THE ELECTRIC UTILITY OF THE FUTURE:
INSIGHTS ON CHALLENGE AND CHANGE IN ONTARIO LDCs

by

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A thesis

presented to Ryerson University

in partial fulfillment of the

requirements for the degree of

Master of Applied Science

in the Program of

Environmental Applied Science and Management

Toronto, Ontario, Canada, 2016

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ABSTRACT

The Electric Utility of the Future: Insights on Challenge and Change in Ontario LDCs

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The traditional role of electric utilities is diminishing in the face of technology, customer, financial, regulatory, and policy changes occurring in the industry. These changes will determine the future viability of local distribution companies [LDCs] in Ontario. A diverse collection of academic, industry, and government literature supports varying opinions of what the LDC of the future should look like. A historical overview and an institutional theory of organizational behaviour method frames the idea that technological innovation can break through the sector's historically and culturally embedded resistance to change. A two-stage survey method is used to construct a dialogue between key players, and finds support for the above proposition from the expert judgements of LDC decision-makers and influencers. The new energy customer, empowered by new energy technologies, is a primary causal factor of the challenges in the sector, and also of the transformative change needed to create the LDC of the future.

ACKNOWLEDGEMENTS

It is a great pleasure to extend my deepest gratitude to the following people for their support and help through the development of this thesis:

Jeff Ranson, Leo Roytman, Immaculate Antony, Hannah Hyder, Anthony Youssef, Ryan Zade, Dan Jakubek, Sikander and Maysum Allibhai, Zohra Karim-Virji, Dr. Debbie de Lange, Dr. Craig Brown, Dr. Sabeena Chopra, the team at Pretium Anderson Building Engineers in Burlington, and the staff and faculty at the Department of Architectural Science at Ryerson University – especially, Professor Ramani Ramakrishnan, Dr. Russell Richman, Dr. Mark Gorgolewski, Dr. Zaiyi Liao, and Professor Vera Straka.

Thank you to the staff at Ryerson's Centre for Urban Energy and to the electric utility professionals who took the time to respond to my survey. Without your efforts and enthusiasm, this study would not have been possible.

I would also like to acknowledge my supervisors, Dr. Michal Bardecki and Dr. Dan McGillivray for their time, dedication, and advice. I have learned so much under your guidance, and I thank you for teaching me that insightful research comes when we are passionate about our work.

DEDICATION

To my family:

For all my words, none can express my gratitude to you.

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LIST OF ABBREVIATIONS [1/3]

CBoC	Conference Board of Canada
CCS	Carbon capture and storage
CDM	Conservation and demand management
CHP	Combined heat and power
COP21	"Conference of the Parties" (2015 United Nations Climate Change Conference)
CSAQ	Computerized self-administered questionnaire
CUE	Centre for Urban Energy
DE	Distributed energy
DER	Distributed energy resources
DES	District energy systems
DG	Distributed generation
DOE	Department of Energy
DSM	Demand-side management
Dx	Distribution
EV	Electric vehicle
FAO	Financial Accountability Office of Ontario
GA	Global Adjustment
GDP	Gross domestic product
GEGEA	Green Energy and Green Economy Act
GHG	Greenhouse gas
HEPC	Hydro-Electric Power Corporation
Hg	Mercury
HOEP	Hourly Ontario Electricity Price
ICT	Information and communication technology
IDEA	International District Energy Association
IEA	International Energy Association
IESO	Independent Electricity System Operator

LIST OF ABBREVIATIONS [2/3]

IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPO	Initial public offering
IPSP	Integrated Power System Plan
IRENA	International Renewable Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
LDC	Local Distribution Company
LTEP	Long-Term Energy Plan
MEU	Municipal electricity utility
MOE	Ministry of Energy
MOECC	Ministry of Energy and Climate Change
MOEE	Ministry of Environment and Energy
MT	Micro turbine
NOx	Nitrogen oxide
NRC	National Research Council
NRCan	National Resources Canada
NZEB	Net-zero energy building
OCAA	Ontario Clean Air Alliance
OCC	Ontario Chamber of Commerce
OEB	Ontario Energy Board
OECD	Organisation for Economic Co-operation and Development
OM&A	Operating, maintenance and administration
OMERS	Ontario Municipal Employees Retirement System
OPA	Ontario Power Authority
OPG	Ontario Power Generation
PM	Particulate matter
PV	(Solar) photovoltaic

LIST OF ABBREVIATIONS [3/3]

QDA	Qualitative data analysis
REB	Research Ethics Board
RRFE	Renewed Regulatory Framework for Electricity
SOx	Sulphur dioxide
TOU	Time-of-use
Tx	Transmission
WEF	World Economic Forum

1.0 BACKGROUND: ELECTRIC UTILITY

1.1 Introduction

> *A dairy farmer peeks at the reading on a pump meter. Kindergarten children sit on a classroom floor interacting with their iPads and each other. A team of surgeons under a bright spotlight prudently consider their next move on the patient in their care. Workers check forms and machinery in a shining industrial setting, as the provincial Minister of the Environment and Climate Change looks on. A solid hockey puck rests undisturbed on glowing ice in a quiet, well-lit arena.*

These are the images that appear on the landing page of alotontheline.ca, a recently launched public awareness campaign by the Electricity Distributors Association [EDA]. This campaign promotes the importance of electrical energy and Local Distribution Companies [LDCs] in delivering energy to consumers (EDA, 2015). Cliché though they may be, these images are true representations of the indispensable and comprehensive impact of electrical power on every sphere of modern life.

Distributors are essential service providers and a vital piece of any electricity system (EDA, 2015). In the province of Ontario, the distributors that connect electricity generation and transmission to millions of homes, businesses, and institutions are LDCs. They take high-voltage power from transmission wires (which come from large electricity generators), transform that high-voltage power to a lower voltage level, and deliver this electrical energy to end users through an extensive network of distribution wires. LDCs own and make investments to grow their electricity distribution system infrastructure (Elston *et al.*, 2012), in order to deliver power more reliably to more customers. They are also responsible for billing customers (EDA, 2015; Ontario Energy Board [OEB], 2015a) and for implementing electricity conservation programs (OEB, 2015a) that are intended to save consumers money, protect the environment, and help address Ontario's energy supply challenge (EDA, 2015). LDCs are only one part of Ontario's complex and multilayered electricity market. Figure 1 illustrates the key institutional and technical players in Ontario's electricity market, and Figure 2 also illustrates these players with the local electric utility as the central node. LDCs are vital subjects of inquiry because they are the primary point of contact between millions of consumers and the rest of the system (EDA, 2015).

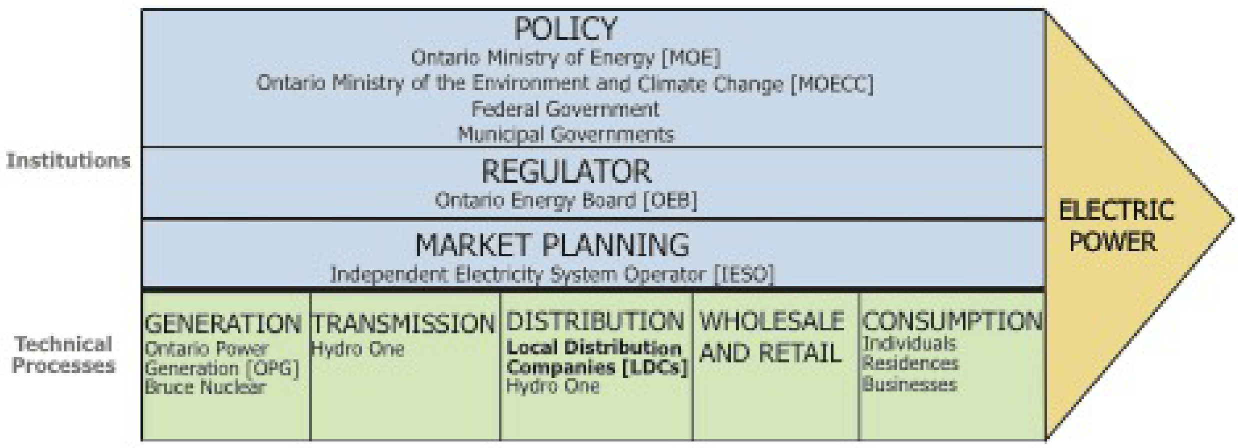

Figure 1. *Key players in Ontario's electricity market, adapted from McGillivray, 2015; Hewson, 2015; Porter, 1985.*

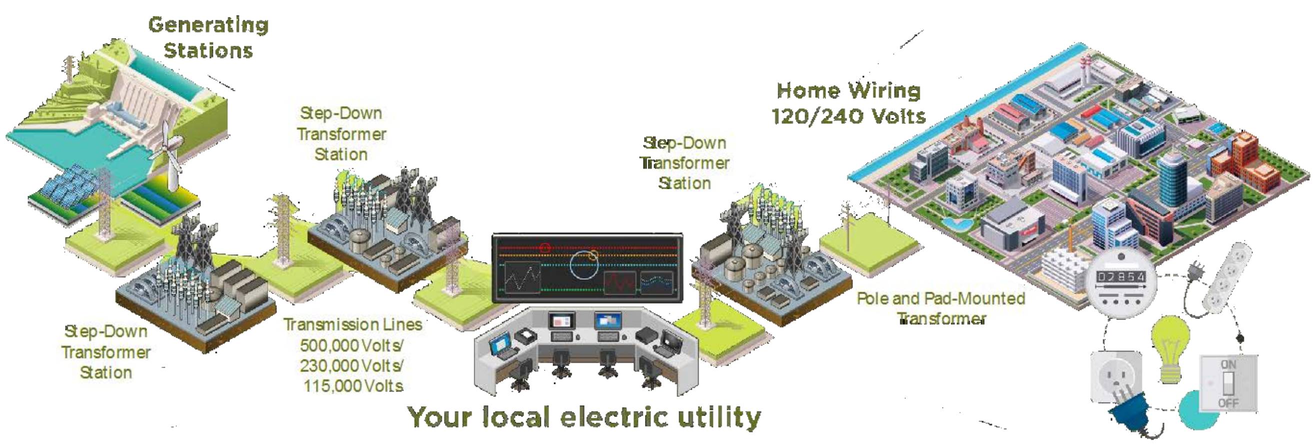

Figure 2. *Ontario's electricity system (LDC node), (EDA 2015).*

This thesis investigates the changing role of LDCs in Ontario. The indispensability of LDCs has been taken for granted, but new developments in energy, information, and communication technologies are instigating disruptive challenges (Kind, 2013) that are transforming the electricity industry. These challenges arise in the form of higher customer expectations, greater financial pressures, restrictive regulations, and government policies demanding more than just economic value from LDCs. To overcome these challenges, LDCs must change their traditional business activities in order to remain viable components of Ontario's future.

The historical and cultural development of LDCs have created barriers to change and technological innovation is a way to drive the transformative change that is needed to ensure LDCs' continued viability. The first purpose of this thesis is to examine the recent technological, customer, financial, regulatory, and policy trends that are challenging Ontario's electricity distribution sector. The second purpose is to show how LDCs are not always able to adapt to the current challenges in their environment because institutions in the sector create strong barriers to change. The third purpose is to propose that technological innovation can be the impetus needed to drive institutional change in the sector. The connection between technological innovation and institutional change is framed by a modified version of Künneke's (2008) institutional innovation model for regulated electric utilities. The final purpose of this thesis is to investigate how different professional experts in Ontario's electricity distribution sector characterize an institutionally innovative LDC. This investigation is conducted using a survey to elicit sectoral experts' opinions on a range of timely issues concerning the LDC of the future. The survey is also conducted anonymously, in two stages, and includes a component of respondent feedback in order to establish a dialogue on the issues between sectoral experts.

In many jurisdictions, the range of challenges from new energy technologies, government policies, and increasing customer expectations are already affecting the day-to-day business of electric utilities, or are projected to do so in the very near future (<5 years) (Bronski *et al.*, 2015). In Ontario, LDCs are not yet experiencing a significant disturbance to their businesses as a direct consequence of the technology, policy, and customer challenges seen in other electricity markets. However, there is an awareness of the upcoming challenges, and the implications they could have for LDCs (Zade, Alibhai, & McGillivray, 2015). Comparatively to U.S. electricity markets, Ontario has similarities in terms of technological knowledge, consumer engagement and expectations of political transparency, importance of the rule of law, and sociocultural norms. U.S. electrical utilities (collectively or locally) are particularly influential predictors of the LDC sector's possible future. The awareness of "change" in Ontario's electricity distribution sector can be described by the current and expected trends south of the border.

1.2 Technological Challenges

Technology advancements are emerging all over the energy industry, and are the main disruptor of the status quo for electric utilities. There are frequently different definitions for most of these technologies (Ackermann, Andersson & Söder, 2001), and there is also a great deal of overlap between technologies, even when narrow definitions are used. The alphabetized list in Table 1 provides a brief explanation of some disruptive energy technologies and specialized terms, and their significance to the future of electric utilities. More detailed explanations of the workings of these technologies demands a more advanced level of technical knowledge, which is beyond the scope of this study. It is important to note that this is not an exhaustive list of every technology that is, or has the potential to, disrupt the traditional business models of electric utilities.

Technology	Definition	Source
Battery energy storage	Energy storage using electrochemical batteries.	(DOE, Office of Energy Efficiency & Renewable Energy, 2015a)
"Behind the meter"	Energy technology, especially generation, situated with the customer, instead of on the utility's side.	(Breen, 2013)
Carbon capture and storage [CCS]	Gathering and permanent storage of carbon dioxide [CO_2] to prevent release to the atmosphere.	(DOE, Office of Energy Efficiency & Renewable Energy, 2015b)
Cogeneration	*see "Combined heat and power [CHP]"*	
Combined heat and power [CHP]	Energy systems that produce both useful heat and electricity in a single process.	(Combined Heat and Power for Buildings, 2013)
Demand response	Changes in electricity usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time; intended to alter timing, level of instantaneous demand, or total electricity consumption.	(Albadi & El-Saadany, 2008)
Distributed energy [DE]	Localized, on-site, decentralized power generation and distribution.	(DOE, Office of Energy Efficiency & Renewable Energy, 2015c)
Distributed energy resources [DER]	Similar power sources that can be aggregated to provide power necessary to meet regular demand.	(Electric Power Research Institute [EPRI], 2015)
District energy systems [DES]	Produce steam, hot water, or chilled water at a central plant; piped underground to individual buildings that don't need their own boilers, furnaces, chillers, or air conditioners.	(International District Energy Association [IDEA], 2009)
Distributed generation [DG]	Electricity generation systems with capacities of 200 watts to 10 megawatts and include both isolated and grid-connected home systems, and micro- and mini-grids (either islanded or grid-connected).	(Odarno, Martin & Angel, 2015)

Technology	Definition	Source
Electric grid ("the grid")	Network of transmission lines, substations, transformers and more that deliver electricity from the power plant to the end consumer.	(Department of Energy [DOE], Office of Electricity Delivery & Energy Reliability, 2015a)
Electric vehicle [EV]	Battery-powered electrically driven vehicle; significant energy storage technology for the future of electric utilities.	(DOE, Office of Energy Efficiency & Renewable Energy, 2015a)
Fuel cell	Electrochemical device that converts chemical energy directly into electricity.	(DOE, Office of Energy Efficiency & Renewable Energy, 2015a)
Internet of Things [IoT]	Devices that collect and transmit data via the Internet; can be applied to broad systems (e.g., transportation networks) to help reduce waste and improve energy use efficiency.	(Morgan, 2014)
Microgrid	Infrastructure system that can disconnect from the larger grid and function as an electrical island in case of a disruption in the grid.	(DOE, Office of Energy Efficiency & Renewable Energy, 2015c)
	potentially central to the efficient integration of decentralized power supplies	(Savenije, 2014)
Microturbine [MT]	Small and simple-cycle gas turbines with outputs ranging from 25 to 300 kW; one part of a general evolution in gas turbine technology.	(Zhu & Tomsovic, 2002)
Net-zero, net zero energy buildings [NZEB]	Highly energy-efficient buildings that use renewable technology to produce as much energy as they consume from the grid.	(Crawley, Pless & Torcellini, 2009)
Net metering	Using a single meter to measure consumption and generation of electricity by a small generation facility (e.g. residence with wind or solar PV system). Net energy produced or consumed is purchased from or sold to the power provider, respectively.	(DOE, Office of Electricity Delivery & Energy Reliability, 2015a)

Technology	Definition	Source
Renewable energy (green energy)	Generating electricity from sources thought to be environmentally cleaner than traditional ones; typically wind, solar, biomass. Sometimes also includes power from waste-to-energy and wood-fired plants (produce air emissions), and hydropower (damaging to fish populations).	(DOE, Office of Energy Efficiency & Renewable Energy, 2015a)
Smart grid	Electricity infrastructure combined with digital technology to enable two-way communication between utilities and customers and improve response to constantly changing electricity demands.	(DOE, Office of Electricity Delivery & Energy Reliability, 2015a)
	Information and communication technologies [ICT] that can monitor and manage the distribution of electricity from all generation sources; potentially central to the efficient integration of decentralized power supplies.	(Savenije, 2014)
	Advanced information exchange systems and equipment that, when utilized together, improves flexibility, security, reliability, efficiency and safety of integrated power system and distribution systems.	(Ministry of Energy [MOE], 2011)
Smart meters	Enable two-way communication between consumers and utility companies; allow utilities to immediately know when and where there is a power outage, enabling faster restoration	(DOE, Office of Energy Efficiency & Renewable Energy, 2015c)
Solar photovoltaics [PVs]	Treated semiconductor material that converts solar irradiance to electricity	(DOE, Office of Energy Efficiency & Renewable Energy, 2015a)

Table 1. *Disruptive energy technologies.*

Consumers can exponentially improve the efficiency of their homes and appliances through in-home technology and easily accessible energy usage statistics. Being more energy efficient is the same as buying less utility-supplied electricity. The new suite of home appliances is constantly improving in energy efficiency thanks also to increasingly sophisticated and affordable technology. The same trend in energy efficiency is even more pronounced among high energy consumers in the industrial and large commercial sectors (World Energy Outlook, 2014).

Technical advances have also improved the efficiency of generation, reduced transmission and distribution losses, encouraged decentralised (i.e., distributed) generation, facilitated demand-side management (i.e., controlling the amount and time that consumers use power), and created viable new methods of electricity storage and clean generation using renewable sources (Martins, van Elburg, & Marias, 2015). At the same time, these new energy technologies are also becoming more affordable and accessible (World Energy Outlook, 2014).

Until recently, electricity could not be stored economically (Bronski *et al.*, 2015) – energy technology was simply too limited in this respect. Once electricity was generated, it had to be used immediately, or else transmitted to somewhere where it would be used. Today, increasingly viable, efficient, and economic forms of battery energy storage and other technologies abound. One highly visible example is the company, Tesla, synonymous with its founder and CEO, Elon Musk. Tesla's electric vehicles [EVs] and latest Powerwall offering are mobile and home-based batteries for electricity that can be generated, for example, in the daytime by the customer's own solar photovoltaic [PV] panels, or at off-peak times, when power from the centralised grid is significantly cheaper. Figure 3 illustrates when electricity rates are lower in the Ontario jurisdiction. The time-of-use [TOU] pricing scheme is identical across most electricity markets in Canada, the U.S., and Europe. Globally, the transportation sector has the fastest rate of expansion of electricity consumption, specifically because of the increasing popularity of plug-in hybrid and battery EVs (World Energy Outlook, 2014).

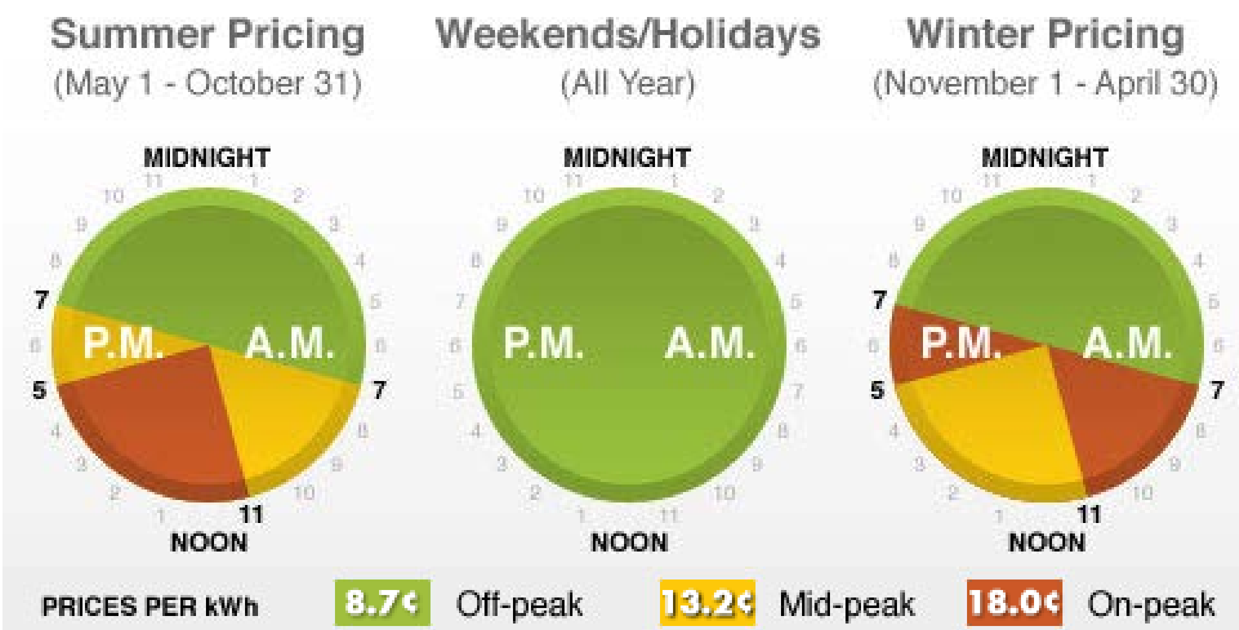

Figure 3. *Ontario electricity TOU price periods, (OEB, 2016).*

In combination with battery storage technology, the cost of solar PV panels to average residential and small business consumers are also dropping. From 2008 to 2013, the price of solar energy dropped by 80% (International Renewable Energy Association [IRENA], 2014). This means that energy customers are no longer compelled to purchase power exclusively from their local utility. They may choose to invest in their own generation technology (whether by solar PVs or a multitude of other options), thereby eliminating or curtailing their reliance on the centralised electrical grid. Distributed solar is predicted to present a particularly serious threat to utility profits (Kind, 2013). Within the next ten years, it is projected that alternative power options – led by battery storage and solar PV – will be on par with the grid (in terms of cost or service quality) in the states of New York, Kentucky, Texas, California, and Hawaii (Bronski *et al.*, 2015). This could indicate why U.S. utilities are seeing the pace of technology adoption by their customers increasing at "exponential rates" (Accenture, 2013).

1.3 Customer Challenges

Increasingly accessible and affordable energy technologies are empowering customers to curtail or entirely eliminate their reliance on the existing grid (Bronski *et al.*, 2014). Customers can now achieve personal energy independence (Lacey, 2015) from utilities. Toffler (1980) referred to this class of customer as the "prosumer" (p. 265) – those who blur the line between producer and consumer in any market.

Customers are expecting more from their utilities: more communication, more innovation, more reliability, more services, more value. These increasing expectations are largely fuelled by the increased choice and competition provided by new energy technologies. A series of studies by Accenture (2010-2014) describes the "New Energy Consumer" as more mobile, more informed, and more interconnected. They are less tolerant of power outages and slow reaction from the utility, demand innovative energy services as well as the traditional electricity product, and desire new avenues of engagement and more available information. For many utilities that still operate in uncompetitive, monopoly markets, this is a stark contrast from years past when they needed only to deliver an undifferentiated commodity to passive consumers at a reasonable rate. Now, unique customers increasingly expect a personalized portfolio of product and service offerings. If the utility cannot deliver, new competitors – distributed generators, energy service companies – will be able to offer better value propositions (Savenije, 2014).

Sustainability issues related to energy are also rising in prominence in the public mind frame. The People's Climate March and movement for transition to 100% renewable energy shows evidence that consumers want environmentally and socially responsible options (Heinburg, 2015).

1.4 Financial Challenges

The cost economics of electricity distribution which have been traditionally understood are also changing due to a multitude of factors. Demand for electricity in the U.S. is flat across the country, and for the first time, GDP growth has been decoupled from electricity demand growth (Savenije, 2014). Figure 4 (Hirsh & Koomey, 2015) shows that real GDP increased 41 percent while electricity consumption rose only 19 percent from 1996 to 2007. According to the findings of Hirsh and Koomey (2015), the commonly held belief that positive economic growth is strongly correlated with more electricity consumption is not accurate. A prediction about the future follows from this finding: utilities will not have a product that everybody, without fail, needs. This prospect is especially damaging for utilities that operate in non-competitive markets where their monopoly on electricity distribution and the rate (price) they set for their customers (ratepayers) is tempered by a government-appointed regulator. In other words, the mechanism for profit (electricity rates) is limited in regulated monopoly electricity markets. However, now that customers can conceivably choose not to buy the product (electricity) from the traditional provider (the electric utility), the traditional business model of the regulated monopoly electric utility ceases to be viable.

