealized outcomes, we need to present these outcomes and allow for the freedom of innovators to come up with methods to achieve them. Innovation has been stifled in Ontario through program administration and funding constraints, and it stops people from identifying other ways you reach these idealized outcomes. In order to foster innovation, this needs to be fixed. Innovation is always clearly stated in federal and provincial policy directions. What needs to be changed is how to best develop these programs to allow the innovation to take place.

Response from Colin Andersen: Although there are cheaper ways for reducing carbon, other than completely cutting coal, the initial motivation in Ontario was health-driven, resulting in large savings in the healthcare sector. Additionally, smog days have been completely reduced. This side of the equation is often forgotten when discussing coal elimination and the associated costs. There are external costs to be considered. Encouraging policymakers to see these externalities is important when trying to shape policy and spur innovation.

CONCLUSIONS

The Technology Innovation & Policy Forum 2016 focused on microgrids and decentralized energy systems and brought together industry, policy and academic experts to shed light on the future of the energy grid. Innovations in decentralized energy and microgrid developments are rapidly advancing, and it is predicted that the future of the energy grid will consist of new market models and regulatory structures. However, effective financing strategies are needed to invest in and further develop these systemic advancements. Due to the fast pace of energy innovations, a variety of new stakeholders may participate in the energy grid. In addition, as consumer type and preferences change, adapting to the 'consumer of the future' by utilizing consumer-based approaches is crucial for the LDC of the future. Although the technology is not at the current stage for systemic change, current microgrid advancements provide significant opportunities for remote communities in Canada and abroad for the achievement of accessible, affordable and sustainable energy.

At the closure of this event, Dr. Jatin Nathwani, identified the topic of microgrids and decentralized energy as being important enough to be addressed annually to ensure technological developments are incorporated into a system that is sufficiently flexible and the framework for policies, regulatory developments and markets are in alignment to deliver the best outcomes for customers. Furthermore, Dr. Nathwani highlighted that, "technical innovation needs to provide a suite of solutions that would drive the need for policy interventions to zero – those innovations that are truly cost effective, that are robust and scalable and, additionally, where there is no need for new infrastructure." Glen Wright further concluded that this is the right conversation to be taking place; where technology, policy and finance come together to face the challenges of the future.

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

Appendix 1
Conference Program and Presenters

Technology and Innovation Policy Forum 2016 Report
April 2017

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

Conference Program

8:30 am **Registration & Continental Breakfast**

9:30 am **Welcome**
Glen Wright, Chairman, Council for Clean & Reliable Energy (CCRE)
Jatin Nathwani, Executive Director, Waterloo Institute for Sustainable Energy (WISE); Member CCRE

9:45 am **Keynote Speaker**
Bruce Campbell, President and CEO, Independent Electricity System Operator

Innovation in Ontario's Electricity Sector

10:15 am **Break**

10:30 am **Panel 1: Technology and Disruptive Innovation**

Declining cost structure of distributed energy resources (solar, EVs and storage, microgrids) pose a challenge to the utility distribution network. Will prosumers proliferate? Is the state of technology mature enough for a massive exodus of customers and is there a real threat of stranded assets?

Moderator: **Jatin Nathwani**, Executive Director, WISE; Member, CCRE
Panelists: **Mark Henderson**, EVP, Asset Management and COO, PowerStream
Josipa Petrunic, Executive Director and CEO, Canadian Urban Transit Research and Innovation Consortium (CUTRIC)
Hartmut Schmeck, Professor of Applied Informatics, Karlsruhe Institute of Technology (KIT), University of Karlsruhe, Germany
David Teichroeb, Business Development, Emerging Technology, Enbridge Gas Distribution

Q&A Session: 45 minutes

12:00 pm **Lunch**

12:30 pm **Innovation Showcase, Networking & Industry-Academic Collaboration**

1:15 pm **Optional Lab Tours** (for Pre-registered Guests)
Lab 1: Fuel Cell and Green Energy Lab
Lab 2: Centre for Advanced Photovoltaic Devices

1:30 pm **Panel 2: Financing: Business Models; and, Regulatory Construct: Policy Alignment**

The traditional 'cost recovery' model for the electricity sector was designed and built for a one-way flow of energy technology. Technology is changing the texture of the system. Will distributed energy resources, high penetration of variable generation and ICT-enabled consumers undermine the existing business model of the distribution utilities?

