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LDC ASSET RENEWAL SERIES

Executive Summary

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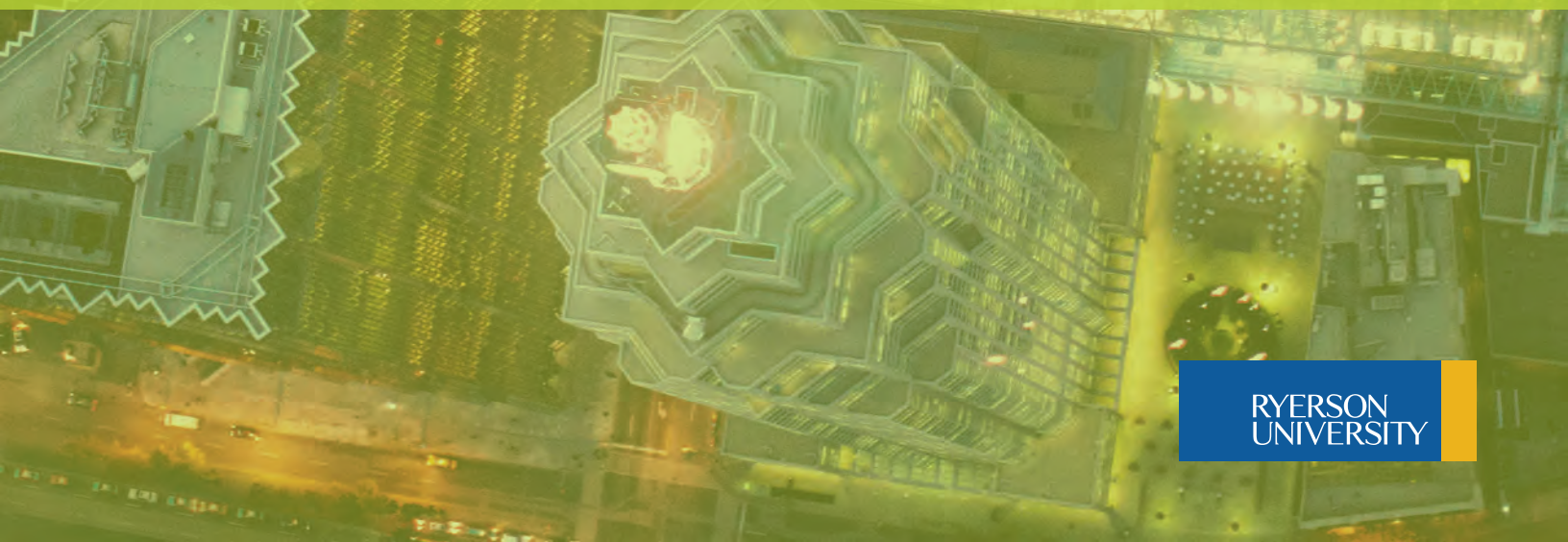

RYERSON UNIVERSITY

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Executive Summary

In February 2014, Bala Venkatesh, the Centre for Urban Energy's (CUE) Academic Director, invited Paul Murphy – past President and Chief Executive Officer of the Independent Electricity System Operator (IESO) – to chair a series of discussions on the future of electricity distribution in Ontario. A group of LDC sector participants[1] and Sean Conway – CUE's Hydro One Distinguished Research Fellow – joined us for six roundtables governed by the Chatham House Rule. Ryan Zade joined the CUE as a Visiting Research Fellow to provide background research, author discussion papers, facilitate workshops, and produce summary documents. The topics discussed at those workshops were:

1. New technology;
2. Climate change;
3. Asset upkeep and renewal;
4. Reliability; and,
5. Government.

Our goal – as articulated in our mission statement – was to provide an environment for open dialogue among our experts to consider the future conditions in which Ontario's distribution sector will operate:

> "Over the coming years, the distribution sector in the province of Ontario will undergo a period of significant asset renewal. This process will occur within the context of rapidly evolving technology, a changing climate, and an ever-increasing need to keep the lights on. Our mission over these workshops is to come together in a collegial and open environment to discuss the many challenges, changes, and opportunities faced by all of our participants. We hope to find common ground on how we can work collaboratively to enable the distribution network of the 21st century."

In this spirit, we have reached the following conclusions:

New Technology

Both consumer appliances and distribution assets are rapidly digitizing. This accelerating technological growth is changing how LDC assets operate. It also will lead to consumers that require service that is more reliable and of higher quality into the future. Investing in increasingly intelligent distribution assets is one way that the LDC sector can continue to meet their own and their customers changing needs. Among the

[1] We define LDC sector participants as those who participate or influence in the distribution of electricity in Ontario. This includes LDCs, government agencies, shareholders, planners, the regulator (as observers), and the government itself. By no means does this definition indicate or imply the composition of our workshop group.

technologies that can meet these needs are consumer-scale solar photovoltaics, energy storage, electric vehicles, and demand response tools.

However, the emergence of energy-efficient homes, cheaper solar power, and advances in battery technology will enable customers to achieve or move towards energy independence. A large migration of customers to self-sufficiency could fundamentally change the relationship between LDCs and their customers. Ongoing innovation and technological progress will require changes in the way that LDCs, agencies, the regulator, and the government approach electricity distribution. LDCs will face the expectation of maintaining substantial asset bases in the face of declining revenues. Accordingly, the sector must look beyond rate decoupling: technological progress will require an evolution of the LDC business model and the rules that regulate it.

Climate Change

The dominant threat of climate change lies in the increased occurrence of severe weather events that will test the reliability and resiliency of Ontario's LDC assets. The sector must prepare by fully incorporating climate adaptation into their corporate planning processes. Part of this understanding must acknowledge that the impacts of severe weather are diverse, even within communities.