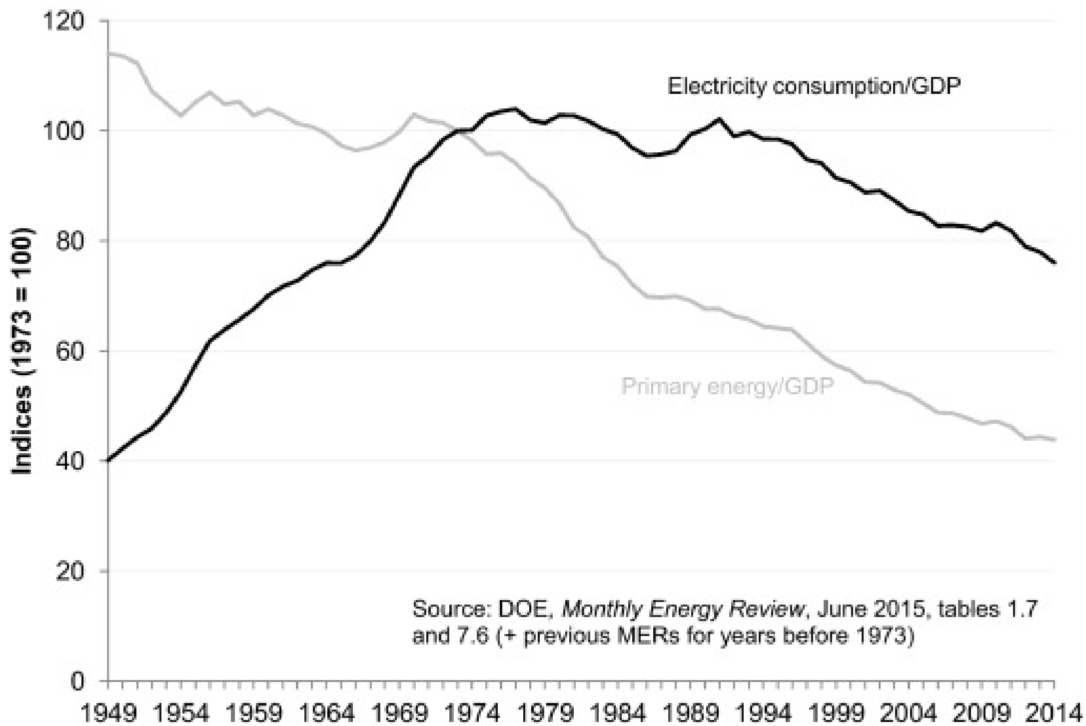

Figure 4. *Indices of ratios of U.S. primary energy consumption and electricity consumption to inflation-adjusted GDP, normalized to 1973 = 100, (Hirsh & Koomey, 2015).*

Utilities also have a pressing need to repair and renew their transmission and distribution infrastructure – the "poles and wires" that are used to actually deliver the commodity. Recent extreme weather events and the rise of distributed sources of renewable power are adding new stressors to the grid infrastructure (DOE, 2014). Since the world's first commercial power grid was constructed in lower Manhattan in 1882, the electricity delivery infrastructure has expanded and become more complex (DOE, 2014). It has safely, efficiently, and reliably delivered electrical power to millions of users across the North American continent, and it has done so without much technical change since the 1880s (Warshay, 2015). However, what has always worked will no longer be sufficient to meet consumers' changing energy demands. The aging infrastructure of the electric grid requires extensive upgrades to be effective into the future (DOE, 2014).

The increased cost of supporting a network that can integrate DG sources combined with the decline in electricity sales leads to a situation where more revenue is needed from a smaller pool of remaining ratepayers. This results in a corresponding increase in electricity rates (Felder & Athawale, 2014). The result of higher electricity prices and competitive threats is projected to further encourage customers to take on DG projects (Felder & Athawale, 2014). In the financial world, risks would erode credit quality, leading to a higher cost of capital, and putting further upward pressure on customer rates (Kind, 2013). The beginnings of this scenario may have already occurred: in May 2014, Barclays credit risk analysts downgraded the entire electricity industry based on the plausible competitive risk of solar PV and storage technologies (Aneiro, 2014).

"Stranded assets" (Weiner *et al.*, 1997) describes any capital investment that becomes obsolete ahead of its useful life, and must be recorded on the owner's balance sheet as prematurely depreciated assets. Stemming from the prediction of a shrinking customer base, this is the next stage of utilities' possible financial challenges with regard to their capital investments in electricity distribution infrastructure (Weiner *et al.*, 1997). When an electricity distributor is owned by a private corporation (e.g., Fortis Inc., the largest private utility owner in Canada) its shareholders pay for the capital investments, and these costs are usually passed on to their customers. When an electricity distributor is public, it often provides an important source of revenue to the government body that owns it. If the utility ceases to be a source of revenue and turns into an expense instead, the citizens of that government incur the burden of that expense through decreases in public services, higher taxes, and other cost recovery measures (e.g., higher rates on their electricity bills to pay down the debt of a stranded asset).

The most costly future scenario for utilities is perhaps also the most likely, according to academic and industry research (Khalilipour & Vassallo, 2015; Bronski *et al.*, 2015). Customers moving off-grid may choose not to sever their connection from that grid entirely. Rather, they may elect to preserve grid connection as a kind of insurance, while simultaneously minimizing electricity purchase in favour of PV and battery power (Electricity Currents, 2014). This partial energy independence would compel utilities to continue maintaining their costly electricity distribution infrastructure, while their primary source of revenue – actual electricity sold – gets increasingly smaller.

The combined effect of these financial challenges have been termed by some industry watchers (Bronski *et al.*, 2015, 2014; Pricewaterhouse Coopers [PwC], 2015; Lucas, 2015; Accenture, 2010-2014; Hannes & Abbott, 2013; Kind, 2013) as a "utility death spiral". The key assumption of the death spiral is that technology advancements would allow some customers to transform into prosumers and to leave the grid, thus spreading the cost of grid renewal and stranded assets over fewer customers and causing electricity prices to increase. The economic attractiveness of leaving the grid would increase for the remaining customers and would expedite further customer losses. This loop would continue like a spiral until collapsing the utility industry (Khalilipour & Vassallo, 2015).

1.5 Regulatory and Policy Challenges

The Barclays report of utilities' credit risk analysis states that technological change creates precisely the environment where slower-moving incumbents and their regulators can fall behind the curve, risking credit volatility, disrupting the regulatory compact[1], and possibly leading to unexpected losses for bondholders (Aneiro, 2014). Regulated monopoly utilities are "famously slow moving," and it is suggested that the greatest obstacle in the future of electric utilities is how they are regulated (Savenije, 2014). The current regulatory model was established in the early 1900s to provide universal access to that essential commodity, electricity. It does not permit utility

[1] *Regulatory compact:* The regulator's formal responsibility to balance the provision of reliable, reasonably-priced electricity with a fair level of profitability for the owners of the electric utility bears the risks and investments of providing electricity (Zade *et al.*, 2015).

companies to engage in business "behind the meter," nor does it reward risky investments in new technology or innovation (Szolgavaya, Golub & Fuss, 2014). Today's regulation gives very little incentive to utilities to evolve in the way society needs them to evolve (Savenije, 2014). Regulatory evolution is an essential part of the answer to how electric utilities could adapt to the challenges in the sector; the traditional utility regulatory models will not fit with the new imperative of change implied by the above challenges.

Regulatory forces are shifting to a more sustainable mindset partly in response to consumer demands and emerging technologies (Accenture, 2013), and, perhaps even moreso, in response to the direction established by government policy. At COP21, the most recent global climate change conference held in December 2015, national governments pledged to achieve major reductions in energy use and carbon emissions (Heinburg, 2015). Electricity and heat production accounts for 25% of total GHG emissions globally (Intergovernmental Panel on Climate Change [IPCC], 2014). Conservation, energy efficiency, and clean/green/renewable energy sources will play an important role in the integration of new technologies in electricity. For instance, the transition to a low-carbon power grid means that the grid must be able to absorb the intermittent inputs of renewable generation – which it currently does not have the full technical capacity to do.

1.6 Background Summary and LDC Focus

According to the Rocky Mountain Institute (Bronski *et al.*, 2015), the electricity industry is facing the greatest disruption in the grid's century-long history. The incumbent model of central generation and one-way electricity distribution to end-use customers out on the grid's distribution edge is proving increasingly outdated. Figure 5 summarizes the above discussion to provide a more concise list of some of the trends reshaping the distribution sector within the electricity industry.

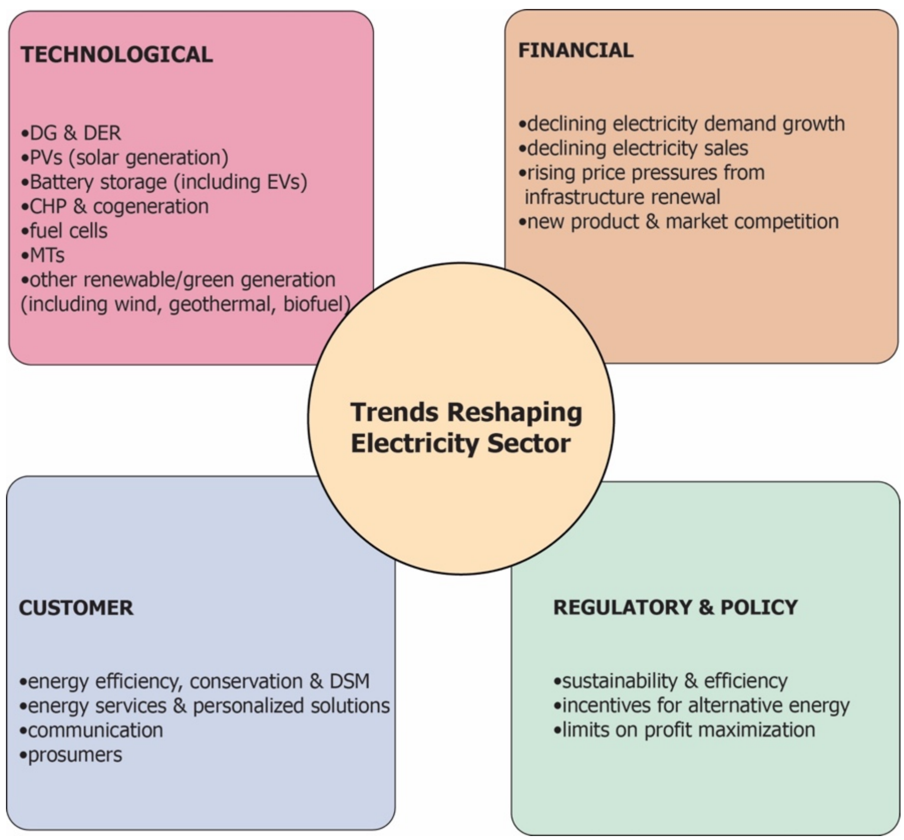

Figure 5. *Trends reshaping the electricity sector, adapted from Independent Electricity System Operator [IESO], 2015b, slide 10.*

An extensive review of the academic and industry literature (e.g., Bronski *et al.*, 2015; Pyper, 2015; Energy Council of Canada [ECC], 2015; Kofler, Netzer & Beuermann, 2014; H.H. Angus & Associates Limited, 2014; van der Hoeven, 2014; Accenture, 2010-2014; Aliff, 2013, Chu & Majumdar, 2012; Dubash, 2003) suggests that utilities (local electricity distributors) need to undergo a fundamental cultural shift in order to successfully adapt to various challenges emerging in the industry. The conversation has evolved from the recognition *that* things are changing, *what* those changes are, and *why* they are occurring, to now arrive at *how* societies and decision-makers should act to adapt to these changes. This thesis approaches the question of "how" specifically from the perspective of Local Distribution Companies [LDCs], in Ontario, Canada. Chapter 2.0 further elaborates on the reasons for this focus.

Research Objectives:

1. Contextualize LDCs in Ontario's electricity industry to understand its unique challenges.
2. Conceptually explain LDCs' institutional barriers to change and the potential for technological innovation to drive change via Künneke (2008) and Williamson's (1998) combined model of technology to institutions.
3. Answer key questions about future challenges and changes for LDCs via the informed judgements of sectoral experts.

Scope:

The scope of this thesis is restricted to top-level thematic discussion of the many and varied technologies, policies, trends, stakeholders, and institutions at play in Ontario's LDC world. The purpose of this approach is to illustrate the complex and multi-faceted nature of this vitally important sector. Detailed explanations of technology, history, policy, and economic principles are outside the scope of this thesis. These can all be found in more specialized reports and research from the respective disciplinary perspectives. Additionally, reports and researched authored by government, not-for-profit, and industry organizations are all important sources to be consulted. The challenges seen in the electricity industry are intensified by the rapid pace with which they are emerging and changing the traditional role of LDCs. Therefore, a comprehensive review of the sector necessarily includes materials that are published on a shorter turn-around time, and not always peer-reviewed.

Organization:

This thesis is organized into five chapters plus references and five appendices.

Chapter 1.0 introduces the impetus for the present study by discussing the challenges facing utilities and the electricity distribution sector at large. It concludes with the objectives of the study focusing on electric utilities in Ontario, Canada.

Chapter 2.0 reviews the academic and industry literature on Ontario's electricity distribution sector, with a focus on the historical and cultural development of LDCs, the unique challenges in their environment, and the reason for the present study with regard to ongoing dialogue on how LDCs should adapt to remain viable in the future.

Chapter 3.0 discusses the methods used to address the question of how LDCs should change. First, an explanation for the barriers to change based on an institutional theory of organizations is offered. Next, a conceptual model connecting institutional change with innovative technology is proposed as a way to ensure that LDCs can successfully adapt to the challenges in their sector. Finally, primary data for this study are collected using a two-stage, iterative survey to explore how sectoral experts think that LDCs should change to remain viable in the future.

Chapter 4.0 summarizes the results of the theoretical and survey research methods. Implications of the findings are discussed with regard to the question of how LDCs should change.

Chapter 5.0 concludes the thesis, outlines the study's significance and limitations, and explores opportunities for future research.

2.0 LITERATURE REVIEW

This chapter is organized into five separate themes which pertain to a comprehensive overview of Ontario LDCs. First, an introduction explains what these entities are and why they are important. Second, public, private, hybrid, and combination LDC ownership structures are summarized. Third, a historical review traces the origin and development of LDCs to their current form. Fourth, the challenges specific to the electricity distribution sector in Ontario are examined. Fifth, identification of a gap in our understanding of the different ways that LDCs could change, and the contribution of conceptual and expert-supported explanations of what the ideal change should be.

2.1 Introduction

Ontario is the largest consumer of all energy sources and commodities in Canada (Canadian Electricity Association [CEA], 2015). Ontario's electricity sector comprises generation, transmission and distribution of electrical power as well as several oversight, regulatory and integrating agencies (Clark *et al.*, 2014). Ontario's distributers and transmitters represent close to $27 billion in assets and are investing nearly $3 billion annually in new capital (Association of Power Producers of Ontario [APPrO], 2012). Electric utilities distribute electrical power from higher-voltage generators (e.g., Ontario Power Generation [OPG], Bruce nuclear plants) or transmitters (e.g., Hydro One) to the end user (e.g., individual residences, businesses – the ratepayers). These entities are called Local Distribution Companies [LDCs][2], and are the last step in the process from electricity generation to end user. Electricity can be generated in many ways, such as by large, centralised hydro and thermal plants (e.g., nuclear powered), by large amounts of moving water (i.e., hydroelectricity), and by other renewable or non-

[2] Interchangeable synonyms are distributor, local or electricity distributor, utility, local or electric utility, utility, distribution company (Elston *et al.*, 2012).

renewable fuels. The resultant power produced is then transmitted at high voltages through high-tension cables to centres of demand, where it is subsequently distributed through local networks, at lower voltages, to end-users (World Energy Outlook, 2014).

In 2015, about 70 LDCs delivered electricity to about five million customers (Clark *et al.*, 2015). They vary considerably in size (Table 2), as does their economic, political, societal, and environmental impact in Ontario LDCs. For instance, Toronto Hydro-Electric System Limited [Toronto Hydro] serves approximately 740,000 customers (Toronto Hydro Corporation, 2016) in the country's largest metropolis and financial centre. Its influence on provincial (and national) economic health and environmental degradation (or conservation) is many times more than that of an LDC located in a rural Ontario community that serves less than 1,000 customers. Figure 6 illustrates the largest LDCs in the province as a percentage of the total number of customers. Ontario has a preponderance of small LDCs, with about a third of them serving less than 4 percent of the population (Elston *et al.*, 2012).

Small	Under 12,500 customers
Medium	12,500 to 100,000 customers
Large	100,000 to 500,000 customers
Extra-large	Over 500,000 customers

Table 2. *LDC sizes, (Elston et al., 2012).*

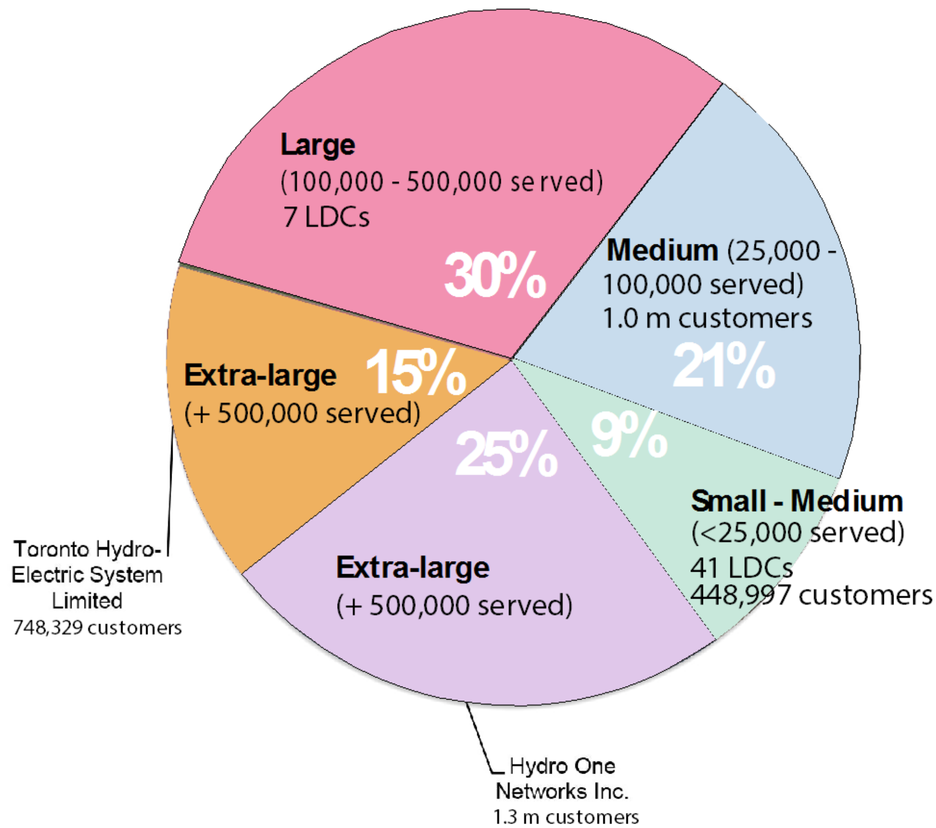

Figure 6. *Percentage of distribution customers, total = 4,988,859, (OEB, 2015b).*

While there has been much research conducted about the challenges facing electric utilities in the United States, an empirical investigation of Ontario's electricity distribution sector is still rare. In a very recent study commissioned by MaRS energy tech incubator (affiliated with the University of Toronto), Chicago-based global management consulting firm, Navigant, finds that grid parity for residential or commercial solar installations could occur in Ontario within the next five to ten years (Figure 7). This study is the start of much-needed data specific to Ontario LDCs, but there is much more work to be done. There is a dearth of hard data for reliable projections of grid parity, grid defection, and load defection in Ontario. It cannot therefore be said conclusively that the challenges for LDCs are certainly equal to the situation in United States. However, this provides more motivation for potential problems in the sector to be addressed proactively and collaboratively.

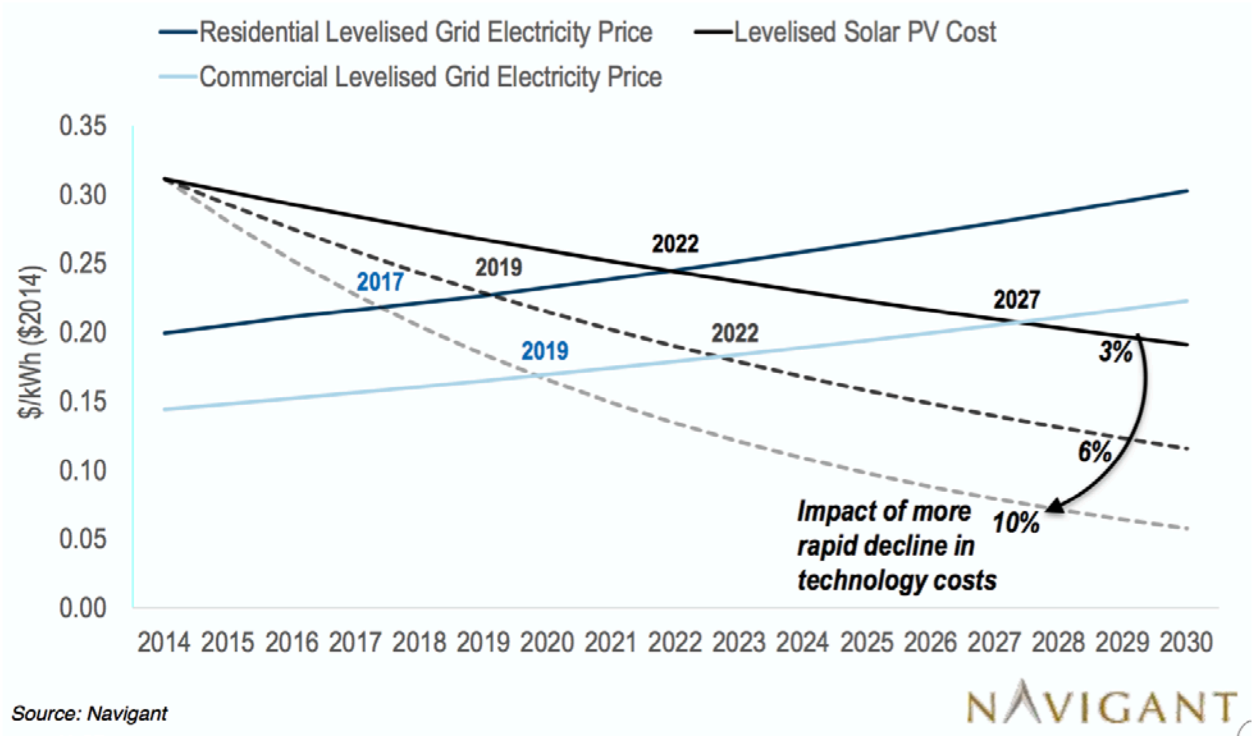

Figure 7. *Ontario grid parity projections from Navigant Consulting, (Dizy, 2016).*

2.2 LDC Ownership

"Public" utilities are those owned by government. Ontario's municipal governments own the majority of LDCs. The provincial government currently owns about 85 percent of Hydro One[3], the largest LDC (serving about 1.3 million customers located primarily in rural communities) and also the main electricity transmitter in Ontario (accounting for 97 percent of total high-voltage transmission capacity) (Elston *et al.*, 2012). Some utilities are also fully or partially "private." FortisOntario, a subsidiary of Newfoundland-based, Fortis Inc., is currently the largest private owner, with interests in Algoma Power Inc., Canadian Niagara Power Inc., Cornwall Electric, and Eastern Ontario Power (FortisOntario, 2016). A number of pension plans have also purchased

[3] The Government of Ontario is in the process of selling 60 percent of its ownership stake in Hydro One's distribution business to private investors. The Hydro One IPO will be discussed in further detail below.

partial ownership interests in LDCs (e.g., the Ontario Municipal Employees Retirement System [OMERS] owns 10 percent of the Mississauga utility, Enersource) (Elston *et al.*, 2012).

The Premier's Advisory Council on Government Assets ("the Council") was appointed in April 2014 to find ways to maximize revenue and returns from key government-owned assets including the Hydro One transmission and distribution utility, and OPG, the electricity generator. One of the Council's most publicized and controversial recommendations was that the province should "dilute its interest" (Clark *et al.*, 2015) and "broaden the ownership" (MOE, 2015) of Hydro One's distribution business. Following recommendations from the Council in April 2015, the government announced its intention to sell sixty percent of its shares in Hydro One's distribution entity. The initial (Clark *et al.*, 2014) and final reports (Clark *et al.*, 2015) of the Council outline several points supporting this recommendation, and address both short and long-term costs and benefits, mitigating against unforeseen consequences of ownership dilution, and sensitivity to labour issues during the transition. Ultimately, they argue that diluting the Province's ownership in the distribution business of Hydro One will enable efficiency savings for electricity ratepayers, introduce additional private-sector capital into the distribution system, and generate productivity improvements. Hydro One's first IPO took place in November 2015, selling 13.6 percent of the company to private investors, and raising $1.83 billion that the government states will be dedicated to fund transit and infrastructure development, and to pay down their debt. According to the Council, their recommendations are in line with the core conclusions of the Ontario Distribution Sector Review Panel, whose December 2012 report, *Putting the Consumer First* (Elston *et al.*, 2012) integrated submissions from several LDCs, among several other influential organizations in the space (p. 44-45). Implementation is cited as the point of disagreement amongst LDC decision-makers, not the ideas about how to renew the sector itself.

