Ontario Smart Grid Progress Assessment: A Vignette

Ontario Smart Grid Forum

September 2013

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SECTION 1: Background:

"Why is the Smart Grid Important?"

The promise of the smart grid's potential benefits coupled with Ontario's extensive efforts to realize those benefits over the past five years is a development that will ultimately affect all Ontarians. Efficiency, customer value, security, privacy, safety, economic development, environmental benefits and reliability are just a few of the official smart grid-related objectives that have been expressly identified by the Ontario government, detailed by the provincial regulator, and pursued by public utilities and the private sector. The very nature of these objectives underscores the importance of the smart grid as a means to realize them. How Ontario came to target these objectives and why so much effort has already been expended in pursuing them is an important story that threads its way through this paper. Perhaps an even more important question however, is whether or not the smart grid will actually live up to the promises often associated with it.

Getting to an exacting definition of "smart grid" is a challenge in itself, given its broad reach. Over the past five years, Ontario has become one of a small number of jurisdictions around the world that has gone through an extremely rigorous exercise to define the meaning of 'smart grid' in legislative terms, articulate its overarching goals, and ensure those goals translate into a comprehensive regulatory framework to assist their realization. As will be explored in section 2 of this report, this has been a massive undertaking involving a broad spectrum of sector organizations, government, regulatory bodies and private industry.

About the Ontario Smart Grid Forum

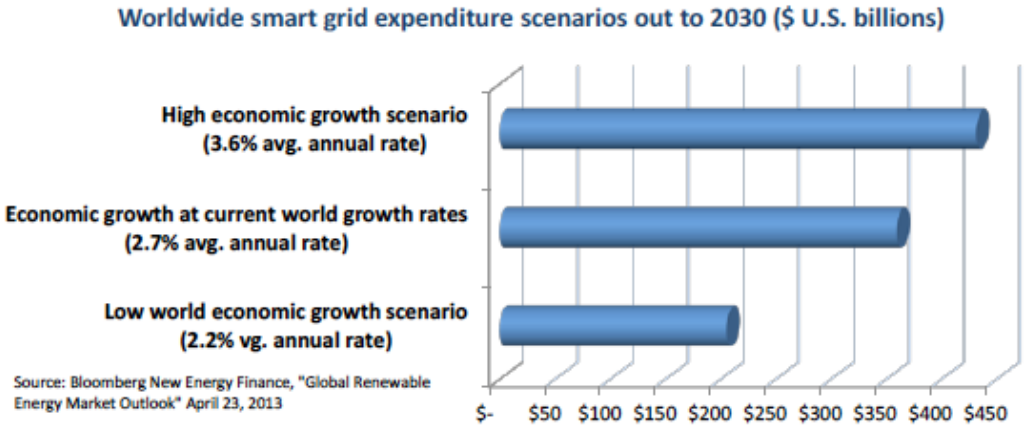
The Ontario Smart Grid Forum includes member organizations from Ontario's utility sector, industry associations, non-profit organizations, public agencies and universities working together to propose a vision for a smart grid in Ontario and examine the many components that comprise it. It is supported by the Corporate Partners Committee, which represents more than 45 private sector organizations active in the smart grid space – including, electric vehicles, energy retailers, energy management companies, systems integrators and equipment manufacturers.

For further information, and to download a copy of the Forum's May, 2011 report, 'Modernizing Ontario's Electricity System: Next Steps,' please visit: www.ieso.ca.

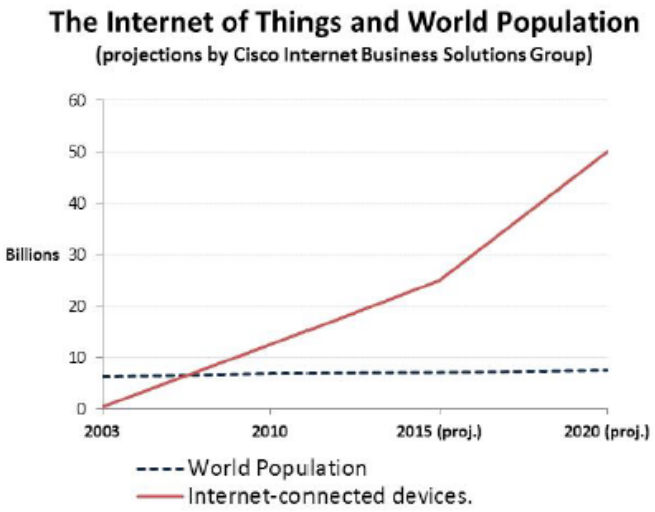
Part of a worldwide trend:

While this paper focuses on the progress of smart grid development within the province of Ontario, it is important to bear in mind that Ontario's experiences are part of a much larger, global context. The smart grid connects to several key, worldwide trends that extend beyond the boundaries of the traditional electricity sector, or the jurisdictional boundaries of any one country. Smart grid is interwoven with several social, economic and technological trends sweeping the globe at the moment, including:

- **Investment and Economic Development:** Over the span of the Forum's existence since 2008 worldwide smart grid investment has experienced a fourfold increase, according to the International Energy Agency. However, these statistics likely only scratch the surface of the indirect economic activity and pools of investment that are affected by the impetus towards smart grids – a topic explored in more detail in section 3 of this paper. The International Energy Agency (IEA) has estimated that direct investment in the smart grid worldwide currently stands at about $14 billion/year and this will rise to approximately $25 billion/year by 2018. As the IEA also points out that this public-side investment should be much higher in order to realize the environmental targets of holding worldwide average temperature increases to 2 degrees Celsius over the coming years. In addition, the IEA points to the indirect economic spin-offs and investment activity that are enabled by such investment. By the IEA's estimate, a $126 billion ***cumulative*** investment in North America's smart grid by 2020 would yield over $461 billion in benefits[1]. Bloomberg estimates that similar, worldwide investments rates should be achievable under various economic growth scenarios (as depicted in the chart above). This is a crucial point the Smart Grid Forum has examined in various contexts over its five-year history. The Smart Grid is very much an *enabling investment* which opens the door to new products and services in the customer domain that were never possible before. New technologies that better govern the generation, delivery, storage and consumption of energy in various forms have a complex symbiotic relationship with a smart grid where new areas of economic value are derived.



[1] International Energy Agency, "*Tracking Clean Energy Progress*" April 2013, pg. 110



- **The 'Internet of Things'**: Estimates vary, but likely at some point since the Ontario Smart Grid Forum began meeting five years ago, the number of physical devices connected to the Internet exceeded the number of human beings on Earth. It is also estimated that in early 2013 the number of *mobile*, internet-connected devices in the world also exceeded the number of people. This trend, broadly referred to as the "Internet of Things" (IoT) is expected to drastically increase over the coming decade. In one sense, the "smart grid" can be viewed as a substrata of this trend. In the most general sense a future world with ever more internet-connected devices yields greater opportunity to gather information for situational awareness, effect control and enable automated responses – all essential landmarks of the smart grid. The intensified generation of data from these activities also connects to the growing field of 'data analytics' which also has important touch points with the smart grid and the ability of customers, utilities and service providers to better understand the changing dynamics of the power system.

- **Smart Homes**: The 'smart home' is emerging as one of the most visible facets of the smart grid from the consumer's standpoint. A combination of overall internet access, smart metering, smart appliances, distributed generation, building codes and a growing array of services are all combining to turn residential 'consumers' of energy into sophisticated 'prosumers' of energy (in various forms) and related services. In 2010, Statistics Canada estimated that over 80% of Ontario households had access to the Internet – a steadily growing worldwide trend. Coupled with the availability of interoperable devices, the home, and the Internet of Things, Smart Homes are quickly becoming an important fixture of the smart grid.

- **Greenhouse Gas mitigation:** In many jurisdictions around the world Smart Grid is seen as an integral part in the strategic realization of greenhouse gas reductions. Here in Ontario, the *Green Energy Act* and associated regulations[2] require prescribed public entities to have report on their progress relative to their energy management and greenhouse gas reduction plans. In a recent International Energy Agency (IEA) report, it was recognized that worldwide, "*Smart grid technologies contribute between 0.2 and 0.5 $GtCO_2$ emissions reductions in 2020, through both direct and enabled reductions. Direct reductions include energy savings from peak load management, accelerated deployment of end-use and system energy-efficiency programmes, and reduced system losses; enabled reductions include reductions from integration of large-scale, variable renewable power generation and facilitation of electric vehicle deployment*."[3]

[2] See also, Ontario Regulation 397/11, "*Energy Conservation and Demand Management Plans*", Aug. 17, 2011

[3] Ibid., pg. 108

- **Climate Adaptation:** According to the World Meteorological Organization, every year of the decade spanning 2000 to 2010 (with the exception of 2008) was, *"…the warmest for both hemispheres and for both land and ocean surface temperatures."*[4] In North America, 2012 was the second-most expensive year on record for weather-related insurance losses[5]. Overall on the North American electricity system in 2012, the top 10 most stressed days on the continent's electricity system were all weather related.[6] The cumulative effect of such events has been to drive up the "climate adaptation" issue on the policy agenda. While this issue of course extends well beyond the electricity industry, various facets of smart grid technology, particularly in the areas of Fault Detection, Isolation and Restoration (FDIR) offer new options for creating an electricity system that is more resilient to a changing climate context.
- **Smart Energy Networks:** The overall energy efficiency of society across all forms of energy, including electricity, is a goal that serves many strategic, economic and environmental objectives. A smart electrical grid, is one part of a broader, 'smart energy network' that enables time-sensitive pricing, fuel switching, storage of various energy forms (kinetic, electric, thermal, chemical, etc.) and other measures to dynamically shift the overall energy burden to both different sources and patterns of production, storage and consumption. Increasingly, the interrelationship between the electrical grid and other energy networks is emerging as an area where new technological applications can optimize the overall efficiency opportunity.