There are many different avenues to build a resilient network. The smart grid will help build resiliency into the system; its digital components will provide real-time information to LDCs to help them determine problems and reroute power faster than ever. Distributors can invest in robust, hardened infrastructure. They can also place greater emphasis on quick restoration. Finally, investments in local supply and/or the encouragement of at-home solutions such as generators can help keep the power on during large storms. LDCs will have to find a balance among these options to maintain a resilient, reliable grid at reasonable cost. Finally, the sector must invest in and improve on its ability to communicate clearly, effectively, directly, and quickly with its customers and their public sector partners during severe weather events.

Asset Upkeep and Renewal

Even with enhanced maintenance regimes, Ontario's LDCs will need to replace significant portions of both their human and physical asset bases in the coming years. LDCs, the regulator, and the government all expect robust asset and capital management plans to address these challenges. Yet, uncertainty around future load profiles, customer needs, climate change, government policy, regulation, and the rapid pace of technological change is making it increasingly difficult to plan for the long term.. The significant financial requirements to replace and renew these assets requires an evaluation of the rate structure and of the LDC ownership model, including encouraging equity stakes of private or public sector bodies. These investments will also require coordination and partnership with the post-secondary sector to encourage and prepare students to enter the LDC workforce.

Reliability

Although we have a robust set of tools to measure reliability, the sector should adopt measures of power quality and momentary interruptions. Despite these indices, the required level of system reliability ultimately depends on the expectations and demands of the customer. These expectations will vary from place-to-place. Further, we must acknowledge that socio-economic factors require that some areas and customers receive greater reliability. The implementation of value-based reliability planning will require both a strong understanding of customer interruption costs down to the community level, followed by some form of customer segmentation.

Technological developments may fundamentally challenge both the level of reliability required by customers and how such reliability is achieved. Many customers have adopted backup solutions, such as generators, outside the purview of LDCs. The emergence of energy storage solutions and the potential for solar panels on every roof may lead to the consumer taking responsibility for both their own supply and reliability. Distributors, regulators and governments should consider this potential departure from the centralized delivery model very seriously as their decisions could tip the balance one way or the other.

Governance

The Government of Ontario has always used electricity policy as an economic development tool. Government implements electricity policies that attempt to balance industry needs with the economic and social needs of the electorate. Consultations on the Long-Term Energy Plan demonstrate the Ministry's desire to hear from the sector and all Ontarians before setting policy. Further, government has proved that it can show leadership by pushing change in what has historically been a risk-averse industry.

That said, government has absorbed much of the responsibility for long-term planning and policy implementation. These exercises can be strengthened by the increased participation of experts in the energy field, whether it be from other government organizations or utilities.

Continued coordination, cooperation, and consultation between government and the LDC sector will be particularly important in a period of rapid technological change, rising rates, fiscal constraint, and less-than-normal economic growth. We look forward to working together to ensure that policies are well-rounded, informed by knowledge on the ground, and executable.

We suggest that the sector consider establishing or funding one – perhaps independent – organization to lead the charge on educating Ontarians on energy policy and

programming, acting as a "one-stop shop" for all the helpful information already available and that will continue to be provided by LDCs, the OEB, the IESO, and the Government. We believe that Ontarians will seek this information if it is presented in a way that is clear, understandable, relevant, and communicates the value of electricity.

When siting critical infrastructure, early communication and outreach is essential. A customer service approach where all workers – from the CEO to the line person – can effectively communicate and educate the consumer as to the need for a particular project will promote acceptance and understanding of asset renewal.

Glossary

AMI – Advanced Metering Infrastructure
ADMS – Advanced Distribution Management System
Blue-Sky – Typical weather conditions
CDM – Conservation and Demand Management
CHP – (Natural Gas) Combined Heat and Power
CUE – Centre for Urban Energy
DC – Direct Current
DG – Distributed generation
ES – Energy storage
ETR – Estimated time of restoration
EV – Electric vehicle
IESO – Independent Electricity System Operator
Inverter – A device used to convert DC to AC power, or vice versa
IT – Information technology
LDCs – Local distribution companies
LSE – Load serving entity
Net Zero– A building that, on average, produces the same amount of electricity as it consumes
OEB – Ontario Energy Board
Off-peak hours – periods of low electricity demand and price
On-peak hours – periods of high electricity demand and price
OM&A – Operations, Maintenance, and Administration (Costs)
OPA – Ontario Power Authority
OPG – Ontario Power Generation
PQ – Power quality: that electricity is delivered in such a way that it allows devices and equipment to operate properly
PV – (Solar) Photovoltaic
SCADA – Supervisory control and data acquisition
TOU – Time-of-use (pricing)

1.0 Overview and Introduction

1.1 The Centre for Urban Energy

The CUE is an academic-industry partnership that is exploring and developing solutions to urban energy issues, such as the advancement of clean energy technologies, energy conservation and demand management, energy storage, and smart grids. Ryerson University founded CUE with the generous support of Hydro One, Toronto Hydro and the Ontario Power Authority (OPA). Some of our ongoing research projects include utility scale battery storage, understanding the impact of photovoltaics on Hydro One assets, and the development of a smart grid laboratory. From its inception, CUE has attracted approximately $20 million in funding.

CUE is also home to the iCUE, a business incubator and accelerator devoted to urban energy solutions. Launched in November 2012, the iCUE focuses the innovation process between ideation and technology development. Its goal is to help new companies turn their ideas into commercial products, services and/or technologies. To do so, iCUE encourages research innovation (applied research in collaboration with industry); business innovation (entrepreneurship); and student innovation (experiential learning).

1.2 LDC Asset Renewal Series

This collection includes five background papers, drafted by CUE Visiting Research Fellow Ryan Zade in consultation with Mr. Murphy and Dr. Venkatesh. Ryan asked pointed questions and made policy recommendations – sometimes controversial – to facilitate a wholesome debate. For each topic, we have prepared a bibliography, works cited, and a one-page executive brief that includes a visualization of our discussion.

We have divided each of the five topics in this report into two sections. The first is a summary of the background findings, as prepared for the workshop. The views, content, opinions, and recommendations within these backgrounder summaries, along with the five background papers themselves, are solely those of the CUE. The second contains a summary of our roundtable discussion, where some of the participants responded to facts, claims, and suggestions made in the backgrounders while others simply observed the discussions. The roundtable discussion summaries represent, for the most part, a consensus on the topic at hand.

