Technology Innovation & Policy Forum 2017

Disruptive Innovation over the Wires: Business Models for Success

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Authors

Bronwyn Lazowski
Energy Council of Canada Fellow
Faculty of Environment
University of Waterloo

Shashi Kiran Ravikumar
Research Associate, Policy & Sustainable Development
Waterloo Institute for Sustainable Energy
University of Waterloo

Jatin Nathwani
Professor and Ontario Research Chair in Public Policy for Sustainable Energy
Executive Director, Waterloo Institute for Sustainable Energy (WISE)
University of Waterloo

in partnership with

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.

Shashi Kiran Ravikumar
Shashi Kiran Ravikumar is a Research Associate at the Waterloo Institute for Sustainable Energy. He is a former regulatory analyst from India, and he graduated from the Master of Climate Change Program from the Faculty of Environment at the University of Waterloo. His research focuses on the development of innovative solutions, policy instruments and procedures, in support of climate action, sustainable development, and environmental governance.

Drawing from his experience in developing community action plans for climate change and working with provincial governments and private corporations, on energy and sustainability projects, his multi-disciplinary approach to research explores the potential of carbon pricing mechanisms, divestment from fossil fuels, and innovation in governance structures, in accelerating the transitions towards greener economies. He is also an advocate for the United Nations Sustainable Development Goals & their Implementation.

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 2017 organized by the Council for Clean and Reliable Energy and the Waterloo Institute for Sustainable Energy entitled: "Disruptive Innovation Over the Wires: Business Models for Success". 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 a tour of the Centre for Advanced Photovoltaic Devices and Systems Lab.

Thank you to the University of Waterloo for hosting this second 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 2018 to help shape next generation smart energy solutions.

INTRODUCTION

The 2017 Annual Technology and Innovation Policy Forum was held at the University of Waterloo on November 9, 2017. Representatives from public, private and institutional organizations attended the second annual Technology Innovation & Policy Forum at the University of Waterloo.

This year's theme, Disruptive Innovation Over the Wires: Business Models for Success, brought together one keynote presentation, two panels and a set of presentations by technology developers. The Keynote presentation by Pamela Jones, the Director of Transmission and Distribution Policy at the Canadian Electricity Association focused on innovation mechanisms and pathways in Ontario.

The first panel focused on technology, its potential disruption and the role of economics; and, the second panel looked at financing business models, directions for future development and learning from past experiences. The presentations by technology developers highlighted leadership in this transition, their current or notable projects, and perspectives for future development.

This report brings together the commentaries provided during each segment of the day's presentations and panels as well as highlights the main findings of the second annual Technology Innovation & Policy Forum 2017.

Overall, the Forum aimed to achieve several goals and objectives:

- To highlight the role of emerging disruptive technologies on the distribution sector business model arising from embedded distributed generation and storage on a large scale within the existing distribution network;
- To provide panel presentations from leading industry, government experts and academics with extensive opportunities for networking;
- To bring together policy makers, technology innovators, leading researchers and entrepreneurs to address the alignment of climate policies with the need to accelerate cost-effective integration of emerging distributed resources at the distribution level; and,
- Through dialogue and extensive opportunities for discussion, the Forum focused on establishing a common basis for accommodating divergent interests.

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 the time to read this report on the second Annual Technology Innovation and Policy Forum.

This report summarizes the outcomes from the second Annual Technology Innovation and Policy Forum. This Forum was intended to bring together policy makers, technology innovators, leading researchers, entrepreneurs and industry thought leaders to help shape next generation smart energy solutions.

The goal of the 2017 Forum was to highlight the role of emerging disruptive technologies on the distribution sector business models arising from embedded distribution generation and storage 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 networking, collaboration and discussion, the Forum focused on establishing a common basis for accommodating divergent interests.

We are pleased that you have decided to join the discussion by reading this report, and we look forward to your future participation.

Glenn Wright
Chairman
Council for Clean & Reliable Energy

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

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

SYNOPSIS OF THE KEYNOTE ADDRESS BY PAMELA JONES:

INNOVATION MECHANISMS

Pamela Jones is the Director of Transmission and Distribution Policy at the Canadian Electricity Association (CEA). Ms. Jones is a seasoned policy and government relations professional with a proven track record of securing favourable regulatory outcomes and influencing stakeholders and building consensus. With over twenty years of experience working in policy development for public and private entities in Canadian telecommunications, broadcasting and electricity, Pamela is known for her ability to promote and defend the long term strategic interests of her employers and clients.

As the Forum's keynote speaker, Ms. Jones articulated the importance of innovation and driving sustainability, along with the role that the Canadian Electricity Association is playing in this innovative transition within the distribution grid. The following section provides a synopsis of the keynote address.

Considering the theme of the forum's event, taking the long view is a crucial and valuable element within the distribution grid's transition. The CEA is known for their ability to promote and defend the strategic interests of stakeholders in the long term. Innovation, and long-view thinking is also something seen in the Region of Waterloo, especially as the LRT is in late stages of development. The CEA acknowledges the importance and significance of the theme of the Forum, and its respective events. The CEA has done a significant amount of research and this presentation highlighted a few key findings from the research that will be released shortly. In particular, one study investigated the innovation funding mechanisms used around the world that are facilitated by regulatory schemes.

The first story shared during the keynote address was an outcome from a direct discussion with a senior Ontario Energy Board (OEB) executive. The executive was asked about the promise of incentives from the renewable electricity framework. Bringing innovations into the rate structure is crucial, and there are many mechanisms that are used in other jurisdictions that can also be utilized. At the end of this conversation, the OEB executive agreed that more could be done. A significant gap exists where federal regulations are not aligned to the necessity and speed of innovation within the country; consequently, creating an 'innovation gap.' This gap is prevalent where there are differences in the aspirations of the government and the level of actions taking place to support and drive these innovations. The energy innovation gap is significant and can hinder Canada's leadership in this space going forward. A key question remains: why is more action not taking place at the provincial and federal levels to reduce this gap and to harness a leadership in energy innovations?

Ms. Jones went on to discuss the role of the Long Term Energy Plan (LTEP) in the Ontario's innovative energy transitions. One section that is important in the LTEP is the barriers to innovation. Despite the OEB's efforts, what still remains is uneven investment levels within Local Distribution Companies (LDCs), resulting in unevenness of the diffusion of innovation between regions. Barriers to innovation remain, and there were interesting initiatives presented within the LTEP to work with other stakeholders to create an innovation culture. Some examples included, the development of investment funds by utilities and development of renewable energy distributed generation and other distributed resources. Overall, regulatory regimes can involve the implementation of these technologies and systems. However, problems can occur within this process of disruptive innovation, when the innovators involved might not be aware of the regulators, their respective roles, and relevant regulations.

Going forward, Ms. Jones presented three guiding principles and recommendations for the LTEP in this energy transformation.

The first principle introduced was 'do no harm.' As we make transition towards this new grid we need to recall the role of the electricity system in the economy and Canadian life during this process. Electricity is a commodity that is easily forgotten. Additionally, electricity is deemed as a critical infrastructure as it functions as an enabler as all other important infrastructures. There is also a significant responsibility for utilities in this transition. The development of the electricity sector needs to be done correctly and needs to ensure equality. It is crucial to consider the safe and reliable system and not stray away from that principle.

The second principle discussed was 'it's not easy being green.' The transition towards functional and reliable renewables is an expensive process. It is also expensive to move towards bidirectional and intelligent technologies; however, this transition is necessary, since climate change is a global imperative. Consequently, Canada's growth needs to be focused on clean development. The electricity industry is positioned to commit to reducing greenhouse gas (GHG) emissions, due to the ability to electrify carbon intensive fields. Yet, it requires provincial and federal communication and alliance for a stable and predictable policy framework. Overall, technologies and utilities within Canada play a significant role for reaching Canadian and global goals in GHG emissions reductions.

The third principle presented was 'come together.' It is imperative to recognize that the electricity grid is a system, and like all complex systems, there are a lot of agents requiring coordination, and orchestration is necessary at all distribution levels. There was a MIT study of the utility of the future, which provides different models of the utility of the future. The CEA believes that, as an industry, we are at an inflection point. What needs to be the focus throughout this transition is to accelerate innovation for a more successful future.

Concluding this keynote address Ms. Jones identified that, in order to grow as a nation, we need to bridge this aforementioned innovation gap. One-time funding mechanisms are not the answer to bridging this gap, and funding needs to be prioritized. Provincial regulations should not curtail innovation funding and development. The CEA will have three papers coming out in the short term. In particular, the third report provides the regulatory management structures across the world and presents data and interviews with the regulatory providers. Within this report there are a multitude of excellent examples, including Ofgem, which is a gas regulator in the UK, which has two mechanisms: a network allowance and a network innovation competition. The CEA is interested in the power of investing in this innovation and how it can spur developments in the grid. Ms. Jones ended the keynote by stating there is there is no single right way for the electricity industry to evolve, adaptive structures are required. The process is a balancing act and only a collaborative environment can facilitate this transition, and this path is far from simple.

PANEL 1: TECHNOLOGY AND DISRUPTIVE INNOVATION

Moderator: **Dr. Jatin Nathwani**, Professor and Executive Director, Waterloo Institute of Sustainable Energy, University of Waterloo

Panelists: **Paul Grod,** President and CEO, Rodan Energy Solutions
Ingo Mauser, dr-Ing, Research Associate, Applied Informatics (AIFB), Karlsruhe Institute of Technology (KIT), Germany
Malcolm McCulloch, Professor and Head, Energy and Power Group, Department of Engineering Science, University of Oxford, UK
Neetika Sathe, Director, Emerging Technologies, Alectra Energy Solutions Inc.

The large cost declines in several parts of the energy supply chain - batteries, LED's solar and wind, sensors, devices, and computational power - is the context that will determine new business models and relationships between the utility, the customer and new service providers. During the first panel, the panellists discussed financial and regulatory implications likely to emerge for the electric utilities. Panellists were further driven to discuss whether it is just

technology driving this disruption, or whether there are other drivers. Moderated by Dr. Jatin Nathwani, the panel opened with the discussion of the disruption of automobile technology, and whether there were parallels in the energy sector. Dr. Nathwani further challenged panellists to answer the following questions:

- Are we seeing a Kodak Moment?
- Is there a death spiral? Or will new technologies enable the modern utility?
- Will the convergence of ICT bring new opportunities for financial flows within the energy sector?
- Will the revenue model based on kWh be changed?