Ontario has achieved much in the past five years, but cannot rest on its laurels. Over the course of this paper we will examine some of the prominent, ongoing challenges to the smart grid's development in Ontario. Some of these questions have arisen during the Forum's deliberations over the past five years, and for the most part, extend beyond the traditional boundaries of what might be described as merely a regulatory or public utility concern, including:

- **The 'diffused benefits problem':** *How will private investors in smart grid technology be compensated for the benefits provided to the electricity system and society at large?* As will be discussed in Section 3, valuing smart grid investments and rewarding investors for the benefits they provide to society and the broader power system is fast becoming one of the predominant challenges facing smart grid development.
- **Meeting point between customers, third parties and LDCs**: *How will issues be addressed when they arise at the boundary between the "regulated" utility infrastructure and the "unregulated" realm of customer and third party systems?*

[4] World Meteorological Organization, Press Release No. 976 "*2001-2010, A Decade of Climate Extremes*", July 3, 2013

[5] Source: Munich Reinsurance

[6] NERC, "*State of Reliability, 2013*", May 2013

- **Sources of Investment**: *Is it enough to relegate the smart grid financing question to a matter of public infrastructure investment*? Smart grid investment is spread across each of the domains of the electricity sector, from bulk generation, transmission, distribution right down to the customer level. So too are investments being made by new private sector players offering products and services related to smart homes, commercial buildings and community energy networks for example. Investments made by customers in smart home technologies may provide benefits to the local utility company by providing localized demand side management services to the distribution system. Conversely, investments by Ontario distributors in advanced monitoring and control technology for example, may benefit the customer through improved service and reliability. Section 3 of this report will examine how recognizing and harnessing additional sources of investment remains one of the biggest, though most elusive, opportunities presented by the smart grid.
- **A sense of urgency from the private sector**: *Can the pace of public-side investment in the smart grid keep up with the pace of development of new products and services by the private sector?*

Few, if any, of these questions are unique to Ontario, and there are numerous examples from other jurisdictions around the world where these are playing out. For the most part, these questions frame the extensive, ongoing work that needs to be done over a longer period of time – and will be examined further in **Section 3** of this paper ("What still needs to be done?")

Measuring the success of the smart grid:

Tracking the progress of smart grid development is a topic of intense interest around the world. It's also a daunting task, given the impact of the smart grid beyond the electricity sector into so many areas of our society. Recently the International Energy Agency (IEA) reported that, "*Demonstration and deployment of smart grid technologies intensified in 2012, but better data and deployment indicators are required to provide an accurate picture of progress.*"[7] This interest has been paralleled in Ontario, where the electricity sector has been keen to measure and monitor the progress of smart grid development. Indeed, this has been a topic explored by the **Ontario Smart Grid Forum** in the lead-up to the development of its 2011 report, ''*Modernizing Ontario's Electricity System: Next Steps."* Ontario has an opportunity to gain international recognition from capitalizing on the public and private investments already made. However, the ultimate outcome of these efforts remains an evolving story, and one which needs to be closely followed, particularly to ensure that customers reap the benefits from the investments being made on their behalf.

[7] International Energy Agency, "*Tracking Clean Energy Progress*." pg. 10

Ontario has the opportunity to gain international recognition from capitalizing on the public and private investments already made. While many jurisdictions around the world still equate the concepts of 'smart metering' and 'smart grids', Ontario has moved well past this early stage of dialogue about the smart grid. With nearly all of its retail customer base of 4.8 million customers below 50 kW of demand already on smart metering and time-of-use rates, Ontario's smart grid debate has turned to an exacting discussion on leveraging the commercial opportunities of data access. This is a subject the Smart Grid Forum has extensively examined and advanced through its work, including the December, 2012 publication of, "*Access to Consumer Data: A Vignette.*" Ontario is now one of the first jurisdictions outside of the United States to begin implementing the fast-emerging 'Green Button' standard[8] for access to smart metering data and has a vibrant community of private sector companies offering products and services that leverage its value. Already in Ontario, over 2.6 million retail customers can access their smart metering data in Green Button format.[9] This functionality enables them to analyze and act upon their consumption data by utilizing a variety of applications designed for tablet and mobile computing devices – most of which can be accessed as easily as any downloadable 'app' through sources such as iTunes and Google Play.

Options for the Future:

The smart grid can aid in achieving societal objectives and can enable options for addressing future goals as well. Here in Ontario, various policy initiatives such as the shutdown of coal-fired power plants, promoting renewable energy, economic development and load shifting are all examples of where the smart grid has already provided assistance. This is also an area the Smart Grid Forum has examined during the past five years as is highlighted further in Section 2 of this paper. Beyond this, the smart grid appears to be an enduring concept that offers a flexible platform to support future policy options and the public good in an ever-changing context. For example, **i**n the realm of **future policy options**, the smart grid inherently provides more data regarding society's use of energy. Everything from smart meters and smart appliances, to sensors and powerful data analytics have the potential to both identify new challenges that need to be resolved, and at the same time, provide the informational insights to resolve them.

Smart grids also have the ability to integrate new **technological options** as they arise. Through the use of open, internationally-accepted interoperability standards, new technologies developed anywhere in the world can be widely employed. Adherence to interoperability standards has been an important position taken by the Smart Grid Forum, not only to allow Ontario to take advantage of these emerging technologies, but also to provide the widest range of opportunities for Ontario companies to take advantage of emerging export markets.

The smart grid also raises new **financing options** for the ongoing development of Ontario's electricity infrastructure. The smart grid does not entirely fall within the confines of public utility investment. Indeed the largest and most important swaths of future investment may very well come from consumer and third party sources – a topic explored further in Section 3 of this paper.

[8] The "Green Button" is in fact a suite of standards that has two major parts as follows: .i) A data access standard called, "Download my Data": This is the first major phase of Green Button - a common data format now in use in an expanding customer base in the U.S. ii.) A comprehensive Energy Service Provider Interface (ESPI) called, "Connect my data," which facilitates the manner in which customers grant and revoke third party access to their data and automatically provide it to various applications.

[9] Source: MaRS Discovery District

SECTION 2: Progress Check - "What has been done so far?"

Ontario's early lead and its implications …

Over the past five years, there has been a flurry of activity in smart grid development worldwide. While Ontario has felt, and continues to feel, the competitive pressures of this global trend, it does so from the unique vantage point of one of the few jurisdictions that made a deliberate foray into this arena well ahead of most of in the world.

In 2009, much of the developed world suddenly took a heightened interest in the term "smart grid" in no small part due to the massive infusion of U.S. Government stimulus spending allocated to smart grid development through the *American Recovery and Reinvestment Act.* At this point however, Ontario was already well along in in the implementation of the Ontario Smart Metering Initiative, which the Ontario government and the Ontario Energy Board began to lay the groundwork for as early as 2004. By 2006, Ontario had formalized its smart metering implementation program under the stewardship of the Independent Electricity System Operator and the province's distribution sector. While stimulus funding enabled under the 2009 U.S. legislation was largely devoted to the deployment of Advanced Metering Infrastructure, Ontario was already three years into the implementation phase by that point. Today, Ontario's smart metering system and attendant time-of-use rates have been deployed across virtually all of its almost 4.8 million retail customers under 50 kW of demand. Perhaps more importantly, Ontario's smart grid dialogue has matured into a sophisticated discussion of such topics as smart homes, interoperability, and third party data access, just to name a few examples.

Ontario's early experiences with smart metering have certainly come with their challenges. The current debate regarding smart metering data access continues to be shaped by the realities of the existing Advanced Metering Infrastructure that has been installed across the province over the past six years. There is a looming question of how quickly to upgrade a purpose-built smart metering system, which was designed to support time-of-use billing, with more recently-available communications standards to support other uses as well, such as providing real-time data to Home Area Networks for example. As noted in the Forum's previous Data Access Vignette in December 2012[10], various options are being explored to address these matters over the longer term. The smart grid offers a constantly evolving set of solutions for data access and customer control, while metering infrastructure inherently has a longer lifespan than other technologies in the customer domain. Utilities have made the point that a viable solution cannot rely on constantly replacing meters on a faster timescale than their intended service life. Reconciling these differing technology lifespans with the needs of customers, third parties, and utility companies is one of the many issues that are wrapped up in the data access debate which Ontario is experiencing well ahead of many jurisdictions around the world.

The International Energy Agency estimates that over 700 million smart meters will be deployed worldwide over the next five years.[11] While much of the world will remain preoccupied with the smart metering implementation for some time to come, Ontario is well positioned to move ahead with the next steps beyond smart metering. As will be discussed below, the Ontario Smart Grid Forum has devoted considerable time and effort to looking ahead to the possibilities that are emerging from a fully-deployed smart metering system, the technologies it can potentially interoperate with, and the commercial and regulatory issues that emerge from this new meeting point. Exploiting the potential benefits of these possibilities is complex and needs to balance a number of competing considerations. The collective challenges facing Ontario's electricity sector today will be ones faced by much of the rest of the world a few years from now. That difference of a few years could very well be where Ontario's competitive advantage can be further leveraged.