2.0 New Technology

2.1 Backgrounder Summary

Distributed generation technologies (DG) are emerging that will allow small-scale power production. Increasing numbers of customers will be able to generate their own electricity, most likely through solar photovoltaics (PV). Wind turbines and bioenergy generation are also entering the market. To accommodate these facilities, distribution networks are increasingly "two-way" streets: providing electricity to consumers and distributing power from embedded DG sources.

In the coming years, energy storage (ES) systems will supplement DG and will provide a variety of functions in the electrical grid. Devices such as flywheels, batteries, and gas storage will help conserve electricity, provide opportunities to store off-peak electricity for on-peak use, and reduce the problems of power quality (PQ) and intermittency that come with renewable energy.

Electric vehicles (EVs) will also become more popular. They present LDCs with a challenge: since a consumer using an EV charger is akin to adding another house to the grid, a cluster of EV owners would strain transformers. They also present an opportunity for consumers: EVs will eventually be able to act as batteries for using vehicle-to-home technology. LDCs are exploring the potential impact of EVs on distribution systems for different levels of EV uptake to get an understanding of the current system capability and future investments needed to address capacity and other issues. So far, it appears that current LDC infrastructure can handle EV integration at its current pace.

All of these technologies working together will allow consumers to produce and store their own electricity, reducing their demand from traditional generators. Neighbourhoods will be able to form micro-grids. The micro-grid represents a paradigm shift from interconnected and radial distribution networks fed by large generators to self-contained, isolated, and community-based generation and distribution within an LDC. Condominium designers are already planning with micro-grids in mind.

Technology is also enabling the smart grid: the digitization of the distribution network assets. LDCs are installing systems such as:

- *Smart Meters and Time-of-Use*
  Smart meters facilitate time-of-use (TOU) billing, allowing customers to pay a lower rate if they shift consumption to off-peak periods. The wireless feedback from AMI enables efficient billing, provides instant information on outages, and helps consumers both understand their consumption patterns and shift their energy use to cheaper, off-peak hours. With smart meters and AMI, the sector has new responsibilities for data privacy and security.
- *Distribution Technology*
  Advances are allowing for the integration of digital technology into traditional LDC

assets, like transformers and substations. LDCs can now remotely monitor asset health and respond to changing conditions.

Information Technology and Grid Automation
The wealth of data produced by smart meters and other distribution technologies require LDCs to invest in IT infrastructure. IT systems and advanced communication networks allow for the integration of existing supervisory control and data acquisition (SCADA) and outage monitoring, functions with telemetry from new smart assets and Advanced Distribution Management Systems (ADMS). Accordingly, operators will have an increasingly holistic view of their system and be able to manipulate almost all of their systems from a control room. It will enable a self-healing grid: the automatic or remote rerouting of electricity to minimize the effect of an outage or eliminate the chance of an interruption altogether.

With new technology at home and at work – such as advanced manufacturing, computers, and smart phones –consumers are more reliant on electricity than ever. At the same time, customers are becoming more energy efficient. Conservation and demand management (CDM) programs are encouraging users to reduce their electricity use. Manufacturers are embedding sensors in appliances to optimize their electricity use. New buildings are increasingly energy efficient, using technology to minimize power usage. Supported by distributed generation and storage, we will soon see more net-zero buildings: structures that, on average, consume only as much electricity as they produce.

The distribution sector is participating in efforts to understand and encourage new technology:

- The IESO Smart Grid Forum and the Ontario Energy Board (OEB) Smart Grid Advisory Committee bring together LDCs, consumers, the regulator, and the private sector to share insights on new technologies;
- Several LDCs are testing new innovative technologies and connecting distributed generation and storage into their systems;
- The OPA, LDCs, and the OEB are helping consumers conserve energy through CDM programming;
- The OEB requires that LDCs have sufficient capacity to connect distributed generation. The regulator also requires that distributors use efficient capital and asset planning processes to facilitate the smart grid, paced to meet customer preferences. The latter are generally good business practices that LDCs would likely undertake without regulatory intervention.

2.2 Roundtable Discussion

Technological change in the distribution sector is accelerating as it did in the telecom industry over the last decades. The landline was the only means of communication for over half a century. Mobile devices then entered the market, but it took decades until they were widely adopted. Today, iPhones, Blackberries, or other smartphones are in nearly every pocket, less than a decade after their introduction. Many are now abandoning their traditional landline.

While the electric industry is in the early stages of transformation, keeping pace with these changes is already a significant challenge for the sector.

Innovation continues to change customer needs. Increasing reliance on computers, smartphones, and the Internet require a reliable supply of electricity. The pace of change in customer demand is making load forecasting harder for distributors. Further, most new consumer technologies rely on direct current (DC) electrical flow. These devices introduce power quality problems into the distribution system, making the challenge of maintaining reliable service more difficult. The advent of the Internet and social media is changing the way customers communicate with their LDCs.

On the asset side, new technologies are emerging so fast that there is little time to understand their characteristics and their implications for the distribution system. Regulations and standards are having a hard time keeping up. Asset modeling processes based on the old "wires and boxes" paradigm need updating. Assets are becoming "smart", enabling LDCs to better maintain reliability and respond to customer needs. Nevertheless, LDCs are working to ensure that they invest in the best equipment for their needs, not necessarily the newest.

Ontario LDC's can play an important role in innovation, creating, testing, and implementing new technology into their systems. That said, innovation in a regulated market with a multitude of relatively small, risk-averse firms is challenging. Further, advances that lead to lower consumption will reduce LDC revenue, while offsetting revenue for such activities are ultimately the decision of the regulator. Meanwhile, private industry is concurrently developing innovative products and programs for both LDCs and their consumers. Government initiatives such as the Ontario Smart Grid Fund and the Advanced Energy Centre at MaRS are helping to facilitate the deployment of innovation. In such an environment, LDCs may be better suited as *hosts* of innovation, focusing on existing efforts to act as test-beds for new technology, while coordinating, collaborating, and sharing with partners in industry, universities, government, and research institutions.