PRESENTATION 1: Paul Grod, President and CEO, Rodan Energy Solutions

Is Technology Disruption Driven by Economics?

The first presentation was by Paul Grod, the President and CEO of Rodan Energy Solutions. This presentation investigated whether the technology disruption is driven by economics. In this presentation, it was identified that innovation needs to be balanced by economic and system benefits. Although system operators are keen on innovations, they need to be tempered by existing systems. The lack of a robust energy supply is a reality in some jurisdictions. A crucial issue is the justification of introducing new technologies into the existing system, especially in energy systems with long-term investments. The key challenge for existing energy systems is how to successfully transition technologies into systems where 20-year investments have been made.

Rodan is a North American smart grid integrator and leading developer of demand-side energy resources. Rodan's customers include power distribution companies, including Peak Saver Plus residential and industrial programs. Rodan is an innovator in demand response, as a leading network operations center, and an Ontario Energy Association company of the year.

The main question Mr. Grod answered during this presentation was 'is technology disruption driven by economics?' McKinsey & Company recently presented an article, highlighting 12 potentially economically disruptive technologies, with energy technologies included in this list (e.g., energy storage, renewable energy, advanced oil and gas exploration and recovery). Transitions in the electricity industry involves these disruptive energy technologies, including: wind and solar generation; energy storage; demand response; distributed generation; and new fuel sources. These disruptive energy technologies require subsidies and increased development of transmission and distribution. These disruptive technologies have the potential to dramatically increase system costs. Depressed electricity market prices are also possible through an oversupply and marginal costs of production (low electricity prices). Costs are recovered through capacity payments, such as the Global Adjustment in Ontario.

The Global Adjustment is a key element to consider in Ontario's energy transition, which is a result from long term contracts made with IESO with generators, including fixed prices or guaranteed revenue. This adjustment includes the costs of green energy technologies introduced in Ontario. Through these experiences, it is clear that it is hard to recover costs through market mechanisms. This adjustment will be a part of the Ontario electricity system for 20 years. So, how do we balance the Global Adjustment with new innovation because there are sunk costs? The cost of the global adjustment over the next 10 years will be $450,000 per MW; therefore, it is a large economic driver for innovation. This is an element that Rodan is working on today.

Introducing green energy technologies through subsidies has caused market-pricing imbalances, resulting in few opportunities to consumers to reduce costs. Additionally, there are evident economic impacts, especially resulting in higher costs for manufacturing resulting in manufacturers either leaving the jurisdiction or finding off-grid solutions. Off-grid distributed energy resources is the next disruptive energy technology. Distributed energy resources are driven

by economics, and system costs with green energy techs. A main challenge of this innovation is that fewer consumers are available to pay system. Utility infrastructure costs still remain; therefore, grid costs will not be eliminated by this transition and disruptive technology, in this region.

At the conclusion of this presentation, Mr. Grod returned back to the main question: is DET driven by economics? The immediate answer provided was 'It depends.' These economic drivers can change dramatically over time. Regulators can change economic drivers. For example, if a change in government occurs, the influence of the global adjustment may also be changed. The market is playing the stronger role of creating these technologies at the utility scale.

PRESENTATION 2: Ingo Mauser, dr-Ing, Research Associate, Applied Informatics (AIFB), Karlsruhe Institute of Technology (KIT), Germany

Is Technology Disruption Driven by Economics – A German Perspective

During Dr. Mauser's presentation, a German perspective was provided on the key questions asked. Mr. Mauser presented in his introduction that there is a lab at KIT to test distributed technologies, including smart metre gateways, in order to realize Demand Response mechanisms.

Dr. Mauser first discussed whether this is a Kodak moment for utilities. Regarding the probable redundancy of the distribution grid, Mr. Mauser responded with a resounding 'no,' since energy distribution will not become redundant, and this technology will not disappear. This is especially the case in Germany because of population density.

Dr. Mauser then focused on whether distributed energy generation and storage will be cheaper than distribution. In his response, Dr. Mauser identified that there will be three Kodak moments in the realm of energy generation and distribution. The first Kodak moment will be for energy generation, as seen in high prices of fossil fuels versus low renewable energy prices. The second Kodak moment will be for ancillary services. A key example is in the development of battery storage systems. We will see a large distribution of demand side management business models related to battery storage systems. The third Kodak moment will be for distribution utilities. The network economics of distribution grids are clear, it does not make sense to continue building large grids that are publicly owned. The current distribution grid is all over Europe and remains hard to change. It is the case in Germany, where privately owned energy services are often more efficient than publicly owned grids. In the case of privately owned enterprises, many people are not concerned about slightly higher costs (5-10% more) because these companies provide public welfare, including: public swimming pools, ice rinks and cultural event sponsorship. One example is the privately sponsored public ice rink outside of Karlsruhe Palace in Germany.

Dr. Mauser then addressed the role of regulated entities versus innovation in this energy transition. Utilities look forward on long-term and lasting solutions to have a very strong and reliable grid. Current regulations are focused on incentives, where decisions are made on the current situation. However, to achieve electric mobility, innovation is necessary. Innovative technologies will be necessary to provide grid expansion for electric vehicles (EVs).

The benefits of information and communication technologies (ICT) for customers were then presented. ICT is not a sustainable solution, since it is not long-term and does not provide lasting solutions. As a result, customers might not achieve long-term reliability. ICT is more for providing information, but the question remains, do people want to know more about their energy? Electricity is a commodity, and if it is provided regularly and at a low price, having additional information might not be the most effective way to achieve change. In Germany, since energy is just a commodity, they introduced a green electricity tariff to achieve change.

Dr. Mauser then addressed whether there is clash between distributed generation and existing network assets, and the potential of replacing the revenue model based on delivering kWh. The issue with this is, when looking at price, we have the problem that revenue is based on kWh consumed. Yet, nuclear energy is heavily subsidized, and renewable energy pays for the costs. To fix this reality of energy costs, the revenue needs to change, but this will not take place in the near future, since there are lots of investments in the current energy system. To increase the basic charge of energy is (politically) not acceptable. This presents a social justice issue, since those who consume the less do not have the money to pay a larger bill. Energy efficiency is important in this transition.

In the closing part of Dr. Mauser's talk, the discussion focused on whether technology distribution is driven by economics. Dr. Mauser identified three drivers for technology distribution going forward. First are superior products, which is mostly because they provide higher safety, better products, increased comfort, and improved product characteristics. Second is economics, which forms the glue in-between superior technologies, regulation and subsidies. Third is regulation and subsidies, which are both the drivers and barriers for disruption and innovation. In the case of ICT, more work needs to be done in order to provide these long-lasting solutions within the electricity grid.

PRESENTATION 3: Malcolm McCulloch, Professor and Head, Energy and Power Group, Department of Engineering Science, University of Oxford

The Oxford Martin Programme on Integrating Renewable Energy: Change

Dr. McCulloch began the presentation with a statement 'the national grid will likely evolve into a battery charging service from about 2040.' The Oxford Martin Programme on Integrating Renewable Energy is doing a considerable amount of work in this realm. The main focus of this research group is how to introduce renewable energy at the 100 percent scale. There are many energy transitions taking place in the energy system, and it is important to understand what they are, what they look like and how we should prepare.

Energy access and renewables generation is one of the main areas of research within the Oxford Martin Programme. There are countries that are at the bottom of pyramid that have low energy with a very high cost, yet there are countries that produce more energy than consume. This creates issues for energy access. To move towards more energy produced than consumed is a significant target, and this is what we have to achieve across world.

The big challenge for the existing electricity consumer is the rise of the 'prosumer,' where the end user that provides energy services. Yet, the idea of the 'prosumer' driving this change can be misleading in this transition. In the case of the large-scale distributed energy systems, many new disruptive technologies are required (e.g., storage), as well as different business models. If these 'prosumers' are developing, how fast can a system actually change?

An example can be seen in the adoption of vehicles. Dr. McCulloch presented a few images throughout time, where on a city street in 1898, there were zero cars, yet in 1913, there were 100 percent vehicles on the road. The rise of cars can be used as a valuable example, where early data is good at predicting trends. If there will be an S-curve, then future trends can probably be predicted. For example, according to data derived from the UK and Ontario for the percentage of new sales of EVs in the UK after 2020, half of all vehicles in the UK will be electric, however it will take until 2030 to make this transition in Ontario.

It is important to consider whether these are realistic predictions, and whether we have the ability to achieve this transition. Change in storage is happening fast and most power does account for this, since battery production capacity predictions might not be as accurate. Dr. McCulloch presented that colleagues in New Zealand, specifically Alison Andrew, CEO of Transpower, have done foresight studies to determine role of batteries in the system. If batteries are allowed into the system allow batteries into the system, then the system will be changed dramatically. It is crucial to investigate how to create this future.

In looking at the potential impact of EVs on the electric system, it is important to investigate the National travel strategy. The adoption of EVs will substantially increase the demand (20GW onto the system). In this transition, it is crucial to consider how adjustments can be made to the system to achieve benefits and without doing harm. Optimal charging can help to achieve these benefits, looking at the existing demand peak can assist in this transition. If the demand peaks are inverted to identify the ideal charging profile based on demand curve, then portions of the profile can be charged during optimal charging patterns.

In the conclusion of his talk, Dr. McCulloch highlighted that the prosumer is coming, and this can either be a challenge or opportunity for the electricity system. Going forward, the impacts, value creation and who captures the value needs to be thoroughly investigated.

PRESENTATION 4: Neetika Sathe, Director, Emerging Technologies, Alectra Energy Solutions Inc.

Customer Perspective

In this presentation, Ms. Sathe, the Director of Emerging Technologies at Alectra Energy Solutions Inc., answered the questions posed by Dr. Nathwani through the customer's lens. In addressing the role of economics as a driver, Ms. Sathe confirmed that economics is a driver in this transition, yet it is not the sole driver. It depends on the other alternatives that the provider will give, or that the consumer will choose. Additionally, a large factor is the traditional cost of conducting business as usual.

In terms of costs related to distributed energy resources (e.g., solar, storage), there is a steep decline. It can be seen as a 'two-for-one' where storage can also be used for transportation, with the transition to EVs, resulting in massive economies of scale. There will be a point of intersection when this will make more economic sense, and this is highly influenced by political will and incentives. Utilities need to be involved in this process, because this transition will happen anyway.