However, there has been vocal disagreement from government watchdogs and citizens' groups (Keep Hydro Public, 2016) on the Hydro One privatization decision: Hydro One has provided a reliable revenue stream averaging $913 million per year to the province since 2000. Privatization will cause the cost of electricity to customers to increase, and available evidence does not show that privately-owned utilities are more efficient than publicly-owned ones. In *An Assessment of the Financial Impact of the Partial Sale of Hydro One* (2015), the Financial Accountability Office of Ontario [FAO] stated that the privatization will have a negative impact on the province's finances in the long-term, although it will secure a large short-term revenue injection.

2.3 History

The current electricity distribution system in Ontario has been formed by historical events, and not necessarily by deliberate decision-making with long-term goals and data support (Office of the Auditor General [Auditor General], 2015; Winfield et al., 2010). For this reason, the Report of the Electricity Sector Review Panel (Elston *et al.*, 2012) proposes that the "heavy hand of history" (p. 16) could undermine the future viability of the sector. If it is true that LDCs are the product of history rather than the outcome of rational planning (Elston *et al.*, 2012), how did the sector come to be this way, and how should LDCs change to adapt to the upcoming challenges? Understanding the history of the electricity distribution sector can help to bring about proactive, instead of reactive change. If challenges are foreseen, LDCs decision-makers and other key players in the sector have the knowledge to act before the impacts of those challenges are felt, and they can potentially benefit from the new form that the sector is taking (Gummesson, 2000).

The province’s electricity distribution sector was created in the early 1900s to support the growing economic prosperity of Ontario’s largest communities (Toronto, Kitchener, and London, among others) (Biggar, 1920). The Hydro-Electric Power Corporation [HEPC] was created by the provincial government in 1906 to in response pressure from community politicians and business leaders, and set about building the large electricity generation plants and extensive transmission infrastructure (“poles and wires” in industry parlance). Over the years, increasing economic prosperity enabled the founding and growth of several other municipalities, all of whom needed connection to the electrical grid, and therefore established their own municipal electricity utilities [MEUs] to act as the conduit for delivery and billing end users (Freeman, 1996).

The electricity system was a vertically integrated monopoly (Winfield et al., 2010) in which the HEPC held singular authority to plan, build, and operate electricity generation, transmission, and distribution systems. In 1974, it was reconstituted as a crown corporation known as Ontario Hydro (Denison, 1960). In 1996, the Advisory Committee on Competition in Ontario’s Electricity System (“the Committee”) recommended that Ontario’s then 307 MEUs should merge in order to lessen the number of utilities, and to establish geographically-contiguous distribution systems (i.e., where no distributors are embedded inside another distributor’s territory) (Macdonald *et al.*, 1996). The Committee also proposed that Ontario Hydro be broken up into separate generation and transmission companies (Macdonald *et al.*, 1996).

Many changes occurred in Ontario’s electricity distribution sector under a Progressive-Conservative provincial government in 1998. Passing of the Energy Competition and Electricity Acts (collectively referred to as the ECA) resulted in the break-up of Ontario Hydro into separate, smaller companies individually responsible for generation (OPG), transmission and rural distribution (Hydro One), and distribution in Ontario’s more densely populated areas by the new LDC entity (CEA, 2015). The ECA also mandated a number of other structural changes toward competitive electricity markets along the lines of the Commission's recommendations. LDCs were charged with an obligation to sell electricity to deliver safe, reliable, and reasonably priced power to everyone connected to the grid (Canada Energy, 2015). Rates would be subject to regulated price controls in the interest of protecting consumers buying an essential commodity (electricity) from a single (monopoly) provider (OEB, 2015c). LDCs were also required to encourage and facilitate energy conservation, DSM (by influencing the amount and times that electricity is demanded by users), and renewable energy integration. All these requirements would negatively impact the traditional LDC business model and their bottom line. Therefore, the ECA promised to financially compensate LDCs for the potential loss of revenue (Canada Energy, 2015). This consideration was particularly important because, at this time, LDCs also underwent a legal transformation from local government commissions to business corporations (Canada Energy, 2015). This meant that they were able to generate profit and be a source of revenue to their owners – often, municipalities (Farbridge, 2015).

The ECA prompted a period of numerous mergers and acquisitions among MEUs, resulting in a major reduction in the number of utilities from 307 to 89 (Freeman, 1996). Though improved from this policy, a persistent geographic separation (non-contiguity) of LDC service territories continues to mark the provincial landscape (Figure 8). LDCs' messy geography is seen to be a remnant of their cities' pre-amalgamation borders; a product of history rather than rational planning (Elston *et al.*, 2012).

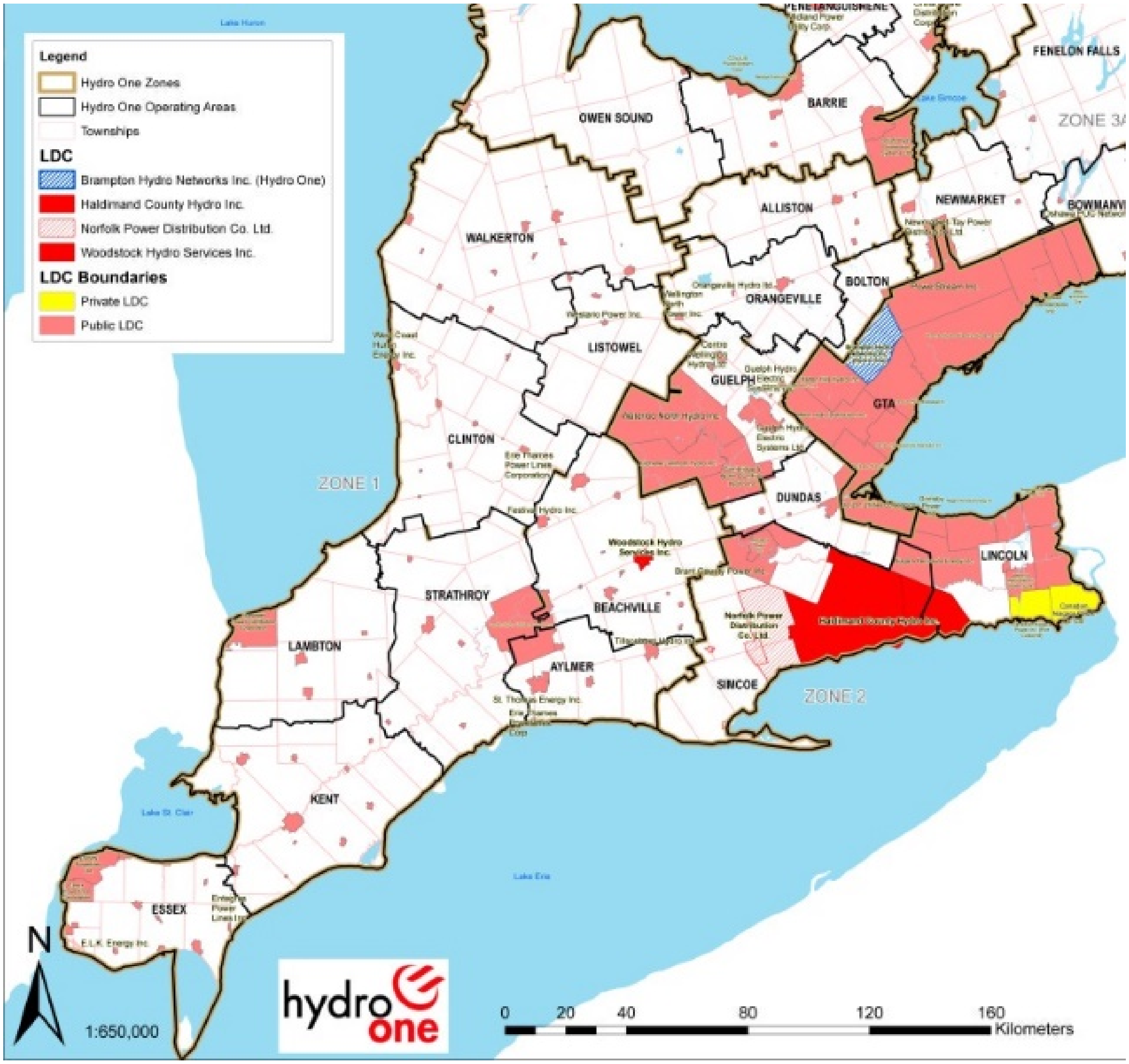

Figure 8. *Discontiguous LDC service territories (southwestern Ontario only), adapted from Hydro One, 2014.*

Although electrical power is an essential commodity, it also leaves LDCs open to the risk of undiversified revenue (Daniels, 1996). In other words, they have put "all their eggs in one basket." LDCs are dependent on the generators of high-voltage electricity that is their single marketable product. Provincially-owned OPG is responsible for about half of all the electricity generated (OPG, 2015) and privately-owned Bruce Nuclear provides roughly one-third (IESO, 2015). All LDCs are reliant upon these two largest generators, and there also multiple smaller generating entities creating electrical power from natural gas, hydro, wind biofuel, and solar sources (IESO, 2014).

The Ontario Energy Board [OEB] was originally established in 1960 (OEB, 2015c). In 1998, it evolved into a quasi-judicial administrative tribunal with the specific authority to regulate[4] the electricity in sector in the public interest (Hewson, 2015). The regulator's legislated authority over the prices that for-profit LDCs[5] are allowed to set on electricity was meant to ensure that consumers and industry pay fair and reasonable rates for an essential commodity and public good (OEB, 2015c). While providing conditions under which LDCs could continue to enjoy reasonable financial returns, the regulator protected the consumer in lieu of competitive market dynamics (Taylor, 2015). LDCs enjoyed monopoly status in electricity distribution because alternative did not historically exist in Ontario (Warren, 2015). The OEB has a mandate of five objectives (Ontario Energy Board Act, 1998) in its role as the electricity regulator:

1. To protect the interests of consumers with respect to **prices** and the adequacy, reliability and quality of electricity service.
2. To promote **economic efficiency** and **cost effectiveness** in the generation, transmission, distribution, sale and demand management of electricity and to facilitate the maintenance of a **financially viable** electricity industry.
3. To promote electricity **conservation and demand management** in a manner consistent with the policies of the Government of Ontario, including having regard to the consumer's economic circumstances.

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[4] *Regulatory governance:* The role and powers of regulatory agencies, and their relationships with ministries, parliaments and courts who oversee them, i.e., how and by whom regulatory policies are made (Holburn, 2011).
[5] *Utility governance*: The structure of relationships between utilities and their government shareholders, and the respective roles of utility boards of directors, executive officers, and government ministers (Holburn, 2011).

4. To facilitate the implementation of a **smart grid** in Ontario.
5. To promote the use and generation of electricity from **renewable energy sources** in a manner consistent with the policies of the Government of Ontario, including the timely expansion or reinforcement of transmission systems and distribution systems to accommodate the connection of renewable energy generation facilities.[6]

Two out of these five objectives are concerned with the OEB's responsibility to control the cost of electricity, and the resultant regulatory regime reflects this. Regulation in the electricity distribution sector has historically discouraged new ventures of all sorts because they are, by nature, more uncertain, more costly at initial adoption, and have lower quantifiable returns if related to service improvements (Angen & Jeyakumar, 2015). Risky ventures and uncertain investments ultimately increase costs to the end users, especially in cases of failure or underperformance, and were therefore not in line with the OEB's objectives. Risk-taking behaviour was actively discouraged by the regulatory regime in various ways. Regulated utilities were only permitted to increase revenue through regulated rates. Adding capacity to the grid (i.e., by investing in more capital infrastructure) guaranteed greater financial returns for LDCs than concentrating on emerging technologies, service, conservation, or demand management. In an environment where customer demand is inelastic and growing, and cost control is the primary expectation from all stakeholders, the risks of uncertain business ventures cannot be justified.

Winfield *et al.* (2010) describes how the challenges for Ontario's electricity distribution system started to become more pronounced between the mid-1990s to early 2000s. Ontario Hydro had accumulated $38 billion in debt due in large part to expensive

[6] emphasis added

construction projects of nuclear generation plants. Increased emphasis on coal-fired generation led to unhealthy concentrations of air pollution and greenhouse gas [GHG] emissions, causing measurable degradation of human and environmental health. By the end of 2003, cost pressures on the system were significantly increased because most of the province's electricity generating plants were nearing the end of their useful lives. In addition, Ontario's season for peak electricity demand had shifted from winter to summer (Table 3), as space heating became increasingly powered by natural gas, and electrical air conditioner usage shot up. Summer peaks were also higher and more difficult for the aging system infrastructure to meet. The serious economic and social consequences of system unreliability can be seen in events like the major blackout across eastern North America in August 2003.

Season	Normal Weather Peak (MW)	Extreme Weather Peak (MW)
Winter 2015-16	22,360	23,261
Summer 2016	22,649	24,623
Winter 2016-17	22,378	23,355

Table 3. *Seasonal peak demand summary, (IESO, 2015, p. ii).*

The Electricity Restructuring Act, 2004 formally established a "hybrid" electricity market, with elements of market-based, competitive dynamics within a centralised, regulated monopoly model (IESO, 2009). The development and implementation of a technical electricity power system plan with a 20-year horizon (called the Integrated Power System Plan [IPSP]) was also mandated to guide the province in achieving its energy goals and to protect the interests of electricity consumers (Auditor General, 2014). Electricity power system planning involves the management of long-term demand for electricity and decision about how to meet that demand through various generation, conservation, and transmission solutions. An enormous amount of technical planning is required for Ontario to determine how it will meet its future electricity demands (Auditor General, 2014). A frequent criticism, especially from business, industry, and some spheres of academia and policy research, is that restructuring efforts over the sector's history have been misguided and not supported by adequate empirical research (Cronin & Motluck, 2006). As recently as January 2015, the responsibility of system planning and producing the IPSP underwent another significant retooling, when the IESO amalgamated the Ontario Power Authority [OPA]. The IESO now has full jurisdiction of the technical details of the MOE's policy direction for Ontario's electricity sector (Auditor General, 2014). The Government of Ontario has the power to use energy policy to achieve various political ends, such as job creation, economic development, social welfare, and environmental protection. It is usually represented by the decisions of one person, the sitting Minister of Energy. The Government also appoints board members of all the other institutions that influence LDCs: the OEB, OPG, the IESO, and Hydro One (OEB, 2015c).

The Green Energy and Green Economy Act [GEGEA], 2009 aggressively encouraged renewable generation integration into the system (Winfield et al., 2010), energy conservation (Love, 2015), and the creation of clean-energy jobs (Auditor General, 2015). The GEGEA included provisions for wind and solar PV-generated power, on both smaller and larger scales, through a new guaranteed-price program called "FIT," which stands for feed-in tariff (MOE, 2013a). It also gave the Minister of Energy the authority to expedite the development of renewable energy by superseding many of the government's usual planning and regulatory oversight processes. Proponents of the FIT program argued that it can support successful industrial development while limiting costs to ratepayers and integrating safer, cleaner technologies (Winfield & Dolter, 2014; Greenpeace, 2010). While the IESO (2014) reports that renewables now form a much greater proportion of Ontario's electricity supply mix (Table 4), the Auditor General's report (2015) found that this occurred without a comprehensive business case analysis and to evaluate the impacts, trade-offs, and alternatives of renewable energy sources (p. 225). Critics of the FIT program have argued that it will not create jobs, will raise unit production costs, and diminish competitiveness (Winfield & Dolter, 2014). The provincial government is criticized for making major energy policy decisions via directives to OPG, the OEB, the IESO, and Hydro One, without sufficient evidence of consideration of long-term effects, eventually costing taxpayers billions of dollars in electricity overpayment (Trebilcock & Hrab, 2005). The FIT program for projects over 500 kW was terminated in May 2013, largely over cost concerns (Winfield & Dolter, 2014).

Electricity Sources	Ontario's Electricity Mix
Water power	24.1%
Alternative power sources	7.1%
Solar	1.1%
Wind	4.9%
Biomass	1.0%
Waste	0.1%
Nuclear energy	60.0%
Natural gas	8.7%
Coal	0.1%

Table 4. *Ontario's system-wide electricity supply mix, (IESO, 2014).*

Renewable energy policies entrenched in the overall reform of Ontario's electricity sector initiated by the GEGEA also took many other forms. One of the most widely publicized of these was the phase-out of coal-fired electricity generation. In 2014, Ontario became the first jurisdiction in North American to fully eliminate coal as a source of electricity generation, thereby improving air quality and environmental health, and reducing GHG emissions (MOE, 2016a). The Government of Ontario emphasizes this as a significant step in the fight to mitigate global climate change (MOE, 2016b), and indeed, many organizations point to Ontario as an example of what could be achieved (Harris, Beck & Gerasimchuk, 2015). At the same time, criticisms abound that the elimination of coal-fired generation has been a disproportionately costly undertaking that did not secure the greatest possible reduction of GHGs (e.g., as compared to restructuring mass transit and discouraging the use of cars) (Auditor General, 2015). While coal was eliminated by this initiative, natural gas power doubled (McGillivray, personal communication, 2015). While natural gas is a "cleaner" fossil fuel than coal, Ontario's net GHG emissions stayed the same.

The same criticism applies to another government directive to install province-wide smart-meters (i.e., electricity meters equipped with two-way information and communication technology), which are intended to provide more accurate TOU data, and therefore help control DSM of electricity. The Auditor General's report (2014) called the smart-metering policy an almost $2 billion investment for which the financial benefits had not yet been seen. Short-sighted government decisions about the above, and other aspects of electricity system planning are seen to be costing ratepayers billions of extra dollars (Lara & Nathwani, 2014). Aggressive renewable energy policy in Ontario has subsequently retreated in the wake of criticisms against the GEGEA and other directives from the Minister of Energy.

2.4 Challenges in Ontario's Electricity Distribution Sector

Figure 9 shows that electricity prices in Ontario are tending toward the high end, compared with similar markets in other parts of Canada and the U.S. Figure 10 breaks down the components and trends that determine the overall electricity price further. It shows that the Hourly Ontario Electricity Price [HOEP] portion of the energy cost on the customer bill has decreased significantly, but the Global Adjustment [GA] has risen (IESO, 2009). The GA is a regulatory mechanism designed to make up the financial difference between the market price and the regulated contract price paid to electricity generators (Spears, 2014). It was first introduced in 2005 as a net *credit*, but has since reversed to an *expense* as the market price of electricity dropped and system maintenance costs increased (Holmes, 2015). According to the Ontario Chamber of Commerce [OCC], rising electricity prices could jeopardize the province's overall economic growth. As advocates for business priorities in the provincial legislature, they state that low rates are part of the package that businesses look for when considering where in the world to do business (p. 2). Thus, there is a growing risk that investment will bypass Ontario for other jurisdictions (p. 4).

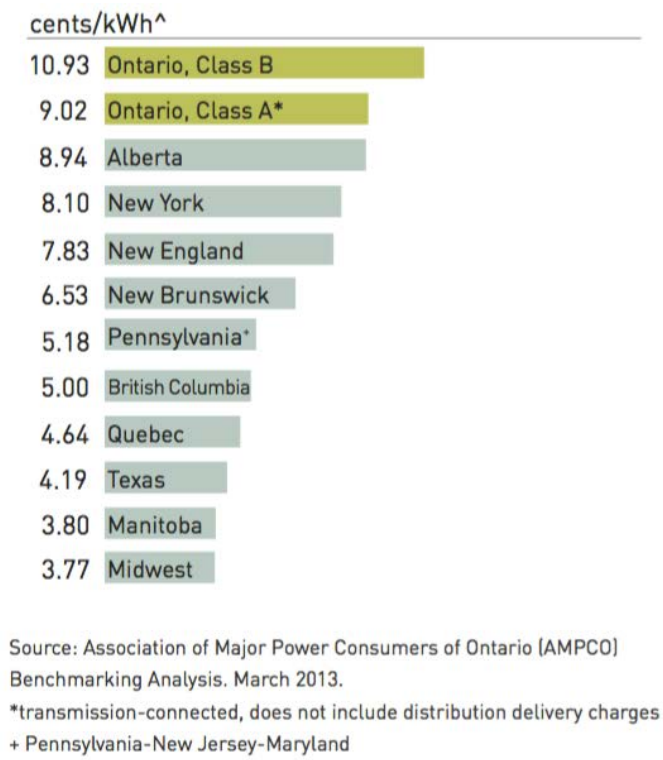

Figure 9. *2013 comparison of industrial electricity rates by province and U.S. state, (Holmes, 2015, p. 4).*

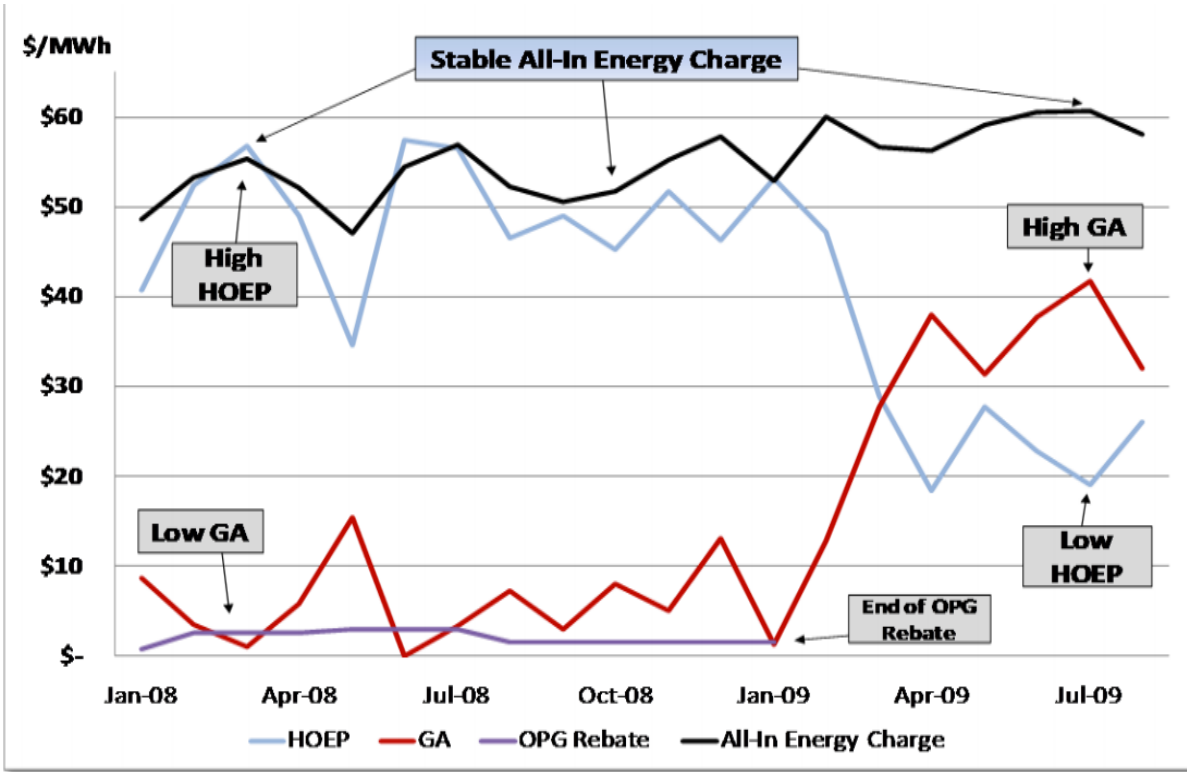

Figure 10. *HOEP decline vs. GA growth over time, (IESO, 2009, slide 5).*

Apart from the GA, a second major reason for rising electricity prices is Ontario's aging distribution infrastructure and its impact on system costs. Existing network components are unable to accommodate new technology advancements (e.g., smart grid, DES), and will undergo a period of significant asset renewal over the coming decades (McCarthy, 2015; Melville, 2015). There has been a consistent underinvestment in all infrastructure relative to needs over the twentieth century – from electricity and water distribution, to transportation (CEA, 2014). The Conference Board of Canada [CBoC] (Baker *et al.*, 2011) estimates that it will cost about $20.6 billion[7] to renew and transform Ontario's electricity distribution infrastructure over 20 years (2010 to 2030) (p. 23). Many large electricity generation plants will also be reaching end of life by the year 2030, and

[7] Total projected distribution investments in Ontario are $20,602 million ($16,636 million sustaining costs plus $3,966 million growth costs) over the 20-year period examined (Baker *et al.*, 2011)

decisions will have to be made about extending their service mandates, replacing them with renewable energy or some other form of generation, or a combination of both (Melville, 2015).

In Ontario, as in other jurisdictions, consumer demand for electricity is falling, and most of the system infrastructure is oversized to deal with the highest daily and annual levels of demand – which do not exist all day or all year (Sioshani, 2012). The growing prevalence of residential and commercial energy conservation, and the decline in energy intensive manufacturing, means that Ontarians do not want or need so much power (Holmes, 2015). From 2003 to 2014, the province's energy demand dropped by 8 percent (OPA, 2014), and from 2005 to 2013, the provincial GDP rose by 9 percent while electricity demand fell 10 percent (Ontario Clean Air Alliance [OCAA], 2014). Electricity distribution capacity is costly. If it is also underutilized, how "essential" could the product provided by LDCs really be? There is clearly a need to re-examine these "taken-for-granted" (DiMaggio & Powell, 1983) beliefs which may no longer be true.