Understanding the rapidly changing needs and wants of the customer will guide the future of the sector. We believe that the rapid adoption of new technology will necessitate a change to the LDC business model. Net metering and DG will increasingly turn customers into generators and profit takers. Already, LDCs are integrating small-scale generation into their system. The combination of cost-effective DG matched with energy storage or small-scale natural gas electricity generation will encourage energy self-sufficiency and community micro-grids. In addition, companies like Rogers, Bell, Google, and Apple are entering the electricity market and may soon compete directly with LDCs.

As competition enters a traditionally monopolistic market, LDCs must be innovative in how they do business. While carrying on the traditional delivery obligations, we envision the LDC of the future heading in one of several directions:

- Backup electricity providers: LDCs would facilitate interconnection of micro-grids to provide redundancy, and/or provide backup power from traditional sources. By

facilitating these interconnections, managing load, directing power, and intervening in issues of power quality: LDCs would become small-scale system operators;
- Energy service providers: LDCs could facilitate installation and maintenance of DG, conservation, rate offerings and other services for consumers;
- Micro-grid operators: As owners of DG capacity on the LDC side, a distribution network may evolve into a micro-grid in-and-of itself, with the ability to operate without the need for large-scale generation or transmission;
- Multi-asset managers: LDCs could capitalize on economies of scale by acquiring other utilities, like water, gas, and wastewater distribution;
- The status quo: but with lower customer intensity reducing commodity revenues; and/or,
- Fade away: LDCs become redundant as consumers abandon utilities in favour of micro-grids and home-based batteries and PV, leaving billions of dollars in stranded assets.

Accordingly, we find that:

Both consumer appliances and distribution assets are rapidly digitizing. This accelerating technological growth is changing how LDC assets operate. It also will lead to consumers that require service that is more reliable and of higher quality into the future. Investing in increasingly intelligent distribution assets is one way that the LDC sector can continue to meet their own and their customers changing needs. Among the technologies that can meet these needs are consumer-scale solar photovoltaics, energy storage, electric vehicles, and demand response tools.

However, the emergence of energy-efficient homes, cheaper solar power, and advances in battery technology will enable customers to achieve or move towards energy independence. A large migration of customers to self-sufficiency could fundamentally change the relationship between LDCs and their customers. Ongoing innovation and technological progress will require changes in the way that LDCs, agencies, the regulator, and the government approach electricity distribution. LDCs will face the expectation of maintaining substantial asset bases in the face of declining revenues. Accordingly, the sector must look beyond rate decoupling: technological progress will require an evolution of the LDC business model and the rules that regulate it.

3.0 Climate Change

3.1 Backgrounder Summary

In the coming decades, Ontario will be hotter, wetter, and experience shorter winters. Although changes in the average conditions will be incremental, LDCs will have to contend with more numerous severe weather events. Ice storms, thunderstorms, flash flooding, and heat waves will increasingly test the strength of our distribution and transmission systems. It will also reduce the life expectancy of most assets on the network. Distributors have always planned with severe weather in mind and will have to contend with this increasing threat as we modernize our networks.

Responding to climate change necessitates an adaptation strategy. LDCs will need to adjust asset management practices, change equipment standards, and prepare for higher insurance premiums. If severe weather hits Ontario more often, the sector may need to change its definition of "normal" operating margins.

More severe weather resulting from climate change will encourage the adoption of storage or other means of backup supply by customers to ensure a supply of electricity during a storm. We anticipate increased interest in scalable natural gas combined heat and power (CHP) generation. CHP can operate independently during an outage, while PV and wind turbines require a connection to an energized grid to produce and deliver electricity.

Vegetation management will become even more important than it is today. Tree damage to LDC assets account for a majority of outages during severe weather. A longer growing period will encourage additional growth, while tree species will migrate north. LDCs will need to balance the need to protect their assets with maintaining the aesthetic and environmental benefit of trees, often owned by their shareholders and desired by their customers.

In planning, LDCs can build cost-effective resiliency into their networks. For instance, burying wires will increase resiliency, but at a much greater cost than overhead infrastructure. These costs can be hard to justify to the public and to the regulator, particularly during a time of rising prices for cost-sensitive consumers. When the storm does arrive, LDCs will have to refine how they respond. The smart grid will help LDCs locate and respond to interruptions, while well-trained staff can help minimize downtime through quick mobilization. A resilient network can be achieved through quick restoration, not just insulated assets. Strategically located and well-stocked reserves of replacement parts can also accelerate restoration times. LDCs will have to continue to balance these costs.

Severe weather affects the entirety of society's infrastructure. LDCs, other utilities, and public institutions need to work together on formal communications protocols and emergency plans. Communication and coordination of restoration services during outages is critical, including the provision of timely and accurate estimated time of restoration (ETR). Recent experience suggests the sector needs to improve on reaching their customers during a major event.

3.2 Roundtable Discussion

Smart grid technology is useful in providing situational awareness and helping LDCs restore power. Nevertheless, new smart grid assets do present some challenges: for instance, having thousands of AMIs reporting outages during a large interruption is both redundant and can flood LDC servers with too much information. Other technology will help LDCs stay ahead of severe weather: for instance, IBM's Deep Thunder can help predict the impact of storms – down to the community level – allowing time for LDCs to mobilize.

There was consensus on the need for often-reviewed climate adaptation plans. The inclusion of weather as a factor in risk analysis appears to be sector-wide, as well as agreement that LDCs must consider climate change in capital and asset planning. Vegetation management is increasingly important: LDCs are looking at decreasing the time between their trimming cycles. At the centre of these strategies is the need to balance resiliency, reliability, safety, and keeping rates manageable through cost-effective investments.