There is a reason why there is an S-curve for technology adoption; the, status quo and the normative standards highly influence this adoption of technology. The customer adoption piece that takes place after the economics is reliant on the fact that we have to appreciate that there are choices. Therefore, the value proposition is very important, and you have to articulate the value to the customer, not just provide an incentive. There are a small number of people who are willing to take that 'flight from safety,' so you cannot provide radical innovations to everyone; therefore, radical innovations are not the sole element of this transition.

Ms. Sathe continued to express that electricity is not just a commodity, there can be lifestyle oriented sound bites and social benchmarking and product design that can influence electricity consumption. In a pilot project with Rogers for smart home energy management, these customer perceptions rang clear. An important consideration is how to enable the customer in this transition, and how to make it more user-friendly and more relevant. Customers are so used to online access to real time data that the presentation of information needs to be in similar and familiar formats. An example of a statement from a consumer was "I can do everything online, how come I cannot check my energy online?

Consequently, this transition is not just about economics, it is about the value that comes with the economics. Ms. Sathe continued to express that this was not necessarily a death spiral for LDCs, this could be a moment for those utilities who are in the lead to take the majority of the market.

SUMMARY OF THE AUDIENCE QUESTIONS AND RESPECTIVE REPONSES

QUESTION 1: Restructuring of wholesale market within the electric grid
The first question was focused on the restructuring of the wholesale electricity market, and the timing of when transitions will take place within the LDCs and OEB to face this disruption on the grid.

Response from Ms. Sathe: In the future, LDCs may move towards different types of pricing models. There is currently a billing pilot program looking at three types. Most you can save is $50/year if you can level your load, which makes Time of Use (TOU) rates difficult for large-scale transitions. Passion should be directed towards those who make the prices.

Response from Dr. McCulloch: An interesting transition can be seen in New Zealand. A law was just passed in New Zealand that individual customers can have up to 3 suppliers. A number of suppliers providing a cost associated with the retail market.

QUESTION 2: Transactive markets
The second question involved net metering and the transition towards virtual net metering. It was asked what the differences are between a transitive market and virtual net metering.

Response from Ms. Sathe: We have been working around block chain technology and want to put this into a pilot program to understand how transactive energy can be utilized. It is not about matching the consumption load, it is about determining how we can implement real-time financial tracking technology that can be audited into the system. Block chain technology can be very valuable, as it can put in verifiable mechanisms to settle real-time transitions as well as provide the ability to create different types of transactions that can be translated to different values (e.g., not just dollars and cents, can be points). This transition needs to be able to provide trusted, auditable, real-time settlements, not just within the billing period. Huge benefits to net metering are a good solution until that point comes about, but it seems like it could be compared to the 'pager in energy). Virtual net metering removes physical/technical boundaries.

Response from Mr. Grod: The big issue is the archaic management of data. Future transitions will need to take a completely different view of data and how transactions are managed within the system.

QUESTION 3: Significant price of energy in Ontario
The third question looked at the price of electricity in Ontario, and asked whether it is possible to produce energy at no price within Ontario's electricity system

Response from Mr. Grod: Good question, and there are many parts to consider. The cost of the commodity is such a small part of the energy bill, that it is not large enough to move the needle, since the other embedded costs compound. We need to encourage certain types of behavior through more significant price signals for electricity.

MODERATOR SUMMARY

What emerged at the end of this panel the simple idea of a physical energy network is not going away soon; it is the backbone to the quality of our lives. One of the central themes coming out of this discussion was the lens in which we look at how we create the protocols – we need to transition from a cost lens to a value lens. The emerging smart technologies and the host of new innovations that comes into play within this smart network as the opportunity to create immense value to the customer. To create a good marriage between the existing infrastructure and the value of the new technologies and what they bring are key considerations going forward.

PANEL 2: FINANCING BUSINESS MODELS: THE GOOD, THE BAD AND THE UGLY

Moderator: **David McFadden**, Counsel, Gowling WLG (Canada) LLP
Panelists: **Michael Nobrega,** Chair of the Board, Ontario Centres of Excellence
Colin Kelleher, CEO, Kelleher Group
Ron Dizy, Managing Director, Advanced Energy Centre, MaRS Cleantech

Financing innovation is almost always an issue. This highly experienced panel focused the discussion on alternative approaches towards financing and the associated advantages and pitfalls, which need to be considered. The panel also considered the successes and failures with alternative business models and discussed the role of government in fostering innovation. David McFadden served as the moderator and initiated the panel discussion by asking for a brief description of the organizations that the panelists represented.

Mr. McFadden then provided the following questions to each of the panel members, as the key topics for discussion:

1. Can you share examples of businesses or investments that worked and then elaborate on whether these strategies or models could be replicated to advance funding for new innovation?

2. An entrepreneur who has not seen any failures could never be on the frontier of any market or field. What are the examples of things that did not work, and what were the key take away points from such experiences?

3. What role do governments play in such scenarios and what would ideally be their role in fostering innovation?

PRESENTATION 1: Michael Nobrega, Chair of the Board, Ontario Centres of Excellence (OCE)

Mr. Nobrega provided a brief insight into the functions of the Ontario Centres of Excellence (OCE). The OCE, in partnership with industry, co-invests to commercialize innovation originating in the province's publicly funded colleges, universities, and research hospitals. Mr. Nobrega described that the organization takes interest in businesses and ideas that display high potential, and offers them the opportunity to grow. In other words, OCE supports and invests in early-stage projects, where the probability of commercial success and potential total return on innovation are substantial. The OCE acts as a coordinator to match funding to create technologies and encourage small or medium-sized enterprises (SMEs) to enter the market, help expand economic growth, and create more jobs. The OCE started initially with an annual budget of $45 million, which has now expanded to $350 million, serving as a large contributor to emerging innovators.

Mr. Nobrega identified two developments in the market that he believed to be encouraging for entrepreneurs and universities. First, the major industrial and financial companies, that hold more than 90 percent of the wealth in Canada, have begun to recognize the emergence of disruptive technologies and have understood that they could get on board with the innovation space and emerge as market leaders. Mr. Nobrega cited the specific example of banks and insurance companies, that have remained protective of their markets and customers, have opened their interests and come together to invest in cybersecurity. Accounting firms including Deloitte, KPMG and major banks have developed a keen interest in the space of cybersecurity and have set up centres of excellence outside their organizational structures. Second, the public and private sectors have come together to set up the Vector Institute at the University of Toronto, with a specific focus on the advancement of artificial intelligence and its implementation across various sectors like finance, telecommunication, and finance.

Further, the lack of collaboration between organizations and businesses serves as a major hurdle to the innovation space. He stated that everyone functions with a notion of being bosses and CEOs and focus is shifted away from harmony and collaboration. Despite the many investments in STEM and startups via OCE and MaRS, there have been a very few revolutionary companies, generated in the last ten years. Further, Canada has various organizations and centres of excellences working in silos with minimal collaboration. A specific example would be the debate and quarrel between experts at Waterloo and Vancouver over quantum computing. Mr. Nobrega stated that we must recognize that we share marginal resources, in a marginal country in a vast world. We should aim on working together, establishing a collaborative ecosystem for innovation and thus, take innovative ideas and products to the global arena. When there is not a lot of collaboration then failure is imminent.

Mr. Nobrega expanded on the role of governments towards fostering innovation and disruptive technologies. He iterated the fact that governments functioning with an attitude of seeing no harm done, by protecting the finance sector and not opting to take any risks, only prevent the things that are effective and that should be done. They should not just pick winners but create an environment for innovation to flourish across various sectors like cybersecurity, or autonomous vehicles and then extend the invitation for the private sector to participate. Thus, expanding the space and opportunities for innovation and disruptive technologies.

PRESENTATION 2: Colin Kelleher, CEO, Kelleher Group

Mr. Kelleher provided a brief insight into the functions of the Kelleher Group. The Kelleher Group specializes in angel investing in early-stage technology start-ups. The organization usually looks at companies for a year before investing. With no specific focus on the area or industry of projects, company generally follows a product or a team. Current deals that he is involved in include investments in the areas of Unmanned Aerial Vehicle (UAV) technology, digital agriculture, e-retailing, energy informatics and analytics, medical devices, and digital content optimization. Prior deals he has been involved with include energy optimization technology, water technology, 3D mapping and asset management modelling software for municipalities and utilities.

Mr. Kelleher believes that ideas or businesses that held an easily financeable idea or product with a stable scaling strategy, proved to be highly successful in securing financing. He cited two examples of the companies he had invested in. The first, named Ecologix, was a company that tested leaks in high pressured pipes. While the competitors had to be invasive the pipe system to detect flaws, Ecologix was able to do so without shutting down the system by just passing a sine wave through them. This also attracted municipalities and cities on board and helped create a niche in the market. The second, a company based in Ireland that implemented spine angle technology to detect lameness in livestock, which was witnessed as one of the most debilitating issues in dairy cows. It proved to be very financeable, and the stable scaling strategy for the business that made it cost-effective for larger farms to adopt the technology compared to smaller farms, helped the company enter a new market and develop into a market leader.

Mr. Kelleher iterated the lack of focus in keeping up with emergent technologies, the lack of harmony amongst shareholders and the lack of effort to define and contain the internal dynamics of an organization, always spelled trouble for businesses. He cited three examples of ventures that have failed, and the lessons learnt as a result from the failures. First, was the investment due to a pilot error. The investment was in a technology that could continuously scan images, but due to disruption in technology and the fast pace of technological advancement, there already existed a more advance and efficient program to achieve the same task at a university in California. Second, was an investment that could not be saved due to the lack of harmony and collaboration between shareholders. Third, was an investment that should not have failed, but did due to dysfunctional dynamics between the shareholders and the CEO. The disarray resulted in the firing of the CEO and the board members lost the patent for their technology. Mr. Kelleher stressed that it is vital in any business, for the CEO or the founder to recognize when to take a step back and pass on the reins to someone else.

Mr. Kelleher expanded on the role of governments towards fostering innovation and disruptive technologies. He stated that governments should shift focus from a "research push" way of operation to a more "industry pull" way of operation. Governments could improve collaboration with the industry to identify the issues that need to be solved and then generate funds for start-ups to enable change. Even though there is always room for improvement, we are functioning more effectively when compared to other jurisdictions.