Moderator: **David McFadden**, Counsel, Gowling WLG (Canada) LLP; Member, CCRE
Colin Andersen, Chair, Energy Council of Canada
Brian Poth, Partner, Power and Utilities, PricewaterhouseCoopers
Paul Murphy, Board Chair, Advanced Energy Centre
Vicky Sharpe, Corporate Director and founding President and CEO, Sustainable Development Technology Canada (SDTC)

Q&A Session: 45 minutes

3:00 pm **Wrap-Up and Closing Remarks**
David McFadden, Jatin Nathwani and **Glen Wright**

3:15-5:30pm **Reception, Innovation Showcase, Networking & Industry-Academic Collaboration**
Please join us for a Networking Reception

Optional Lab Tour 3:45 pm (for Pre-registered Guests)
Lab 2: Centre for Advanced Photovoltaic Devices

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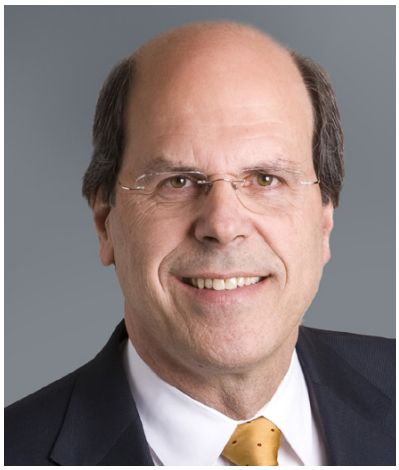
KEYNOTE SPEAKER



Bruce Campbell

Bruce Campbell is President and Chief Executive Officer of the Independent Electricity System Operator (IESO). Under Mr. Campbell's leadership, the IESO oversees the safe and reliable operation of Ontario's bulk electrical system and market as well as long-term energy planning and procurement, and the promotion of a conservation culture in the province.

Mr. Campbell was instrumental in preparing Ontario's power system for the integration of Ontario's growing investment in renewable wind and solar generation. Under his direction, the IESO has introduced innovative technologies such as storage into the power system and is actively pursuing more competitive, cost-effective solutions to meet future power needs.

In addition, Mr. Campbell represents Ontario on several international fronts. He serves on the North American Electric Reliability Corporation's (NERC) Member Representative Committee, the Council of Independent System Operators and Regional Transmission Organizations which supports sustainable and reliable electric power delivery to millions of consumers across the continent.

A graduate of Osgoode Hall Law School and the University of Waterloo, Mr. Campbell is a member of the Law Society of Upper Canada, and also holds the Institute of Corporate Directors ICD.D (Certified Director) designation.

On January 1, 2015, Mr. Campbell assumed responsibility as President and CEO of the merged Independent Electricity System Operator, which integrated with the Ontario Power Authority.

Colin Andersen

Colin Andersen is Chair of the Energy Council of Canada, which was established in 1923 as a founding member of the World Energy Council. The Energy Council of Canada strives to shape an affordable, stable and environmentally sensitive energy sector for the benefit of all Canadians. The Energy Council covers all sectors involved in energy in Canada, and brings together senior executives from industry and government engaged in regional, national, continental and global activities.

Mr. Andersen was Chief Executive Officer of the Ontario Power Authority (OPA), responsible for ensuring a reliable, sustainable, cost-effective supply of electricity for Ontario. He led the organization in its efforts to coordinate province-wide conservation initiatives, plan the electricity system for the long term and procure clean supply resources.