During our discussion, we considered the balance between focusing on a "standard consensus" on future climatic conditions to inform capital expenditures and the regulatory process, or if the sector should maintain a flexible position towards climate change at the risk of "overinvesting" in particular assets or needlessly purchasing above-code equipment. Flexibility in grid design generally lends itself to robustness, but at greater expense. Our participants argued this need not be the case. We note that the effects of climate change are not uniform: storms can have very different effects within different areas of an LDC's service territory. Efforts to understand these changes, their ramifications, share practices, and develop communication strategies for customers and market participants are taking place through a number of forums, such as Toronto's WeatherWise Partnership and the Canadian Electricity Association. In short, the responsible LDC engages in both – flexibility but justifiable expenditures where required, while maintaining reliability standards. The LDC community has a role to play to influence the standards makers – such as the CSA – on their future requirements.

During severe weather, customers are not just looking for electricity restoration: they need clear roads, access to emergency services, and clean water. The public sector should approach climate change planning in a coordinated, holistic manner, where electric infrastructure is a part of the complete plan. To this end, municipalities should include consideration of electric infrastructure and encourage LDCs to become part of local emergency preparation, planning, and training processes. In return, LDCs also need to work on improving coordination with other utilities and officials.

Recent events revealed challenges in communicating with customers. During the 2013 ice storm, call centres were overwhelmed with volume. Customers grew frustrated with automatic responses, desiring to speak to an agent. A new generation of customers turned to the Internet, leveraging the remaining battery life of their smartphones to tweet or post to social media sites. Even if customers were able to communicate with customer service agents, providing estimated times of restoration proved a difficult and imprecise science.

The sector recognizes that there are many ways to build a resilient distribution system, and each method has its tradeoffs. For instance, undergrounding does improve reliability during storms but costs much more than overhead wires. Continued work on building the smart grid and distribution automation should continue to add resilience to networks. Quick restoration of electricity by power workers can also achieve a desired level of resiliency. Finally, it may be most cost-efficient to encourage Ontarians to incorporate resiliency into their homes: in lieu of higher rates to make the distribution system more robust, it may be cheaper for customers to buy a generator. Customer adoption of CHP, DG, and ES will allow their homes and businesses to become more resilient.

Accordingly, we find that:

The dominant threat of climate change lies in the increased occurrence of severe weather events that will test the reliability and resiliency of Ontario's LDC assets. The sector must prepare by fully incorporating climate adaptation into their corporate planning processes. Part of this understanding must acknowledge that the impacts of severe weather are diverse, even within communities.

There are many different avenues to build a resilient network. The smart grid will help build resiliency into the system; its digital components will provide real-time information to LDCs to help them determine problems and reroute power faster than ever. Distributors can invest in robust, hardened infrastructure. They can also place greater emphasis on quick restoration. Finally, investments in local supply and/or the encouragement of at-home solutions such as generators can help keep the power on during large storms. LDCs will have to find a balance among these options to maintain a resilient, reliable grid at reasonable cost. Finally, the sector must invest in and improve on its ability to communicate clearly, effectively, directly, and quickly with its customers and their public sector partners during severe weather events. This includes improving their abilities to determine estimated times of restoration (ETRs) in an accurate and timely fashion.

4.0 Asset Upkeep and Renewal

4.1 Backgrounder Summary

As much of our distribution network assets are approaching or have reached their end-of-life, billions of dollars of investment will be required to maintain a safe and reliable network. Decisions about how to make these investments are part of the asset management process. Asset management includes how LDCs collect information on their equipment, consider their customer's needs, and plan their networks. LDCs link asset management to capital planning, balancing asset expenditure with operations, maintenance and administration (OM&A) costs, spending on non-distribution assets, rate of return, and regulatory costs.

Maintenance regimes help LDCs maximize the value of their assets. Best practices have moved from *time-based* maintenance (TBM) – inspecting equipment at regular intervals – to *predictive* or *performance-based* maintenance (PBM), where LDCs can optimize the intervals between inspections based on the lessons they have learned through TBM. LDCs also practice *condition-based* maintenance (CBM) by using telemetry from "smart" assets to dictate visits to equipment. The next evolution in maintenance regimes is *reliability-centered* maintenance (RCM), where LDCs factor in the criticality and cost of equipment to develop a program that maximizes reliability while minimizing expenditure. This progression has extended asset lives, increased reliability and controlled reactive and preventative maintenance costs.

Eventually, an asset needs refurbishment or replacement. An LDC must find the investment that optimizes the balance between cost, reliability, performance, and risk exposure. When an asset does need replacement, utilities must decide next whether to replace like-for-like or with new technology. Typically, the larger or more critical the asset, the less likely outright replacement will take place. The decision to replace with smart grid technology must account for the risk of obsolescence.

We found that LDC asset and capital planning processes are mature and well informed. Through the *Renewed Regulatory Framework* and *Distribution System Plan*, the OEB requires LDCs to file five-year holistic system plans that do not differentiate between investment types. This new process is easier and streamlined for LDCs than previous iterations. It also requires that LDCs set a metric to measure their success at asset management for their customers.

We argue that so long as utilities are driven by the current rate of return structure, there remains an incentive for LDCs to invest more in short-lived capital to maximize returns on capital as opposed to managing longer-term assets through increased maintenance costs. Utilities can spread capital costs over many years, while maintenance costs affect the bottom line that quarter. We learned this capital return model works well during a period of high growth, but not during periods of rebuilding, increasing maintenance costs, and potentially shrinking LDC asset bases. New York State is grappling with this same issue, and is looking at a model in the UK where regulators have devised a regime that leaves utilities indifferent between capital and operating expenditures.

LDCs also need to consider renewing their workforce. A new generation of workers with different skill sets, attitudes, and from a new labour market will need to replace a wave of retiring workers. This presents a chance for LDCs to increase representation of women, Aboriginals, and immigrants within their teams. Finally, LDCs will need to find ways to capture and transfer the knowledge and experience of retirees to the next generation of power workers.

4.2 Roundtable Discussion

The group noted that as LDCs continue to become more sophisticated in their maintenance regimes, the cost of maintenance per asset is falling. Nevertheless, there remains an "age bulge": large proportions of LDC assets are reaching end-of-life and require replacement. Thus, capital investments are rising at a steady pace. To help optimize their asset portfolio, some LDCs use a tool not mentioned in our backgrounder: scenario analysis. Planners run simulations of future requirements, each time changing variables – government, customer, and regulatory volatility among them – to inform their investments.