The retirement of Ontario's coal-fired generating plants in 2014 had two major implications with oppositely perceived impacts on the electricity industry. On one hand, it was a major advancement in the government's plan to build a cleaner, greener, and healthier energy future (MOE, 2016b). On the other hand, many studies also point to the combined effect of coal plant shutdowns with expensive renewable energy integration as a primary reason for the high cost of electricity in Ontario (Holmes, 2015). In terms of reductions in air pollutions emission (e.g., GHGs, nitrogen oxide [NOx], sulphur dioxide [SOx], particulate matter [PM], and mercury [Hg]), coal plant shutdowns have been compared to taking up to seven million cars off the road (MOE, 2016a). Ontario's contribution to global climate change mitigation has pioneered the elimination of coal-fired generation (Harris *et al.*, 2015). Therefore, debates about electricity generation in Ontario centre less on coal and climate change, and more on the viability, cost, and security of nuclear power, natural gas, and renewable energy integration (Greenpeace, 2015). However, renewable sources of power are not yet technologically or economically feasible (Dewees, 2012).

The regulatory environment of electricity in the province determines what LDCs must offer, can offer, and are prohibited from offering (Pyper, 2015). Under the traditional regulated rate regime, LDCs earn greater financial returns when they were able to deliver more reliable power to more people, and several factors prevent or discourage them from stepping outside their traditional roles (Swift & Stewart, 2009). LDCs would enjoy limited gains in either competitive advantage or shareholder returns from non-traditional business ventures; the risks of innovation far outweigh the potential benefits (Angen & Jeyakumar, 2015; Schaltegger & Wagner, 2011). The risk profile of an innovation business model directly opposes the conservative, low-risk culture and competencies that LDCs have cultivated since their inception (Daniels, 1996). The clear incentive has been to build more infrastructure, and to expand the reach of their systems. As legislated monopolies unchallenged by competition, providing an essential public good, and benefitting from inelastic consumer demand, utilities had guaranteed revenue growth because they were the sole delivery agents of an essential and undifferentiated commodity (Lara & Nathwani, 2014).

However, as cost and competitive dynamics in the sector are shifting as a result of new technology entrants, rising customer expectations and falling demand, policy shifts, and greater capital expenditure needs, many are wondering how the profit advantages of LDCs' protected monopoly status can be justified (Swift & Stewart, 2004; Daniels, 1996). Indeed, recent direction from both the regulator and government indicate that they cannot. A Renewed Regulatory Framework for Electricity [RRFE] (OEB, 2012b), released in October 2012, was a major nod from the OEB in recognition of the challenges in the sector. It is a shift to a more flexible, performance-based (as opposed to prescriptive) regulatory model for the sector, and emphasizes customer service, operational effectiveness, good public policy, sustainable financial performance, and long-term regional energy system planning in a concertedly different manner than past regulatory regimes (APPrO, 2012). In 2013, the Ministry of Energy released their direction-setting reports on energy policy: *Conservation First: A Renewed Vision for Energy Conservation in Ontario* (MOE, 2013a), and *Achieving Balance: Ontario's Long-Term Energy Plan* [LTEP] (MOE, 2013b). Both confirm that expanding energy demands must be met through gains from conservation, rather than by building new distribution infrastructure and generating more electricity. The government has also pointed to challenges stemming from the problem of too many distributors. The current system is described as fragmented and inherently unable to adapt to the changing environment. There are too many entities in the system, some of which are highly inefficient and lack capital to modernize or consolidate (Clark, 2014; Fyfe, Garner & Vegh, 2013).

2.5 Change and Dialogue

In reviewing the many challenges facing the electricity industry in general, and specifically in the province of Ontario, there is a consensus that the strategies implemented today will determine the direction and continued viability of the electric utility in the near future. The Pembina Institute (Angen & Jeyakumar, 2015) proposes three broad categories where diversified, modernized service offerings and business models from utilities could be the answer. First, clean technology and distributed generation recognizes a growing public interest in the transition to greener sources of energy and to reduce energy consumption. The report states that leading-edge utilities are beginning to offer services that include microgeneration, EV charging infrastructure, energy storage, and energy efficiency.

Second, information and system management is improving with better collection and utilization methods. Understanding and influencing change in energy consumption behaviour is transformed with improved data access (e.g., from smart meters), fault detection and mitigation, demand response (which can be adjusted from the utilities' side instead of dictated by millions of users).

Finally, utilities are improving their customer service to target the needs of individual homeowners, commercial entities, municipalities, and even other utilities. They are exploring what types of value-add services they can provide that enable other actors, they engage customers in pilot projects, and are redesigning asset ownership and capital investment models.

From the perspective of the Government of Ontario, via the *Initial Report of the Premiers' Advisory Council on Government Assets* (Clark *et al.*, 2014), private sector capital, rather than public funds, should be used to support the required consolidation of LDCs. Further, barriers and incentives (such as taxes), which impede consolidation, should be lifted.

The OCC (Holmes, 2015) believes that lowering and controlling the cost of electricity should be the primary objective of change, and will ensure that the province is an attractive location for continued and future business investment. It outlines five final recommendations to this end: increase transparency of electricity pricing and system cost drivers; keep the Debt Retirement Charge on residential bills until it has been retired; incentivize voluntary consolidation of LDCs through multiple channels; move away from a central procurement model to a more competitive capacity market structure; and unlock the power of smart meter data by capitalizing on meter data analytics at a province-wide level.

Taking a more social and environmentally-conscious slant to change, QUEST – Quality Urban Energy Systems of Tomorrow (Campbell & Laszlo, 2014), focuses on how utilities need to support and enable smart energy communities. Encompassing but going beyond an exclusive consideration of economic competitiveness, smart energy communities equally look at efficiency, reliability, and GHG emissions. Instead of providing an individual energy service (i.e., electricity) LDCs should advance a more integrated and holistic view of energy at the community level by integrating conventional energy networks, supporting smart land use decisions, and harnessing local energy opportunities.

2.6 Literature Summary and Gap

The aim of the literature reviewed for this study has been to outline how LDCs came to be the way they are and what changes are occurring and not occurring in their unique environment (i.e., Ontario's electricity distribution sector). Research about this area is vital and actively evolving. Excellent work from academia, as well as industry, not-for-profit, governmental organizations, and popular media commentary has also been produced on the past, present, and future conditions of electricity distribution and energy in general in the province, the country, and on a global scale. The speed with which the sector is evolving makes it practically impossible for academic and peer-reviewed research to keep pace with the cutting-edge developments, and therefore necessitates the review of many diverse types of sources in order to capture a moderately clear picture of the current state of affairs.

A number of studies and reports propose different ways for how LDCs could adapt to the challenges they are facing, but there is a need for ongoing dialogue between decision-makers and influencers with expertise in LDC issues. This is because of the rapid pace of change in the sector, the tendency of LDCs toward inertia and risk aversion, and the serious economic, social, and environmental consequences (for LDCs' own viability and for the province at large) of inaction or short-sightedness. Whatever the eventual combination of changes that individual LDCs and the electricity distribution sector at large implements to adapt to the upcoming challenges, the development and execution of the right business strategy is a shared responsibility between LDC management, the board, and their shareholder (Farbridge, 2015). This demands a continuous dialogue between all three players.

The gap in our understanding of the challenges facing LDCs stems from present and past forces. At present, the rapid pace of development in the technological, customer, financial, regulatory, and policy environments of Ontario's electricity distribution sector are disrupting traditional knowledge about how LDCs can and should operate. Historically, institutions in the sector have played an important part in compelling LDCs to cultivate a risk-averse and change-resistant culture that will not be viable in the face of these challenges. The gap in our understanding of the changes needed for LDCs to successfully adapt to the challenges stems from present and future choices. Today, there are a diversity of opinions among LDCs and their influencers about how the sector should change. To ensure the continued viability of these companies, technological innovation will be the primary driver of the institutional change needed to remove historically and culturally embedded barriers to change.

The contribution of this thesis corresponds to these gaps. First, it explains how institutional forces have created barriers to change for LDCs. Second, it proposes the idea that institutional change can be driven by technological innovation. Third, it supports this idea through an iterative survey of sectoral experts about how LDCs should change. These experts first address key questions about the future for LDCs independently, then revisit the issues in a second survey with more knowledge about the other respondents' opinions in order to construct an anonymous dialogue between all key players.

3.0 METHODS

This chapter describes the methods selected to address the gap in the literature which this study aims to fill. The overall issue of challenge and change is explored conceptually from an institutional theory lens. The rationale for using an institutional theory framework to explain the problems and the path forward for LDCs is in the way it can integrate historical and present-day forces to predict the future of these important companies. Künneke's (2008) modified model connecting technological innovation and institutional change provides a valuable starting point for LDCs looking to identify the best way to ensure their continued viability. The final method is a two-stage survey of energy experts attending Ryerson University's "LDC of the Future" conference on June 3rd, 2015.

3.1 Framework: Institutional Barriers to Change

> *Long-term thinking may be hampered by institutions which, owing to their origin in a different time, 'have long frozen all human relationships into patterns and customs and law which resist change not because of conservative tradition or evil intent but because of rigidities inherent in the structure of every order.'* (Farbridge, 2015 from Leopold Kohr, *The New Radicalism* [1967])

In attempting to conduct a valuable study about the future for LDCs, the accuracy of forecasts, or predictions about the future is closely related to the institutional, temporal, and historical contexts in which forecasts are made (Dunn, 2012), therefore necessitating a brief discussion of a plausible theoretical perspective that could help to explain LDCs current state of affairs. One way of understanding organizations' or individuals' actions is through the lens of institutional theory (also called institutionalism) (Lawrence & Suddaby, 2006). It has been one of the most influential theories developed in recent decades seeking to enhance our understanding of organizations' structure and actions

(Oliver, 1991). It offers an alternative understanding of the world from that of neoclassical economics, which says that organizations and individuals are primarily rational actors concerned with maximizing utility and profit. Organizations are social units of people that are structured to meet a particular need and have a shared goal (DiMaggio & Powell, 1983). The institutional perspective states that they are not one-dimensional economic actors; rather, their decisions are also strongly influenced by socio-political, geopolitical, and environmental forces, among others (Tolbert & Zucker, 1996). These powerful influences are known as institutions – the enduring rules, practices, and structures built into the social order that organizations are constantly interacting and negotiating with (DiMaggio & Powell, 1983). These institutions work to condition the actions or individuals and organizations, and ultimately, direct the flow of life. Scott (2001) describes institutions as "humanly devised rules that enable and constrain action and make social life predictable and meaningful." Meyer and Rowan (1977), DiMaggio and Powell (1983), Zucker (1977), and Meyer and Scott (1983) represent the formulative pieces of institutional theory.

Institutions do not always condition action in the most efficient or effective way possible, rather, they are entrenched patterns of behaviour that create social and cultural pressures for organizations to conform to a given structural form. A central idea in institutional theory is that of institutional isomorphism (from Greek, *iso* + *morphe*, meaning "equal + change"), summarized forthwith. Conforming to explicit or implicit rules and belief systems helps to ensure that organizations will survive in their fields and societies (DiMaggio & Powell, 1983; Meyer & Rowan, 1977) because they are perceived as more "legitimate" than divergent or non-conformers. That is to say, organizations or firms that conform to societal and political expectations in their fields/industries tend to perform better, have more influence, and easier working relationships with organizational peers (Deephouse & Suchman, 2008; Deephouse, 1996). Nonconformity with institutions amounts to deviation from the social order, increased costs and risk, greater cognitive demands, and an overall challenge to an individual or organization (Lawrence & Shadnam, 2008).

Especially apparent in well-established fields, organizational actors making rational decisions create environments where their ability and willingness to change is constrained (DiMaggio & Powell, 1983). This change-resistance is referred to as institutional inertia, and is a phenomenon that has been widely observed by institutional theorists, especially in essential industries with deep historical legacies (e.g., law [Sherer & Lee, 2002], healthcare [Scott, 2000], energy [Ha-Duong, Grubb & Hourcade, 1997], education [Kotler & Murphy, 1981]). Three kinds of pressures work to further embed institutional inertia: coercive pressures, such as government and regulatory policies; normative pressures, which are internally initiated by professionals or tradespeople (or their associations); and mimetic pressures, which arise when organizational peers copy common practice in the industry due to uncertainty and risks of taking some different action (Meyer et al., 1991; DiMaggio & Powell, 1983). In classic institutional theory, these pressures toward *stasis* (from Greek, meaning "a standing still") are powerful determinants of organizations' behaviour.

The recent focus of institutional theory (an intra-theoretical shift also referred to as new institutional theory, or neoinstitutionalism) has been on institutions as rules that frame our understanding of behaviour. Institutional change is the idea of changing/disrupting these rules, and opens up a role for firms/organizations to affect this disruption. (Lawrence, Suddaby & Leca, 2009). To change in the desired way, organizations must disrupt their own established ("taken-for-granted") ways of doing things ("rules of the game") by envisioning and executing innovative ways of doing business in order to remain competitive and viable (Hockerts & Wüstenhagen, 2010). Joseph Schumpeter (1942) argued that the "entrepreneurial spirit" is critical to the health of the economy.

Innovation by the entrepreneur within existing structures, leads to processes of "creative destruction" and the obsolescence of old processes and technologies in favour of new and better ways of doing things. Institutional entrepreneurs are actors who initiate changes and leverage resources to create new or transform existing institutions (DiMaggio, 1988), and they are distinct from entrepreneurs because their innovations generate new business models (Battilana, Leca & Boxenbaum, 2009).

However, if the existing institutions which structure organizational or individual actors' behaviour and interactions are as powerful as institutional theorists posit, how can it be that any actor, even the entrepreneurs, can influence or change these institutions in any way? This tension between the agency and purposive action of actors against the embedded power and deterministic influences of institutions is another central idea in institutional theory known as the paradox of embedded agency. The literature on institutional entrepreneurship aims to build theory on how actors can influence and change the institutions that structure their fields, the recursive relationship between actors and institutions, and strategies for purposive action (Lawrence *et al.*, 2009; Hardy & Maguire, 2008; Seo & Creed, 2002; Holm, 1995).

Critics of institutional entrepreneurship say that this theory relies on actors to have an almost heroic (Demil & Lecocq, 2006) level of power and clarity, enabling them to resist the influence of institutional pressures. A sociological framework of behaviour (i.e., institutional theory) loses credibility if it is true that anomalies (e.g., institutional entrepreneurs) can simply contradict that framework. Therefore, organizations should both diverge and converge with the institutional structures in their field, a tension recognized by institutional theorists (Chen & Hambrick, 1995; Abrahamson & Hegeman, 1994; Porac, Thomas, & Baden-Fuller, 1989). Deephouse (1999) puts forward a proposition for strategic balance, which states that moderately differentiated firms have higher performance because they benefit from the reduced competition (by being different than their peers) while maintaining legitimacy (because they are not so different as to invite challenge and distrust from that members of the organizational field). Moderately differentiated organizations have higher performance than either highly conforming or highly differentiated firms. Entrepreneurship and innovation is valuable, but so too is institutional similarity. Particularly important when considering change in organizations that provide essential services, such as electricity, it is not desirable for existing institutions to bow out completely, or for the service to be completely commoditized. Successful innovation in these types of firms is a combination of risk-taking, and cost calculation/risk mitigation. Innovation does not look the same for any one LDC and can manifest in several forms (Jarzabkowski, Matthiesen & Van de Ven, 2009). The LDCs that will be at the forefront of change will be those that balance the social, environmental, and financial risks and benefits of innovation. Regulation protects the interests of the public and ratepayer. Although reforms in the regulatory environment will be essential to foster innovation and entrepreneurialism in the LDC sector, there will be a role for the regulator with regard to the LDC of the future. The goal should be one of strategic balance between technology innovation and institutional prudence.

3.2 Model: Technology/Institutions

Künneke (2008) proposes a framework for categorizing possible interrelations between technological and institutional change and applies this framework to the case of the economic liberalization of the electricity sector. Coherence between institutions and technological practice allows for a better understanding of the potential drivers for change and the evolutionary processes of which they may be part. Research underscores the importance of co-evolution of technology and governance systems (Perez, 2009; Von Tunzelmann, 2003; Saviotti, 1996; North, 1990; Soete, 1985; Dosi, 1982), and the electricity sector provides an interesting case for illustrating the possible nature of the interrelations between technological and institutional change.

At the time Künneke's (2008) paper was written, technological innovations in decentralized electricity production and other disruptive technologies proved not to be lucrative enough to spur any essential changes in the functioning of the electricity system. This was because, by and large, the existing technology depended on integrated system planning to balance numerous generation inputs and usage outputs from the system. In other words, the limits of technology limited the institutional framework to one of centralized planning and control. However, as the preceding discussion of technological challenges in the electricity industry shows, innovation is today at previously unseen levels. For example, where the essential law of electricity has historically been generation and immediate use, we are now seeing unprecedented advancements in energy storage technology which renders this "law of nature" inaccurate.

Additionally, Künneke proposes that regulated electricity markets are increasingly showing signs of institutional change in the form of open competition, deregulation, and private ownership. A novel institutional framework would provide sufficient incentives for even more innovation in technological practice. Williamson (1998) proposes a four-level model of institutional change which Künneke aligns to his four-level model of technological change. The combined model in Figure 11 illustrates the basis of a hypothesis of the recursive relationship between technology and institutions, as applied to the case of regulated electricity markets. The four levels of the pyramids represent progressively more embedded stages of technology and institutions; from more changeable practice at the top of the pyramid, infrastructural and systemic policies in between, and more deeply-held norms/knowledge at the base level. There is an expression of both technology and institutionalism at each level, and connection can be observed between the two factors (i.e., technology and institutions).

At the most visible level, daily challenges are addressed through familiar and tested technical solutions. At the same time, institutions structure day-to-day operations as best practices.

Infrastructural policies shape these technical applications or best practices. The infrastructural limitations of specific systems determine how the products or policies of technological knowledge can be applied. In the institutional sense, regulatory and legal arrangements outline the formal and specific rules of specific systems.

Infrastructural design of the systems themselves is determined at a deeper policy level. Broader social design stems from formal and informal policy objectives.

Technology and institutionalism also manifest in deeply-held, ingrained belief systems. Though knowledge is constantly evolving, so-called "scientific facts" are very difficult to change, especially when they have permeated general societal knowledge over decades or centuries. Socially and culturally-embedded customs, traditions, norms, and values are equally influential determinants of organizational behaviour, and equally difficult to change.

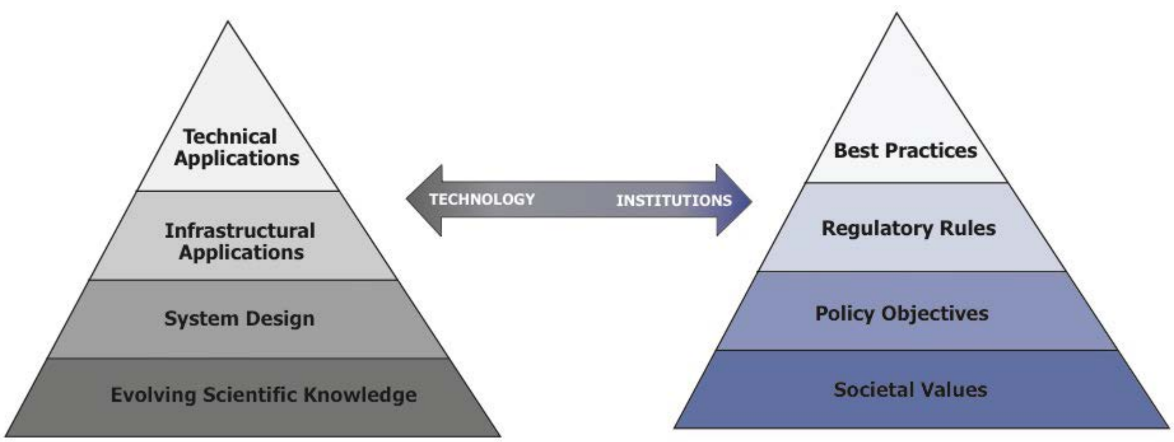

Figure 11. *Technology/institutions model, adapted from Künneke, 2008.*

3.3 Opportunity: The CUE Conference

Original research for this thesis was conducted at an invitation-only conference ("The LDC of the Future") presented by the Centre for Urban Energy [CUE] at Ryerson University in Toronto, Ontario on June 3rd, 2015. The conference provided a unique opportunity to ask sector experts key questions about the future for LDCs, and to create a dialogue between them to deeply explore the reasons for the judgements and the reasons for their divergence.

The invitees to the conference, and therefore, desired participants of this research study, are comprised of the following groups:

- Board members of Ontario LDCs/municipal government representatives ("the Owners Group"),
- LDC executives and managers ("LDC Management"),
- LDC regulators (OEB, IESO) ("Regulation"),
- Federal and provincial government representatives ("Government"),
- Researchers with an interest in Ontario's electricity distribution sector ("Academics and Researchers"),
- Professionals, consultants, analysts and other industry professionals with sectoral interest ("Industry"),
- Lawyers with sectoral interest,
- Not-for-profit organizations and professional associations with sectoral interest.

Figure 12, adapted from the figure presented in "LDC of the Future" conference proceedings document, shows the number of people from each profession who attended the conference (horizontal bars), and the percentage of each profession that made up the total number of conference attendees (doughnut chart).

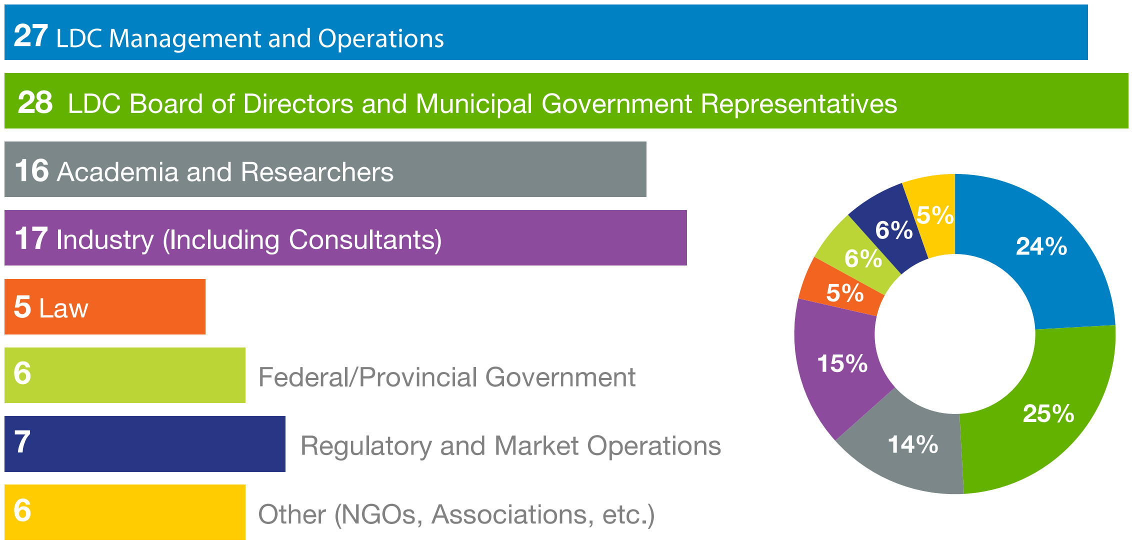

Figure 12. *"LDC of the Future" conference participants by professions, adapted from Zade et al., 2015.*

The Owners Group and Management of Ontario LDCs would necessarily possess particular insight on issues, trends, problems, and solutions in their industry owing to their positions and professional experience. Government representatives, academics, analysts, and financial specialists within the Ontario electrical energy sector would provide complementary expertise on electricity distribution. The targeted group is educated, experienced, and invested in the day-to-day and/or strategic, long-term decisions that will eventually determine the path(s) forward for electrical energy distribution in Ontario. As a gathering of industry-specific experience and specialized knowledge, this event created a rare opportunity for learning and dialogue between invested and engaged professionals. Informed judgment, the knowledge based on experts' insight, is typically constructed from an abductive[8] logic which begins with an idea of the future and then works backward to the information and assumptions necessary to support that claim (Dunn, 2012).

[8] *Abductive reasoning:* Accepts a conclusion on the grounds that it explains the available evidence (Honderich, 2005).

In *Eliciting and Analyzing Expert Judgment: A practical guide*, Meyer and Booker (2001) offer a comprehensive, generalized guide for researchers from various disciplines wishing to design and conduct a deliberate and structured data collection from a target group of experts. An expert is a person who has background in the subject area and is recognized as qualified to answer questions. In attempting to define the key characteristics of the LDC of the future, expert judgement can provide invaluable insights as a consequence of the training and experience of LDC board members, management, and industry specialists. Expert judgement has been shown to be particularly useful to forecast future events, to provide estimates on poorly understood phenomena, to interpret existing data, and to determine what is or is not already known or worth knowing in a given field of knowledge. Adelman and Munpower (1979) provide a good overview and argument for increasing the use of expert judgments in successful public policy making, especially for complex issues with multiple interdependent system variables. While discordant viewpoints will certainly arise between experts, successful decision-making is not hurt by the existence of agreements.

3.4 Investigation: Survey Strategy and Design

The notion of a survey relates to a method of systematic data collection, where people are asked questions by using standardized questionnaires for the purpose of analysing some population of interest (Fowler, 2002). An iterative, two-stage survey method was selected (Miller & Salkind, 2002) to construct an anonymous "dialogue" between the conference attendees on a number of timely issues relevant to the LDC sector. The first survey ("S1") was conducted before the CUE conference, and the second survey ("S2") was designed and conducted after the conference. S2 incorporated a feedback component, where the findings from the responses of S1 were relayed back to the participants in the course of answering S2 questions. The purpose of having two surveys was two-fold: first, to investigate if the participants' opinions would show any change after hearing the information presented at the conference; second, to supply participants with information about the opinions of other study participants, in order to construct an anonymous dialogue between them.