[10] Ontario Smart Grid Forum, "*Access to Consumer Data: A Vignette*", December 2012, available on the IESO website at: www.ieso.ca

[11] International Energy Agency, "*Tracking Clean Energy Progress*" April 2013, pg. 106

Policy Developments

Ontario's early success with smart metering has sprung forth from a deliberate policy initiative and the coordinated efforts of the entire electricity sector to achieve a specific set of implementation objectives. It can be safely said that there are both similarities and differences between the needs of a successful smart metering deployment, which centres on a specific technology domain, and the broader needs of a "smart grid" which encompasses virtually every aspect of a modernized electricity system. Unlike a smart metering project with specific goals and objectives, the smart grid is an ongoing trend of modernization, involves extensive investment by both regulated and unregulated parties and has a broad set of benefits that accrue to investors, utilities, customers and society at large. There is no single control lever that can address all of these issues at once. In the realm of the smart grid, good policy needs to span legislation, regulatory approaches, standards, sector organizations, and ultimately, the needs and interests of the customers. In Ontario over the past five years, there has been an array of policy-related activities on all of these fronts. The table below, lays out a summary of some of the landmark events that have shaped Ontario's overall smart grid policy framework over the past five years.

Table 1 - Smart Grid-Related Policy Developments

	Activity	Description	Why it is important
2008	• Ontario Smart Grid Forum created	• Over its five year history, the Forum has provided a focal point for smart grid dialogue in the province.	• The Forum has played an important role in translating high-level, legislative goals into specific recommendations to be addressed by the electricity sector.
2009	• Ontario *Green Energy Act*	• Enacted for the purposes of *"…fostering the growth of renewable energy projects, which use cleaner sources of energy, and to removing barriers to and promoting opportunities for renewable energy projects and to promoting a green economy*"[12]	• The Act brought about a legislated, formalized definition of the "Smart Grid" which now shapes the detailed regulatory instruments used to govern its implementation.
	• *First report of the Smart Grid Forum*	• The Forum's first report focused on encouraging all branches of Ontario's electricity sector to make an early effort in piloting and implementing a wide variety of smart grid technologies while	• Since 2009, a number of the Forum's recommendations have come to fruition. Most notable from the 2009 report was to encourage distributors to exploit the potential of various types of

[12] Bill 150, 1st Session, 39TH Legislature, Ontario, 58 Elizabeth II, 2009, preamble section.

	Activity	Description	Why it is important
		adhering to the use of open interoperability standards.	smart grid technology – an approach now formalized as part of the *OEB Renewed Regulatory Framework (*see below)
2010	• Development of Ontario's smart grid objectives	• The Smart Grid Forum provided assistance to the Ministry of Energy's efforts to establish a set of detailed principles to guide the regulatory approach to the implementation of the smart grid in a manner consistent with the definition set out in the Green Energy Act. In November 2010, this culminated in the Minster's directive to the Ontario Energy Board[13] enshrining those objectives.	• The smart grid principles have been further instituted in the OEB Renewed Regulatory Framework (see below) and over the course of the coming years, will guide the regulator's assessment of the capital investment plans of all regulated utilities in the province. In 2011 the combined net capital investment portfolio of Ontario's distribution sector was $1.9 billon
	• Privacy by Design Principles	• Developed by Ontario's Information and Privacy Commissioner, the 'Privacy by Design' principles set out an approach to safeguarding customer privacy across smart grid-related technology platforms and has gained international recognition.	• Pro-actively addressing customer concerns about privacy of their data removes a significant impediment to implementing various smart grid technologies. Over the past several years various projects around the world have been delayed, altered or outright cancelled as a result of a failure to address such concerns. • Most areas of Ontario's smart grid development are now being guided by the Privacy by Design Principles
	• Creation of the Corporate Partners Committee (CPC)	• In 2010, the Ontario Smart Grid forum and the Ontario Energy Association cooperated to establish an arms-length advisory body to provide a private sector perspective on smart grid development in Ontario.	• The CPC has provided invaluable input to smart grid policy discussions in Ontario – particularly in the areas of data access, interoperability, energy storage and intelligent load management (see also Section 3)
2011	• *Second report of the Smart Grid Forum*	• In 2011 the Ontario Smart Grid Forum issued its second report, "Modernizing Ontario's Electricity System: next steps" which put an extensive focus on the development of the Ontario	• To date, the adoption of smart home technologies has met or exceeded the timelines envisioned in the roadmap • The report's extensive focus on data access issues has helped lead

[13] Ontario Minister of Energy's Directive to the Ontario Energy Board: Ontario Order-in-Council 1515/2010, November 23, 2010

	Activity	Description	Why it is important
		Smart Home Roadmap, data access and success metrics for monitoring the progress of smart grid development.	to a determined focus on this issue by industry and regulators. In addition, Ontario is one of the first jurisdictions outside of the United States to have implemented the "Green Button" Standard for open access to smart metering data.
	• Ontario Ministry of Energy - Ontario Smart Grid Fund	• Awarded in 2011, this $50 million fund by the Ontario government is currently sponsoring a number of smart grid-related projects in the areas of behind-the-meter services, distributed resource integration, data management, and grid automation. [14] • Second round of funding announced in July 2013 – application window open as of date of this paper.	• The Ontario Ministry of Energy took the policy position to assist the commercialization process through funding to smart grid ventures at the crucial early stages of development.
	• Canadian Smart Grid Standards Roadmap	• The Canadian Smart Grid Standards Roadmap presents a consolidated, nation-level view of the challenge Canada faces in ensuring that it does not get out-of-step with internationally-accepted interoperability standards for the smart grid	• Early adoption of widely-accepted interoperability standards will give Ontario utilities and customers the widest possible selection of smart grid products and services. Conversely, Ontario-based companies utilizing such standards will have the widest possible international marketplace for their products.
2012	• Ontario Building Code amendments	• Various amendments to the Ontario Building Code either recognizing or codifying stringent energy efficiency standards for both residential buildings (e.g. recognition of Energy Star standard) and commercial buildings (e.g. Model National Energy Code for Buildings and ASHRAE 90.1)[15]	• Helps create further incentives for behind-the-meter investments by customers AND utility investment in smart grid to harness the capabilities of some of those investments.
	• OEB Renewed	• The OEB Renewed Regulatory	• Smart Grid has factored into the

[14] See Ministry website for details regarding specific projects: http://www.energy.gov.on.ca

[15] Ministry of Municipal Affairs and Housing webpage: "*Are you ready? 2012 Requirements for New Construction*" accessed August, 7, 2013 at: http://www.mah.gov.on.ca/Page9714.aspx

	Activity	Description	Why it is important
	Regulatory Framework for Electricity - main Board Report	Framework is a major overhaul to the way in which the regulator evaluates the proposed expenditures of Ontario's regulated utilities sector.	OEB's considerations in a number of ways, including its accounting for the guidance of the smart grid principles as contained in the Minister's 2010 Directive to the OEB[16] • The regulator has expressly recognized the need for competition for behind-the-meter products and services, cyber-security, interoperability, and evaluation of the widest possible range of smart grid-related technologies.
	• Ontario Energy Storage Alliance	• The Ontario Energy Storage Alliance is an offshoot from the Corporate Partners Committee which has grown steadily into an advocacy body for removing the barriers to energy storage technologies in Ontario	• The Ontario Energy Storage Alliance has articulated a consolidated view from Ontario's energy storage sector on what they see as the major barriers to the deployment of this technology, and in the process, greatly sharpened the policy discussion.
2013	• OEB Renewed Regulatory Framework smart grid paper	• The Ontario Energy Board's smart grid paper has further clarified the OEB's intended approach to evaluating smart grid-related issues when they intersect with the capital investment plans of Ontario's regulated utilities.	• Ontario's regulated utilities will increasingly be held accountable for evaluating the widest possible array of technical solutions when designing their capital investment plans – and demonstrate due consideration for such issues as reliability, security, and consumer privacy.
	• Ontario Intelligent Load Management (ILM)Task Force	• Ontario's Intelligent Load Management (ILM) Task Force was formed by the Corporate Partners Committee with the intended purpose of ensuring that ILM technologies and capabilities are harness as part of Ontario's long-term planning goals.	• Across the United States, demand response capacity has more than doubled over the past six years highlight the tremendous potential of loads utilizing smart grid technologies to provide services to the broader power system

[16] Specifically, Minister of Energy's Directive to the Ontario Energy Board (OEB) (Ontario Order-in-Council 1515/2010, November 23, 2010

Job Creation:

As noted earlier, job creation is one of the many expected benefits that are enabled by the smart grid. However, given the overarching scope and nature of the term 'smart grid', quantifying its job creation potential is not an easy exercise. One of the more prominent studies of this potential is a recent U.S. Department of Energy follow-up study on the impact of the *American Recovery and Reinvestment* Act (ARRA) of 2009. Specifically, the study examined the economic and job creation impact of the $2.96 billion of smart grid-related investment pumped into the U.S. economy via both utilities and private sector companies under the auspices of the ARRA stimulus funding[17]. The study examined both the direct impact on what the report classified as "smart grid vendors" as well as the indirect effects on the broader economy. The study found that:

- The original $2.96 billion ARRA smart grid investment triggered over $6.8 billion in overall economic output as of the end of 2012[18]
- The job creation impact included 33,000 direct, indirect and induced jobs with "smart grid vendors" and another 14,000 jobs in the broader economic sectors that fed into the smart grid vendor community, for a total of 47, 000 direct and indirect jobs.[19]

The enduring life cycle of these jobs of course remains to be seen and is often the subject of intense debate when public stimulus funding is involved. It should be noted however, that many of these jobs were created in areas that were deep-rooted in the innovation end of the value chain, as opposed to short-term construction jobs. Indeed, according to the study, the three largest sectors of direct job creation came from: i. computer systems design services; ii. management, scientific and technical consulting services; and, iii. other various professional, scientific and technical services. [20]

In Ontario, an anecdotal example of the job creation effect of Smart Grids comes from a 2012 annual survey of 39 energy sector companies conducted by the **MaRS Discovery District**. That sample study yielded the following findings:

- over 660 jobs, of which 157 were new hires were reported at the end of 2012 by MaRS energy sector venture clients
- $55M total revenues generated
- $46M total international revenues generated
- $56M total funds raised

While this small sampling of relatively new companies certainly doesn't encompass the entire smart grid sector in the province, it does provide an indication of the economic potential of smart grid. A point often emphasized by the Forum's Corporate Partners Committee is that the greatest job creation dividends from the smart grid are yet to come. Activity across the entire product lifecycle from initial innovation, to widespread adoption, to ongoing improvement are all facets of the economic value proposition where enduring long-term job creation can come from.