Even with modelling, the degree of uncertainty in the future is making it difficult for LDCs to choose asset portfolios. Consumption intensity is declining, the importance of electricity to power our digital lives is increasing, and distributed generation is emerging. Consequently, LDCs will face a different demand growth pattern than they have over the last century. Accordingly, utilities inform their asset renewal program with their best projections of the future LDC business model, changing customer needs and preferences, the adoption of technology, economic growth, public policy, and regulation.

It will become more important for LDCs to continue their investment strategies that balance cost with performance, and to avoid automatically investing in the newest technology, or the " bells and whistles." For example, LDCs have found that in many situations retrofitting existing assets to allow SCADA control is not cost effective. In determining a level of SCADA control for distribution assets, LDCs have sought to ensure that such investments are cost effective.

To understand the costs and return of new assets, LDCs test new equipment. For instance, through testing some LDCs have learned that many new smart grid assets like protective relays generally have shorter lifespans and present a risk of obsolescence much quicker than initially envisioned. There is no forum for distributors to coordinate and share their test results on new purchasing opportunities. A barrier preventing such information exchange is the prospect of legal action by a vendor for discriminatory comments against their product.

Regardless of any incentive to invest in capital over operations, Ontario's LDCs have always invested in a way that maximizes the long-term value and reliability of their systems for their customers. Further, any attempt to maximize return on equity by making "suboptimal" investment decisions would be met with considerable resistance from both the OEB and intervenors in the hearing process. In short, good utility business practices emphasize long-term strategic planning over year-to-year returns. In addition, the net benefit to society of optimized design outweighs the returns to shareholders, who are more often than not municipal and provincial governments.

To finance asset renewal, some LDCs believe they could benefit from increased equity investments by their owners. Since municipalities seem unwilling or unable to infuse equity into an LDC, those distributors are required to seek debt financing. When the OEB considers rate applications, its revenue requirement rulings assume a debt-to-equity ratio of 60:40. LDCs that are more indebted risk lower returns to their shareholders, particularly if they surpass the 60:40 benchmark. With rising commodity costs and little equity, LDCs must stretch their asset renewal programs over longer periods to smooth rate increases, thus increasing the risk of the failure of aging assets by extending their time in-service.

If public owners provided equity to their LDCs, they would be investing in both their company and local economic development by facilitating a more reliable local grid. Another way to encourage equity financing is to eliminate barriers to mergers and investments – like the provincial transfer tax – for entities like public sector pension plans.

There was general agreement that fewer, larger LDCs could better manage capital by exploiting economies of scale and purchasing power. Since LDCs are for-profit actors, there is no incentive for large LDCs – prospective acquirers – to work with smaller LDCs on asset optimization. That said, some smaller LDCs demonstrate sophisticated planning and may be able to do as well on their own. Further, when a merger does occur, it takes time to reconcile the asset planning, system layout, and equipment between the two or more former distributors.

On workforce renewal, participants acknowledged that the latest generation of workers approach the workplace differently. LDCs are finding new workers are more mobile and entrepreneurial, and thus more likely to leave the company, taking the company's human capital investment with them. Further, widespread drive for management positions and better salary levels has left potential employees less inclined to learn specialist, technical skills, leaving an employment deficit in some LDCS in key engineering areas. Collective agreements can inhibit movement into different business units to provide new workers exposure to the whole corporation. Mentorship opportunities for new hires are few, due to less hiring in the 1990s, and pressures to find efficiencies in labour costs. Cost pressures provide a disincentive for LDCs to hire before retirements occur: new hires immediately add to OM&A costs without immediate return. We found the challenge of workforce renewal is different for each of our participants.

Participants noted partnerships with postsecondary institutions are helping: co-op education is helping LDCs fill the gap. Nevertheless, graduates of contemporary engineering programs lack the skills specifically required for the distribution sector. The effects of this "skills shortfall" is a burden on LDCs to varying degrees. The LDC community must reach out to postsecondary schools to address what skills graduates are lacking. This could be done through directly funding programs like in Quebec, or working with these institutions to develop and promote new curricula. Private product vendors have developed consulting practices to fill the "knowledge gap."

Accordingly, we find that:

Even with enhanced maintenance regimes, Ontario's LDCs will need to replace significant portions of both their human and physical asset bases in the coming years. LDCs, the regulator, and the government all expect robust asset and capital management plans to address these challenges. Yet, uncertainty around future load profiles, customer needs, climate change, government policy, regulation, and the rapid pace of technological change is making it increasingly difficult to plan for the long term.. The significant financial requirements to replace and renew these assets requires an evaluation of the rate structure and of the LDC ownership model, including encouraging equity stakes of private or public sector bodies. These investments will also require coordination and partnership with the post-secondary sector to encourage and prepare students to enter the LDC workforce.

5.0 Reliability

5.1 Backgrounder Summary

LDCs have a number of indices to measure reliability. The most common are average number of outages (SAIFI), average outage duration (SAIDI), and average restoration time (CAIDI). Measuring momentary outages is becoming more important as they are having a greater effect on customers. These indices are scalable from system-wide to the feeder-level. These statistics can be corrected for events beyond the distributor's control, such as loss of transmission supply or extraordinary storms.

The OEB only requires LDCs to report on their performance, although they are currently developing a reliability target regime. Another option to incent reliability is performance-based regulation (PBR): providing incentives by penalizing and/or rewarding utilities for reliability, although it is unclear how to build such a regime without penalizing the ratepayer.

Distribution reliability has improved in Ontario over the last decade. Although nominally it appears that we fall behind counterparts in Asia, Europe, the United States, we caution that it is difficult to compare between jurisdictions. Climate, grid age, system design, and geography all influence reliability. There is a correlation between undergrounding and reliability, and between undergrounding and population density; an important consideration when comparing a territory as large as Ontario to a city-state like Singapore.