A combination of open-ended and closed-ended style questions further extends the value of this study to the Ontario LDC case. Any issue in the energy industry is characterized by wide interdependence with other issues and the ability to affect multiple large realms (e.g., economic growth, environmental health, social cohesion) (Guimond, c. 2010). This fact demands a holistic approach to problem analysis, and not an exclusively analytic approach (Jupp, 2006). Miles and Huberman (1994) find that both qualitative and quantitative methods should be used to explore, explain, or describe complex social phenomena rather than a purely qualitative approach. Surveying is flexible to integrating both kinds of research (Given, 2008), and is therefore one of the useful methods of primary data collection for this study.

Computerized self-administered questionnaires [CSAQs], where a respondent administers the entire process of answering the questionnaire without the involvement of an interviewer (Callegaro, Lozar Manfreda & Vehovar, 2015) were chosen for several reasons (Silver & Lewins, 2014; Cole, Donohoe & Stellefson, 2013; Klenk & Hickey, 2011, Skulmoski, Hartman & Krahn, 2007), including:

- Flexibility and ease of survey dissemination and response collection;
- Setting and environment control afforded to participants;
- Improved anonymity for participants.

Due to the specialized nature of electricity distribution in the province of Ontario, the study population, wholly comprised of the invitees to the CUE conference, was already limited to the relevant group of sector professionals and interested parties. This is a sample of "specialized informants" (Gillham, 2008) from the realm this research is interested in finding out more about. The final registration count on June 2nd was 112. The sample of S1 (and S2) data sources were obtained through a nonprobability *convenience sample*[9] of invitees who volunteered to participate in the present research study (i.e., to fully or partially complete the surveys). Participation was entirely voluntary and in no way impacted the target population's participation or inclusion in the conference. Respondents were able to withdraw from involvement in this study at any point. Although it was not possible to generate a probability sample for these surveys, systemically asked questions can provide extremely valuable information (Guppy & Gray, 2008). Consistent with conditions seen commonly in social science research (Given, 2008), the responses are intended to uncover insights from individuals and small groups with valuable professional experience, not to find trends or patterns that are generalizable across the sector. Nonprobability sampling in surveys is explicitly criticized (Gillham, 2008; Fowler, 2002; Fink & Kosecoff, 1998) because of this reduction in generalizability and the early introduction of bias in the results. In response to these legitimate criticisms, it is emphasized that this research is concerned with exploring a current social phenomenon in a narrow realm (i.e., electricity distribution in Ontario) by eliciting the informed judgments of people often with strong pre-existing biases; generalizability was not a primary objective of this study's design.

① Pre-Conference Survey ("S1")

The first survey was composed of eleven questions, the first three collected respondent demographic data while the final eight queried their judgements on several subjects relevant to the future of Ontario LDCs (e.g., DG technology, drivers of change in the sector, cost of infrastructure renewal). Appendix A provides the content of S1 questions.

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[9] Respondents were selected by their willingness and availability to participate in the surveys (Fink & Kosecoff, 1998).

The issues covered in S1 which were selected for experts' consideration were based on information gleaned through a review of academic literature, government reports, and industry commentary concerning current challenges, drivers, barriers, and strategies of change in the electricity industry provincially, nationally, and globally. First considering the advantages and disadvantages (Table 5), a preponderance of open-ended questions was ultimately used to elicit a more textured and nuanced understanding of the participants' viewpoints.

Advantages	Disadvantages
• Provide full expression • Allow for the drawing of salient distinctions • Tap unanticipated answers • Add to the respondents' enjoyment • Provide rich vignettes • Are a good first step • Work well with endless lists	• Comparability • Vagueness • Recording • Coding/summarizing • Ordering/intensity • Greater demand on respondents • Potentially greater costs

Table 5. *Advantages and disadvantages of open-ended survey questions, (Guppy & Gray, 2008).*

It is good methodological practice to consult survey questions used in previous, published studies (Lavrakas, 2008; Converse & Presser, 1986). It was found that most accessible, widely-used national surveys were conducted for a U.S. context, mostly regarding social and political attitudes of the general public, and were largely irrelevant to a study of expert opinions in Ontario's electricity distribution sector. Other studies that used surveying as a method of data collection which had some level of similarity to the present study are listed below. These studies were sought out to identify pretested surveys which could inform the question wording and overall survey design used in this thesis. Questions were ultimately designed by the researcher, in close consultation with academic supervisors. Questions were pilot-tested a minimum of ten times over evolving stages of development to ensure that research instrument was clear, relatively easy, and sufficiently unbiased for potential respondents.

- The first *State of the Electric Utility* (Utility Dive, 2014) surveyed over 500 U.S. utility executives on industry threats and opportunities;
- The second *State of the Electric Utility* (Utility Dive, 2015) surveyed over 400 U.S. utility executives on emerging issues and opportunities influencing industry future;
- *Strategic Directions in the Electric Utility Industry* (Black & Veatch Corporation, 2012) surveyed over 500 respondents on U.S. utility operations, regulations, new technologies;
- *Understanding Consumer Preferences in Energy Efficiency* (Accenture, 2010) was an online survey of over 9,000 consumers in seven countries on their opinions and preferences toward electricity management programs;
- Pätäri and Sinkkonen (2013) conducted a Delphi study on the viability of the Energy Service Company [ESCO] business model through a two-round, online, iterative survey of Finnish energy experts;

- Brown and Gorgolewski (2014) conducted satisfaction questionnaires in Toronto, Ontario to understand how building occupants interact with innovative mechanical ventilation strategies.

The main ethical requirements for surveys are that the purpose is clear, that consent is obtained to use respondents' information, and that confidentiality is protected in the way that was promised (Gillham, 2008). A participant consent agreement (Appendix B) was presented before the survey questions providing information on several important components of the planned data collection, including:

- Overview of the research study process;
- Analysis methods;
- Eventual objectives of the study;
- Voluntary nature of participation;
- Potential risks of participation;
- Privacy and confidentiality maintenance;
- Secure storage of response data; and
- Data dissemination.

The Ryerson Research Ethics Board [REB] granted final approval to conduct human-subject research for a one-year period beginning June 1st, 2015. S1 was disseminated on June 2nd, 2015 via the *SurveyMonkey* platform. S1 was also disseminated in hard copy at the conference on June 3rd to encourage a higher response rate. The final sample, n_1, of S1 was 39, representing about 35% of the target population (i.e., 112 conference registrants). S1 respondents represented 6 identifiable LDCs of about 77 that existed in Ontario at the time of the conference:

- CollusPowerStream (serving Collingwood)
- ERTH (serving and owned by Ingersoll, East Zorra-Tavistock, Zorra, Central Elgin, South-West Oxford, Aylmer, Norwich Central Huron, and West Perth)
- HydroOttawa
- Innpower (serving Innisfil)
- Utilities Kingston
- Veridian (owned by Pickering, Ajax, Clarington, and Belleville)
- Waterloo North Hydro

The majority of respondents represented organizations in the realms of government, business, technical, and professional occupations, not-for-profit, and academia. Because of the greater demand on respondents and other disadvantages of open-ended question styles, dropout rates were expectedly higher for questions asking for free-text responses. To mitigate against this, participants were permitted to move forward and backward between questions, and there were no questions with required responses (apart from the initial study consent agreement).

② Post-Conference Survey ("S2")

The purpose of the second survey was two-fold: first, to confirm the findings of the first survey, and second, to touch upon a six more important issues meriting expert comment on the LDC of the future, which were not raised in S1, but were the subjects of some important discussions at the June 3rd conference (i.e., future focus, community energy, raising rates, social equity, consolidation, and the tax incentive for consolidation). S2 was designed to take about half the time to complete as S1, was composed of thirteen mostly closed-ended questions, including four questions to collect respondent demographic information, and included graphical results of the preliminary findings from S1. Appendix C provides the content of S2 questions.

The final sample, n_2, of S2 was 39, representing about 35% of the target population (i.e., 112 conference registrants). The population size of potential respondents was wholly comprised of the attendees to the CUE conference on June 3rd; again 112 people. S2 respondents represented fifteen of 77 LDCs:

- Cambridge and North Dumfries Hydro
- ERTH (serving and owned by Ingersoll, East Zorra-Tavistock, Zorra, Central Elgin, South-West Oxford, Aylmer, Norwich Central Huron, and West Perth)
- Haldimand County Hydro
- Halton Hills Hydro
- Innpower (serving Innisfil)
- Niagara-on-the-Lake Hydro
- Oakville Hydro
- Oshawa Hydro
- PowerStream (serving Vaughan, Markham, Richmond Hill, and Barrie)
- Rideau St. Lawrence
- Utilities Kingston
- Veridian (owned by Pickering, Ajax, Clarington, and Belleville)
- Waterloo North Hydro
- Whitby Hydro

The majority of respondents again represented organizations in government, business, technical and professional occupations, not-for-profit, and academia. Professional categories were slightly altered to better reflect the actual population that attended the conference (Appendix D).

For the second survey, the presentations and discussions held at the conference on June 3rd, 2015, were particularly pertinent. The five-point Likert scale question used in the first survey was the only non-demographic question repeated verbatim in the second survey. It included a total of eleven items that described significant forces at play in the electricity distribution sector according to an evaluation of the industry and academic literature. Other questions revisited issues already raised in S1 in different words (e.g., infrastructure renewal costs, distributed generation and distributed energy). In addition, S2 began with two simple (non-mandatory) feedback-type questions to inquire on participants' opinion of the "LDC of the Future" conference on behalf of CUE.

Dissemination of S2 deliberately coincided with a report of the conference proceedings from the CUE (Zade *et al.*, 2015). The purpose of bundling the final stage of the research study with the CUE report was to accord a greater degree authority and legitimacy to the survey, encourage participant response, and to illustrate that the findings from the overall study would be integral to the work done at the CUE conference.

A distinctive component of S2 was the incorporation of the findings and preliminary analysis of S1 responses. The objective purpose of including feedback for the participants was to help structure an anonymous dialogue between attendees of the CUE conference on the subject of pertinent issues in the sector. S1 responses were aggregated and redistributed to study participants over the course of completing S2.

4.0 RESULTS AND DISCUSSION

This thesis set out to discover how sectoral experts think LDCs should change to remain viable in the future in the face of forthcoming challenges in new technology, customer expectations, government policy, decreasing demand, and increasing infrastructure renewal costs. In this chapter, results from the findings of the primary data collection instruments are presented. A checklist correlating technological to institutional change is the result obtained from the first method (the institutional theory framework). From the second method, the expert survey, insightful qualitative and quantitative data from participants' responses are reported and discussed. S1 results are presented in aggregate for all respondents, while the results from S2 can be further divided according to the respondents' self-identified profession categories.

4.1 Checklist for Technological/Institutional Change

Institutional barriers to change are the practises, rules, and knowledge that have embedded into the LDC sector culture by their historical development. That culture is one of risk-aversion and resistance to change, and was the product of LDCs' need to be legitimate, stable, and trustworthy organizations as providers of an essential, undifferentiated public good (i.e., electricity). Therefore, LDCs became progressively more institutionalized and alike over several decades in the twentieth century. A consideration of the challenges facing LDCs through an institutional theory lens offers a valuable explanation for how their historical legacy and present-day interactions affect the direction of their decision-making.

While there are currently numerous forces at play which influence the future for LDCs, this thesis posits that technology is the primary determining factor of change. Technological innovation and institutional change have a recursive relationship; meaning that one can activate the other. The difficulty in starting from the institution side is that they are notoriously cemented in organizations'/individuals' behaviour, and are often beyond the ability of intrapreneurs[10]/agents to oppose.

Figure 13 outlines a series of checks for LDC decision-makers based on Künneke's (2008) modified framework connecting technological innovation to institutional change. The bidirectional arrow at the top of the triangle underscores the recursive relationship between technology/institutions. The levels of change numbered 1 to 4 emphasize the fact of progressively more embedded stages of technology and institutions; from more changeable practice (Level 1), infrastructural and systemic policies in between (Levels 2 and 3), and more deeply-held norms/knowledge (Level 4). This result is synthesized from the first research method (the institutional theory framework), combined with an analysis of the Background literature on the electric utility (Chapter 1.0). The responses to any of the technology or institution checks indicate that transformative change is about to occur for LDCs.

This result means that LDC decision-makers need to have very specific strategic directions. They should be making investments in technology applications and developing innovative business models, *not* prioritizing lowest cost options that are less risky right now, but eventually ineffective for future viability. This hypothesis is supported by the examples provided for each check question.

[10] *Intrapreneur:* An inside entrepreneur; person within a large corporation who takes direct responsibility for turning an idea into a profitable finished product through assertive risk-taking and innovation (Pinchot III, 1985).

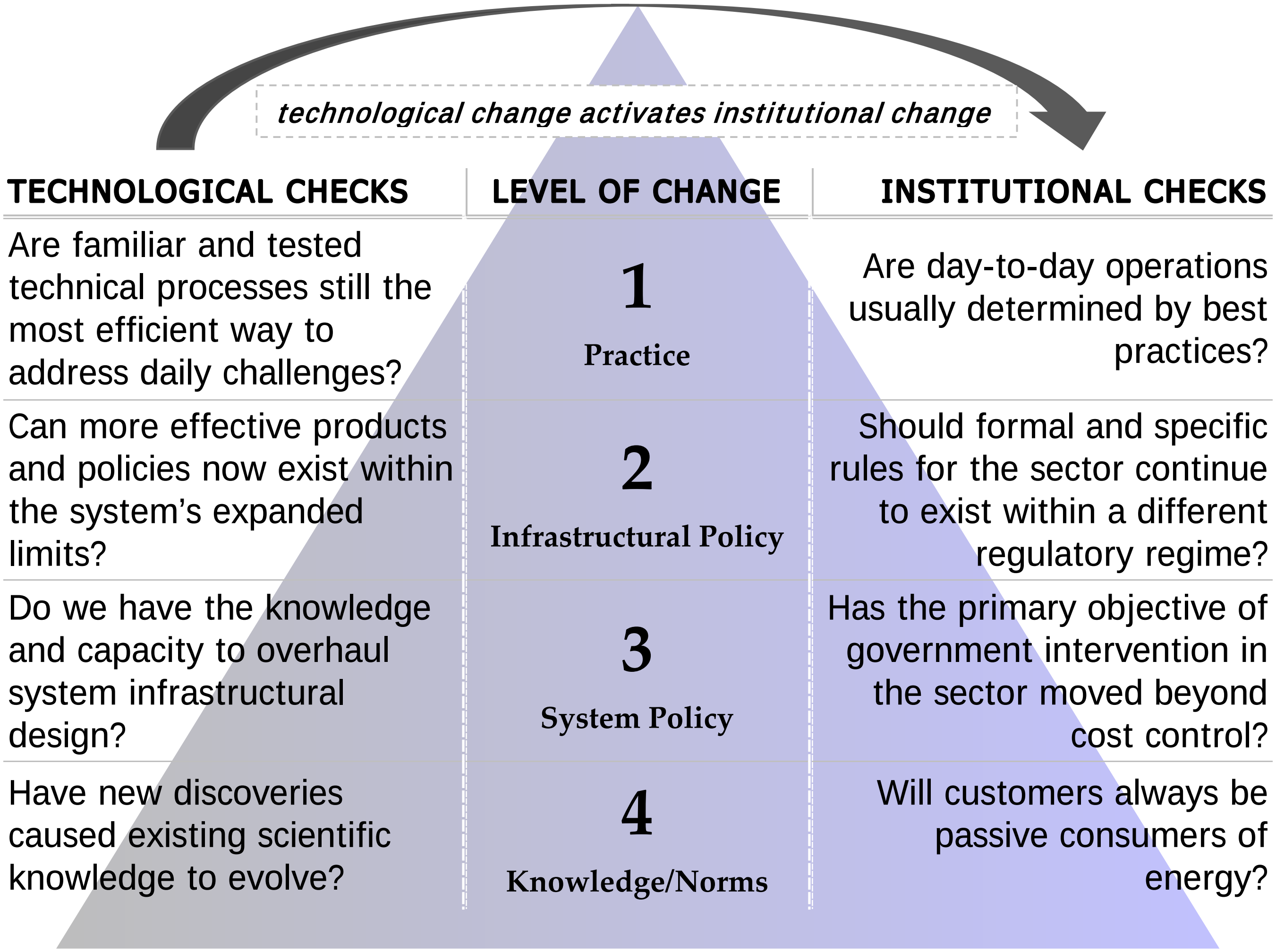


Figure 13. *LDC change – technological and institutional checks.*

In Ontario's electricity distribution sector, there is a positive response to *both* technological and institutional checks at *each* level of change. Table 6 further illustrates how there are observable examples of technological and institutional change happening for LDCs today. This expansion of the result from the institutional theory method is informed from by the Literature Review of Ontario's electricity distribution sector (Chapter 2.0).

			Technological	Institutional
Level of Change	1	Practice	Customers should not have to call in to report power outages.	Troubleshooting system failures is becoming a more proactive, less reactive, part of daily operations.
	2	Infrastructural Policy	CDM is a better way to meet energy demand than constructing new generation plants.	The RRFE is a performance-based, not prescriptive, approach to sector regulation
	3	System Policy	Two-way communication enabled by information technology (smart grid); integration of intermittent renewable energy sources.	The Government of Ontario uses energy policy to advance environmental and social objectives, often in preference to lowering the cost of electricity.
	4	Knowledge/ Norms	Electricity will soon be stored cost-efficiently.	Ontarians want personalized services, usage data, control, and flexibility from their energy providers.

Table 6. *Examples of technological and institutional change in Ontario's electricity distribution sector.*

Synthesizing the results presented separately in Figure 12 (LDC change – technological and institutional checks) and Table 6 (Examples of technological and institutional change in Ontario's electricity distribution sector) leads to important implications for the LDC of the future.

Example 1: Technology, Level 1 (Practices)

Check question: "Are familiar and tested technical processes still the most efficient way to address LDCs' daily challenges?"

Evidence: The onset of smart metering technology along with new expectations of customers require to be able to detect when and where outages occur when they happen.

Example 2: Technology, Level 4 (Knowledge/Norms)

Check question: "Have new discoveries caused existing scientific knowledge to evolve?"

Evidence: It is starting to become cost-efficient and technologically possible to store electricity, whereas in the past, electricity had to be used or transported as soon as generated. This was the premise upon which the entire system was built.

Therefore, LDCs should integrate a strong technology focus in their adaptation strategies. This idea is also supported by the opinions of sectoral experts retrieved during the survey method, as will be discussed further below.

4.2 Survey 1: Pre-Conference

$n_1 = 39$

Results and discussion in the section below are presented in the following general format:

Question topic
Survey 1 (S1), Question number (Q#): Question content
** References (if any)*
Number of total question respondents, $n_{1,Q\#}$
Discussion:
Selected Quotes: <u>key take-aways</u>
Data visualization (graphs, charts, word maps)

Figure 14. *S1 results reporting format.*

Qualitative data are reported by word map graphics, identical to the feedback provided to S2 participants. To accurately reflect trends among the respondents' different answers, common meanings were captured under a single word (e.g., grid "independence"), phrases appear as a single or hyphenated word (e.g., "netmetering", "raise-rates"), articles, and conjunctions (e.g., "of") have been removed.

4.3 Demographics

Age (S1)

S1,Q1: What is your age range?

$n_{1,1} = 34$

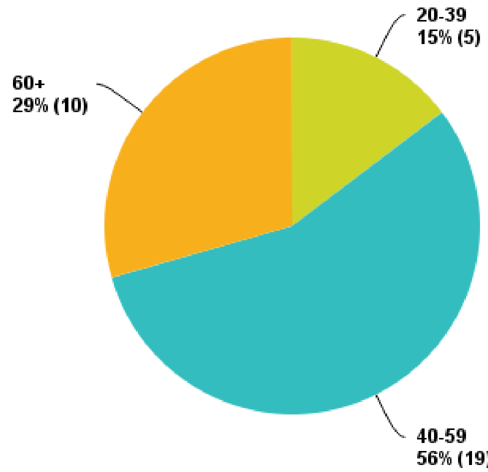


Figure 15. *S1 demographics – age.*

Board (S1)

S1, Q2: Are you currently, or have you ever been, an LDC board member?

$n_{1,2} = 34$

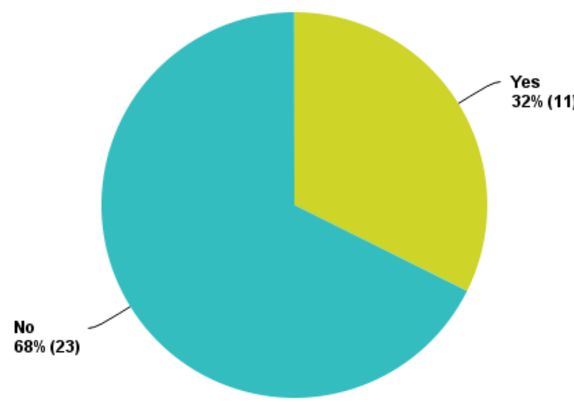


Figure 16. *S1 demographics – board.*

Discussion (Q1 and Q2):

50% of respondents over 60 years, 32% of respondents between 40 to 59 years, and no 20 to 39 year-olds have been on the boards for LDCs.

Profession (S1)

S1, Q3: Do you identify with one or more of the following groups?

$n_{1,3} = 34$

Discussion:
Responses do not add up to 100% as this question permitted respondents to self-identify with more than one profession category, and the specified professions were not identical to those specified for the CUE conference attendees (these categories were defined after S1 was disseminated).

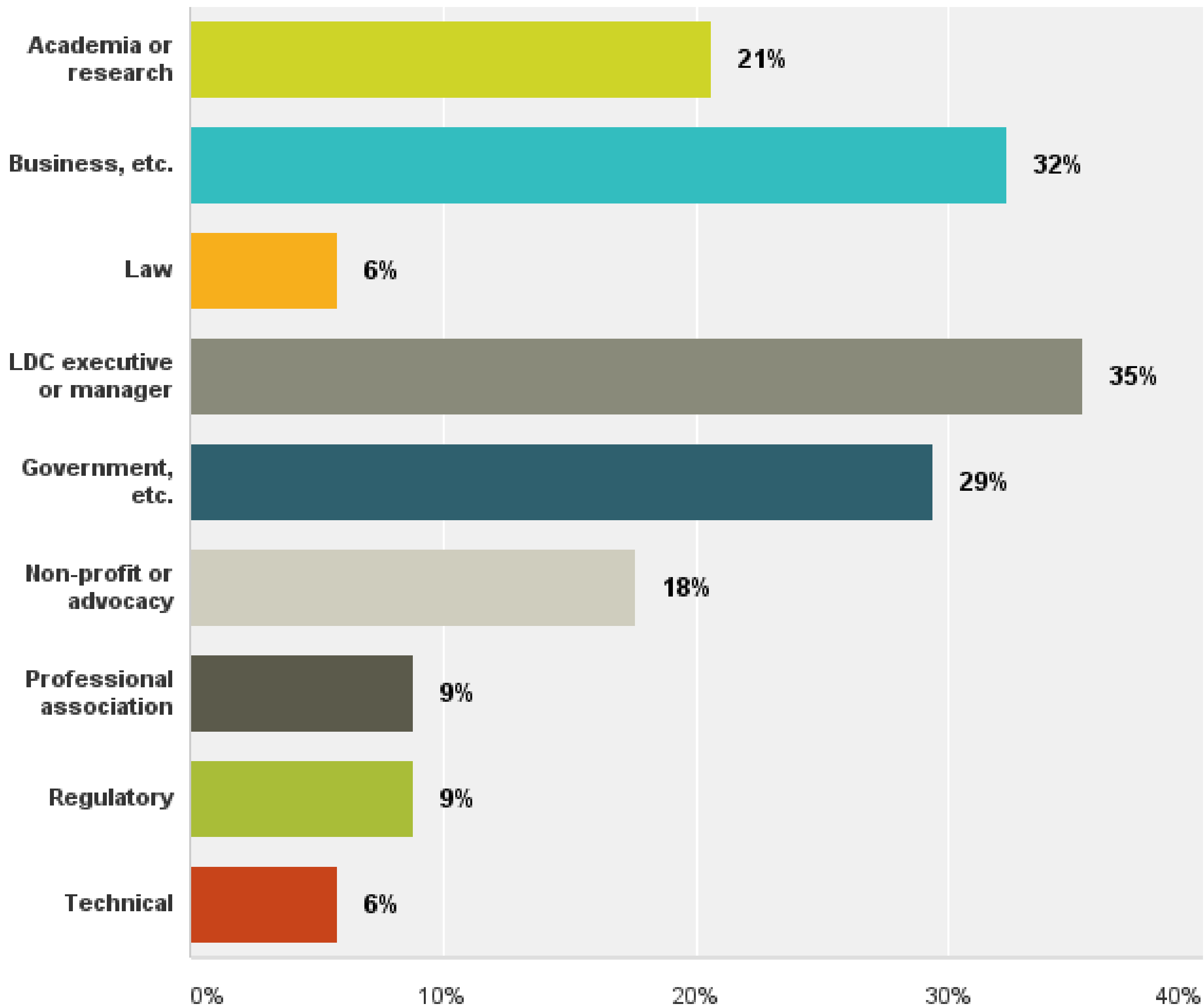


Figure 17. *S1 demographics – profession.*

4.4 Response Analysis: Questions and Research Feedback

DG Technologies

S1, Q4: What do you think will be the standout applications or technologies of DG into the future?