Prior to joining the OPA in 2008, Mr. Andersen held a variety of senior financial and policy positions in the Ontario Public Service, including as Deputy Minister of Finance, of Revenue, of Policy, Cabinet Office and Acting Deputy Minister of Health and Long-Term Care; Secretary of Treasury Board; Chair of the Ontario Financing Authority; and Chair of the Ontario Electricity Financial Corporation.

In these and other senior management positions, Mr. Andersen provided successive governments with advice and assistance on all aspects of fiscal and financial policy and planning, expenditure management and overall stewardship of Ontario's financial resources. In addition, he has led strategic asset management initiatives, extensive intergovernmental negotiations at the federal and municipal level and large-scale infrastructure and procurement projects.

He has a Masters Degree in Economics from the University of Toronto and an Honours Bachelor of Arts from the University of Calgary.

Mark Henderson

Mark Henderson is Executive Vice President, Asset Management and Chief Operating Officer of PowerStream Inc., the second largest municipally-owned electricity distribution company in Ontario.

PowerStream serves more than 360,000 customers in eleven communities across York Region and Simcoe County and is jointly owned by the City of Vaughan, the City of Markham and the City of Barrie.

Formerly, Mark was President and CEO of Barrie Hydro Distribution Inc. Prior to joining Barrie Hydro, Mark spent more than a dozen years in the business strategy and management consulting industry.

David McFadden, Q.C.

David McFadden is a Counsel at Gowling WLG and formerly served as a member of both the firm's Board of Trustees and Executive Committee. David has extensive experience, whether it be for clients investing or operating in Canada, Canadian clients investing or operating internationally or international clients investing abroad, particularly in the energy, infrastructure, financial services and technology industries.

David acts for corporations, municipalities and utilities involved in the generation, distribution, marketing, transmission and financing of energy. He also acts for clients involved in infrastructure development, management and renewal. He has acted as counsel in a variety of infrastructure projects including toll highways and tunnels, light rail systems and health care facilities.

David serves in leadership roles in the Canadian energy industry. He is currently the chair of the board of directors of the Ontario Energy Association and a member of the board of directors of the Energy Council of Canada. He is a member of the Smart Grid Forum of the Independent Electricity System Operator and serves on the advisory board of the MaRS Advanced Energy Centre and on the Council for Clean & Reliable Energy.

David is active in the business corporation sector. He currently serves as chair of the board of directors of 407 International Inc. and is chair of the Canadian and international infrastructure advisory board of Fengate Capital Management Ltd. David is also the chair of the board of directors of Toronto Hydro-Electric System Ltd. and PCI Geomatics and the former chair of the board of directors of Collus PowerStream Inc.

Over the years, David has advised government on energy matters both in Canada and internationally. He served as co-chair of the Electricity Transition Committee of the Ontario Government (1998-2002), a member of the Electric System Working Group of the Joint Canada-US Task Force established to investigate the power blackout that hit Ontario and much of the northeastern United States (2003-2004), a member of the Ontario Government's Electricity Conservation and Supply Task Force (2003-2004), co-leader of an investigation established by the Government of Jamaica to review the reliability of the island's transmission system (2006), a member of the Ontario Government's Electricity Distribution Sector review panel (2012), and chair of the Independent Review Committee appointed by Toronto Hydro to review its response to a major ice storm event in December 2013 (2014).

He has a B.A. from the University of Toronto, an LL.B. degree from Osgoode Law School and was called to the Bar in Ontario in 1972. In 2011 he was awarded an honorary doctorate from York University.

Paul Murphy

Paul Murphy is the Chair of the Board of the Advanced Energy Centre. He has been involved with the planning and operation of the Ontario and North American electric system for over 35 years.

Prior to joining the Advisory Board of the Advanced Energy Centre, Paul was President and CEO of Ontario's Independent Electricity System Operator, responsible for directing the reliable operation of the Ontario power system and for administering the competitive electricity market.