[17] U.S. Department of Energy, "*Economic Impact of Recovery Act Investments in the Smart Grid*", April 2013
[18] Ibid. pg. 1
[19] Ibid. pg. 13
[20] Ibid. Appendix 'B', pg. 20

Publicly-financed programs and research:

Strategic investment in smart grid technologies has become a national imperative for many jurisdictions around the world. In Canada, this imperative is of course shared with the provinces' jurisdiction over energy policy as well. Keeping pace with research and development efforts by national governments is just a small part of what it takes to encourage the development of smart grid development however. For example, development of interoperability standards is a crucial element of smart grid development and is an effort that no single national government should have a monopoly over. In addition, academic

institutions, local regulators, utilities, private sector technology/service providers all have a role to play in this effort. There are however, some areas where publicly financed research can and does have an important role to play, though they are often not easily identified given the complex interactions between various domains of smart grid technologies.

"Team Ontario" entry in the U.S. Department of Energy's Solar Decathlon, 2013
(Queen's University, Carleton University and Algonquin College)

For example:

- **In the federal government domain:** Various departments and agencies are supporting research in smart- grid-related topics spanning from the social sciences, to pure research to applied technologies such as micro grids.
- **In the provincial government domain:** In addition to funding research at the academic institution level (see below), the province's Ministry of Research and Innovation and the Ministry of Economic Development, Trade and Employment - also maintains an **Ontario Network of Entrepreneurs** (formerly referred to as the 'Ontario Network of Excellence' prior to May, 2013). Consisting of organizations such as the MaRS Discovery District and the Ontario Centres of Excellence, the Ontario Network of Entrepreneurs offers a full spectrum of programs and services ranging from the research phase to the commercialization phase – including industry segments both directly and indirectly related to the smart grid. Smart grid development in Ontario also benefits from various electricity sector programs such as the Ontario Power Authority's Conservation Fund as well.
- At the **Academic Level:** Ontario universities have engaged in cross-border dialogue on a variety of sustainable energy issues through research networks such as the Great Lakes Sustainable Energy Consortium. In addition, some universities have taken a broad, generalist approach to the topics of 'smart energy networks' while others have chosen to specialize in specific topics such as electric vehicles, wind energy, or information technology applications for example. Ontario's conservation and efficiency measures have increasingly relied upon the smart grid, and as with many facets of the smart grid, the province is only beginning to scratch the surface of the potential at hand. As an example, Ontario's Queen's University, Carleton University, and Algonquin College

provided an entry for the U.S. Department of Energy's Solar Decathlon 2013 – one of the world's most prestigious competitions to build a 'net zero' house. The notion of a net zero house which produces at least as much energy as it consumes from the legacy electricity system, represents one of the many profound changes that loom from the smart grid over the longer term. The impact on customers, utilities and financing of public infrastructure could be profound. Also, as noted earlier, the Ontario Smart Grid Fund is a provincially-financed initiative that assists smart grid projects during the crucial 'commercialization' period as smart grid technologies emerge from the research phase to widespread usage.

- **Large commercial customers:** In Ontario, member companies of Building Owners and Managers Association (BOMA) are participating in Ontario Power Authority (OPA) conservation and demand response programs fostering the use of next generation building automation technologies meeting emerging international standards such as ISO 50001 and Leadership in Energy and Environmental Design (LEED) for example. BOMA also administered a Building Environmental Standards ('BESt') program which is supported by the OPA and promotes, *"…standards for energy and environmental performance of existing buildings based on accurate, independently verified information*." [21]

The table in **Appendix 1** highlights some examples where research and development affecting smart grid development within Ontario span a variety of different types of institutions.

Implementation achievements:

Ontario's early lead with smart metering has allowed it to delve into the broader topic of smart grids. While this has certainly been a helpful head start, it has not been without its challenges either. As will be discussed in Section 3, one of the biggest challenges for Ontario in the coming years will be to address the issue of interoperability between the province's existing population of smart meters, and the growing array of behind-the-meter technologies provided by non- utility actors. This has been an issue that the Smart Grid Forum commented on extensively in its May 2011 report, where it called for a province-wide test bed facility and a clarification of the interactions between local distribution companies and third party service providers. Since that report, there have been several positive developments in that regard:

- As noted earlier, the **Ontario Energy Board (OEB)**, has clarified its position allowing for competition for behind-the-meter services as part of its ***Renewed Regulatory Framework for Electricity*****.** Given this regulatory development, the Smart Grid Forum intends to continue to monitor the impact on smart grid investment as it takes effect over the coming years.
- The **Ontario Ministry of Energy** and the **MaRS Discovery District** have jointly launched the **Ontario Green Button Initiative** in conjunction with several Local Distribution Companies. As noted in the Forum's Data Access Vignette published in December 2012, implementation of the Green Button interoperability standard is a first step towards facilitating customer control over this critical integration point between a public utility's Advanced Metering Infrastructure and other non-utility services that the customer may choose to invest in.
- The **Corporate Partners Committee** is continuing to pursue the establishment of a **provincial test bed facility** to
- allow third parties to test the interoperability of their products and services with Ontario's smart metering system. In addition to assisting the immediate needs of the Ontario Green Button Initiative, such a test bed facility could play an important role in facilitating real-time smart meter data access over the longer-term.

[21] Source: BOMA BESt website (http://www.bomabest.com/)

Across the province public utilities and third party service providers are moving forward past the pilot project phase with ongoing investments that exploit the potential benefits of smart grid technologies. Today, one can find examples of Ontario distribution companies and transmitters routinely implementing grid automation and sensing equipment energy storage and aggregated intelligent load control as part of their regular capital investment cycle. With the recent completion of the OEB's Renewed Regulatory Framework for Electricity, this stream of smart grid investment will become even more entrenched in the fabric of Ontario's electricity system. At the wholesale market level, Ontario's Independent Electricity System Operator has conducted a preliminary procurement of grid regulation services from a series of different alternative technologies as well. Proving such technologies as Intelligent Load Management and energy storage in a real-world application such as this is an important early experience for Ontario.

Conservation and Efficiency:

Across the North American continent, demand response capacity has risen significantly in recent years. According to a study of U.S. markets by the U.S. Federal Energy Regulatory Commission (FERC), the United States' demand response capacity has more than doubled over the past six years.[22] Smart grid is intertwined with the increasing sophistication of the load side of the market in terms of how and when electricity is consumed, generated and stored. As FERC pointed out, future growth of demand response capability will be assisted by the ongoing development of open interoperability standards for facilitating automated response and control.[23] Open standards are pushing out the scope of potential sources of demand response capacity from an ever-widening array of sources – a topic being studied here in Ontario by the **Intelligent Load Management Task Force**, established by the Smart Grid Forum's Corporate Partners Committee.

According to the **Ontario Power Authority**, "*Ontario's long-term energy target is to achieve a 7,100-megawatt peak electricity demand reduction and 28 terawatt-hours in energy savings by the end of 2030.*" At the time of publication of this paper, Ontario's long-term targets for conservation and demand management are currently under review.[24] Already, smart grid is playing an important role in the realization of that goal. Ontario's public sector investment portfolio in conservation and demand management programs are both extensive and span the full range of customer classes. From a smart grid standpoint these programs are increasingly employing smart grid technologies in the areas of building automation, home area networks, retrofits, and air conditioning control to name a few examples. Across Ontario, conservation and demand management programs are carried out by a combination of Ontario's Local Distribution Companies and the Ontario Power Authority. In addition, new third-party service providers in Ontario and across North America are developing new, innovative behind-the-meter services which can also help yield conservation and demand management as a by-product of a competitive marketplace in this area.

On July 16th, the Ontario government proposed that Conservation will be a principal component of the next round of updates to Ontario's *Long-Term Energy Plan.*[25] As part of the review of the plan which is underway at the time of this paper's publication, the government has proposed policy measures that would, *"…ensure the province invests in conservation measures before building new generation*." In the white paper, *Conservation First: A Renewed Vision for Energy Conservation in Ontario"* the Ontario government expressly tied smart metering and smart grids as major landmarks in the progress towards Ontario's conservation and energy efficiency goals.