$n_{1,4} = 31$

Discussion:

In total, this question elicited 83 unique responses and highlighted the technologies that experts were watching with regard to DG. Response analysis shows that there was strong agreement among survey respondents regarding predictions of the standout applications of DG for the LDC of the future, specifically:

- solar PV generation
- energy storage (batteries)
- CHP or cogeneration

Within these, most respondents favoured solar PV generation plus battery storage to be the technologies to watch. Others identified cogeneration/CHP as the technology to watch.

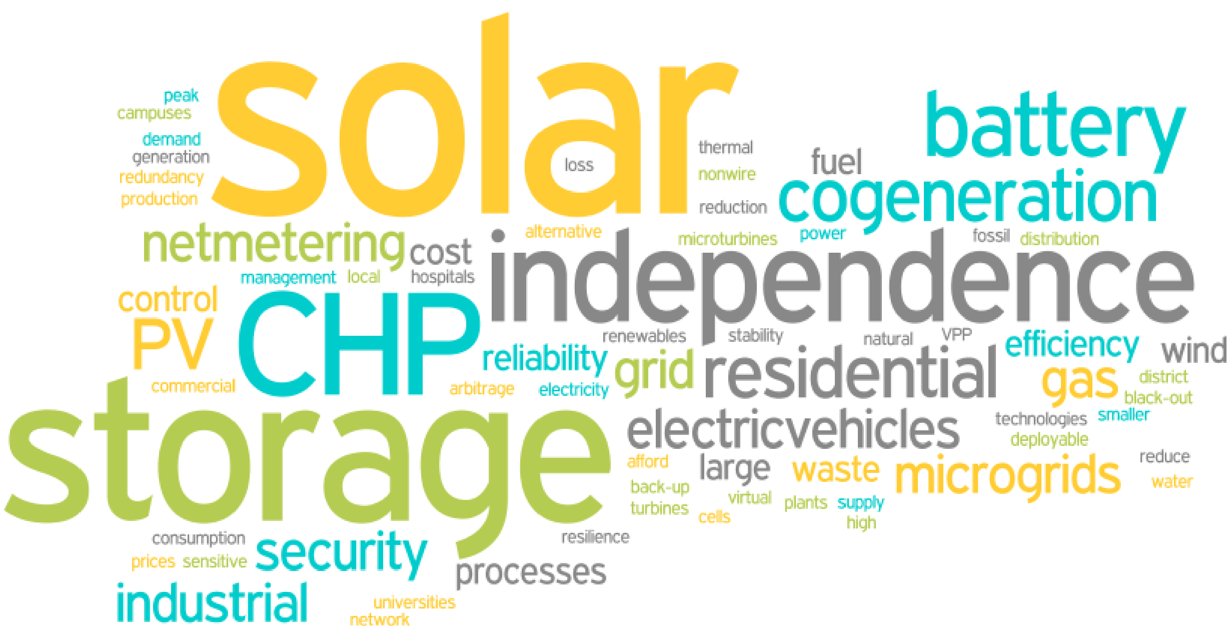


Figure 18. *DG technologies – word cloud.*

Drivers of Change: Ratings (S1)

S1, Q5: On a scale of 1 to 5, please rate each according to your judgment of its likelihood to influence the direction of the industry.

$n_{1,5} = 34$

Discussion:

Respondents rated all eleven proposed drivers of change fairly equally. Battery technology and energy storage were rated to be the most influential drivers of change. Factors are ordered by average score in Figure 19:

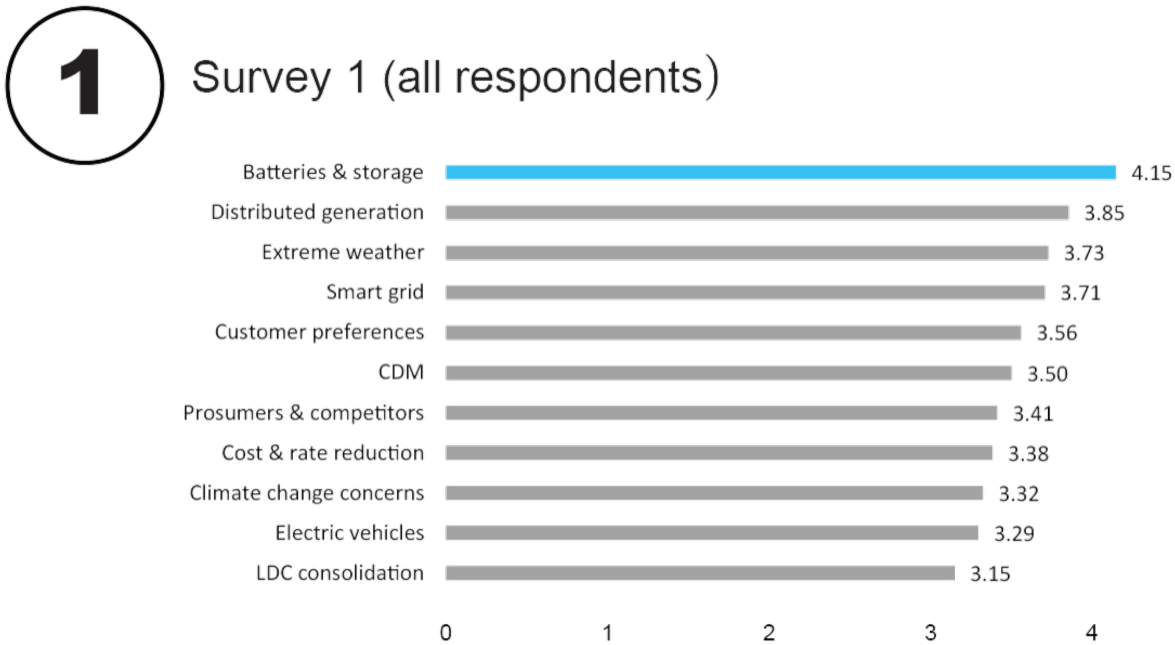


***Figure 19.** Drivers of change (S1) –average score.*

Drivers of Change: Reasons (S1)

S1, Q6: Please tell us briefly about the reasons for your ratings in question #5.

$n_{1,6} = 29$

Selected Quotes:

Extreme weather: presents a "real" tangible sense of risk that the public can see and understand. Our society tends to respond readily in a reactive fashion to threats, rather than evaluate risks and be proactive (hence climate change concerns are rated lower). Lack of consolidation is currently a tangible barrier that cuts across most sector evolution initiatives, from rates to performance. It has been the political elephant in the room, impacting the ability of the sector to evolve and of the regulators to affect change.

The industry is already well-positioned to enable the electricity cloud (i.e., electron sharing) and to provide cost-effective storage to prosumers. DG and smart technologies are an opportunity within the existing business model, not a threat. The threat is to central generation, transmission and planning.

The LDC industry will not be able to adapt to very many of the above changes other than CDM. They are too slow, risk-averse, and their ownership structure and regulatory compact will not be responsive. External forces will impact them (i.e., imposed CDM and consolidation by moral suasion).

Time frame is everything in this question, over the next few years LDCs will need to replace more transmission equipment, and OPG will need to invest unsustainable amounts for nuclear. The resulting price increase will drive DG and local power. Technology is on the side of DG.

Figure 20. *Drivers of change (S1) – word cloud.*

Forecasting: Ideal Future (S1)

S1, Q7: What do you think should be done to encourage an ideal future for the industry?

$n_{1,7} = 30$

Selected Quotes:

Consolidation must be more actively encouraged. Rather than leaving the sector in reactive mode to let extreme weather create impetus for action, planning and governance need to be rethought as a whole, but consolidation must happen first.

Drive resilient, low-carbontechnology that both drives mitigation and adaptation to climate change. Allow system to react to changing consumer preferences and available technology. Keep infrastructure base solid and allow innovative applications over top.

Let the LDCs be passive enablers and let the more nimble innovators lead the market. Monopoly market structures with heavy regulation is not a recipe for innovation. Give LDCs a single clear mandate - deliver safe, reliable power and a reasonable price.

Focus on bread and butter business of running an efficient utility. Know your customers; really get to know what drives them. Be open to consolidation as an opportunity to serve better. Work with regulators to adapt to, not exacerbate, problems.

Figure 21. *Ideal future – word cloud.*

Infrastructure Renewal Costs: Raising Capital

S1, Q8: *How do you think [the cost to renew Ontario's electricity distribution infrastructure*] should be addressed?*

Reference: ** Canada's Electricity Infrastructure: Building a Case for Investment (Conference Board of Canada, 2011) estimates $20.6 billion cost for Ontario*

$n_{1,8} = 27$

Selected Quotes:

Currently rates are the only mechanism for capital. Expanding the scope of LDC business opportunities will address efficiency.

The starting point is for government to require people to pay the true cost of electricity. That will have a number of effects. First, it will drive the development, and use of, energy-saving technologies. Second, it will force people to become more efficient users of electricity. Third, it will force people to become more engaged in energy policy issues. The ultimate result will be a more informed and democratic discussion about what investments should be made and by whom.

Figure 22. Raising capital – word cloud.

New Energy Consumer

S1, Q9: *What do you think are the best ways for LDCs to meet the needs of Ontario's new energy consumer* into the future?*

Reference: ** The New Energy Consumer: Architecting for the Future (Accenture, 2014): "Today's energy consumers seem to want it all: competitive pricing, value for money, new products and services, and consistent service." (p. 10)*

$n_{1,9} = 30$

Selected Quotes:

Understand relationship between <u>cost</u> of service and <u>reliability</u> and "put their money where their mouth is" regarding distress over outages and trying to push rates down. Develop better systems to <u>estimate outage durations accurately</u>. "Mechanize" or <u>automate</u> some line construction tasks that are still human-focused by requiring more <u>standardization</u>.

Become the <u>energy service provider</u> of choice by helping consumers manage their energy portfolio. Become multi-service energy providers offering a constantly <u>evolving</u> portfolio of offerings structured to meet customer needs.

Figure 23. New energy consumer – word cloud.

Consolidation: Predictions

S1, Q10: How many LDCs do you predict will exist in Ontario in the year 2030?

$n_{1,10} = 29$

The majority of respondents (28%) predicted that there would be between six to ten LDCs in Ontario in 2030. This corresponds to the provincial government's recommendation that the existing 70 LDCs should voluntarily consolidate into 8 to 12 (Elston *et al.*, 2012) regional distributors. Most sectoral experts believe that consolidation will deliver economies of scale and improved efficiency. However, some respondents also held a dissenting view that there is no proof that larger utilities are more efficient, cost-effective, or customer-focused than smaller ones.

Forecasting: Sector Restructuring [1/2]

S1, Q11: *Looking forward to the year 2030, what will emerge as the dominant process for restructuring Ontario's electricity distribution system?*

$n_{1,11} = 31$

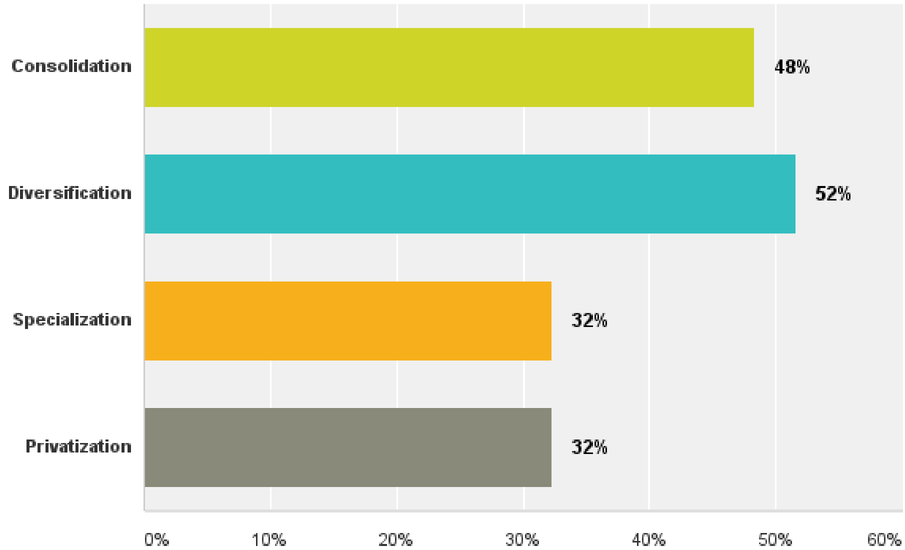


Figure 24. *Sector restructuring – predictions.*

Discussion:

Respondents identified 'Diversification' as the process that will dominate the restructuring of the electricity distribution sector, but their explanatory comments reveal that their interpretation of the words are not mutually exclusive. Particularly, restructuring the sector through diversification was tantamount to selecting all of the options. Responses do not add up to 100% as this question did, in fact, permit more than one selection.

Most respondents believed that LDCs should diversify their business offerings and become comprehensive energy services providers. This would include going "behind the meter," providing energy sources other than electricity to the customer, and helping to integrate small-scale and renewable energy generation. However, some sectoral experts held the dissenting view that LDCs should specialize and concentrate on what they are good at: providing safe, reliable, cost-effective electricity.

Forecasting: Sector Restructuring [2/2]

Selected Quotes:

The energy system will become more decentralized and horizontally integrated. The "LDC of the Future" will need to offer a wide range of energy services tailored to the needs of differing customer groups or even individual customers. Energy services to typical end users will be broadly defined and include electricity, heating, cooling, thermal fuels, energy efficiency and energy information. In the future, water and waste water could be considered as an integral part of the utility offering. Energy services to communities could additionally include infrastructure for electrification of transport, waste-to-energy infrastructure and services, and energy information to enable active integration of energy into urban planning decisions.

LDCs do not need restructuring.

The answer depends on the amount of regulation imposed by the government or the OEB. "Consolidation" if it is imposed, "Diversification" if it is allowed by regulation changes. OM&A expenses are the smallest piece of the customer bill. LDCs would look for other ways to reduce customer bills if the government was not pressuring consolidation.

All of the above. They are not mutually exclusive.

Figure 25. *Sector restructuring – word cloud.*

4.5 Survey 2: Post-Conference

$n_2 = 42$

S2 results are presented in aggregate and further divided into four categories according to respondents' self-identified professions where trends have emerged in the analysis:

1. LDC Board of Directors and Municipal Government Representatives + LDC Management and Operations ("LDC Owners + Managers")
2. Federal/Provincial Government + Regulatory and Market Operations ("Government + Regulation")
3. Industry
4. Academics and Researchers

Results and discussion in the section below are presented in the following general format:

Question topic *Survey 1 (S2), Question number (Q#): Question content* ** References (if any)* Number of total question respondents, $n_{2,Q\#}$ Discussion: Selected Quotes: <u>key take-aways</u> Data visualization (graphs, charts)

Figure 26. *S2 results reporting format.*

Overall Themes:

Free text responses provided in S2 were coded thematically (Fowler, 2002) based on the different challenges apparent in the sector (i.e., technological, customer, financial, regulatory/policy). Overall themes were also determined using the responses provided in the exploratory survey, S1 (e.g., business model, climate change/renewables). A word frequency query according to these themes was executed over respondents' comments in S2 data via the qualitative data analysis [QDA] computer software package, *NVivo*. A "tag cloud" presentation style illustrates the uppermost issues on experts' mind, in decreasing order of importance by most frequently mentioned words or word variants*:

1. **Technology** (80 mentions, including word variants [e.g., technolog<u>ies</u>, innovat<u>e</u>]):

   technology* (26) storage* (18) innovative* (13) smart (12) battery (11)

2. **Business Model** (80 mentions)

   consolidation(35) diversification (18) privatization (15) specialization(12)

3. **Financial** (66 mentions, including word variants [e.g., cost<u>s</u>, pric<u>ing</u>, affordab<u>ility</u>)

   cost*(33) rates (16) price* (10) affordable* (7)

4. **Customer** (58 mentions, including word variants [e.g., consumer<u>s</u>, customer<u>'s</u>]):

   consumer* (29) customer* (29)

5. **Climate Change and Renewables** (56 mentions, including word variants[e.g., efficienc<u>y</u>]):

   solar (28) climate(14) efficient* (14)

6. **Regulation** (43 mentions, including word variants [e.g., governmen<u>tal</u>, regulat<u>ory</u>]):

   government* (11) regulation (11) allow (10)

4.6 Respondent Feedback: CUE Conference

S2, Q1: Which session(s)[11] did you find most useful?

$n_{2,1}$ = 42

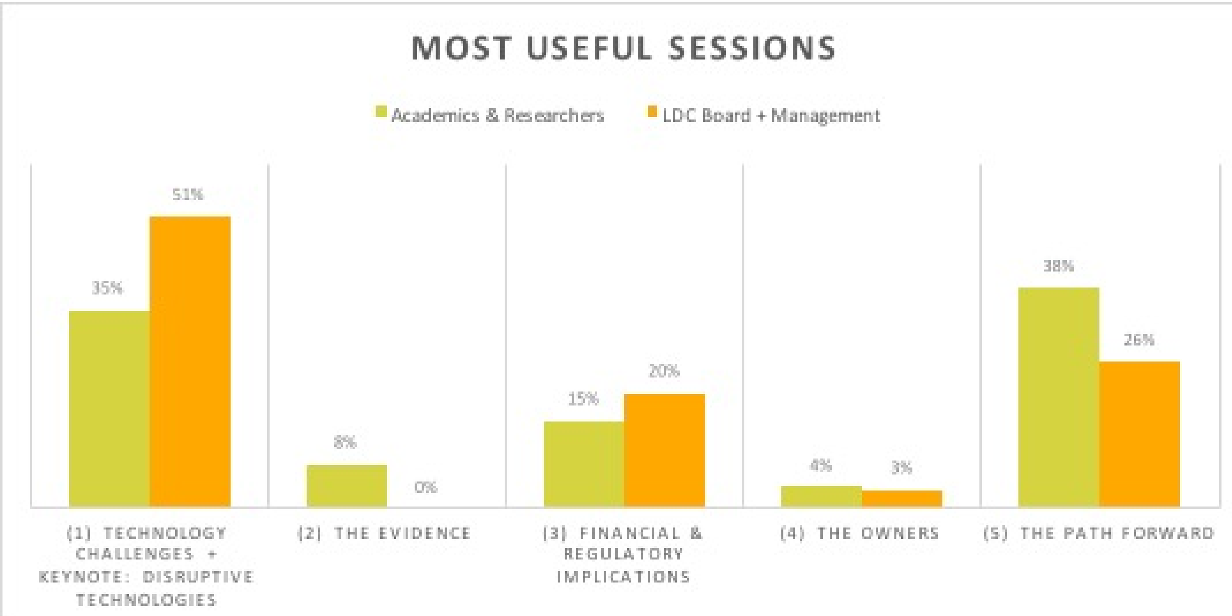


Figure 27. *Topics to explore further – Researchers vs. LDC Managers.*

[11] "LDC of the Future" conference agenda (Appendix E)

S2, Q2: What topics are you interested in exploring further? *$n_{2,2}$ = 39*	
Profession Category	**Selected Quotes**
Academics and Researchers	How can we overcome barriers to get to a more environmentally friendly and more efficient electricity system? What are the quick wins to get us there? Who are the winners and losers?
	I am interested in exploring how the relationship between utilities and customers is changing. In particular, I am interested in exploring ways in which utilities can respond to this change by borrowing ideas from other industries and business models.
Industry	Behind the meter generation, unregulated activities of LDCs, storage, renewable energy best practices from other jurisdictions, carbon trading.
	energy storage and business models for LDC participation in new technology deployments
Government + Regulation	Project level examples of the concepts explored from this day (i.e., municipal leadership/engagement, rates versus unregulated affiliates vs. working with private sector, etc.)
	implications of this array current and future changes for core competencies, leadership, labour relations and staffing and development
LDC Owners + Managers	Capacity and financial effect of DER on entire electricity system, central generators, through transmission including the IESO and effect on revenue to the province. Role of distribution system in microgrids
	1. Cost and rate impact of customers shifting from the grid, whether in whole or in part. 2. Regulatory construct that allows LDC diversification

Table 7. *Topics to explore further – quotes.*

4.7 Demographics

LDC Size

S2, Q3: *Based on the categories outlined in the 2012 Report of the Ontario Distribution Sector Review Panel*, what is the size of your LDC?*

Reference: ** Elston, Laughren, McFadden: Renewing Ontario's Electricity Distribution Sector: Putting the Consumer First (2012), p. 7.*

$n_{2,3} = 42$

Discussion:

Small LDC representatives disagreed with the consolidation of Ontario's 70 to 80 LDCs into 8 to 12 regional distributors (as advocated for by Elston *et al*., 2012). Large LDC representatives did not strongly agree with it either. Small LDC representatives disagreed that the tax break is a sufficient incentive to encourage consolidation; large LDC representatives feel that it is sufficient. Both small and large LDC representatives support business diversification as the model of the LDC of the future.

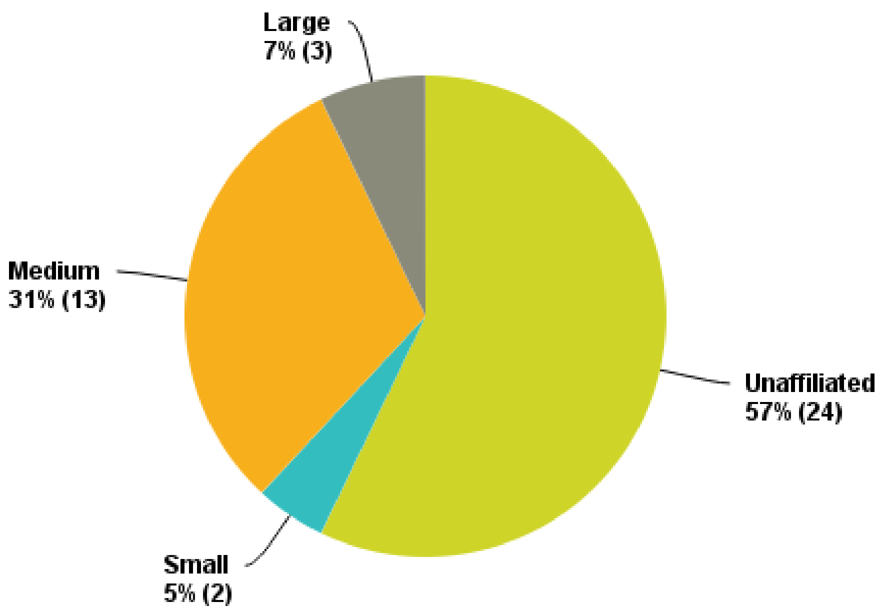


Figure 28. *S2 demographics – LDC size.*

Age (S2)

S2,Q4: What is your age range?

$n_{2,4} = 34$

Discussion:

A large percentage of respondents identified as over 60 years in age. This implies that many decision-makers and influencers will be approaching retirement in the near term, when challenges in the sector may start to have a tangible impact on LDC business models.

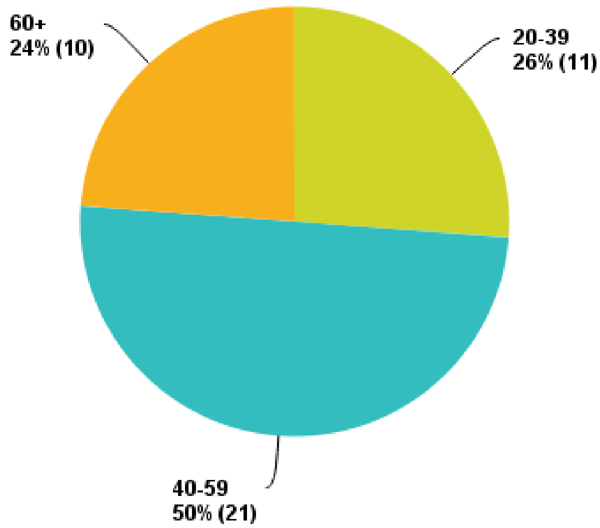


Figure 29. *S2 demographics – age.*

Board (S2)

S2, Q5: Are you currently, or have you ever been, an LDC board member?

$n_{2,5} = 42$

Discussion:

Of the respondents to this question, nine sectoral experts identified as being formerly or currently part of the board of directors of an LDC. These same respondents comprise 50% of the LDC Owners + Managers profession category.

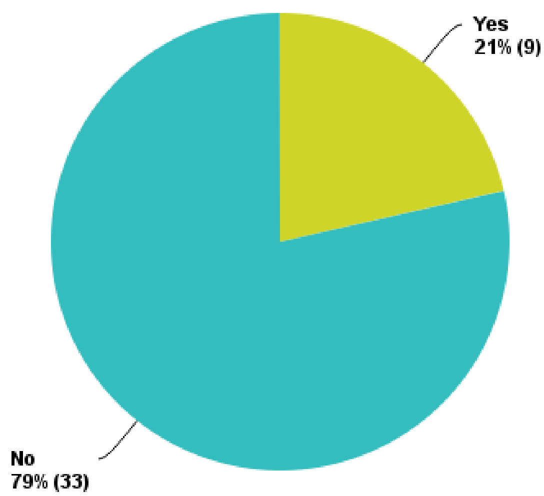


Figure 30. *S2 demographics – board.*

Profession (S2)

S2, Q6: As a participant of the CUE's 'LDC of the Future' conference, what group do you predominantly identify with?

$n_{2,6} = 42$

Discussion:

Responses do not add up to 100% as this question permitted respondents to self-identify with more than one profession category, and the specified professions were not identical to those specified for the CUE conference attendees (these categories were defined after S1 was disseminated).