While with the IESO, Paul was the founding Chair of the Ontario Smart Grid Forum. The Forum brings together members from the utility sector, industry associations, non-profit organizations, public agencies and universities to propose a vision for a smart grid in Ontario and examine the many components that comprise it.

Paul has a BSc in Applied Science from Queen's University and is a registered Professional Engineer in Ontario.

Dr. Jatin Nathwani

Professor Nathwani is the founding Executive Director, Waterloo Institute for Sustainable Energy (WISE) and holds the prestigious Ontario Research Chair in Public Policy for Sustainable Energy at the University of Waterloo.

WISE brings together the expertise of 110+ faculty members to develop and implement large-scale multi-disciplinary research projects in collaboration with business, industry, governments and civil society groups. The vision of the Institute is simple: clean energy, accessible and affordable for all.

His current focus is on implementing a global change initiative. He is the Co-Director, with Professor Joachim Knebel (Karlsruhe Institute of Technology, Germany), of the consortium 'Affordable Energy for Humanity (AE4H): A Global Change Initiative' that comprises 100+ leading energy access researchers and practitioners from 23 institutions and 12 countries.

Prior to his appointment at the University in 2007, Professor Nathwani worked in a leadership capacity in the Canadian energy sector over a 30 year period. He brings a unique combination of academic perspectives with extensive experience in the business sector that includes corporate planning and strategy, energy sector policy developments, power system planning, environmental and regulatory affairs and research program management.

Professor Nathwani serves on several Boards at the provincial and national levels and has appeared frequently in the media (print, TV, radio) and has over 100 publications related to energy and risk management, including seven books.

Professor Nathwani holds a PhD in Engineering from the University of Toronto and is a registered Professional Engineer in the Province of Ontario.

Dr. Josipa Petrunic

Josipa Petrunic is the Executive Director & CEO of the Canadian Urban Transit Research & Innovation Consortium (CUTRIC). She is leading the formulation of several large-scale transportation technology trials through CUTRIC's consortium of private and public sector stakeholders, including the Pan-Ontario Electric Bus Demonstration and Integration Trial.

Dr. Petrunic also served as the lead researcher in electric vehicle policy studies at McMaster University. She is currently completing the Ontario Electric Vehicle Technology Roadmap funded by a federal Automotive Partnership Canada (APC) grant and slated for publication in Fall 2016.

Dr. Petrunic worked previously as a senior research fellow at University College London (UCL) in the United Kingdom focusing on Science and Technology Studies and the history of mathematics and engineering. She completed her PhD in the History of Mathematics at the University of Edinburgh (Scotland) as a Commonwealth Scholar, after completing a Master's of Science in Science and Technology Studies (STS), also as a Commonwealth Scholar. She previously completed a Master's of Science in Political Philosophy at the London School of Economics and Political Science (LSE) and a bachelor's degree in Political Science and Journalism at Carleton University.

Before pursuing graduate studies, Dr. Petrunic worked as a journalist at the Globe and Mail, Toronto Star and Edmonton Journal. Dr. Petrunic continues to lecture in Globalization Studies at McMaster University as part of the Institute for Globalization, and she lecturers in interdisciplinary research methods as part of the Master of Arts in Integrated Studies program at Athabasca University.

Brian Poth

Brian is a Partner in PricewaterhouseCoopers (PwC) Toronto office, leads the Canadian Power and Utility practice and is a member of PwCs' global Power & Utility Centre of Excellence. Brian has spent more than 20 years helping electricity and gas utilities improve their performance in both consulting and operational support roles. He has a passion for the energy sector transformation that is underway and experience to share across customer, asset, work management and technology domains.