PRESENTATION 3: Ron Dizy, Managing Director, Advanced Energy Centre, MaRS Cleantech

Mr. Dizy provided a brief insight in to the functions of MaRS. MaRS is a leader in the trend towards urban innovation districts, which allows entrepreneurs access to corporations, investors, mentors, university institutions and labs to test their concepts. It serves as an incubator across different sectors, especially in the health and energy sectors, where the sectors themselves struggle to adopt to new change and innovation; MaRS helps in fostering the adoption of advanced energy domestically and internationally by providing insights into other markets.

Mr. Dizy identified that a long-term vision supported by clear policy pathways, and market signals, ultimately contribute to the success of innovative businesses. Mr. Dizy cited the example of renewable portfolio standards (RPS) in the United States that helped pave the way for innovation and investments in the clean energy sector. Further, the RPS helped businesses identify market signals and target customers. Thus, relatively clear direction provided by policy makers helped generate stability in the clean energy markets and made innovative businesses more fundable. When funding innovative businesses like energy storage, where the product is yet to be developed and made more financially viable, it is essential to keep the consumers in mind. This is vital, as the customers are the ones who ultimately fund the business by generating a revenue stream. In such cases it would not be ideal to just fund pilot projects, but instead, it would be essential to consider the long-term rollout of the innovative technology, thereby achieving the inflection point in the technology disruption s-curve.

Mr. Dizy provided three perspectives on avoiding failures for innovative businesses. First, was the way we looked at funding describing that many entrepreneurs focus on the immediate problem of the lack of financial resources and not on the bigger picture of creating a consumer base or devising clear pathways to enter markets. This lack of an integrated approach hinders businesses in achieving innovations. Second, was the struggle to design products that the customers want. Mr. Dizy cited the example of taking on 50 ventures, where two business failed to produce their final product due to its high technical complexity, and the rest built the wrong product. He said that even the companies that became successful from this group had trouble pivoting. These scenarios usually arise from the failure to understand what the customer needs and the complexity behind developing that product. Third, was the policy interventions that come into play. Mr. Dizy cited the example of the energy sector where the change in policy influences a large share of the market disruptions. Alberta now has policy provisions in place that allow innovations in the clean energy sector to expand. Direct policy interventions exacerbate the dependency of innovative businesses on more direct interventions. For example, if policies create the mandates for renewable energy generation, it would drive the focus of investors and innovators towards generation and away from other areas like storage or transportation. It is vital to create more market based approaches to policy making.

Mr. Dizy reiterated the point from Mr. Nobrega that governments functioning with an attitude of 'do no harm.' Especially in highly regulated sectors like electricity, there are bound to be winners and losers with disruption in technology, and we cannot protect everyone but help advance the new technology and help to make the transition smoother. Governments should focus on creating clear pathways to identify and break barriers for fostering innovation. Innovation is invention and adoption, and about 80 percent of our efforts and resources are spent on invention, when we should be directing our efforts towards adoption as it is the major factor for advancing innovation.

SUMMARY OF THE AUDIENCE QUESTIONS AND RESPECTIVE REPONSES

QUESTION 1: An Investor's perspective on business models

Most people in the technology sector know that the most successful technology companies are the ones who redefine the customer requirement i.e. Apple with its computer interface, and Blackberry with the smartphone. Are people who finance tech companies interested in the business plan or those redefining the customer experience?

Response from Mr. Nobrega: The reality of our position is that we have liability to fund, and under the Pension Benefits Act there is an obligation towards the due diligence rule. In terms of heavy capital investors, the focus is towards customer base and supply chain, and many business models do not detail the long term hurdle in the supply chain and in bringing the product to market. When long term plan is identified from an investor perspective, funds would be more likely to be invested.

Response from Mr. Kelleher: Focus on inflection points and customer funding is something people don't put forth during their pitch. Moreover, with smaller deals it is vital to assess the ability to pivot. Business models are the general documents considered during a pitch, but they are not the only points of focus.

Response from Mr. Dizy: Business models are a way to start the conversation. You don't make decisions based on them. It is a way for the investors to understand the business and know what the risks are and whether they are willing to take the risk. Investors usually look at reportable results, technology companies need to have the metrics that demonstrate cash flow and history.

QUESTION 2: Tracing the source of a business or investment

In terms of investing in Canadian businesses compared with American businesses. Are ideas coming from America or moving to the south of the border, based on the investments. Are we too conservative with investments in Canada?

Response from Mr. Dizy: Venture capitalism has fairly progressed since the early days, and money is portable now. Why should you worry about where the funds are coming from? Americans are voting with their feet and coming to Canada and there are big and important companies that are taking root in Canada. Companies in the US are moving to Canada due to the political environment. Canada is a good place for talent, business development and growth.

Response from Mr. Kelleher: A company must be where it belongs, where it would have the most success – it is as simple as that. For example, if we are starting a robotic business with offices in Toronto and Silicon Valley, we are most likely to call ourselves an American company.

QUESTION 3: On changing the mindsets of investors

We need to get into the development of product offerings where we need to keep the old stuff existing, try the new stuff while mitigating the risk. How do we change the mindset to determine what we should invest in and how?

Response from Mr. Nobrega: As an LDC, you cannot build funding for innovation because of regulatory structures for funding. A regulator may be giving you a rate base that would encourage you to innovate. And if you ask the private sector to innovate, then you could ask for some return

Response from Mr. Dizy: There are some LDCs who have used non-regulated funding to develop innovations and to diversify their revenue assets. If you focus on the customer and focus on elements to make the customer experience better, that would provide you with room for securing funds towards innovation. The shareholder is often the barrier for investing in these developments

Response from David McFadden: The larger utility can do all the basics. The owners are a big part of the issue. It creates a conundrum. You need to set up a system with the regulators and the markets that work.

QUESTION 4: On changing the perspective of government investments
Rodan purchased Energent and are looking at developing new energy transitions and market based programs. Are financiers ready for that? In our experience, the government has been spoiled with 20-year contracts. Are Canadian financiers willing to invest in innovative energy projects when the revenue is not secure?

Response from Mr. Dizy: There is no evidence on what the future market will look like and the things that are getting funding could have a 2-3 bet on results. 20-year bets are too far in the future for funding; why would we buy things for 20 years? We need to see some evidence that this would work, and it would be tough to expect the investors to see the future. You can expect to see shorter term investments – does the market need to backstop these items?

Response from Rodan Energy (Mr. Grod): This is a contract market, the truth is we have had 15 years of bad policy, it is important for the government to know that the industry is willing to follow these risky developments and are looking for support.

PRESENTATIONS BY TECHNOLOGY DEVELOPERS

Presenters: **David Teichroeb,** Business Development, Emerging Technologies, Enbridge Inc.
Paul Pauze, P.Eng, Vice President Business Development and Sales, Innovus Power Inc.
Julie Morin, Internet of Things, Solutions Sales Professional Global Black Belt Team, Microsoft Canada
Alif Gilani, Head of Engineering, Energy Management Division, Siemens Canada

PRESENTATION 1: David Teichroeb, Business Development, Emerging Technologies, Enbridge Inc.

Technology Priorities for Our Low-Carbon Energy Future

With a presentation entitled, 'Technology Priorities for Our Low-Carbon Energy Future,' David Teichroeb highlighted opportunities for integrating technology to construct energy systems and enhance building performance to achieve 80 percent GHG reductions in the buildings sector by 2050, through Enbridge's recent developments.

David Teichroeb discussed the opportunities to reduce household carbon footprint, reduce household energy costs, and increase energy resilience to achieve the trifecta of building energy performance. In addition to the development of net zero buildings, alternative pathways could be complemented by reducing energy needs, reducing fuels used and greening the fuel to achieve deep decarbonization. Net zero energy homes are proven to be cost effective, it pays dividends. We need to start with emphasis on deep energy efficiency improvement while maintaining consumer choice for energy supply via improved thermal envelope, advanced window performance standards, and improved insulation standards and advanced building skins. Enhancing the energy efficiency for buildings contributes towards 40-50 percent reduction of the overall physical energy requirement of buildings. Further, it is essential to monitor and understand how buildings interact with the systems around them and how they influence the bulk energy system, and it begins with the understanding of the needs of building energy, whether it is derived from onsite generated energy, or whether it is derived from the bulk energy grid, and integrate them with advanced technology such as renewable natural gas heat pumps and geo exchange heat pumps, or duel fuel systems. This would effectively reduce the physical energy input or fuel use by another 40 percent. Once we re-establish the physical energy needs for the building, we can concentrate on 'greening' the fuel. We have effectively put together an efficient energy system, but have not paid much attention towards renewable fuel. By increasing the renewable content in fuels by 40 percent, after we have established the physical energy needs for buildings, we can successfully reduce the GHG emissions in buildings by 80 percent by 2050.

Greening the fuel could be derived from simplistic types of fuels like landfill gas, and biogas from organic waste, which could be transported across the province via existing cost-effective pipelines and storage, creating a pathway for delivering biogas directly to consumers. This also helps pave the way for advanced technology that would enable harvesting CO2 and combining it with hydrogen to create synthetic renewable fuels. We know this is possible, as there are projects in Europe currently experimenting with synthetic renewable fuels. However, to make these synthetic fuels more viable, we need to include them in our portfolios. Such advanced technologies and practices seem expensive when compared to natural gas, but we need to look at the cost effectiveness when compared to other renewables. Enbridge is currently working on a pilot program in Markham that will use hydrogen storage, allowing Ontario to explore an integrated approach to manage energy. The natural gas system is the largest, most cost-effective storage system in Ontario, based on its current capacity of underground storage. We need to think of how to use this cost-effective form of storage to complement renewable solutions.

The next step is to integrate these various energy systems into buildings. Combining solar PV with combined heat & power and with micro-combined heat and power (CHP) with the correct size of solar and storage and utilize combined heat and power. Integrating renewables, energy storage and hybrid heating can even support virtual power plant (VPP) capability within a community. When pieced together in the right size, it provides lower upfront costs and lower Operation and Maintenance (O&M) costs, making it viable for commercialization.

PRESENTATION 2: Paul Pauze, P.Eng, Vice President Business Development and Sales, Innovus Power Inc.

The Innovus Power Platform: The Future Backbone for Distributed Generation

With a presentation entitled, 'The Future Backbone for Distributed Generation,' Paul Pauze provided insights on the future of generation technology by decoupling Alternating Current (AC) frequency control from Synchronous '1 Speed' Generation using an Innovus software enabled Power Electronics and proprietary Software Controls.