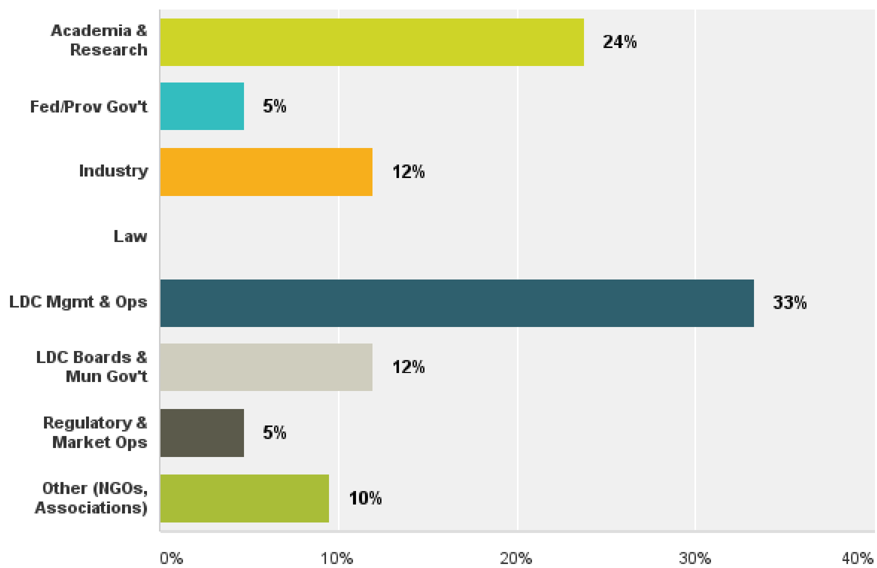


Figure 31. *S2 demographics – profession.*

The six professions which respondents self-identified with have been further combined into the following four profession groups, for reporting purposes.

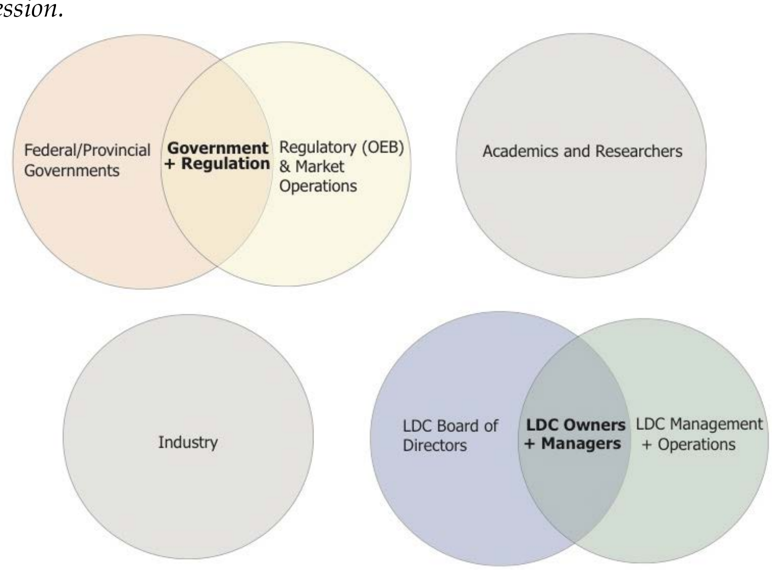


Figure 32. *Profession categories.*

4.8 Response Analysis by Profession Categories

DE Technologies

S2, Q7: *What applications of DE technology* would you invest in?*

Reference: ** Distributed energy: Disrupting the utility business model (Bain & Company, 2013, p. 2) provides a good overview of areas that could be opportunities for the LDC of the future. Consider all possibilities highlighted in the figure (i.e., central supply, customer segments, technology applications, demand management).*

$n_{2,7} = 42$

Discussion:

57% of Academics and Researchers identified 'Demand management'. 31% of Industry and 63% of LDC Owners + Managers identified 'Distributed energy supply'. 44% of Government + Regulation identified 'Energy storage'.

The most repeated comments were for technological applications of DE and combined heat and power [CHP], including microCHP and large-scale power plants [CHPP]. These findings are congruent with respondents' comments in S1, Q4 ("What do you think will be the stand-out applications or technologies of DG into the future?").

S1	S2
solar PV generation	distributed energy supply
energy storage (battery technology)	energy storage
CHP/cogeneration	distributed energy supply CHP

Table 8. *DE/DG –S1 and S2 response comparison.*

Drivers of Change: Ratings (S2) [1/2]

S2, Q8: Considering what you heard at the conference, please rate each according to your judgement of its likelihood to influence the direction of the industry.

$n_{2,8} = 40$

Discussion:

Respondents again rated all eleven proposed drivers of change fairly equally. "Conservation and demand management (CDM)" rose from sixth place to fourth place. "Cost-cutting and rate reduction" rose from eighth place to tie for fifth place with "Shifting customer preferences." "Climate change concerns" rose from ninth place to sixth, "LDC consolidation" rose from eleventh place to seventh. Interestingly, the top four forces deemed most likely to influence the direction of the industry. "Battery and other storage systems," "Distributed generation," "Extreme weather," and "Smart grid and other smart technologies" held their positions in S2. Factors are ordered by average score in Figure 33.

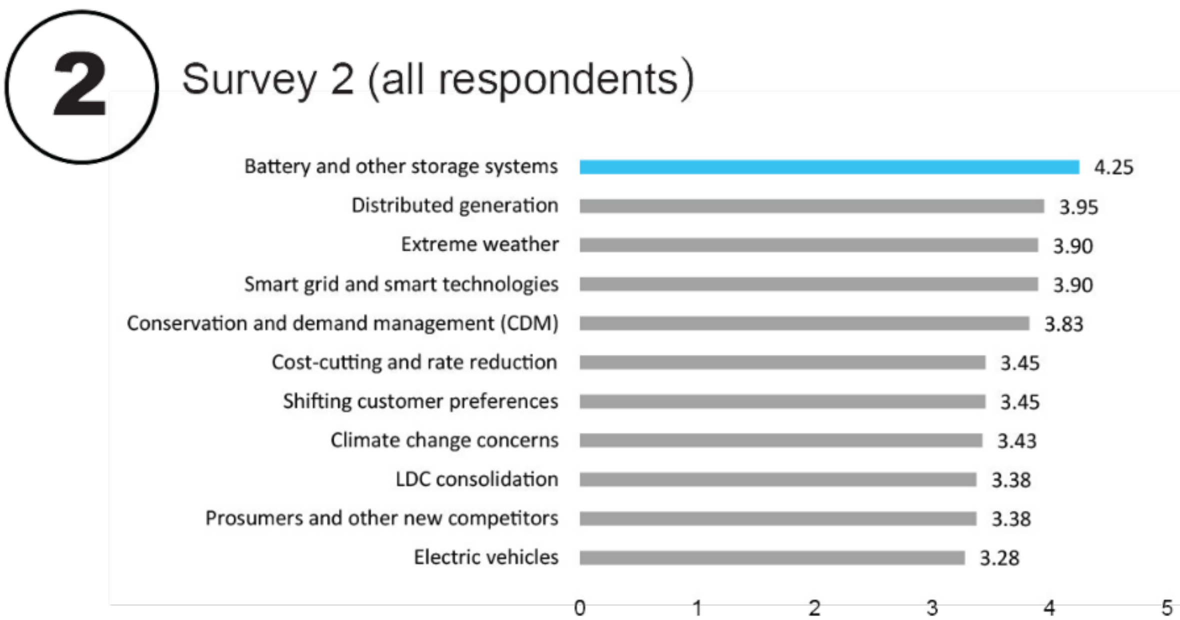
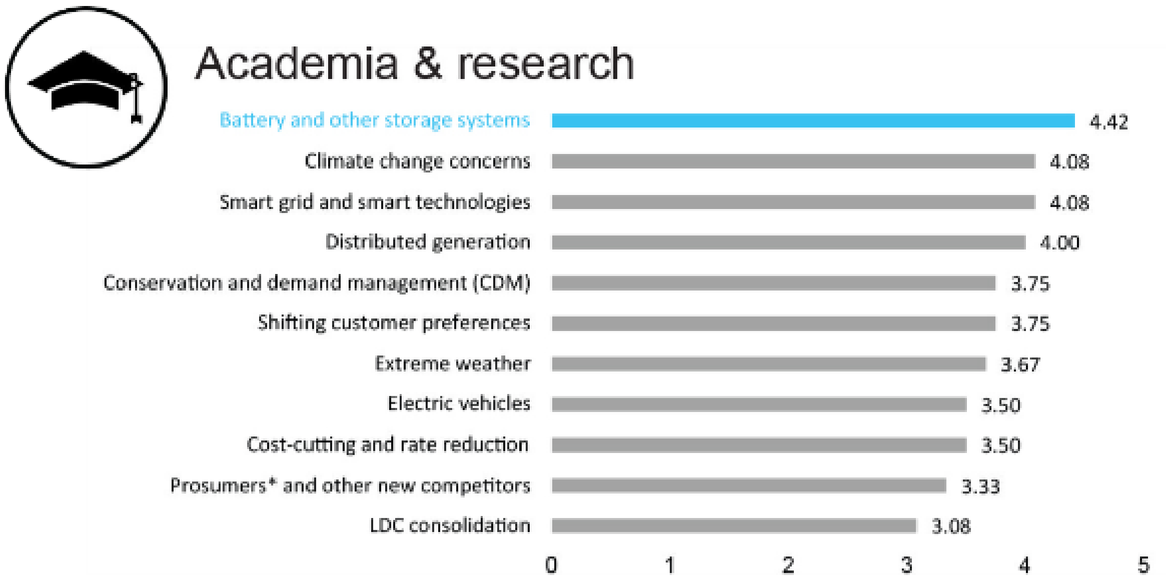


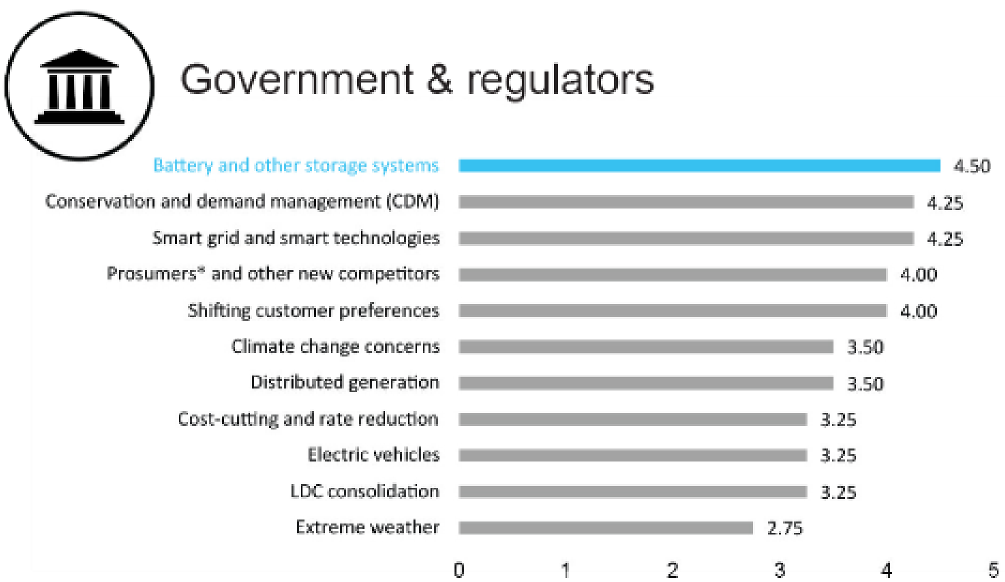
Figure 33. *Drivers of change (S2) –average score, all respondents.*

Drivers of Change: Ratings (S2) [2/2]

Discussion:

While there was some slight variation between professions regarding the lower-ranked "drivers," all profession categories scored "Battery and other storage systems" most heavily. Only the self-identified Industry respondents identified "Extreme weather" as having the greatest potential to influence the direction of the industry (Figure 34). The selection as "Batteries" as top influencer in the judgement of sectoral experts is congruent with respondents' weightings in S1, Q5.





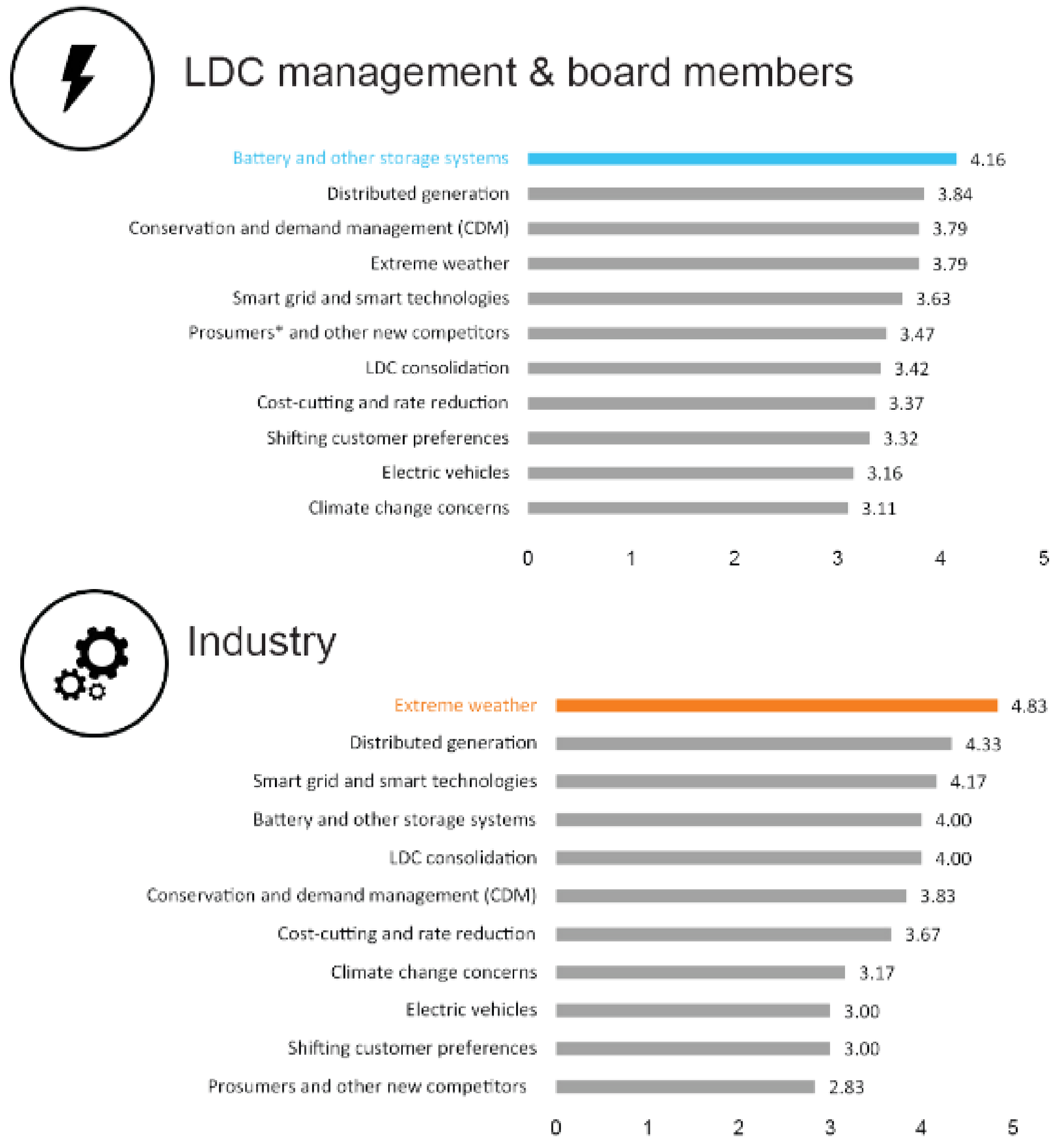


Figure 34. *Drivers of change (S2) –average score, profession categories.*

Forecasting: Community Energy

S2, Q9: Where can the LDC of the future have the most impact in a Smart Energy Community?*

*Reference: * Introduction to Integrated Community Energy [ICES] (QUEST, 2012, p.12) lists ways that LDCs can implement community energy solutions*

$n_{2,9} = 40$

Discussion:

Most respondents who self-identified as Academic and Research and Government + Regulation profession categories thought that LDCs could have the most impact in a Smart Energy Community by "Providing ownership and oversight of system infrastructure." Most respondents who self-identified with Industry and LDC Owners + Managers thought that "Generating new opportunities and attracting investment (locally)" would be the most important role for LDCs in Smart Energy Communities. These findings are not congruent with respondents' ideas of how to encourage an "ideal future" for the industry addressed in S1, Q7. Sectoral experts did not appear to have Community Energy topmost in their minds before the CUE conference, where the concept was frequently mentioned by a number of speakers.

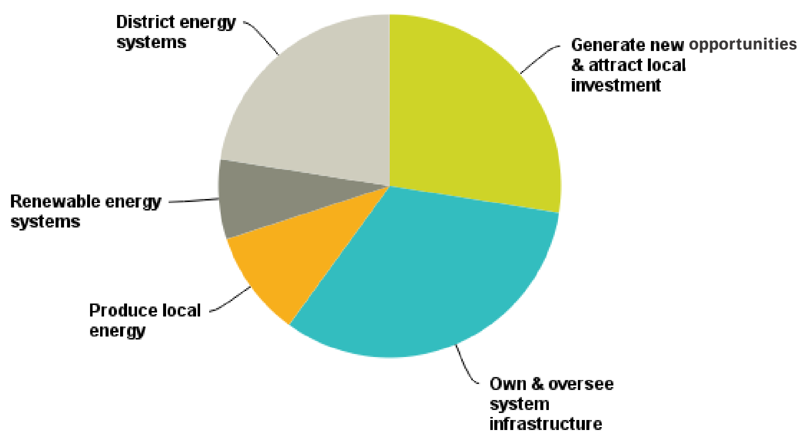


***Figure 35.** LDCs and community energy – predictions.*

Profession Category	Selected Quotes
Academics and Researchers	Opportunities to partner with municipalities, developers, third party owners and operators.
LDC Owners + Managers	Note that <u>system infrastructure</u> in the future will look different than it does today and may include <u>district energy</u>, <u>local energy production</u> and energy <u>storage</u>.

***Table 9.** LDC and community energy – quotes.*

Infrastructure Renewal Costs: Raising Rates

S2, Q10: *Should ratepayers bear more of the cost of infrastructure renewal (i.e. via raised electricity rates, distribution rates, global adjustment)?*

$n_{2,10} = 40$

Discussion:

Three of four profession categories answered this question similarly, with approximately two thirds of each group agreeing that ratepayers should bear more of the cost of renewing Ontario's aging distribution infrastructure, and about one third of the group disagreeing. In slight contrast, the Government + Regulation professional group was split evenly between agreement and disagreement, with a further split between the two professions (i.e., Federal/Provincial Government versus Regulatory and Market Operations). The additional comments showed that sectoral experts have a distinctly different view about raising capital through rate increases versus raising capital through taxes. Respondents' comments to S1, Q8, which asked how the cost to renew and transform Ontario's electricity distribution infrastructure should be addressed, showed that they were thinking about raising electricity rates as a primary mechanism for the needed cash influx, but there was no explicit mention of revenue that could be raised through taxes as an alternative.

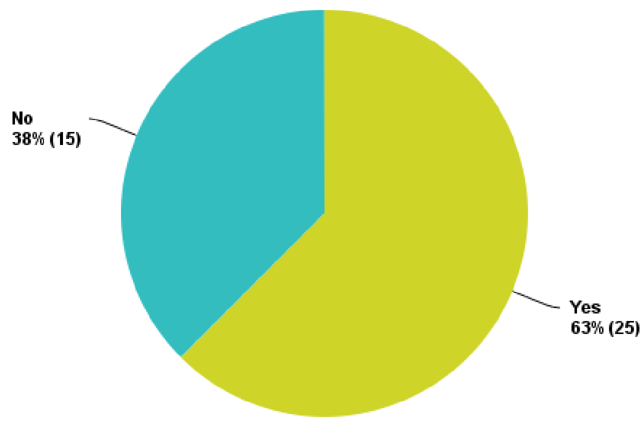


***Figure 36.** Should electricity rates be raised?*

***Table 10.** Raising rates – quotes.*

Profession Category	Selected Quotes
Academics and Researchers	Yes, but some public policy objectives should be supported via taxpayer dollars. It's not only about raising rates.
Industry	Until…the current investment is being efficiently applied, don't push more cost to ratepayers. Market will find a way to economically transform the grid, if market players are efficient and innovative.
Government + Regulation	Electricity rates are not progressive in nature. Some large infrastructure expense should be tax-based.
LDC Owners + Managers	Government should not add new social initiatives and we should allow markets to evolve rather than incent abnormal or faster paced behaviour.

New Energy Consumer: Social Equity

S2, Q11: *Considering the essential nature of the electricity commodity, is it the job of an LDC to consider issues of social equity* in its customer base before making business decisions?*

Reference: ** Social equity was a recurring theme at the 'LDC of the Future' conference**. Between richer vs. poorer individuals/households, urban vs. rural municipalities/communities, and larger vs. smaller LDCs, social equity issues may present a valid challenge to decision makers in the electricity distribution sector.*

*** "As LDCs lose customers to DE, there is a risk that the remaining customer base will be disproportionately comprised of low income households and small businesses."*

$n_{2,11} = 40$

Discussion:

Once again, three of four profession categories answered this question with strong or very strong preference toward LDCs' obligation toward social equity when making business decisions. Respondents' comments to S1, Q9 ("What do you think are the best ways for LDCs to meet the needs of Ontario's new energy consumer into the future?") show that there was no recognition of the social equity issue vis-à-vis the new energy consumer prior to the CUE conference. There is some incongruence between the two surveys as it appears that sectoral experts were calling on LDCs to better anticipate and meet the "wants" of their customer in their responses to S1, but the focus shifted to one of "needs" and "essentials" in S2. The dissenting group in this case were those who self-identified with LDC Owners + Managers, who were split evenly between agreement and disagreement.

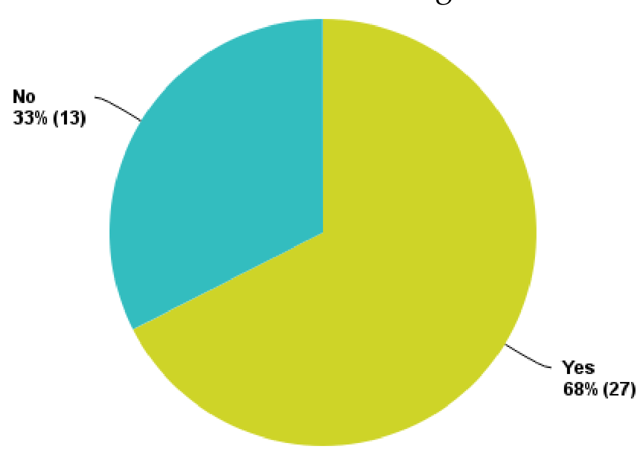


Figure 37. *Social equity in LDC business.*

Selected Quotes (LDC Owners + Managers):

"With municipal ownership, social equity may be an appropriate consideration… but in general, <u>social equity issues are better left to policy and regulatory bodies than to for-profit operating organizations</u>."

"Whether LDCs like it or not, electricity is an <u>essential service so customers cannot be stranded</u>. As some shift from reliance on the grid, <u>those left behind will have to pay more for electricity service</u>. This could pose a <u>significant challenge for the regulator</u> and provincial government."

Consolidation: Agree/Disagree

S2, Q12: *In general, do you agree or disagree with consolidation*?*

** Renewing Ontario's Electricity Distribution Sector: Putting the Consumer First (Elston, Laughren, McFadden, 2012, p. 29): The provincial government recommended that LDCs should be consolidation into "8 to 12 regional distributors that are large enough to deliver enhanced customer focus, while at the same time maintaining connections with local communities."*

$n_{2,12} = 39$

Discussion:

This question elicited clearly diverging opinions. 73% of Academics and Researchers agreed or did not have a problem with the provincial government's recommendation of LDC consolidation. 61% of LDC Owners + Managers disagreed with consolidation.