Prof. Dr. Hartmut Schmeck

Hartmut Schmeck studied at the Universities of Kiel (Germany) and Waterloo (Canada). He obtained his academic degrees (Dipl. Inform., Dr.rer.nat., Dr. habil) at Kiel. Since 1991, he has been a Full Professor of Applied Informatics at the Karlsruhe Institute of Technology - (KIT).

Dr. Schmeck is (co-)author of more than 140 publications on advanced algorithms and architectures, in particular on nature-inspired methods in optimisation, algorithms for reconfigurable architectures, and on self-organising, adaptive systems applied to energy and traffic systems. He has been program and conference chair for numerous international workshops and conferences (a.o. RAW, ARCS, IFIP BICC 2006, 2008, ATC 2009, ICAC 2011, D-A-CH Energieinformatik) and coordinator of the German priority research program SPP 1183 on "Organic Computing".

At Karlsruhe, he is one of the two Scientific Spokespersons of the KIT-Center "Information • Systems • Technologies". As a principal investigator of several cooperative projects in various funding programs he is pushing the development of intelligent systems in tomorrow's energy systems and for electric mobility, shaping the new discipline of "Energy Informatics", in particular as a director of the FZI Research Center for Information Technology.

In 2016, his achievements were honoured with the Heinrich-Hertz Price from the EnBW Foundation.

Dr. Vicky Sharpe

Vicky is a long term champion of integrating the environment and the economy. As the first employee and founding President and CEO of SDTC, Vicky has built an internationally renowned global cleantech fund. She increased public funding from $100M in 2001 to over $1.4B in 2014 and mobilized private sector capital for project funding and commercialization financing of $4.3B.

Dr. Sharpe has successfully applied her 35 years of diverse experience in the energy, power and financial sectors with her entrepreneurial attributes, operations and leadership skills to deliver innovative solutions to Canada's primary economic sectors, increasing productivity, competitiveness and boosting exports. As VP of Ontario Hydro International Inc., she created new revenues for environmental and energy utilization practices as well as for generation and transmission businesses. Previously, she held management positions in marketing, business development and technology innovation.

Vicky is helping to shape the Canadian cleantech and investment landscape through the provision of strategic advice and leadership. She is a founding member of the Boards of; The Capital Markets Regulatory Authority, Alberta Enterprise Corporation - a fund of funds entity, Carbon Management Canada Inc. (CMC) a national network focused on a low carbon future for Canada's fossil energy sector, amongst others. Recently Vicky joined the Board of Temporal Power Ltd. (energy storage) and QUEST (Quality Urban Energy Systems for Tomorrow). Vicky has applied her governance skills (ICD.D, 2005) to boards on which she has served as well as many of SDTC's 270+ portfolio companies. She is cited by "Women on Board" and the Canadian Board Diversity Council (2015 cohort).

Vicky has served on numerous technology, industry association, investment and government committees. She represented the Canadian energy sector at the Asia-Pacific Economic Cooperation (APEC) Business Forum and has chaired both the National Advisory Board on Energy, Science and Technology, and the Board of Clean Air Canada Inc. As part of Vicky's commitment to delivering tangible commercialization results, she has joined EnerTech Capital's Advisory Board and is a member of the Advisory Panel for Mercer's Sustainable Opportunities Fund. She is an inaugural member of the Leaders Group of Smart Prosperity that is driving a more sustainable approach to Canada's environment and the economy, has provided a report to the Ecofiscal Commission on financing options for utilization of carbon pricing revenues, delivered a strategic review and recommendations on strengthening innovation in the cleantech ecosystem for the Ontario Government and been a panel member for the Council of Canadian Academies.

For her work in advancing sustainability and clean capitalism Vicky has been awarded a number of honours. In 2016 she received the Chemical Institute of Canada Society for Chemical Industry Purvis Memorial Award (for business development for the chemicals sector). Vicky, "#Innovation Booster", was one of the 2012 Clean16 and 2015 Clean16 recipients as part of Canada's Clean50 initiative (www.clean50.com). Also, she received a Lifetime Achievement Award from Sustainable Buildings Canada, The Globe Foundation's Finance Award for Sustainability and the National Energy Conservation Association's inaugural Energy Efficiency Award.