[22] FERC, "*2012 Assessment of Demand Response and Advanced Metering*" December, 2012, pg. 23
[23] Ibid. pg. 51
[24] With reference to the Ontario Ministry of Energy review of the *Long-Term Energy Plan*, publicly announced on July 10, 2013
[25] With reference to Ministry of Energy news release, "*Ontario's New Energy Vision Puts Conservation First*" July 16, 2013

Smart Grid and Renewable Integration:

Over the course of the Smart Grid Forum's existence, Ontario's smart grid-related policy developments have paralleled its efforts to integrate renewable sources of generation. Ontario's *Green Energy Act*, which gave rise to a formalized definition of "smart grid" and its objectives, has also provided an expansive test of a power system's ability to integrate variable, renewable sources of generation at both the bulk electricity system level and the distribution level. As of the IESO's latest 18-month Outlook, Ontario is poised to integrate *6,800 MW* of renewable energy across both levels of the system. Nor is Ontario alone in this trend. Across North America, NERC expects that renewable generation capacity will grow by approximately 60 GW by 2022 - faster than any other generation resource.[26]

Across Ontario, smart grid implementation efforts are moving well beyond the pilot stage and this will have an important impact on the electricity system's ability to integrate renewable generation. This is particularly striking in the customer domain, where an array of sophisticated smart home-related products and services are already widely available to Ontario customers. In many areas, the availability of such products and services has exceeded the expectations of the Forum's ***Ontario Smart Home Roadmap*** published in 2011. In this respect, some of the biggest implementation achievements for Ontario's smart grid may lie just ahead as a critical mass of Ontario customers with sophisticated on-site generation, storage and load management capabilities begin to play a more active role in smart grid.

The changing nature of Ontario's Smart Grid Dialogue:

Equally important to the development of the smart grid in Ontario, is the changing way Ontario is approaching the topic. At the outset of the Smart Grid Forum's involvement five years ago, the Forum was one of the few focal points examining the topic of smart grids. Five years later, the dialogue in Ontario has reached a level of sophistication where it is now playing out in a variety of venues, often devoted to specific topics – for example:

- In June 2012, the **Ontario Government** and the **MaRS Discovery District** announced a partnership to assess the potential of a **Clean Energy Institute**. The vision of the Institute would be to drive economic growth by connecting Ontario energy innovation with international markets, and to act as a powerful catalyst for energy sector collaboration. MaRS, the Ministry of Energy and **Ministry of Economic Development, Trade and Employment** have reached out to stakeholders across the province - including large multinational corporations, small and medium-sized enterprises, utilities, regulators, academia, and others - and are now in the final stages of this work.
- The **MaRS Discovery District** in conjunction with several Ontario distribution companies is also leading the implementation efforts for Ontario's Green Button Initiative and has put in place a project structure that spans both regulated utilities and non-regulated companies.[27]
- The **Corporate Partners Committee** has spawned several sub-groups devoted to the topics of privacy, energy storage, interoperability and intelligent load management (explored further in section 3 of this paper).
- The **Ontario Energy Board** has conducted a series of regulatory consultations delving into the detailed implementation of smart grid-related considerations and recommendations – and has now created a standing '**Smart Grid Advisory Committee'** to assist in that regard.[28]

[26] NERC, *Long-Term Reliability Assessment*, Dec. 2012, pg. 28
[27] see also, description of Green Button on page 5
[28] Ontario Energy Board announcement "*Smart Grid Advisory Committee*", June 27, 2013

Measuring Ontario's smart grid-related implementation achievements remains a daunting task. Much work needs to be done in order to arrive at a rigorous assessment of progress – a topic explored further in the next section of this paper. What seems to be emerging however, is that Ontario is standing on the cusp of completing the foundational platform which will facilitate true competition for smart grid-related products and services.

Smart Grid Success metrics:

As noted at the beginning of the paper, measuring the progress of smart grid development has lately become the focus of an emerging international interest. Again, Ontario has led most jurisdictions when it began to turn its attention to this issue three years ago. For example, in the regulatory arena, the Ontario Energy Board has signalled in a recent report that it will be regularly monitoring distributor performance in the areas of "Customer Focus, Operational Effectiveness, Public Policy Responsiveness, and Financial Performance" as part of the same framework that will provide oversight to LDC expenditures on smart grid-related products and services.[29]

Shortly after its formation in 2010, the Smart Grid Forum's **Corporate Partners Committee** began to advocate for the development a set of agreed success metrics to, "*Measure the progress of development of the smart grid in the Province of Ontario and ensure that the intended benefits yielded from it are realized by consumers, industry and society in general*."[30] The Forum's second report set out a high-level description of some of the main success metrics which are listed in the **Appendix 2.** Three years later, the Ontario and federal governments are in the process of developing a set of standards which could and should eventually update and supplant this list. However the table in Appendix 2 still provides a good indication of the types of empirical results that should be examined and tracked over the long term.

[29] Ontario Energy Board, "*Report of the Board: Supplemental Report on Smart Grid*" EB-2011-0004, February 11, 2013, pg. 21
[30] Ontario Smart Grid Forum, "*Modernizing Ontario's Electricity System,: Next Steps*" May 2011, pg. 18

SECTION 3: Conclusions: "What still needs to be done?"

From the customer and utility's standpoint…

Whether they realize it or not, customers are embracing smart grid technologies and services as fast as any utility company – and in some cases even faster. In Ontario, for every dollar spent by a local distribution company on its capital asset base, the average Ontario household spends more than three dollars on consumer electronics and major appliances.[31] Many of those consumer expenditures are already beginning to integrate with 'smart homes' and ultimately, the smart grid. Since the introduction of Ontario's micro-scale Feed in Tariff program, ("microFIT") consumer participation levels in small scale[32] renewable generation has resulted in thousands of applications. Pike Research estimates that by 2020 the worldwide market for smart appliances will reach $35 billion annually. While the term "smart grid" may not be top of mind with most customers, their individual investment and participation decisions have the potential to have a profound impact on Ontario's electricity system – a topic investigated in detail as part of the Smart Grid Forum's 2011 report and a joint study on consumer attitudes towards the smart grid, published by the IESO and Smart Grid Canada in 2012.[33]

Ontario Smart Home Roadmap

"Smart homes will improve the lives of Ontarians. Served by a marketplace that provides the tools, information, and incentives, consumers will be easily able to make intelligent energy choices that are in their interest. In the process, they will provide valued services to the electricity grid and benefit society"

Vision statement developed by the Smart Grid Forum, May 2011

There is great potential for customers to play an active role in providing benefits such as reliability, increased asset lifespan and demand response to the broader electricity system. Indeed, the customer site itself is becoming a new meeting spot between the traditional electrical utility and third parties that also have an increasing role to play in the electricity system. The publicly-regulated utility is increasingly finding itself in a role where control over the electricity system is a much more distributed arrangement. Often technologies that give consumers control over their electricity consumption also give third party control centres the potential to harness the control of those devices and resell the aggregated potential of those services into the marketplace. Harnessing this potential can and should benefit public utilities and the electricity system at large. However, new challenges are arising from this complex interrelationship between utilities, customers and third party service providers. Potential divergence between the commercial aims of LDCs and third party activities raises a number of outstanding issues including the future of the utility-customer relationship, regulatory issues, standards, use of customer specific information and cyber-security.

As noted in the 2011 vision statement above, the Ontario Smart Grid Forum has previously articulated its ***Ontario Smart Home Roadmap*** as being served by an open marketplace. In the two years since that report, Ontario's regulatory landscape has taken several steps towards this goal, by recognizing a place for competition for behind-the-meter products and services. While the Forum applauds the progress made thus far, this section highlights a myriad of complex challenges

[31] Data sources: i. Statistics Canada, CANSIM, table 080-0023; and, ii. Ontario Energy Board, "*Yearbook of Electricity Distributors, 2011*"
[32] The OPA mircroFIT program applies to generation that is 10 kW in capacity or under
[33] IESO and SmartGrid Canada, "*The Canadian Consumer and Smart Grids /// A Research Report*", October 15, 2012

to be overcome in order to ensure that consumer-side benefits are harnessed for the good of the broader electricity system, and that consumers themselves are rewarded for the contributions they make in that regard.

From a public policy standpoint…

As noted earlier in this paper, there has been a multitude of public policy developments in Ontario's smart grid arena. In the space of five years, this province's smart grid-related policy landscape has gone from a relatively narrow focus on smart meter implementation to a broad framework for smart grid development spanning legislation, regulatory instruments and strategic public investments. The Ontario Energy Board's recently-completed *Renewed Regulatory Framework for Electricity*, developed on the foundation of the high-level smart grid principles established over the course of 2010 holds the promise of addressing a wide swath of issues and recommendations raised by the Smart Grid Forum over the past five years. Inevitably however, a changing technological and commercial landscape will bring new issues to the fore, in which there will likely be a public interest at stake. The Forum has previously identified a number of potential areas where new policy-related issues may arise, including:

- **Progress reporting and smart grid success metrics**: In 2011, the Forum identified a number of strategic data series that might help indicate whether or not the smart grid is living up to expectation from a public policy standpoint. Measuring reliability, the degree of customer choice, support of new products/services, and economic development are just a few of the areas the Forum recommended for more formalized tracking. To date however, many of these key data series are not formally tracked or easily available for analysis. The Forum does note that efforts are underway at a provincial and federal level to address this gap and urges both governments to continue pursuing this effort as a top priority.
- **Cyber-security:** Earlier in 2013, the Ontario Energy Board began to clarify its own role with respect to ensuring publicly-regulated utilities take measures to "*…require regulated entities to provide evidence of meeting appropriate cyber-security and privacy standards*."[34] The Forum has previously noted however, that overall cyber-security of the smart grid will increasingly rely on the actions of non-regulated third parties who don't necessarily fall under this framework. In Canada, a combination of federal, provincial and local authorities have shared jurisdiction over this critical issue. Canada's Cyber Security Strategy was developed in 2010 and includes partnering to secure vital cyber systems outside of the federal Government. Through this objective, specific initiatives for the Government of Canada to partner with provinces and territories along with the private sector were identified. While various examples of formal and informal cooperation are evident, we note that there is still much work to be done– particularly in this area of unregulated parties having an impact on the security profile of the emerging smart grid.
- **Connection between energy, transportation and environmental policy initiatives**: Around the world, there is often an explicit linkage between smart grid and environmental benefits – perhaps nowhere more so than in Europe. The Forum has previously identified a number of areas where Ontario's smart gird efforts could be linked with other societal objectives of Ontario's public policy framework. One prominent example is in the area of electric vehicles and Ontario's electric vehicle challenge of achieving 1 in 20 vehicles on the road being electric vehicles by 2020[35]. Information sharing between the electricity and transportation sector, planning distribution infrastructure, and harnessing the distributed storage potential of electric vehicles are examples of cross-cutting policy issues that