Synchronous generation is the foundation of electric power. The most modern generators are designed to only run at 1 speed to control power frequency, regardless of the load. This condition results in poor fuel performance (at less than 50 percent loads), and incurs high maintenance costs. Further, most generators today are unable to effectively integrate renewables. Such limitations drive high system complexity, create large hurdles in further emissions reductions and lead to engine damage (at less than 40 percent loads).

Using Innovus proprietary software controls enables power electronics to break through the fix speed operation. By decoupling the AC frequency control, variable speed of the engine is accounted for and allows the engine to operate at its optimal speed. Working with a manufacturer, Innovus has increased their engine operation by 40 percent, enabling the highest efficiency boost for a generator in many years. The software platform is compatible with renewables and could integrate 100 percent renewables without power quality problems. The programmable and controllable software allows the efficiencies of automobile engines to apply to generation.

The idea is to take the brains out of a direct drive turbine and replace the wind with the engine, the embedded Innovus software then allows you to control the turbine itself. A permanent magnet generator is used to harness the energy from the engine to generate high frequency AC and then convert it to DC, to create a DC bus. The Intellectual Property lies in the ability to command the engine to respond faster than engines can do today. By decoupling engine speed from frequency, the power quality is maximized, the operation of the engine is optimized to deliver low maintenance costs. The ability to manage energy through the software, enables the ability to plug in components, creating an optimal power bridge that enables stabilization and storage of power at the source.

The benefits from the Innovus software are witnessed in terms of fuel savings (up to 40 percent in northern and remote communities), reduction in O&M costs, removal of multiple generator sizes resulting in logistical advantages, and high penetration of renewable energy sources that allows cost effective storage.

The Innovus System with renewables compared with Business-as-Usual (BAU) and superior to synchronous generator based microgrids cuts fuel burn by 62 percent and provides up to 30.37 percent more GHG reduction. Further, a savings of approximately $56M in Net Present Cost, saves about $67M fuel cost, saves 3392 kW on renewables integration and reduces 385kW in generation capacity.

PRESENTATION 3: Julie Morin, Internet of Things, Solutions Sales Professional Global Black Belt Team, Microsoft Canada

Digital Transformation with Azure IoT

With a presentation entitled, 'Digital Transformation with Azure IoT,' Julie Morin provided insights on the innovations related to the Internet of Things (IoT) and its application in driving innovation in organizations across various sectors.

Through the presentation, Ms. Morin iterated that most people think of IoT as a consumer thing, but at Microsoft it is a tool that advances more business-to-business (B2B) opportunities. There has been a shift in the trends on what people and businesses want to connect to the internet. In recent times, the focus has grown towards how we collect data, measure data through machine learning, and be able to do more with less. The energy sector is a good example of an area where all data available is actively managed via the IoT. But recently, organizations that handle mergers and acquisitions prefer to own a platform to organize data and have information of their inventories connected via the IoT. This provides a unique challenge as more organizations transition from old to newer systems. In Canada, Ms. Morin is responsible for all the IoT use cases from farms to energy grids. The most interesting aspect of the IoT is connecting a variety of sources, such as wind farms connected with generator stations. The focus is often placed on the desired business outcome as mandated by organizations, ranging from cutting operating costs to lowering energy usage.

The most commonly used modes of IoT in interesting case studies, deal with predictive maintenance. Rolls Royce for example uses IoT for preventive maintenance. They managed to reduce 1 percent of fuel usage, which resulted in a substantial savings for the organization. By analyzing various data inputs and variables associated with engine performance, Microsoft helped Rolls Royce manage their engine usage for aircraft rentals which translated to an annual saving of $250,000 per plane.

If you could apply the same metrics to energy storage, the possibilities could be endless. For example, recovery from a power outage in mere minutes is possible, by using similar energy management systems installed in Germany. In the case of wind turbines, IoT preventative maintenance allows turbines to communicate with the end user, to warn of trouble, so a maintenance crew could be mobilized before the shutdown. Infrastructure is a key element in the energy sector, and it is vital to account for the security of the system.

Azure IoT platform is ready for the enterprise. It is secure, fast, open, scalable, and built on the industry's leading cloud. When everything is digitally connected, you leverage the data that is available to reduce energy consumption, optimize building utilization, improve air and water quality. The Azure platform provides water and energy management solutions for Schneider Electric. Another organization Iconics in partnership with Microsoft has developed Smart energy building solutions for Microsoft's Redmond campus. Microsoft wanted real-time dashboards to understand their energy consumption, and wanted conditional-based maintenance. They were connected to various ICT and SCADA based systems, and were able to figure out how much one particular building was consuming in real time and tie it

into the HVAC systems and installed sensors into the buildings for space occupancy measurement and optimization. The result from this use case proved to be substantial and Microsoft managed to save $56 million dollars, without retrofitting, by reducing consumption by 20 percent. There are many partners and real-world examples of using data for managing consumption and using IoT to revolutionize energy management.

PRESENTATION 4: Alif Gilani, Head of Engineering, Energy Management Division, Siemens Canada

The Future of the Energy System: With Distributed Energy Resources & Microgrid Control

With a presentation entitled, 'The Future of the Energy System: With Distributed Energy Resources & Microgrid Control,' Alif Gilani provided insights on the future transformations of the world energy systems by analyzing global trends and micro use case analysis.

The traditional centralized, unidirectional grid is witnessing a transformation towards a more decentralized, bidirectional grid along with varying generation mixes, and variable capacity additions, globally. Many generation assets are seen to be moving closer to the end user, thereby reducing the transmission distances. The value that micro-grids provide towards a changing energy system are reduced costs, reduction in emissions, increased grid reliability, and grid resilience. We are heading towards a more eclectic world. The sectors of wind and solar are growing substantially across the world, and are projected to grow by 3 percent by the year 2030 when compared to 2015. In countries like Germany, a rise in 30 percent in renewable generation is projected for the year 2030 when compared to their share of renewables in 2015. High chances for electrification is expected from the mobility sector, as well as thermal aspects of heating and cooling. There is clear evidence that technologies of wind and solar power are advancing substantially.

Analysis of use cases of micro grid projects demonstrate favorable outcomes in terms of cost viability, and high resilience and performance towards the electrification of remote communities. When addressing distributed energy solutions, the example of Siemens' tool called the Energy Twin provides technical and financial data on a micro grid projects over a period of 25 years in comparison with systems in status quo. This tool effectively builds your business case towards micro grid electrification. For planning a micro grid to power a remote community through renewables and storage, the tool provides an assessment of the asset resource over a 25-year period with indications on how the micro grid will behave on an hourly basis. The various technical and financial parameters provided by the Energy Twin would help you decide today, when and if your investment in micro grids for a remote region currently powered by fuel based generators, would pay off. It enables you to invest in smart solutions now, to reap the benefits over a fixed period of time. A project executed via this tool, to set up a micro grid in a community of 25000 people in Germany has resulted in the community generating up to five times the required energy. The community benefits by selling excess power to the grid and has witnessed an energy cost saving of 20 percent that translates to an annual saving of 4 million euros and a carbon footprint reduction of 60 percent. Such projects help explore all different avenues of innovative technology. The future energy systems can be envisioned as a cluster of the electricity grid, the gas grid and finally, the electric grid.

SUMMARY OF THE AUDIENCE QUESTIONS AND RESPECTIVE REPONSES

QUESTION 1: Defining a complete renewable grid

The question was directed to Paul Pauze: What do you mean by 100% renewable?

Response from Mr. Pauze: 100% capacity by which a grid consists of up to 100% renewable integration and have no diesel. The grid then removes the need for having a fixed speed generation set by integrating all the elements together at once.

CONCLUSIONS AND CLOSING REMARKS

The Technology Innovation & Policy Forum 2017 focused on emerging disruptive technologies on the distribution sector, business models arising from embedded distributed generation, and large-scale storage within the existing distribution networks. The Forum discussed the 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.

Major industrial and financial companies in Canada have started to recognize the emergence of disruptive technologies and have understood that they could get on board with the innovation space and emerge as market leaders. With the emergence of such innovations, there are also emergent innovative financing strategies and business models to advance disruptive technology and further develop these systemic advancements. Innovations across various fields like the IoT, the buildings sector, mobility, decentralized energy and microgrid developments are rapidly advancing, and have identified the need for integration of various avenues in technology and interdisciplinary collaboration. It is imperative to recognize that the electricity grid is like all complex systems, where a lot of agents require coordination, and where orchestration would be necessary at distribution levels.

At the closure of this event, it was identified that the rapid pace of disruption in technology and of technological advancement is a constant and ongoing process. It was further articulated that there is no single right way for the energy sector to evolve, and adaptive structures are required to create a synergy between innovation and economics. Only a collaborative environment can create the necessary conditions for fostering innovation. One of the central themes that came out of this forum was the lens in which we look at how we create the protocols, the need to transition from a cost lens to a value lens. Emerging smart technologies and the host of new innovations that comes into play within the smart network has the opportunity to create immense value to the customer. More conversation must take place; where technology, policy and finance come together to face the challenges of the future.

Appendix 1: Conference Program and Presenters

Technology and Innovation Policy Forum 2017 Report April 2018

Disruptive Innovation over the Wires: Business Models for Success

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

WISE — Waterloo Institute for Sustainable Energy

University of Waterloo

November 9, 2017
University of Waterloo
Federation Hall

Conference Program

8:00 am **Registration & Continental Breakfast**

9:00 am **Welcome**
Glen Wright, Chairman, Council for Clean & Reliable Energy (CCRE)
Jatin Nathwani, Executive Director, Waterloo Institute for Sustainable Energy (WISE); Member CCRE

9:15 am **Keynote Speaker**
Pamela Jones, Director of Transmission and Distribution Policy, Canadian Electricity Association

Innovation Mechanisms

9:45 am **Panel 1: Is Technology Disruption Driven by Economics?**

The large cost declines in several parts of the energy supply chain – batteries, LED's, solar and wind, sensors, devices and computational power – is the context that will determine new business models and relationships between the utility, the customer and new service providers. The panel will discuss financial and regulatory implications likely to emerge for the electric utilities.