The smart grid should increase reliability. Enhancements in distribution automation will permit fault location, isolation, and service restoration (FLISR). The self-healing grid will eliminate some outages while minimizing the impact of others. Performance feedback will allow distributors to load assets dynamically according to their health and environmental conditions. DG installed at the ends of long feeders or in areas nearing capacity can defer capital replacement and maintain reliability. Voltage management technology and Volt/Var optimization – previously the domain of transmission systems – will become more prevalent in distribution networks as DC electronics and distributed generators introduce power quality issues

Today, Ontarians in urban areas are generally satisfied with the level of their electricity supply reliability. They also appear to be very price conscious: unwilling to pay for more for increased reliability or less for reduced reliability. This may change as customers continue to digitize, technological change accelerates, and prices rise. Exposure to more severe weather events due to climate change could also change customers' attitudes towards costs and reliability.

Planning has moved from ensuring *redundancy* in case of a failure within a system, to *reliability-index planning* where engineers target a specific value of SAIDI or SAIFI. They do so by using historical data and advanced modeling to conduct *predictive analysis*. This process determines which points in their systems would benefit most from investment to maximize overall reliability. The next wave of system planning is *value-based reliability planning*, which places emphasis on where reliability is most valuable to society. In order to facilitate this value-

based reliability planning, an understanding of the direct and indirect socioeconomic costs to customer and society alike is required.

5.2 Roundtable Discussion

Many of the issues discussed in previous sessions threaten reliability, including weather, vegetation, and asset demographics. Participants see asset renewal, smart grid, DG, and micro-grids as methods to increase reliability. Customer sensitivity to momentary interruptions is increasing, particularly with more digital equipment and people increasingly working from home. Further, as more and more electronics enter homes and businesses, DC loads are having an increasing effect on power quality. Increasing urbanization will stress existing assets and increase the number of customers impacted when a device fails. Although apparently content with contemporary reliability levels, customers may demand more of their LDCs in the future, or less in the face of rising electricity prices. The sector is looking to their customers to understand reliability requirements into the future.

The group expressed caution in interpreting reliability indices. Among their concerns:

- They are inherently a measure of past performance , not current conditions;
- Network-wide statistics can be misleading, particularly over large geographical areas or locations with differences in density. Indices on segments – parts of a system that share common characteristics – are more telling. LDCs find the greatest gain by working on outliers;
- Indices do not provide context on the environment in which different distributors operate; and,
- On a philosophical level, does a measure of reliability really matter? Should we measure reliability based on customer satisfaction?

All agreed that reliability indices should be used to track changes of service quality in a particular area. Comparing reliability indices between LDCs – even between neighbourhoods within LDCs – can lead to inaccurate conclusions.

Participants generally agreed that the sector needs to improve their understanding of customer interruption costs, and that smart grid technology should help enable a greater knowledge of these costs down to the node level. Participants predicted the eventual segmentation of the customer base: that different customers may require, receive and pay for different levels of reliability. By introducing segmentation, the sector can respond to individual needs and budgets. Yet, segmentation of rate design to cater to unique needs would be difficult to communicate: can small businesses and residential customers truly understand what a “level of reliability” entails?

There have always been customers more sensitive to outages. For example, large industrial auto, chemical and steel plants have always demanded higher reliability than what standards require.

Discussion led into whether investment in the regulated distribution system or in emerging alternatives to this are the best providers of future reliability. Unregulated competitors already provide well-adopted reliability solutions for consumers, such as surge protectors and power backups for computers. The private sector may be the most efficient way to address the future reliability needs of customers, through small electronics, solar panels or other local generation, and small storage. It is unclear who would best provide different reliability solutions: regulated utilities providing centralized delivery such as today's LDC or unregulated, private competitors providing supply solutions at the home or office.

Reliability is not just about keeping the lights on: it also speaks to the quality of those electrons delivered. With increasing power quality disturbances entering LDC systems, there is no Canadian standard on power quality, nor do LDCs report on power quality within their grids. Some participants have experienced significant variations in product quality from AC-DC inverter vendors. Large industrial customers and electricity generators can introduce power quality issues into distribution networks. Accordingly, they have an obligation to meet certain power quality requirements and do so by installing devices that reduce any anomalies before they enter the grid. Nevertheless, LDCs sometimes install matching devices to safeguard the integrity and reliability of their systems. This duplication is inefficient.

Finally, there is no uniformity on system design or reliability requirements amongst LDCs. Different distributors using various standards and preparing for the future at diverse rates will present challenges during LDC consolidations and in comparing performance across the province. Standardization of LDC equipment and processes, while a very long-term objective, holds tremendous opportunity to increase efficiency in investment and operations.

Accordingly, we find that:

Although we have a robust set of tools to measure reliability, the sector should adopt measures of power quality and momentary interruptions. Despite these indices, the required level of system reliability ultimately depends on the expectations and demands of the customer. These expectations will vary from place-to-place. Further, we must acknowledge that socio-economic factors require that some areas and customers receive greater reliability. The implementation of value-based reliability planning will require both a strong understanding of customer interruption costs down to the community level, followed by some form of customer segmentation.

Technological developments may fundamentally challenge both the level of reliability required by customers and how such reliability is achieved. Many customers have adopted backup solutions, such as generators, outside the purview of LDCs. The emergence of energy storage solutions and the potential for solar panels on every roof may lead to the consumer taking responsibility for both their own supply and reliability. Distributors, regulators and governments should consider this potential departure from the centralized delivery model very seriously as their decisions could tip the balance one way or the other.

6.0 Governance

6.1 Backgrounder Summary

The electricity space in this province has changed significantly in the last two decades. After the breakup of Ontario Hydro, there are many players in the energy space: the OEB has significant new regulatory power, while new entities like the IESO, OPA, and Hydro One interact with a considerably consolidated distribution sector. Government, the regulator, the consumer, and increasingly the private sector have many roles in this environment; roles that sometimes come into conflict with one another.