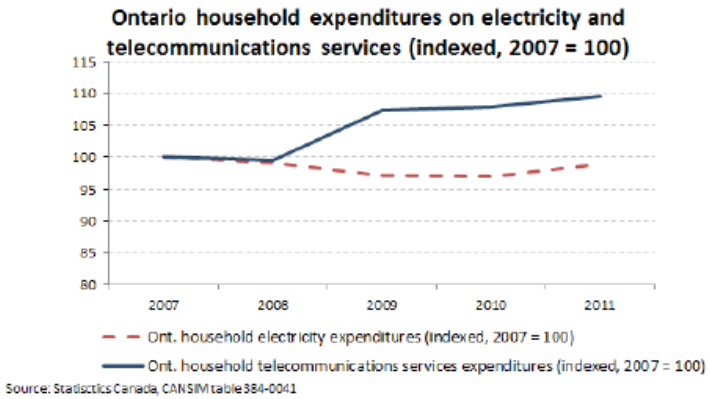
[34] Ontario Energy Board, "*Report of the Board: Supplemental Report on Smart Grid*" EB-2011-0004, February 11, 2013, pg.19
[35] Ontario Ministry of Transportation news release, "*A Plan For Ontario: 1 In 20 By 2020 - The next steps towards greener vehicles in Ontario*" July 15, 2009

emerge from this meeting point. Beyond the realm of public policy, implementation work in this area is already taking place. Ontario's **Plug 'N Drive** Alliance is a coalition of the **Ontario Centres of Excellence**, various utilities and private sector organizations in Ontario striving to educate and inform consumers and improve ease-of-access to electric vehicle-related information and resources. One of their programs is the Charge My Car program, which consolidates information from manufacturers and utility companies into an easy-to-use web portal for consumers to gain access to information about how to obtain an electric vehicle charging station.

- **Smart Energy Networks:** As the Ontario Smart Grid Forum has conducted its work over the past five years, it has observed that the notion of a smart electrical grid is intertwined with the broader context of "smart energy networks." Electrical networks have always had a complex interrelationship with thermal storage, district heating, natural gas, hydrogen gas production, fuel cells, water, oil, telecommunications networks etc. With the intelligence being built into all of those networks however, comes the opportunity for an overall, optimized use of "energy" in the broadest sense of the word – not just electrical energy. To fully exploit these opportunities however, government and regulators may need to examine the smart grid in a manner that does not silo electricity policy from these broader issues. An open-minded approach to how government and regulators approach these broader topics may be needed as these various smart networks become more closely coupled with one another.
- **Leveraging Ontario's existing investments:** As noted earlier, Ontario is uniquely positioned with its Advanced Metering Infrastructure and centralized Meter Data Management/Repository (MDM/R) platform already in place. Various efforts are now underway to capitalize on that investment, including the Ontario Green Button Initiative. Another example is the MaRS Discovery District's investigatory work, in conjunction with industry stakeholders, into the future research potential of the vast quantity of smart meter data in the MDM/R. As events unfold, new policy issues related to data access, security and ensuring interoperability may also require further developments in situations where the public interest is at stake. More broadly, the OEB has set out its own expectations for LDCs to upgrade their AMI systems to help better facilitate data access and behind the meter services as AMI systems are renewed and replaced over time.

From an Investment Standpoint:

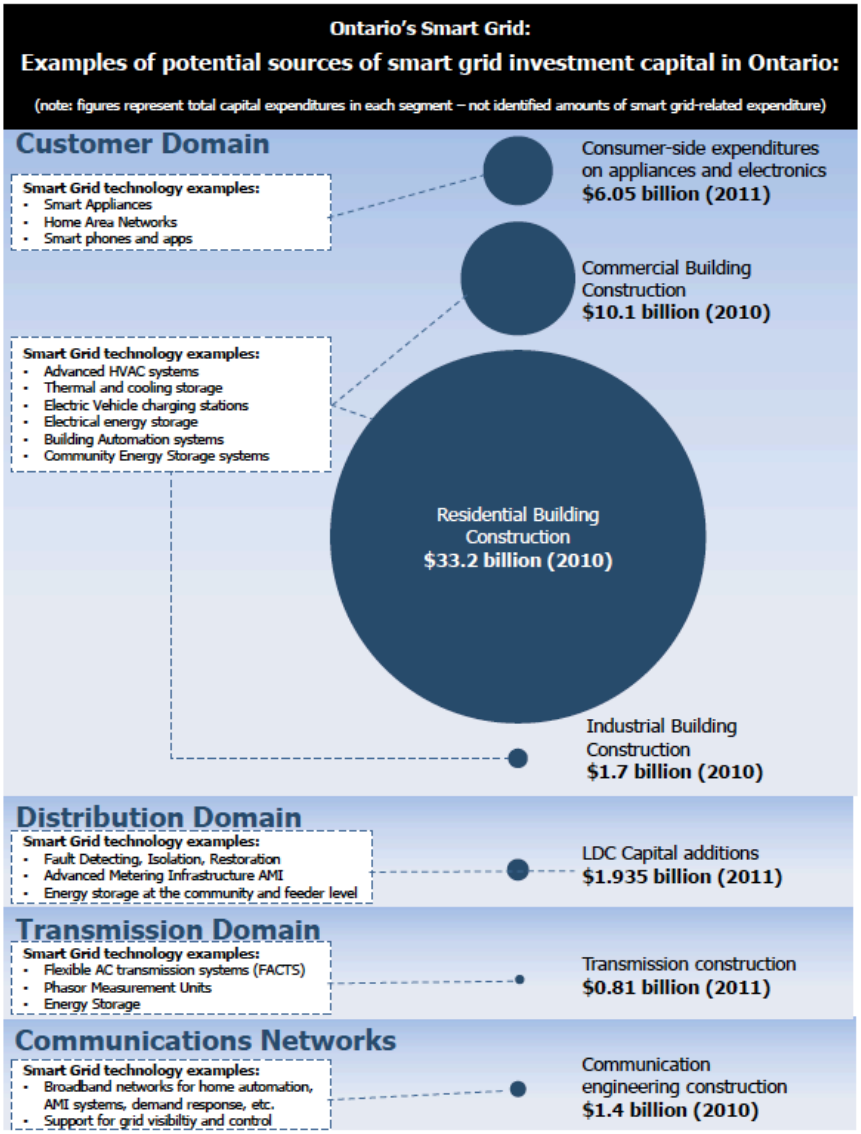
"How will the smart grid be financed?" This question has certainly been a major preoccupation for Ontario over the past five years. As discussed in Section 2 of this paper, the Smart Grid Forum has been heavily involved in the early stages of defining the high-level objectives for the smart grid. Going forward, the **Ontario Energy Board's *Renewed Regulatory Framework for Electricity*,** will govern distribution-side investment in the smart grid over the coming years. The costs of modernizing Ontario's distribution system have also been considered alongside the overall cost-of-capital question in the December 2012 report of the



Source: Statistics Canada, CANSIM table 384-0041

Ontario Distribution Sector Review Panel[36]. However, the smart grid spans all domains of the electricity system – not just the distribution sector. Further complicating this picture is the fact that the smart grid is an amalgam of telecommunications infrastructure, third-party systems, and consumer-side assets. Smart grid investments therefore, are not exclusively a distribution sector issue. Nor are they even exclusively an electricity sector issue. By its very nature, the building of Ontario's smart grid will tap into many sources of investment capital. For example, as illustrated in the graph below, Ontario household expenditures on electricity have taken a different track than spending on telecommunications services in recent years – and yet smart grid spans both of these industry domains. Both private and public investment have a role to play in the investment belong in the domain of the regulated public utility, and those that don't. This of course leads to a closely related financing question:

"Who else besides the distribution companies will be financing smart grid development?" Across various domains of the electricity grid and in related industries throughout the Ontario economy, are pools of potential smart grid-related investment capital. The extent to which these potential funds are harnessed can greatly influence both the rate and amount of smart grid development that takes place. From the customer domain for example, comes the opportunity of new construction, retrofits and ongoing household investments in everything from new appliances to security systems that provide automation and control capabilities. In related industries such as telecommunications for example, investments in broadband networks can enable a wide range of smart grid- related communications paths.



[36] Ontario Distribution Sector Review Panel, "*Renewing Ontario's Electricity Distribution Sector: Putting the Consumer First*" – see Chapter 3, "The LDC of the Future" page 24, which discusses the concept of infrastructure modernization in the context of LDC ability to access capital.

Determining which portions of these pools of investment capital actually constitute a "smart grid investment" per se, is an extremely challenging, and often subjective exercise.

In many cases, no official data series exist to measure the overall private sector investment in providing smart grid-related products and services. However, there is no question that there is a strong association between capital investment being made in various sectors of the Ontario economy, and the procurement of smart grid-related products and services. Indeed as illustrated in the accompanying chart[37], many of the sources of direct expenditure from public utilities is relatively small compared to the investment potential in the consumer domain. Many of these investments may be done as a matter of course, when constructing a new building for example. Other investments may be as a result of other areas of consumer value such as installing a home area network to enable a home security system for example. Assessing the capital investment potential for the smart grid, and how to harness it, is therefore one of the largest outstanding developmental questions facing the smart grid. As will be seen in the section that follows, harnessing non-utility investment in the smart grid has an important interrelationship with the 'diffused benefits problem' that has been explored extensively by the Smart Grid Forum and its private sector Corporate Partners Committee.