Moderator: **Jatin Nathwani**, Executive Director, WISE; Member, CCRE
Panelists: **Paul Grod,** President & CEO, Rodan Energy Solutions
Ingo Mauser, dr-Ing, Research Associate, Applied Informatics (AIFB), Karlsruhe Institute of Technology (KIT), Germany
Malcolm McCulloch, Professor and Head, Energy and Power Group, Department of Engineering Science, University of Oxford, United Kingdom
Neetika Sathe, Director, Emerging Technologies, Alectra Energy Solutions Inc.

Q&A Session: 45 minutes

11:15 am **Break**

11:30 pm **Technology Developers Presentations**
David Teichroeb, Business Development, Emerging Technologies, Enbridge Inc.
Paul Pauze, Vice President, Business Development and Sales, Innovus Power Inc.
Julie Morin, Internet of Things, Global Black Belt Team, Microsoft Canada
Alif Gilani, Head of Engineering, Energy Management Division, Siemens Canada

12:30 am **Lunch, Innovation Showcase & Networking**

1:30 pm **Optional Lab Tour** (for Pre-registered Guests)
Centre for Advanced Photovoltaic Devices

2:30 pm **Panel 2: Financing Business Models: The Good, the Bad and the Ugly**

Financing innovation is almost always an issue. This highly experienced panel will discuss alternative approaches to financing and the advantages and pitfalls which need to be considered. The panel will also consider successes and failures with alternative business models and the role of government in fostering innovation.

Moderator: **David McFadden**, Counsel, Gowling WLG (Canada) LLP; Member, CCRE
Panelists: **Ron Dizy,** Managing Director, MaRS Cleantech, Advanced Energy Centre
Colin Kelleher, CEO, Kelleher Group
Michael Nobrega, Chair of the Board, Ontario Centres of Excellence, former President and CEO, OMERS

Q&A Session: 45 minutes

4:00 pm **Closing Remarks**
David McFadden, Counsel, Gowling WLG (Canada) LLP; Member, CCRE

Reception, Innovation Showcase, Networking & Industry-Academic Collaboration

Thank you to our supporters

Council for Clean & Reliable Energy · WISE Waterloo Institute for Sustainable Energy · University of Waterloo · Canadian Electricity Association / Association canadienne de l'électricité · Power Workers Union · Enbridge · Waterloo North Hydro Inc. · NSERC CRSNG

CONFERENCE PRESENTERS

KEYNOTE SPEAKER

Pamela Jones

Pamela Jones is the Director of Transmission and Distribution Policy at the Canadian Electricity Association. She is a seasoned policy and government relations professional with a proven track record of securing favorable regulatory outcomes and influencing stakeholders and building consensus. With over twenty years of experience working in policy development for public and private entities in Canadian telecommunications, broadcasting and electricity, Pamela is known for her ability to promote and defend the long term strategic interests of her employers and clients.

Trained as a paralegal and as a mediator/facilitator, Pamela holds a graduate diploma from Carleton University in Conflict Studies and bachelor degrees in Political Science and Communications from the University of Ottawa. Prior to completing these university degrees, Pamela graduated top of her class from the Ontario Business College as a Law Clerk/Paralegal. She is currently working on a Masters of Law (LLM) in Energy and Infrastructure Law.

In between securing these university level educational pursuits, Pamela layered in executive education with certificates in financial literacy, governance, and teaching. Over the course of her career, Pamela has further been recognized by the Women in Communications and Technology with the Jeanne Sauvé Fellowship Award for policy professionals, was awarded a relocation (Montreal to Ottawa) by TELUS Communications Inc. and given a President's Commendation Award by Hydro Ottawa.

Pamela's career highlights include providing expert testimony in front of national and provincial regulators such as the CRTC and OEB and being part of regulatory teams that introduced the telecommunications ombudsman and the national do not call list as well as regulatory teams that introduced local and long-distance competition in the telecommunications industry. Pamela also counts among her achievements being part of a senior management team that negotiated the approval of a five-year infrastructure funding agreement for electricity distribution worth nearly a billion dollars.

Ron Dizy

Ron is the Managing Director of the Advanced Energy Centre at the MaRS Discovery District. The Advanced Energy Centre (AEC) collaborates with a diverse set of partners to foster the adoption of innovative energy technologies in Ontario and Canada, and leverage those successes and experiences into international markets. Under Ron's leadership, the Centre is convening energy players in a unique way. At the AEC, Ron and his team provide a forum in which energy players can speak openly, think deeply, ask the hard questions and co-create innovative solutions to complex, system-wide challenges. In doing so, the Centre is helping energy systems become more cost effective, reliable and resilient to change and opportunity.

Ron was previously the President and CEO of ENBALA Power Networks, a smart grid technology company that offers grid optimization services to utilities and system operators to increase the overall efficiency and reliability of the power system.

Ron is viewed as a thought-leader on innovation opportunities that lie within the evolution of the modern power system. Based on his well-respected perspective on the smart grid, he was recruited to the executive committee of the board for the Ontario Energy Association and the Association for Demand Response and Smart Grid. He was also elected chair of the Corporate Partners Committee of the Ontario Smart Grid Forum.

Ron's entire career has been focused on bringing new technologies to evolving markets, including spending nearly ten years as a venture capitalist (both as a direct investor and as a pension fund manager), co-founding a company specializing in artificial intelligence and gathering experience in major consulting firms. Ron holds a degree in Industrial Engineering from the University of Toronto.

Alif Gilani

Alif Gilani is the Head of Engineering of Siemens Canada's Energy Management Division and the Head of Operations & Project Management for the Digital Grid Systems Segment.

Mr. Gilani is responsible for all engineering, innovation and development of Energy Management activities in Canada. He reports directly to the head of the Energy Management Division and works with various business unit heads as well as heads of key support functions of sales, strategy, business excellence and communication within the division.

Prior to his current roles, Mr. Gilani was the Technical Lead Manager for the Energy Automation Division in the Lower Gulf Region Arab Emirates, Bahrain, Qatar, Oman & Yemen. Mr. Gilani has over 12+ years of experience in the areas of protection, control and substation automation and has executed a multitude of projects with varying complexity in a number of countries leading multinational and multicultural teams. In addition to this, Mr. Gilani leads the research and development team within Siemens Canada's Digital Grid Systems segment on the prototyping of a low cost microgrid controller system. He heads all

Microgrid projects within Siemens Canada from a project management, base design development, configuration and testing perspective.

He is a professional engineer and holds a P.Eng from PEO and APEGS and serves as a member and contributes to IEEE, CIGRE and the National Electricity Roundtable (NER).

Mr. Gilani received a Bachelor of Science (B.Sc) Degree in Electrical Engineering from Queens University in Kingston, Ontario, Canada in 2001 and a Masters of Engineering (M.Eng) Degree in Engineering Management from the University of Ottawa in Ottawa, Ontario, Canada in 2003.

Paul Grod

Paul Grod is President & CEO of Rodan Energy. Prior to co-founding Rodan Energy, Paul was a corporate and investment banker with CIBC World Markets and later practiced corporate finance and M&A law with Gowling Lafleur Henderson LLP, one of Canada's largest national law firms.

Paul has grown Rodan Energy into a leading energy services company to many of North America's top power producers, utilities and energy users. Rodan has earned a number of awards under Paul's leadership, including Ontario Energy Association's Emerging Company of the Year, and Canada's Top 100 SME employers for three consecutive years.

Some of Paul's distinctions include the Queen Elizabeth II Diamond Jubilee medal, the 25th Anniversary of Ukraine's Independence Medal from the President of Ukraine, and Embassy/Hill Times Magazine ranking him as one the Top 100 influencing Canada's Global Future. He has served on a number of electricity market stakeholder and advisory panels, and is currently a member of the CEO Roundtable for the IESO's Market Renewal Program.

Paul actively volunteers his time with various charities and community organizations. He is currently the National President of the Ukrainian Canadian Congress and Vice President of the Ukrainian World Congress. Paul is member of the Law Society of Upper Canada and holds a Bachelor of Political Science degree, a Bachelor of Laws degree and a Master of Business Administration degree.

Colin Kelleher

Colin Kelleher is the CEO of the Kelleher Group specializing in angel investing in early-stage technology start-ups. Current deals that he is involved in include investments in the areas of UAV technology, digital agriculture, e-retailing,

energy informatics and analytics, medical devices and digital content optimization. Prior deals he has been involved with include energy optimization technology, water technology, 3D mapping and asset management modelling software for municipalities and utilities.

For the past six years, Colin sat on the Board of Directors of the Ontario Centres of Excellence (OCE), a not-for-profit government funded organization that generates economic benefits for the economy by driving the successful commercialization of discoveries and technologies. OCE also incubates and invests in start-up companies emerging out of industrially relevant R&D being developed in Canadian universities. As part of the director role, Colin chaired the OCE strategic planning committee in 2013 and 2014, setting the five-year plan for the strategic direction for the organization. He also sat on the four sector advisory boards that influence the direction of the organization which included advanced manufacturing, ICT and digital media, energy and environment and advanced health technologies.

Colin has been a regular guest lecturer at the University of Waterloo faculty of architecture and the University of Toronto's planning program on real estate cost/risk dynamics. Colin is a graduate of the executive program at Singularity University where he received the Singularity Prototype Challenge Award for his presentation on the buildings of the future.

Ingo Mauser

Ingo Mauser finished his studies in 2012 and holds a German Diploma in Business Administration and Engineering (Diplom-Wirtschaftsingenieur) from the Karlsruhe Institute of Technology.

From 2012 until 2016, he worked as a Research Scientist at the FZI Research Center for Information Technology. In 2016, he became a Research Associate at the Institute AIFB of the Karlsruhe Institute of Technology (KIT) and received his PhD degree in 2017.

His research focuses on the development of information and communication technologies for intelligent buildings, energy management, and the future smart grid as well as on heuristic optimization.

Malcolm McCulloch

Malcolm McCulloch is Professor and head, Energy and Power Group, Department of Engineering Science at the University of Oxford.

His interests are in the areas related to the domestic energy sector, development of user centric demand side management technologies, useful information to enable behaviour change. Previous work led the spin-out Intelligent Sustainable Energy, of which Malcolm is both a founder and non-executive director. This has merged to form Navetas Energy Management.

In the transport sector, research is ongoing in developing power trains for electric vehicles. A successful project was that of the Morgan LifeCar - the first ever Hydrogen sports car. This project lead to the development of high-efficiency low-weight motors using new materials - the yokeless and segmented armature motor. This has resulted in the Oxford spin-out company Oxford Yasa Motors, of which Malcolm is a founder. He is extending the work of ICERT to create an Integrated Transport Network for Oxford.