During this period, the Government of Ontario has been very active in the sector, from deregulation, to re-regulating retail markets, to the pursuit of a green energy agenda. Government has the responsibility to consider the broader effects of electricity policy on the economy, the environment, and social welfare. Policies such as the end of coal-fired generation and efforts to incubate a new renewable energy economy during a time of recession were not as much about electricity as they were about reducing environmental damage, improving the health of Ontarians, and creating jobs. These policies have cut emissions, reduced stress on the health care system, and made Ontario a leader in non-hydro renewable energy, smart grid implementation, smart meters, and time-of-use pricing.

In pursuing these objectives, it appears that the government policy has been subject to several breaks in continuity, which can discourage investment. Further, by way of ministerial directives and Ministry-driven Long-Term Energy Plans, the government has taken over planning and implementation functions that were assigned to expert agencies like the OPA. Smart metering and conservation policies are two examples of programs imposed upon LDCs and the OEB at the behest of the government. The centralization of power – particularly uploading regulatory and planning functions to a ministry – is not unique in Canada.

Our participants touched on the issue of energy literacy throughout our workshops. We found – and evidence supports – that the sector should continue working on improving energy literacy among Ontarians. All of the participants in the distribution space offer various initiatives and programs to inform the public about electricity in Ontario. We proposed several ideas to encourage greater literacy. First, the government could consider including energy literacy in its elementary and secondary curriculum. Second, we encouraged LDC sector participants to aim to be as transparent as possible.

LDC sector participants are challenged by the fact that most consumers do not look to government or their LDCs for energy information: Ipsos Reid found that customers overwhelmingly look to the Internet and media for energy education. Further the electricity space is inherently complex, and there is a question of what exactly the public should be educated about: the functioning of the electricity market, or the value of power itself?

Recent examples of opposition to gas plants in the western GTA and wind farms across the province demonstrate that securing social licence appears to be increasingly difficult for infrastructure projects. Distributors are infrastructure builders at the local level, constructing

transformers on streets, hanging wires along roads, and participating in regional planning. The IESO, OPA, and the Mowat Centre provide guidelines on how to obtain acceptance for public works from a community.

6.2 Roundtable Discussion and Results

It is important to contextualize this debate by considering Ontario's political culture. We noted:

- Energy policy has been and continues to be used as a tool of economic and social development;
- Energy policy is an issue that some Ontarians consider when voting;
- Ontarians are inherently "incrementalists"; and,
- Our system of governance concentrates power with the minister. Considering the political ramifications of energy policy, most matters will come before the minister's desk.

The Ministry's responsibility to consider energy policy within the context of economic development appears to be becoming more important. Into the future, the LDC community should seek an understanding of the broader, general policy direction of the government, while the Ministry can work with the LDCs to learn more about the indirect effects on the distributions sector of some of their more socially and economically focused policies. Going forward, consultation and cooperation will be critical to success.

Government was the catalyst that began the transition to the smart grid. The government accelerated the adoption of smart meters, time-of-use rates, and CDM; without government directive, the LDC community would have been slower to implement these technologies and policies. In a risk-averse, regulated environment, government intervention is occasionally required to show leadership and drive change. Despite good intentions, there have been problems with the execution of recent policy directions. Mainly, the pace of change required led to many problems, such as the oversubscription of FIT and microFIT initiatives, as well as the common critiques of the government's CDM policies.

The Ministry should continue to dictate general policy direction, but in doing so, it should place increased emphasis on consulting the sector, basing policy on asset lifecycles, and leaving the details and implementation to experts. Government should back policy with a strong business case and should not be afraid to differentiate between different areas of the province: what works for Toronto may not work for Sudbury. It will be a challenge for the government to balance a sense of equality across the province with location-based policy that may appear to the electorate to favour urban versus rural or north versus south. We have seen in recent consultations with Ontarians – notably the most recent *Long-Term Energy Plan* – that the government is striving for such a balance.

Currently, LDCs, the OEB, the IESO, and the Ministry all provide information in differing forms to consumers. These bodies must continue to work together in providing the material for consumers to make the right decision. To build upon these efforts, there may be merit in establishing a central location for Ontarians to learn about energy policy, possibly from an

independent, trustworthy source that is removed from the policy process. Programming must be tangible, clear, consistent, and relevant to consumers. Education must help customers understand the value of reliable electricity. Front-line workers can play a role in this process: for instance, they should be able to educate a customer on why they are trimming a tree.

Even though we associate social licence with large power plants, the LDC community has faced their own opposition to some of their projects. We predict that local opposition will increase with the installation of distributed generation close to loads. A strong communications and outreach plan executed early in the process is critical to gaining social acceptance. Here again, front-line workers can play a role in addressing concerns when approached by a member of the community.

Accordingly, we find that:

The Government of Ontario has always used electricity policy as an economic development tool. Government implements electricity policies that attempt to balance industry needs with the economic and social needs of the electorate. Consultations on the Long-Term Energy Plan demonstrate the Ministry's desire to hear from the sector and all Ontarians before setting policy. Further, government has proved that it can show leadership by pushing change in what has historically been a risk-averse industry.

That said, government has absorbed much of the responsibility for long-term planning and policy implementation. These exercises can be strengthened by the increased participation of experts in the energy field, whether it be from other government organizations or utilities.

Continued coordination, cooperation, and consultation between government and the LDC sector will be particularly important in a period of rapid technological change, rising rates, fiscal constraint, and less-than-normal economic growth. We look forward to working together to ensure that policies are well-rounded, informed by knowledge on the ground, and executable.

We suggest that the sector consider establishing or funding one – perhaps independent – organization to lead the charge on educating Ontarians on energy policy and programming, acting as a "one-stop shop" for all the helpful information already available and that will continue to be provided by LDCs, the OEB, the IESO, and the Government. We believe that Ontarians will seek this information if it is presented in a way that is clear, understandable, relevant, and communicates the value of electricity.

When siting critical infrastructure, early communication and outreach is essential. A customer service approach where all workers – from the CEO to the line person – can effectively communicate and educate the consumer as to the need for a particular project will promote acceptance and understanding of asset renewal.

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