From a private sector standpoint…

As noted in Section 2, since 2010 the Ontario Smart Grid Forum has been assisted by the work of a vibrant, "Corporate Partners Committee" lending insight on smart grid development from a private sector standpoint. Since that time, the Corporate Partners Committee has had a number of active sub-committees which have continued to pursue specific objectives including:

- **A privacy sub-committee**: of the Corporate Partners Committee which is seeking to synthesize Ontario's Privacy by Design principles into specific protocols and customer consent language to assist the transfer of smart metering data. This sub-group has noted its views that there remains much work to be done to translate high-level 'principles' into concrete tools and ground rules that should be followed by parties handling consumer energy usage data.
- **The Ontario Energy Storage Alliance**: which has developed specific recommendations to foster the development and deployment of distributed and grid-scale energy storage facilities. These recommendations address issues such as input costs, ancillary services, and contractual frameworks. As of the date of this paper, progress has been made in practical testing of the ancillary services capability of storage – most notable with the IESO's recent *alternative sources of regulation* procurement. However, other recommendations by the Alliance remain outstanding. Foremost amongst these, is the "diffused benefits" problem of ensuring storage assets are financially recognized for the benefits they can province to the broader electricity system (see below).
- **The Ontario Intelligent Load Management (ILM) Task Force**: devoted to unlocking the potential capabilities of Ontario's load customers as they increasingly adopt smart grid-related technologies. In many jurisdictions, ILM technologies are being used in sophisticated applications such as real-time load balancing and integration of renewable energy sources into the electricity system. As of the date of this paper, the Ontario ILM Task Force is in the process of establishing itself, though it too will likely provide its own perspective on the ubiquitous "diffused benefits" problem.
- **The Ontario Smart Grid Product Interoperability Sandbox Sub-committee:** devoted to setting up a test-bed facility, initially to assist with the interoperability testing between Ontario's existing smart metering system and

[37] Data sources for chart on page 19: Ontario Energy Board - OEB *2011 Yearbook of Electricity Distributors*, Hydro One rate filing with the Ontario Energy Board, Aug. 2012, EB-2012-0031 Statistics Canada: CANSIM table 029-0040, CANSIM table 384-0041

third party solutions, in a smart home and smart building context. As of the date of this paper, the sub-committee is in the process of finding an institutional champion to host the test bed facility and sourcing strategic funding for its establishment.

Despite the varied interest and activities of these sub-groups, the most common challenge is the "**Diffused Benefits" problem** whereby the system-wide benefits of smart grid technologies and investments are shared by many different stakeholders. While these benefits are readily identifiable, it is difficult for a prospective developer or technology provider to monetize a sufficient portion of these benefits to secure financing or generate sponsorship for a given project. In the view of the Corporate Partners Committee, "*Ontario needs to develop new mechanisms designed to value and capture these opportunities to deliver truly innovative solutions that can provide benefits across the power system*." Some of the emerging, system-wide benefits of integrating smart grid-related technologies include:

- New sources and types of ancillary services (a concept the IESO is beginning to explore through its Alternative Sources of Regulation RFP)
- Greater wholesale market liquidity
- Transmission and distribution asset deferral
- Reduced economic costs of wind forecast errors
- Market efficiency gains along the lines called for in the IESO's Market Forum Report[38].
- Renewable integration and efficient asset utilization.
- Absorb Surplus Baseload Generation (SBG) and reduce/economize Global Adjustment payments

A quick scan of the above list immediately highlights the complexity of this issue. In Ontario, there are a variety of regulatory and market-based mechanisms that could potentially be applied to this problem. Nor is Ontario alone in facing this issue. For example, the European Commission Joint Research Centre has undertaken extensive work toward developing a methodological approach to evaluating the costs of various smart grid technologies in conjunction with the complex set of benefits they provide. On the technology front, emerging concepts such as '*transactive energy*', which involves the automated trading of electricity amongst networked devices are being developed by such organizations as the Gridwise Alliance, and various standards bodies. The Smart Grid Forum is one of many venues in Ontario where this debate is playing out. While initial efforts to examine potential solutions to this problem have been started in Ontario, it remains perhaps the most significant challenge to the province's smart grid development that remains to be overcome.

[38] IESO Market Forum Report, "*Reconnecting Supply and Demand: How Improving Electricity Pricing Can Help Integrate A Changing Supply Mix, Increase Efficiency and Empower Customers*" – available on the IESO website.

In summary:

In Ontario various groups and organizations have expended a tremendous effort in articulating both the challenge and the opportunity that smart grid presents. Indeed, over the past five years, the province has gone beyond that step and also articulated the principles that should guide how the electricity sector goes about addressing these challenges. Many of the recommendations arising from this effort remain to be addressed. There is also an outstanding need to develop more formalized mechanisms for tracking the progress of what has been and will hereafter be a major collective investment by customers, utilities and private sector investors.

As the European Commission Joint Research Centre has rightly pointed out in its smart grid evaluation guideline document, "A *good comprehensive analysis of Smart Grid projects, requires adaptation to local circumstances and will ultimately rely on the professional skills and judgement of project developers and relevant decision markers*." Here in Ontario we are now collectively at the stage where the full weight of this statement is sinking in with our own 'project developers and relevant decision markers.' With five years of relevant experience to capitalize on, Ontario is well poised to tackle the remaining challenges and reap the substantial rewards associated with the implementation of the smart grid. However, as the smart grid dialogue continues to spread out amongst a wider array of groups, organizations, and ultimately individual customers, Ontario will need to ensure that its focus, and willingness to stay in the lead of smart grid development, does not diminish.

Appendix 1: Examples of publicly-funded research having an impact on Ontario's smart grid

Area	Description	Why it is important
Federal Government	• Social Sciences and Humanities Research Council – smart grid research project	• In the words of this research project, "*This research will explore the social, technical and political context in which smart grid deployment is occurring in Canada. The principal aim will be to identify the most salient issues surrounding smart grid deployment for the public and, depending on material, thought/opinion leaders.*"
	• Natural Research and Engineering Council – smart microgrid research network	• Established a research network of Canadian universities, government and industry in 2010. • The principle aim is to develop the technologies, identify the regulations and training the skills required for Canada's future electricity grid[39]
	• Natural Resources Canada, Canada Centre for Mineral and Energy Technology ("CanmetENERGY")	• Conducts research on intelligent load control, demand response and microgrids • Research focus on the concept of "net zero" houses, buildings and communities • Supports research on storage, electric vehicles, renewable energy technologies
	• Standards Council of Canada, Canadian National Committee of the International Electrotechnical Commission (IEC)	• Through the Standards Council of Canada, the Canadian National Committee of the IEC represents Canada on this international body which develops numerous standards for smart grid interoperability. In November, 2012, this group published the *Canadian Smart Grid Standards Roadmap* with the help of several Ontario Smart Grid Forum member organizations.
	• Natural Resources Canada, Clean Energy Fund and ecoENERGY Innovation Initiative	• The federal governments is investing $52 million to support 13 smart grid-related research and demonstration projects across Canada under the Clean Energy Fund (January, 2010) and the EcoEnergy Innovation Initiative (May, 2013) programs.
	• Sustainable Development Technology Canada (SDTC)	• Assist several technological development and commercialization projects within Ontario in fields including from energy storage, battery recycling,
Ontario government		•
	• Ontario Centres of Excellence (OCE) Special Energy Fund	• The fund has a smart grid focus and is now in its second phase since it began in 2008, with *"…. a $3 million investment in 11 innovative smart-grid projects at 10 universities across Ontario."*
	• Ontario Ministry of Energy Storage Request for Information (RFI - Jan – Mar 2013)	• This RFI solicited feedback from the energy storage community, on potential policy options for removing barriers to future energy storage projects in Ontario.
Academic	• University of	• WISE is one of the member organizations of the Ontario Smart Grid

[39] NSERC Smart microgrid research network website: www.smart-microgrid.ca

Area	Description	Why it is important
level	Waterloo – Waterloo Institute of Sustainable Energy (WISE)	Forum, and through its research endeavours provides a broad worldview of advanced energy technologies and smart grids in the context of "smart energy networks".
	• University of Toronto Center for Applied Power Electronics (CAPE)	• CAPE has a fully functional grid simulator and "hardware-in-the-loop" testing facility for the development of the smart grid solutions. The research group was part of a research consortium that developed the power electronic solutions for the first urban community lithium ion storage system installed in Ontario.[40]
	• University of Western Ontario - Wind Engineering, Energy and Environment (WindEEE) Research Institute	• Currently in the process of developing the world's first hexagonal wind testing facility which will be able to further research into a variety of areas related to wind energy.
	• Ryerson University – Center for Urban Energy (CUE)	• Established in 2010, CUE is funded by LDCs to conduct targeted research, currently supports commercialization through new business incubators, and has established an Energy Management and Innovation Certificate program.
	• McMaster Automotive Resource Centre (MARC)	• In the process of being established, MARC will be a major research centre for electric vehicle related research – something the Smart Grid Forum has been calling for since 2009.
	• Great Lakes Sustainable Energy Consortium (GLSEC)	• GLSEC is a research network of universities principally in Ontario and New York State devoted to renewable energy, climate adaptation and attendant smart grid technologies
	• Wisesense initiative	• A network of Ontario universities supported by the Ministry of Economic Development and Innovation devoted to, "*…define and study design challenges, scalability and compatibility issues for the development of wireless heterogeneous sensor networks to serve in a wide range of e-Society applications*."[41]
Other organizations	• LEED and BOMA	• Participating in OPA conservation and demand management programs utilizing Next Generation Building Automation, LEED standards, ISO 500o1
	• Continental Automated Building Association (CABA)	• Leading research papers on Smart Grid and Smart Home.