In renewable generation, novel lightweight low speed direct coupled generators are being developed along with a transverse axis tidal turbine, leading to the spinout of Kepler Energy, of which Malcolm is also a founder and non-executive director.

In energy for development, he is developing technologies that leverage advanced intelligence to provide cost effective and nano and micro grid solutions that provide a scalable pathway to distributed electrification.

Malcolm McCulloch was Co-Director of the Institute for Carbon and Energy Reduction in Transport, a member of the Oxford Martin School from 2008-2013.

David McFadden, Q.C.

David McFadden is Counsel at Gowling WLG having served previously on the firm's Executive Committee and Board of Trustees. He has acted for corporations, municipalities and utilities involved in the generation, distribution, transmission, marketing and financing of energy.

David is the Chair of the Board of Directors of Toronto Hydro Corporation, 407 International Inc. and PCI Geomatics Inc. He serves as a member of the Board of Directors of Cricket Energy Holdings Inc. and is a member of the Advisory Board of Forum Vostro Energy Services Inc.

David is the immediate past Chair of the Board of Directors of the Ontario Energy Association and continues to serve on the OEA's Board. He serves on the Advisory Board of the MaRS Advanced Energy Centre, the Smart Grid Forum of the Independent Electricity System Operator and the Council for Clean and Reliable Energy.

David is on the Board of Governors of York University and chairs the Board's Governance and Human Resources Committee. He previously served as Chair of the Toronto Board of Trade and continues to serve as a member of the Board's Audit Committee.

David was the Chair of the Board of the Ontario Centres of Excellence Inc. (2004-2010) and in that position led the creation of the Centre of Excellence for Energy which has supported energy innovation across Ontario.

David has also served as Chair of the Stakeholder's Alliance for Electricity Competition and Customer Choice, was a member of the Canada-US Electric System Working Group which investigated the massive blackout in August 2003, co-led an investigation team into the 2006 nationwide blackout in Jamaica, was a Member of the Ontario Ministry of Energy's Electricity Conservation and Supply Task Force (2003-2004) and served on the Ontario Distribution Sector Review Panel (2012).

David was named the Leader of the Year by the Ontario Energy Association in 2013.

Julie Morin

Julie Morin is part of the Microsoft Internet of Things Global Black Belt Team tasked with helping public and private sector customers accelerate their digital business transformation through the Internet of Things.

She brings experience in driving technology initiatives with Canadian organizations by finding innovative solutions to address high value digital transformation projects. Julie is in line with the industry's fast changing requirements for enterprises looking for guidance with the Internet of Things, predictive analytics, machine learning and data strategy while ensuring compliance, and security as a forefront.

Michael Nobrega

Michael Nobrega became Chair of the Board of Directors of the Ontario Centres of Excellence (OCE) in October 2012. He has been a member of the OCE Board since 2007.

Mr. Nobrega is the former President and Chief Executive Officer of the Ontario Municipal Employees Retirement System (OMERS), a position he held since 2007. OMERS is one of Canada's largest pension plans, with more than $50 billion in assets. It provides retirement benefits to 372,000 members on behalf of over 900 local government employers across Ontario.

Mr. Nobrega is a veteran financial and investment executive with more than 30 years' experience. Before his appointment as President and CEO of OMERS, Mr. Nobrega was the President and Chief Executive Officer of Borealis Infrastructure Management Inc., an investment entity which originated and structured infrastructure investments. Prior to Borealis, Mr. Nobrega was a partner at a major international accounting firm.

Mr. Nobrega holds an Honours BA from the University of Toronto, where he received the Arbor Award for outstanding community service. He also holds a chartered accountancy designation from the Institute for Chartered Accountants of Ontario and the Canadian Institute for Chartered Accountants. In 2009 Mr. Nobrega was named a Fellow of the Institute of Chartered Accountants of Ontario - the highest designation the Institute confers and which recognizes outstanding career achievements as well as excellence in service to the community and profession.

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 Prof. Joachim Knebel (Karlsruhe Institute of Technology, Germany), of the consortium 'Affordable Energy for Humanity (AE4H): A Global Change Initiative' comprising 150 energy access thought leaders, researchers and practitioners from 50 institutions in 22 countries. The overarching vision of AE4H is to drive the scientific, technological and social innovations required for a cleaner, low carbon energy system

CONFERENCE PRESENTERS CONTINUED

that also meets the challenge of universal energy access.

Energy research at WISE spans the full range of renewable energy technologies, energy storage, smart energy networks, sustainable mobility and ICT for micro-power and off grid access. WISE brings together the expertise of over 120 faculty members, drawing its strength from Departments in all the faculties at the University of Waterloo to develop and implement large-scale multi- disciplinary research projects in collaboration with business, industry, governments and civil society groups.

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, integration of environmental sustainability within power system planning, regulatory affairs and research program management.

Professor Nathwani serves on several advisory Boards at the provincial and national levels and has appeared frequently in the media (print, TV, radio).

Professor Nathwani has over 110 publications related to energy and risk management, including seven books and is a Registered Professional Engineer (PEO) in the Province of Ontario, Canada.

Paul Pauze

Paul Pauze is the Vice President of Business Development and Sales for Innovus Power Inc., a North American company who has developed the first commercial, primary power variable speed generator (VSG). The breakthrough technology improves the efficiency of prime power generation and is engine and fuel agnostic. Innovus enabled generators are ideally suited for microgrids, hybrid renewable systems, and primary power grid support. The Innovus generation technology optimizes efficiency by allowing the generator's engine to operate at optimal speeds for any load and maintains microgrid stability at any renewable penetration by producing power through a back to back converter platform. Innovus eliminates the need for storage to provide grid stability for high penetration renewables, therefore significantly lowering the levelized cost of energy, and with a storage-friendly platform allows for the future addition of storage as costs decrease.

WISE recently completed a follow-up study to the two WWF reports, called "Feasibility Studies of Variable Speed Generators for Canadian Arctic Communities," where Innovus' technology resulted in a significantly lower cost of energy and emissions for all community studies compared to the battery based synchronous generation systems in the WWF reports.

Prior to joining Innovus in 2016, Paul was the founder and President of SunRise Power Corp. a leading Ontario solar manufacturer and engineering firm from 2009-2015 specializing in commercial rooftop solar PV systems. SunRise was Ontario's first-string inverter manufacturer and delivered the provinces first commercial rooftop racking systems.

Before joining the renewable industry, Paul spent many years in manufacturing with General Electric in Peterborough Ontario, in a number of rolls from Engineering Manager, Lean Leader to Plant Manager.

Paul has been a professional engineer for 20+ years, and a member of the Ontario Society of Professional Engineers holding a Bachelor of Science in Electro-Mechanical Engineering from Queens University where Paul started his career in renewables as Electrical Manager of the Solar Vehicle program leading the team to a top 5 at SunRayce 95.

Neetika Sathe

Neetika Sathe is Director, Emerging Technologies at Alectra Energy Solutions. Her role in the organization is to identify, analyze and develop leading-edge innovative technologies and business opportunities. Prior to joining Alectra, Neetika was the Chief Marketing Manager at Nissan Canada responsible for the launch of the Nissan LEAF in Canada.

She serves on the board of several industry associations such as SmartGrid Canada and Electric Mobility Canada, including Chairing the Board of NSERC Energy Storage Technology (NEST) Network. Neetika was recognized by Energy Storage North America with the 2016 Champion Award for her leadership and exceptional achievement in advancing energy storage technology.

Neetika has a Masters degree in Physics from Panjab University, followed by an MBA from McMaster University.

David Teichroeb

David Teichroeb oversees business development in emerging technologies at Enbridge Inc. He 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 of 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 a solutions-oriented approach to the challenges of the energy sector. He is the former Chairman of Hydro One Inc. and 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 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 insurance, 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 a senior advisor to a number of federal and provincial leaders.

University of Waterloo Lab Tour: 1:30 – 2:00 pm

Centre for Advanced Photovoltaic Devices and Systems (CAPDS)

Promotes cutting-edge research and development that spans the spectrum of photovoltaic (PV) technology. The 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.

Thank you to our event sponsors

ENBRIDGE · Waterloo North Hydro Inc. · POWER WORKERS UNION · Canadian Electricity Association | Association canadienne de l'électricité · NSERC CRSNG

Appendix 2: Innovation Showcase

Technology and Innovation Policy Forum 2017 Report April 2018

Disruptive Innovation over the Wires: Business Models for Success

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

WISE — Waterloo Institute for Sustainable Energy

University of Waterloo

November 9, 2017
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: 12:30 to 2:30pm and 4:00 to 5:30pm. Auto industry representatives and the University of Waterloo Alternative Fuels Team (UWAFT) have electric vehicles on display outdoors 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 its 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 smart energy system.

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, there are 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
Canadian Electricity Association | Association canadienne de l'électricité
Power Workers Union
Enbridge
Waterloo North Hydro Inc.
NSERC CRSNG

INSTITUTIONAL SHOWCASE

P1 Investigating the Effect of Renewable Energy Incentives and Hydrogen Storage on Advantages of Stakeholders in a Microgrid

Ehsan Haghi, Chemical Engineering, University of Waterloo

P2 Electricity Theft Detection in Power Distribution System

Côme Carquex, Electrical and Computer Engineering, University of Waterloo

P3 Microgrid Control and Optimization

Mostafa Farroukhabadi, University of Waterloo

P4 Power to Gas Pathways

Suaad Al-Zakwani, Chemical Engineering, University of Waterloo

P5 EMS for Isolated Microgrids

Bharatkumar Solanki, PhD Candidate, Electrical and Computer Engineering, University of Waterloo

P6 Combining Thermal Energy Storage (TES) with Compressed Air Energy Storage (CAES) with the Goal to Improve Cycle Efficiency

Logan Erskin Miller
Yash Vyas
Mateus Tinel
Mike DeWeerd

Geological Engineering
University of Waterloo

T1 Novel Optimization of Solar Powered Reverse Osmosis Drinking Water Treatment Systems for Remote Communities

Marina Freire-Gormaly, PhD Candidate, University of Toronto

Abstract

According to the World Health Organization, 663 million people lack access to clean water. Solar photovoltaic reverse osmosis (PVRO) systems are stand-alone water and energy purification systems that can help alleviate this need. To best provide the water requirements of a given community, these PVRO systems require custom design. However, the design expertise required to configure such a system is often lacking in these remote communities. To alleviate this limitation, PVRO systems can be designed using modular design approaches from commercially available components for the cost optimal design. This method has been used to design a one cubic metre of water per day system in La Mancalona, Mexico from a brackish water source (high saline and high mineral content well). However, the current methodology did not consider the potential effects of membrane fouling along with the water pre-treatment and operational considerations to enable robust operation throughout the system lifespan. This novel optimization is on the development of robust design methods to configure custom small-scale (ten cubic meters/day and less) PVRO systems from modular components while considering the effects of variable community water needs, location specific solar insolation, and membrane fouling. The methods enable the configuration of both the system components and operational conditions to provide reliable water to remote communities for the entire life-span of the system. The methods utilize experimentally validated models of system degradation under different operating conditions in conjunction with optimization methods to arrive at an appropriate system configurations for given community water needs.