Dr. Sharpe holds a BSc Honours in Applied Biology from Bath University, UK, and a PhD in Microbiology and Surface Chemistry, as applied to water pollution control, from Trent University, UK. In 2014 Vicky was appointed as a Senior Fellow of the International Institute for Sustainable Development and Senior Fellow at the University of Ottawa in 2016.

David Teichroeb

David has over 20 years of experience in the natural gas and power generation sectors. He is responsible for evaluating and developing new business investments involving emergent technologies. This includes distributed generation, fuel cells, energy recovery to power, hydrogen, electricity energy storage and other renewable technologies.

Before joining Enbridge in 1993, David worked in the diesel power generation industry. He provided engineering and technical services to a varied customer base that included Canada Steam Ship Lines, the Canadian Coast Guard, and John Deere.

David graduated from Niagara College, mechanical engineering technology, and he is a graduate of the Institute of Gas Technology in Chicago, IL, as a Chartered Industrial Gas Consultant. He serves as a Board Director and Vice Chairman, for the Canadian Hydrogen and Fuel Cells Association.

Glen Wright

Glen Wright is the Chairman of the Council for Clean and Reliable Energy, a federally incorporated non-profit volunteer organization that provides a platform for open dialogue and solutions-oriented approach to the challenges of the energy sector. He is the former Chairman of Waterloo North Hydro.

Mr. Wright is currently the Chairman of LeanCor LLC and LeanCor Canada Inc., a global supply chain company that offers a unique combination of training and education, hands-on consulting and outsourced logistics services.

Mr. Wright has served as the Chair of Hydro One Inc. and Chair of the Ontario's Workplace Safety and Insurance Board, and was a Member of the Commission for Environmental Cooperation, part of the North American Free Trade Agreement, where he served as the Chair of the of the Joint Public Advisory Committee.

Glen's private sector career has focused primarily on the insurance and actuary fields. He has served on the Board of a wide range of corporations in the environmental, technology and manufacturing sectors and participated in a variety of charitable and not-for-profit Boards including the Canadian Broadcasting Corporation and Wilfrid Laurier University. Early on in his career he served as a Member of Waterloo City Council and Waterloo Regional Council, and has acted as an advisor to senior federal and provincial leaders.

Lab 1 Tour: **1:15 – 1:45 pm**

Fuel Cell and Green Energy Lab

Investigating green energy topics through modeling, system analysis, experimental research and scale-up design. Among our current projects, we are developing reliable, cost-effective polymer electrolyte membrane fuel cells and clean biodiesel engines for automotive purposes. Our lab capabilities include materials characterization, process development, circuit design and fabrication, and prototyping.

Lab 2 Tour: **1:15 – 1:45 pm**
3:45 – 4:15 pm

Centre for Advanced Photovoltaic Devices and Systems (CAPDS)

Promotes cutting-edge research and development that spans the spectrum of photovoltaic (PV) technology. Our 14,000-square-foot facility includes infrastructure for synthesizing semiconductor base materials; developing nanotechnologies for PV; designing and fabricating advanced PV devices and systems modules; and testing and characterizing PV materials, devices and systems.

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Appendix 2
Innovation Showcase

Technology and Innovation Policy Forum 2016 Report
April 2017

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.

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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.

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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.

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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.

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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.

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POWER WORKERS UNION

ENBRIDGE

Waterloo North Hydro Inc.

Ontario Centres of Excellence
Where Next Happens

Orbit

Green SunRising

NISSAN

ELECTREFY

Ford

VOLVO

NSERC CRSNG

Mitacs

utilismart CORPORATION

MITSUBISHI

GEOSMART ENERGY

Forbes GMC Cadillac

Borealis Wind

fleetcarma

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