[40] http://www.newswire.ca/en/story/1101947/toronto-hydro-introduces-the-first-urban-community-energy-storage-project
[41] http://wisense.ca

Appendix 2 'Smart Grid Success Metrics' **originally proposed by the Ontario Smart Grid Forum Corporate Partners Committee (as published in the Forum's 2011 report)**

metric: "*The degree to which residential and small business customers are using smart meter information to make decisions on their electricity*"			
Measure	**2010**	**2012**	**Notes**
The percentage of premises capable of receiving information from their smart meter	Smart meters deployed (Dec.): 4,569,976[42]	Smart meters deployed (Aug.): 4,777,720[43]	• Ontario's Smart Metering Initiative is now largely complete for the entire retail load base for customers below • Most distribution companies report time of use break-down on retail customer bills and also provide access to the customers smart metering data via a website portal. • As of Q2 2013, over half of Ontario's retail customers can now download their data in standardized, 'Green Button' format for further analysis by third party apps and services.
The percentage of customers opting to make decisions based on their smart meter data	Customers on Time-of-use rates: 1,628,896[44]	Customers on Time-of-use rates (Aug.): 4,391,679[45] (91% of eligible customers)	
Measurable electricity savings by customer class by region	Specific data series not available. Overall domestic energy use in Ontario 2010: 142 TWh	Specific data series not available. Overall domestic energy use in Ontario 2012: 141.3 TWh	• Approximately 57 TWh of consumption is forecast to belong to retail customers under the Regulated Price Plan who predominantly have smart meters.[46] • As per OEB policy, "*RPP prices are set so that a TOU consumer with an average TOU load profile will pay the same average price as an RPP consumer that pays the tiered prices with a typical (non-TOU) load profile*."[47] Notwithstanding this approach, the Ontario Power Authority is about to undertake a formal study of the impact of TOU rates.
Evidence of load-shifting	See note	See note	
metric: *"The degree to which customers, including commercial and industrial customers, are taking advantage of the smart grid through associated technology and service offerings"*			
Measure	**2011**	**2012**	**Notes**
Level of participation in demand-side management programs, measured by number of participants and power load	Retail programs offered by OPA and through LDCs: 645 MW	Data not available as of date of this report.	• Figures do not include dispatchable loads participating in the wholesale market.
The number of different ancillary services in which {retail} customers are participating	See note	See note	• **Wholesale market:** The IESO has markets for three types of Ancillary Services – namely: Certified Black Start Facilities; Regulation Service; and, Reactive Support and Voltage Control Service. In 2012, the

[42] Ontario Energy Board "*Monitoring Report: Smart Meter Deployment and TOU Pricing – December 2010*"
[43] Ontario Energy Board "*Monitoring Report: Smart Meter Deployment and TOU Pricing – August 2012*"
[44] Ontario Energy Board "*Monitoring Report: Smart Meter Deployment and TOU Pricing – December 2010*"
[45] Ontario Energy Board "*Monitoring Report: Smart Meter Deployment and TOU Pricing – August 2012*"
[46] Ontario Energy Board, "Regulated Price Plan Price Report May 1, 2013 to April 30, 2014" pg. 13
[47] Ontario Energy Board, "Regulated Price Plan Price Report May 1, 2013 to April 30, 2014" pg. 24

			IESO commenced a 10 MW procurement of regulation services from alternative sources, including those that involve an aggregation of retail customers. • **Retail market**: Various LDCs across the province are conducting pilot projects in such areas as, grid control and automation systems, microgrids, community energy storage – all of which could enable greater customer participation in ancillary services over time.
The number of active participants in distributed generation and megawatts generated	**FIT program:** 1263 executed contracts **Capacity**: 2,630 MW **MicroFIT (all phases) Program:** 10,695 contracts connected or executed[48] **Capacity:** 92.6 MW[49]	**FIT program:** 1728 executed contracts[50] **Capacity:** 10,576 MW[51] **MicroFIT (all phases) Program:** 15,084 contracts connected or executed.[52] **Capacity:** 131.8 MW[53]	• Figures do not include Non-utility generators (NUGs) whose contracts are managed by OEFC or other distributed generation sites not participating in FIT OR MicroFIT programs.
metric: ***Overall performance of the smart grid and its support for new products and services, including electric vehicles***			
Measure	**2010**	**2012**	**Notes**
The duration and frequency of electricity outages and number of customers affected	Ontario-wide System Average Interruption Duration Index (SAIDI): 3.44 Ontario-wide Customer Average Interruption Duration Index (CAIDI): 1.69	Ontario-wide System Average Interruption Duration Index (SAIDI): 4.00 Ontario-wide Customer Average Interruption Duration Index (CAIDI): 1.76	• These two indices are reported on an annual basis by the Ontario Energy Board (OEB). In addition to the overall averages reported here – the OEB provides a breakdown for every local distribution company (LDC) in the province, thus allowing for an in-depth study of correlations between these indices and specific types of smart grid-related investment. • LDC averages can vary widely from the province-wide average presented here.
Showing carbon content of electricity on an hourly basis	{See note} 2010 Energy supplied from coal-fired generating units: 8.3%	{See note} 2012 Energy supplied from coal-fired generating units: 2.8%	• While there are numerous, informal proxy calculations for the carbon content of overall Ontario's electricity supply mix, Ontario has not formally adopted a standardized calculation methodology for this data series.
Transmission and distribution	**Transmission**	**Transmission**	• Tracking the impact of the smart grid on

[48] Ontario Power Authority, "BI-WEEKLY FIT and microFIT REPORT *January 9, 2012*"
[49] Ontario Power Authority, "BI-WEEKLY FIT and microFIT REPORT *January 9, 2012*"
[50] Ontario Power Authority, "*FIT Contracts and Large FIT Applications as of January 31, 2013*"
[51] Ontario Power Authority, "*FIT Contracts and Large FIT Applications as of January 31, 2013*"
[52] Ontario Power Authority, "BI-WEEKLY microFIT REPORT Data as of January 7, 2013"
[53] Ontario Power Authority, "BI-WEEKLY microFIT REPORT Data as of January 7, 2013"

system load factors	**2010 (all hours, without weather correction):** **Average hourly demand:** 16,233 MW **Maximum demand:** 25,075 MW **2010 Load Factor** relative to peak in that year: 64.74%[54] **2010 Load Factor** relative all-time system peak of 27,005 MW: 60.11%	**2012 (all hours, without weather correction):** **Average hourly demand:** 16,085 MW **Maximum demand:** 24,636 MW **2012 Load Factor** relative to peak in that year: 65.29%[55] **2012 Load Factor** relative all-time system peak of 27,005 MW: 59.56%	distribution-level load factors may require further development of a methodology and more specificity as to what level of granularity it should be calculated (e.g. for the entire distribution system, vs. feeder level, etc.)
The penetration of plug-in electric vehicles in the province, broken down by LDC and Hydro One operating territory	Ontario figures not publicly available	Ontario figures not a publicly available Total E.V. sales in Canada in 2012: 1288[56] World Worldwide cumulatively E.V. registrations as of 2012: 180,000[57]	• The Ontario Ministry of Transportation does not publicly report aggregate electric vehicle registrations • *Canada provides national summary statistics to the International Energy Agency which tracks E.V. deployment data for several countries around the world. At the end of 2009, 41 electric vehicle (EV) and 59,541 hybrid electric vehicles (HEV) were reported as being registered in Canada by the IEA[58]"*

metric: "*level of contribution of the broader electricity sector to the Ontario economy*"			
Measure	**2010**	**2012**	**Notes**
Number of jobs created	See note	See note	While various calculations have been in made in regards to direct job creation for some specific smart grid projects, there is no consistent data series available in the public domain which calculates direct or indirect job creation impact of smart grid in Ontario.
Value of Ontario export of smart grid products and technology	See note	See note	Neither Statistics Canada products and technology nor the Ontario Ministry of Economic Development and Innovation have a publicly available data series for exports of "smart grid products and technology"
Percentage of rate-regulated smart grid investments, government grants/incentives relative to private investment	See note	See note	While some of the data series necessary to conduct this calculation are available in the public domain, reporting on the relative ratio of public and private sector "smart grid investments" will require the development of an exacting definition of what constitutes a "smart grid investment."

[54] Average hourly load relative to peak hourly load for the same year (2010)

[55] Average hourly load relative to peak hourly load for the same year (2012)

[56] Source: International Energy Agency, "*Global EV Outlook*" April 2013

[57] Ibid.

[58] International Energy Agency, "*Hybrid and Electric Vehicles: The Electric Drive Captures the Imagination*", page 61, March 2012

			Alternatively, specific smart grid technologies/services could be selected for specific comparisons, to ensure consistency across the data series.

List of Forum and Corporate Partners Committee member organizations

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Paul Murphy, Chair, Ontario Smart Grid Forum	129 Group
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David Collie, President and CEO, Electrical Safety Authority	Aztech Inc.
Jonathan Dogterom, MaRS Discovery District, Cleantech Practice Lead	Certicom
Norm Fraser, Chief Operating Officer, Hydro Ottawa Limited	Deloitte
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David Barrett, IESO	Ontario Energy Association (OEA)
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	Zerofootprint

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