Website: http://werl.mie.utoronto.ca/research/pvro/
Recent publications: http://www.sciencedirect.com/science/article/pii/S0011916417311104

CORPORATE, ASSOCIATIONS AND GROUPS SHOWCASE

T2 Salient Energy
Commercializing a New Type of Zinc-Ion Battery

Ryan Brown, Chief Executive Officer
Dr. Brian Adams, Chief Technology Officer

Abstract

Salient Energy is commercializing a revolutionary new type of battery called the zinc-ion battery. The zinc-ion battery is safer, longer-lasting, and less expensive than lithium-ion batteries, and will be a complete replacement for lithium in stationary energy storage applications. Additionally, the zinc-ion battery is completely compatible with lithium-ion manufacturing, allowing it to retain its cost advantage over lithium-ion even as lithium-production continues to ramp up globally.

Website: http://salientenergy.ca

T3 HITCH
Smart Wireless Mesh Router and Predictive Content Caching Software Platform

Uche Onuora, Co Founder at HITCH (by Flexfinity)

Abstract

HITCH is a Smart Wireless Mesh Router and Predictive Content Caching Software Platform, that pre-downloads relevant online content once, so many users can access the same information quickly without an Internet connection. Globally, over 4 billion people don't have sustainable (available, affordable and accessible) broadband. Most of these users are un/underserved by existing coverage and service infrastructure; and live in rural and urban emerging markets, and, are denied the ability to benefit from real technology-driven economic growth. Flexfinity has developed HITCH – an enhanced smart wireless mesh router that enables communities to automatically build, operate, and sustain self-contained Internet platforms; accelerating sustainable broadband in emerging markets.

Website: http://tryhitch.com/

T4 Toyota Tsusho Canada Inc.
Yanmar 35 kW micro-Combined Heat and Power (micro-CHP)

Andy Lehman, Sales Engineer

Abstract

Toyota Tsusho Canada Inc. (TTCI) develops new business streams by introducing innovative technology across a variety of sectors.

TTCI Energy Solutions Group recently introduced Yanmar 35 kW micro-Combined Heat and Power (micro-CHP) to the Canadian market. Yanmar micro-CHP has been utilized globally to provide clean, reliable and economical electricity for commercial applications. Hot water, a byproduct of electricity production, can be distributed for space heating, DHW or process use. Yanmar micro-CHP is a plug and play solution featuring Inverter technology. Inverter technology contains logic to produce high quality electricity, grid synchronization and safeguards.

As the electricity market evolves, development of micro grids will require reliable technology that is easy to apply and integrate and proves cost-effective. Yanmar micro-CHP used in conjunction with renewables guarantees a reliable power supply with proven technology that can work seamlessly in conjunction with the grid or as a standalone power generator.

T5 CoLab
Research and Development Services Based at the Velocity Garage

David Morris, Founder

Abstract

CoLab is an online marketplace for R&D services based at the Velocity Garage. Companies use CoLab to ease budgets, shorten timelines and reduce technical risk so they can iterate and get to market faster. Corporate, academic and government labs use CoLab to generate more revenue from their underused equipment.

T6 Sustainable Waterloo Region
Sustainable Program Collaboration for Waterloo Region

Olivia Muysson, Program Coordinator,
Sustainable Waterloo Region

Allan Taylor, Program Development Manager,
Sustainable Waterloo Region

Abstract

Our mission is to foster collaborations that enable local organizations to convert their sustainability interest into action. These organizations participate in our programs to achieve environmental and economic benefits. By building networks, setting a common direction for results, and publicly reporting on progress, we are working to maximize both the individual and collective successes of organizations in Waterloo Region.

T7 AE4H Global Change Initiative
Affordable Energy for Humanity Global Change Initiative

Nigel Moore, Manager, Waterloo Institute for Sustainable Energy, University of Waterloo

Abstract

The Affordable Energy for Humanity Global Change Initiative is an emerging international collaboration between the world's leading scientists, technology developers and practitioners on the topic of universal energy access.

Our Vision is to deliver the next generation technologies, innovations and practical solutions that will drive the costs of energy services to a level low enough for a revolution in energy access without the need for tax incentives and subsidies.

Participants in this initiative are guided by a common purpose to apply their skills, expertise and knowledge to the urgent cause of improving the affordability of clean energy in contexts where it matters most. Harnessing the resources and enthusiasm of researchers in order to change the energy access equation is the primary inspiration behind the initiative.

GOVERNMENTAL FUNDING AGENCIES SHOWCASE

T8 Natural Sciences and Engineering Research Council (NSERC) of Canada

Andrew Sinclair, Manager, Ontario Regional Office

Abstract

The Natural Sciences and Engineering Research Council of Canada (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 post-secondary research projects. NSERC researchers are on the vanguard of science, building on Canada's long tradition of scientific excellence.

Website: http://www.nserc-crsng.gc.ca

T9 Mitacs

Ashley Hannon, Business Development Specialist

Abstract

Mitacs is a national, not-for-profit organization that has designed and delivered research and training programs in Canada for 18 years. Working with 60 universities, thousands of companies, and both federal and provincial governments, Mitacs builds 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.

ELECTRIC VEHICLE SHOWCASE – OUTDOOR DISPLAY

L1 University of Waterloo Alternative Fuels Team

Ramin Shaikhi, Project Manager
Master of Applied Science, Mechanical Engineering

Patrick DiGioacchino, Engineering Manager
Master of Applied Science, Mechanical Engineering

Sid Kakodkar, Associate Project Manager
Master of Applied Science, Mechanical Engineering

Cole Powers, Modelling Lead
Bachelor of Applied Science, Mechanical Engineering with Entrepreneurship Option

Michael Wu, Controls Lead
Bachelor of Applied Science, Mechatronics Engineering

Jake McGrory, Controls & Modelling Lead
Bachelor of Applied Science, Chemical Engineering

Edward Chao, ADAS Lead
Master of Applied Science, Computer Engineering

Abstract

The University of Waterloo Alternative Fuels Team (UWAFT) has been a leader in advanced vehicle technology development, education and awareness for nearly 20 years. Our mission is to develop and integrate ground breaking technology into production road vehicles while promoting sustainable transport through the community at large.

UWAFT works with a variety of automotive technologies and benefits candidates from many disciplines of engineering, including but not limited to; mechanical, electrical, controls, modelling, simulation, software, firmware, project management and manufacturing.

UWAFT is currently taking part in a competition called EcoCAR 3. EcoCAR 3 is the latest U.S. Department of Energy (DOE) Advanced Vehicle Technology Competition (AVTC) series. As North America's premier collegiate automotive engineering competition, EcoCAR 3 is challenging 16 North American university teams to redesign a Chevrolet Camaro to reduce its environmental impact, while maintaining the muscle and performance expected from this iconic American car. UWAFT is one of only two Canadian universities competing in EcoCAR 3, making the competition even more of a unique and exciting experience!

Visit the UWAFT Team in the Electric Vehicle Showcase outdoor display.

Website: https://uwaterloo.ca/sedra-student-design-centre/directory-teams/university-waterloo-alternative-fuels-team-uwaft

L2 Waterloo Region Electric Vehicle Association Volt Vehicle Showcase

Region of Waterloo

Mark Coughlan, WISE Member (2017 Chevy Volt)
Ian Graham, WISE Member (2015 Chevy Volt)

Abstract

Promoting electric vehicle adoption and use within and around the Region of Waterloo, Ontario, Canada. All EV owners/enthusiasts welcome. WREVAG@gmail.com WREVA will be at Federation Hall showing off their electric vehicles. Check out a 2015 and a 2017 Chevy Volt and meet the members of this great local group!

Twitter: @WREVAGroup

L3 Parkway Ford
Waterloo Ford
C-Max Energi or Hybrid

Dan Bolarino, Sales and Leasing Consultant

Abstract

Parkway Ford will be providing test drives from 12:30 to 2:30 pm at the Electric Vehicle Showcase outdoor display.

L4 Forbes Motors
Chevy Volt or Chevy Bolt

Manni Birhanu, Sales and Leasing

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 69-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.

L5 Tesla Owners Club
of Ontario / Southern Ontario

Prof. Alan Morgan, University of Waterloo
Michael Chau-tran
Paul Church
Bryan Duarte
John Hanna
Ankit Juthani
Karl Nieva
Vicknesh Ramachandran
Stefan Schader
Aleksandar Susnjar
Luna Wang

Abstract

The Tesla Owners Club of Ontario/Southern Ontario is comprised of friendly and enthusiastic Tesla owners and reservation holders. The Club meets on a regular basis to discuss anything related to its passion for Tesla vehicles. Club Members exchange ideas and learn from each other, have fun and meet new friends. Our club is a member of Tesla Motors' official Owners Club program which provides direct access to the company and provides community support.

Website: http://ontario.teslaownersclub.ca/

Thank you to all the partners, supporters and innovators who made the 2017 Technology Innovation and Policy Forum possible.

Council for Clean & Reliable Energy
7111 Syntex Drive, 3rd Floor
Mississauga, ON L5N 8C3
Canada

info@thinkingpower.ca
www.thinkingpower.ca

Waterloo Institute for Sustainable Energy
University of Waterloo
200 University Avenue West, CPH 361 (3rd Floor)
Waterloo, ON N2L 3G1
Canada

info@wise.uwaterloo.ca
www.wise.uwaterloo.ca