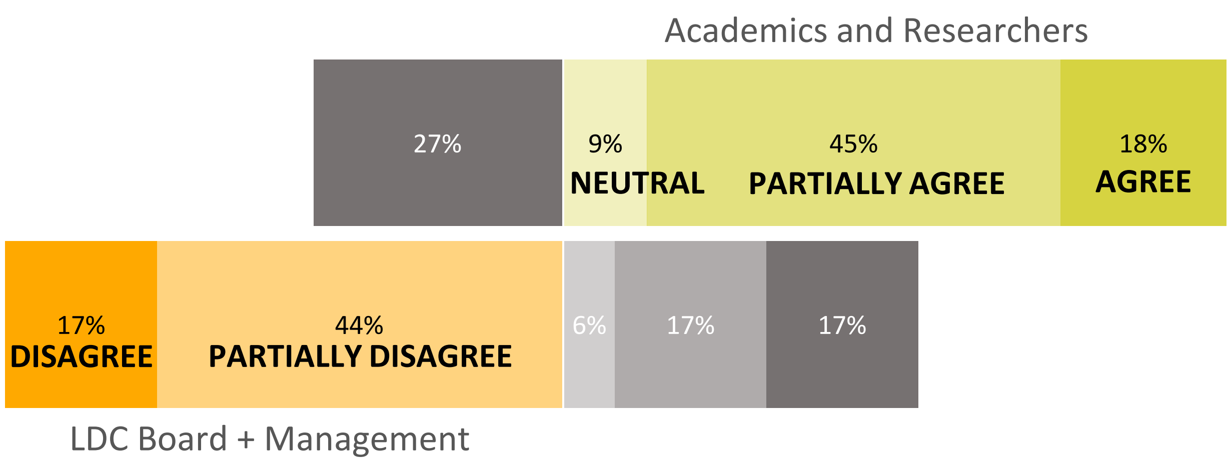


Figure 38. *Consolidation: agreement or disagreement – Researchers vs. LDC Managers.*

Consolidation: Concerns

S2, Q13: *With reference to the previous question, what element(s) of the consolidation recommendation, if any, do you disagree with?*

$n_{2,13} = 39$

Discussion:

Sectoral experts are largely dubious about the provincial government's claims of the various benefits of LDC consolidation. While 23% of respondents agreed with all elements of the consolidation recommendation, the majority disagreed with some elements in particular. First, that consolidation would deliver enhanced customer focus, and second, that it would deliver improved efficiency. Respondents also disagreed with the province's recommendation of the number of regional distributors which would ideally form out of the process of consolidation (i.e., 8 to 12). Three out of four groups also identified different primary concerns:

Profession Category	Primary Concern	Selected Quotes
Academics and Researchers	Enhanced customer service	Consolidation should not be forced. Let the LDCs decide with stakeholder input (local customers).
Industry	Improved efficiency	There is little to no correlation between size and efficiency/customer engagement. I believe LDCs should be pushed to be efficient, and there are many ways to do this.
	Large enough	
LDC Board + Management	8 to 12	The provincial government wants consolidation for two main reasons: 1) it can better drive energy policy through fewer large utilities, and 2) the OEB does not want to regulate 70 separate LDCs.

Table 11. *Respondents' concerns with consolidation.*

Consolidation: Tax Incentive

S2, Q14: Do you think [tax incentive] will be enough to encourage LDC consolidation?*

** 2015 Ontario Budget (Ministry of Finance, Chapter IV, Section 10: Supporting Consolidation of the Electricity Distribution Sector): "The province is proposing additional time-limited relief on taxes** pertaining to transfers of electricity assets…beginning January 1, 2016, and ending December 31, 2018, by (i) reducing the transfer tax rate from 33 to 22 per cent; (ii) exempting [LDCs] with fewer than 30,000 customers from the transfer tax; and (iii) exempting capital gains arising under PILs [payments in lieu of taxes] Deemed Disposition Rules."*

*** LDCs are subject to a transfer tax of 33 per cent on the fair market share value of the electricity assets sold to the private sector.*

$n_{2,14} = 39$

Discussion:

90% of Academics and Researchers, 83% of Industry, and 75% of Government + Regulation showed strong or very strong agreement that the tax exemption proposed in Ontario's 2015 Budget will be incentive enough to encourage voluntary consolidation among LDCs. In contrast, only 39% of respondents who self-identified as LDC Owners + Managers felt that it will be sufficient.

Selected Quotes (LDC Owners + Managers):

"<u>Consolidation by municipal owners are already tax free</u>. The tax relief <u>may be an incentive to private investment</u>. To the extent that private investors buy more than one LDC, it will promote consolidation."

"These incentives <u>may work to those who are sitting on the fence, but not municipalities who value local control and influence of their LDC</u>. <u>Hydro One's perceived poor service</u> will always overshadow small and medium municipalities decisions to consolidate."

Forecasting: Business Model [1/2]

S2, Q15: Considering the discussions at the conference and the results of the first survey, what do you think should be the business model of the LDC of the future?

$n_{2,15} = 29$

Self-identified LDC Owners + Managers appeared to have more agreement about their opinions of a future business model than did Academics and Researchers. They were also more concerned with the issue of cost than Academics and Researchers, whose opinions were fairly equally divided between customer, technology, community (and systems), and reliability issues. A more granular analysis of participants' free text responses revealed that a diversification strategy was usually inclusive of consolidation and a greater orientation toward service offerings and customer service. Whether respondents' opinions were to update regulatory regimes, or to do away with them altogether, the evolving role of the OEB was frequently mentioned. Free text responses were analyzed by word frequency (Figure 39) and by overall themes (Figure 40).

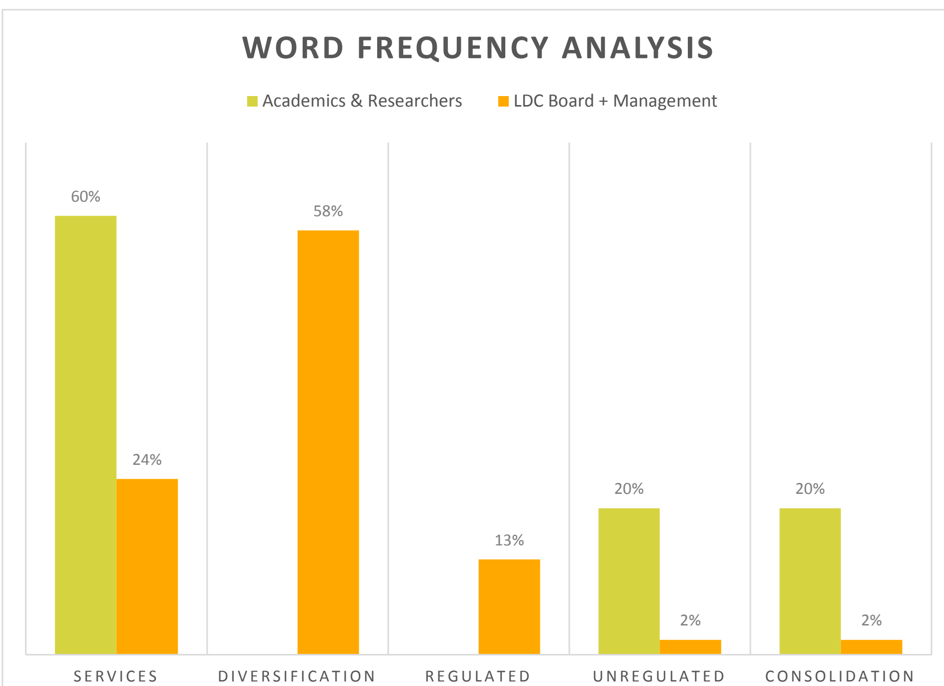


Figure 39. *Business model word frequency analysis – Researchers vs. LDC Managers*

Forecasting: Business Model [2/2]

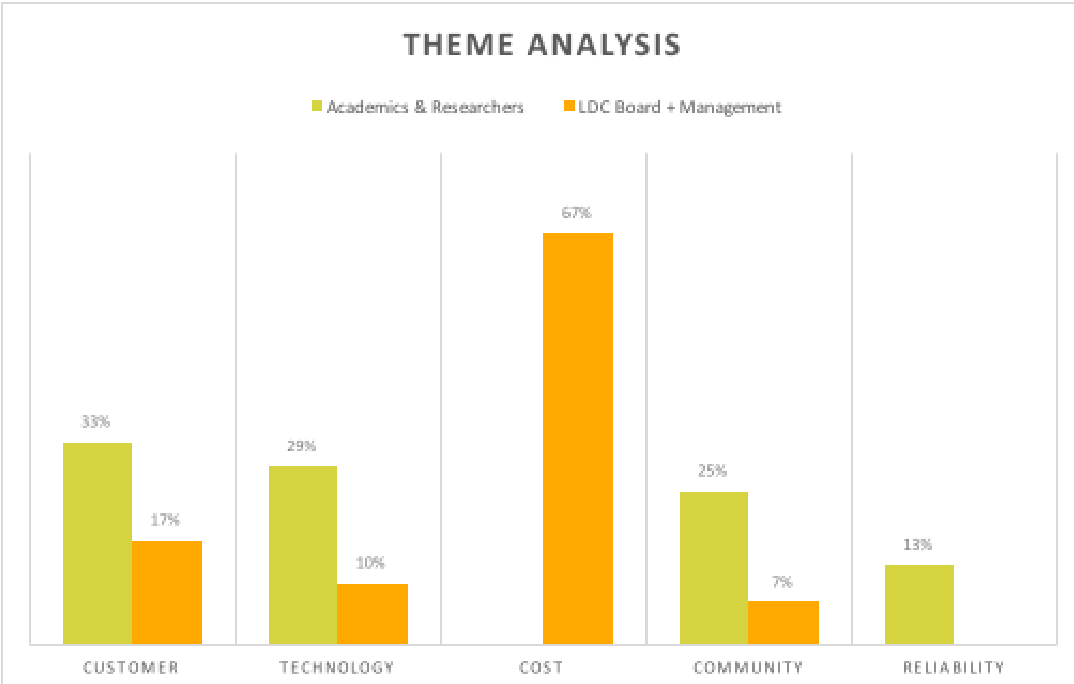


Figure 40. *Business model theme analysis – Researchers vs. LDC Managers*

4.9 Results Summary

The results of this research study have implications for how LDCs could change to remain viable into the future in the face of upcoming challenges presented by technology, customer expectations, financial pressures, the regulatory regime, and government policy. The unique context of Ontario's electricity industry includes additional challenges arising from:

- Aging and oversized distribution infrastructure;
- Retired coal-fired generation plants;
- Higher cost of wholesale electricity versus other jurisdictions;
- Historically-embedded regulatory regime;
- Fragmented political interference;
- Repeated instances of short-sighted sector restructuring;
- Fragmented current system, resulting largely from historical legacy;
- Culture of risk-aversion and an inability to adapt; and
- Shifting cost and competition dynamics.

Sectoral experts who attended the CUE's "LDC of the Future" conference were asked to provide their informed judgements on a diverse number and breadth of issues relevant to LDCs. These issues were selected based on a thorough review of the academic and industry literature, and ranged from the general and conceptual to the specific:

General Issue Topics:

- Forecasting: Ideal Future (S1)
- Infrastructure Renewal Costs: Raising Capital (S1)
- New Energy Consumer (S1)
- Forecasting: Sector Restructuring (S1)
- Forecasting: Business Model (S2)

Specific Issue Topics:

- DG Technologies (S1)
- Drivers of Change: Ratings (S1)
- Consolidation: Predictions (S1)
- Conference Feedback (S2)
- DE Technologies (S2)
- Drivers of Change: Ratings (S2)
- Forecasting: Community Energy(S2)
- Infrastructure Renewal Costs: Raising Rates (S2)
- New Energy Consumer: Social Equity (S2)
- Consolidation: Agree/Disagree, Concerns, and Tax Incentive (S2)

The findings from this study echo the sentiment shared at the CUE conference, namely, that "one size" of change will not fit all 70+ LDCs. The range of respondent opinions from the expert survey method are synthesized into nine insights. They concern important and timely topics that the LDC sector needs to deal with and act upon. Table 12 identifies the nine topics plus the survey questions which provided the source data for these insights. Table 13 articulates the range of respondent opinions that exists on these nine important topics; specifically summarizing the majority opinion and the largest dissenting opinion.

		Topic	Source Data
Insights	1	The Business Model	S1, Q8 (raising capital) S1, Q9 (new energy consumer) S1, Q11 (restructuring process) S2, Q11 (social equity)
	2	Consolidation	S1, Q7 (ideal future) S1, Q10 (number of LDCs) S1, Q11 (restructuring process) S2, Q12 (consolidation agreement/disagreement) S2, Q13 (consolidation concerns) S2, Q14 (consolidation tax incentive)
	3	Customer Centricity	S1, Q7 (ideal future) S1, Q9 (new energy consumer) S1, Q11 (restructuring process) S2, Q11 (social equity)
	4	Distributed Energy/ Distributed Generation Technology	S1, Q4 (DG) S1, Q5 (drivers of change 1 – ratings) S2, Q7 (DE) S2, Q8 (drivers of change 2)
	5	Future Focus	S1, Q6 (drivers of change 1 – reasons) S2, Q7 (DE) S2, Q8 (drivers of change 2) S2, Q9 (community energy)
	6	Privatization	S1, Q8 (raising capital) S2, Q10 (raising rates)
	7	Regulation	S1, Q11 (restructuring process) S2, Q10 (raising rates) S2, Q11 (social equity) S2, Q13 (consolidation concerns)
	8	Social Equity	S2, Q10 (raising rates) S2, Q11 (social equity)
	9	The Tax Incentive	S2, Q14 (consolidation tax incentive)

Table 12. *Insights on the LDC of the future – source data.*

		Majority	Dissenting
Insights	1	LDCs should diversify their business offerings and become service providers (go "behind the meter").	LDCs should specialize and concentrate on what they are good at: providing safe, reliable, cost-effective electricity.
	2	Consolidation will deliver economies of scale and improved efficiency.	There is no proof that larger utilities are more efficient, cost-effective, or customer-focused.
	3	Innovate and diversify to give customers all the new things that they want from their electric utility.	Customers only care about the lowest price of the commodity and aren't interested in paying higher costs for additional service offerings. Guaranteeing the provision of the essential commodity is LDCs' primary responsibility.
	4	Solar PV generation plus battery storage will be the technologies to watch in DE/DG.	Cogeneration/CHP will be the technology to watch in DE/DG.
	5	Technology should be the focus of future discussions about the LDC sector.	Cost should be the focus of future discussions about the LDC sector.
	6	The sector needs a major capital injection and this can be achieved through privatization and ownership diversification.	It is a mistake and bad public policy to relinquish control of a public good to private interests.
	7	The regulatory regime should evolve to allow and encourage innovative business strategies and new technology integration by LDCs. There will continue to be a need to for a "regulator 2.0" into the future.	Government policy and regulation should step out of the electricity market. We need to adopt a fully competitive, unregulated system.
	8	As providers of an essential commodity, LDCs have a responsibility to consider issues of social equity.	Social policy is not the job of an LDC.
	9	The tax break is sufficient to incent voluntary consolidation LDCs.	The proposed tax break is an insufficient incentive and only benefits private investors.

Table 13. *Insights on the LDC of the future – majority and dissenting expert opinions.*

In order to achieve a successful and sustainable change in this sector, it will be essential to continue the dialogue between LDC decision-makers and influencers from all different professional perspectives. The rapidly evolving nature of the energy industry will not be well-served by research conducted only a year previous, let alone a reliance on historical best practices or commonly-held knowledge. Through new technologies in energy storage and generation, our ability to manipulate electrical power is transforming. At the same time, social and environmental concerns are rising in importance relative to economic measures of value, which have often been the only question in electricity system planning. Sectoral change is a shared responsibility between LDC managers, regulators, and researchers. Therefore, opportunities for dialogue, such as that provided by the CUE conference and the present study, should continue.

5.0 CONCLUSION

This thesis has investigated the current challenges facing electric utilities in Ontario, Canada with a view to answering the question of how they should change in order to remain viable into the future. As providers of electric power, an essential commodity and public good, the health of LDCs is intimately tied to the overall economic, social, and environmental health of Ontario. They are also the primary point of contact between millions of electricity consumers and all other technical (e.g. generation, transmission) and institutional (e.g. policy, regulation, market planning) players in the system. However, the historical and cultural development of LDCs has created barriers that inhibit LDCs from adapting to their changing environment. Technological innovation will be the most important way to penetrate these barriers to drive the needed transformation of LDCs. Technology will empower the customer, ahead of other institutional players (i.e. the government, the regulator), to become the most important driver of change. The customer will direct LDC transformation toward more and diversified service offerings, lower prices, and more reliability. If LDCs cannot meet evolving customer expectations, new energy technology makes it possible for customers to stop/significantly cut back their purchases of grid-supplied electrical power.

A review of the academic and industry literature explains why the question of "how" LDCs should change even needs to be asked. Current and forthcoming challenges facing electric utilities cover four areas, identified based on the comments from the conference participants and the literature reviewed. New energy technologies are numerous and have the potential to alter the industry in every aspect. Some of the specific technologies most frequently mentioned in the literature as threatening the traditional business of the electric utility are distributed generation [DG] and distributed energy resources [DER], solar photovoltaic [PV] generation, battery storage (including electric vehicles [EVs]), and cogeneration or combined heat and power [CHP].

In terms of the customer, the biggest challenge stems from the fact that attitudes and expectations toward the electric utility are moving away from passivity. Customers want more services, more communication, more personalization, more flexibility, and more efficiency from their energy providers. If their expectations are not met, customers are becoming empowered by new energy technologies to curtail or entirely eliminate their reliance on the utility.

Financially, utilities are seeing a declining trend in electricity demand growth. While there are more customers overall, individually, they need less power from their utility. At the same time, the grid infrastructure is aging and needs to be replaced, at the very least. More accurately, the grid infrastructure needs to be renewed with more advanced equipment that will be able to integrate many new energy technologies, such as smart-meters, renewable generation sources, and bidirectional information and communication capabilities. In short, as revenues are going down, costs are going up for utilities.

Monopoly electricity markets have a regulating body authorized by the government to balance customer price protection with utility profits. In Ontario's hybrid electricity market, the traditional position of the regulator, the Ontario Energy Board [OEB], has been that innovative business practices are unnecessarily risky ventures that will drive up the cost of electricity (the essential commodity and public good). This is an intolerable result, and contrary to the *raison d'être* of the regulator. At the same time, long-term energy policy set out by the Government of Ontario is moving away from their traditional focus on cost. Pressure from both grassroots (e.g., Keep Hydro Public) and international bodies (e.g., the IPCC) are demanding that players in the energy industry take more ownership of their social and environmental impacts. Looking at the direction of Ontario's Long-Term Energy Plan [LTEP] and the growing focus on conservation and demand management [CDM], government policies regarding energy are more diverse than securing the financial bottom line.

Changes expected to occur in Ontario's electricity distribution sector are often identical to the trends already occurring in many U.S. electricity markets (Bronski *et al.*, 2014), with some specific differences unique to Ontario's case (e.g. the significant greenhouse gas [GHG] reductions from eliminated coal-fired electricity generation). Recommendations from the literature about how LDCs should change are diverse, but it is certain that there is a need for ongoing dialogue between decision-makers and influencers in the sector. This thesis offers an update on the century-long history of LDCs in Chapter 2.0 through a deep review of the literature. Freeman's (1996) review of Ontario Hydro from 1906-1995 was otherwise the most recent scholarly contribution to this effort. Another contribution of the literature review conducted in this research is in providing a critical academic study and assessment of the non-academic literature.

An institutional theory framework provides a valuable lens through which to consider the internal and external challenges for LDCs, and proposes a plausible starting point for a successful transformation. According to this theory, LDCs are a product of a series of historical events, rather than a result of deliberate planning. The rapid pace of development in the external technological, customer, financial, and regulatory/policy environments of Ontario's electricity distribution sector are changing traditional business models. This is exacerbated by institutional forces that have helped exacerbate LDCs' internal tendency toward inertia and risk aversion.

A significant contribution of this thesis is in showing how technological innovation is connected to institutional change, and can start to remove historically and culturally embedded barriers to change. Chapter 4.1 illustrates and describes a "checklist" for LDC decision-makers composed of questions about daily operational practices, practical and systemic policies, and deeply-held paradigms of belief related to the business of electricity distribution. It is found that change is occurring on both the technological and institutional level, and that change in one area will be able to drive change in the other. Challenges to electric utilities from the customer, financial, regulatory, and policy environments have all emerged as a result of the recent surge in new energy technologies. For example, prosumers could not exist without small-scale electricity generation. There would be fewer demands to overhaul the regulatory regime if innovation was not integral to a successful business model transformation. Advancements in climate modeling have trickled down to the government making concerted efforts to reduce Ontario's contribution to global climate change.

The survey method also employed in this thesis shows how LDC sector experts, with practical knowledge and experience, show support for the above proposition. Conducted in two stages before and after the CUE conference, it demonstrates the importance of ongoing dialogue between experts in the sector. When asked about the same issues concerning "the LDC of the future," there was no clear consensus between respondents. Nor was there any clear pattern of convergence between profession categories (Academic and Researchers, Industry, Government + Regulation, and LDC Owners + Managers). This shows that the future for LDCs is a complex discussion with multiple perspectives. For example, the change could try to maximize the greatest amount of good for the greatest number of ratepayers, or the greatest number of people (i.e., all the consumers of electricity). "People" could further be considered on a provincial scale, national scale, or international scale. The "greatest good" could be defined to include non-human entities, such as the environment, and all its various flora, fauna, and natural elements. Alternatively, it might be preferable for LDCs to change in many different ways that work for the many different communities, large or small, that they currently serve.

The opportunity to conduct a survey of expert opinions was afforded by the CUE conference on June 3rd, 2015. In this context, it was neither possible nor practical to choose a random sample of respondents. The results of the survey are therefore based on the informed judgements of a voluntary response sample. That is, it only includes the opinions of people who chose to participate in the study, whereas a random sample would need to include everyone in the target population of conference invitees. Respondents of this survey had more control over their participation than if a random sample was employed. It is therefore not intended to provide reliable predictions for behaviour across the entire sector, but is valuable for illuminating the relationships and depth of issues in the electricity distribution sector. The divergent opinions of sectoral experts seem to support the idea that there is no "one size fits all" solution for LDC change.

Energy independence may soon be a less expensive investment for customers in Ontario than purchasing grid-supplied power. Bronski *et al.* (2015, 2014) show that customers in New York state, empowered by advancements in rooftop solar PV generation and battery technology (e.g., EVs), will soon be able to eliminate or drastically reduce their reliance on the electric utility. There are serious consequences if this trend were to occur in Ontario. The electricity regulator (the OEB) could be made redundant along with all of the province's electric utilities (LDCs). The electricity distribution infrastructure could end up as billions of dollars of stranded assets and become massive costs for Ontario municipalities.

Chapter 4.9 synthesizes the results of the survey method to provide concrete answers to a key question for LDCs: *what kind of change will make "the grid" so valuable and so superior to other technology options that the customer will not leave?* We need to continue the dialogue on *how* LDCs can become more valuable to customers now empowered by technology. Sectoral experts recommend the following actions for LDC transformation:

1. *Diversify business offerings and become service providers;*
2. *Consolidate to deliver economies of scale and improved efficiency;*
3. *Innovate and diversify to give customers the new things they want from the electric utility;*
4. *Solar PV generation plus battery storage will drive distributed energy [DE];*
5. *Focus on technology in general;*
6. *Privatization and ownership diversification will provide the major capital needed to renew infrastructure;*
7. *The OEB must evolve but should not be eliminated;*
8. *Social equity should be part of business strategy;*
9. *Voluntary consolidation can be incentivized by the provincial government's proposed tax break.*

The findings of this research could be valuable for government, policymakers, LDC executives and managers, research organizations and think-tanks, and the customers/consumers of electricity in Ontario. Survey participants helped to identify several important area for future research in their responses to S2, Q2 ("What topics are you interested in exploring further?"):

- Ontario-specific empirical data on grid parity, grid defection, load defection
- How can LDCs overcome barriers to efficient and environmental transformation?
- Who wins and who loses from transformational change?
- How is the relationship between utilities and customers changing?
- What can LDCs learn from other industries and business models?
- What is the future of unregulated business in LDCs (especially "behind the meter" generation, storage and renewable energy integration, carbon trading)?
- How can new technologies be deployed through LDCs?
- Project-level examples of innovation and customer centricity at work in LDCs

- Implications of transformational change on LDC core competencies, leadership, labour relations and staffing
- What is the capacity and financial effect of DER on the centralized electricity system and provincial revenue?
- What is the role of the distribution system in microgrids?
- What is the actual cost and rate impact of full and partial load defection in Ontario?
- Exploration of a regulatory construct that encourages LDC business diversification

Sectoral experts also proposed several innovative business models for LDCs, which provide interesting subjects for future work in this field. For instance, they imagine LDCs as owners and operators of a "transactional grid," not just electricity distribution infrastructure. In this future, customers benefit from the power they can generate on their own property by using the centralized infrastructure as a conduit to deliver unused excess to others. In other words, customers buy and sell from each other, and pay to use the grid to do this, but do not primarily purchase electricity from the LDC.

Sectoral experts questioned if LDCs' traditional mandate of 100% reliable electricity provision remains true for every segment of the customer market. Though users will not readily admit that power outages are permissible to any great extent, survey respondents noted that customers will "put up with a lot" to avoid the hassle and cost of being responsible for their own electricity generation.

LDCs could operate in a completely competitive, market-based future, in which a regulating body has been removed from the profit equation. Prices would be determined by electrical power supply and demand, and customers' interests would be protected by competition between power suppliers in this non-monopolistic environment.

Alternatively, customers may cease to view energy simply as a commodity to be bought and sold, as has historically been true. Rather, communities will adopt a holistic view of energy and will use it to advance smart, long-term, triple bottom line (economic, social, and environmental) systems thinking. LDC should enable investment and opportunities in local communities, own and oversee a modernized transactional grid, and become indispensable parts of how district energy will work in the province. This research has helped to reveal these, and many more, innovative business models for the LDC of the future through an extensive review of academic and industry literature, a conceptual framework based on institutional theory, and the insights from a survey of sectoral experts. LDCs should ensure their continued viability by remaining relevant and valuable to evolving energy customer. A successful change will start with the integration of new energy technologies into traditional LDC business models.

APPENDIX A

Pre-Conference Survey ("S1") – Questions

Demographic:

1. What is your age range?
2. Are you currently, or have you ever been, an LDC board member?
3. Do you identify with one or more of the following groups?

LDC of the Future:

4. What do you think will be the stand-out applications or technologies of DG into the future?
5. On a scale of 1 (least important to 5 (most important), please rate each driver of change (adjacent) according to your judgement of its likelihood to influence the direction of the industry?
6. Please tell us briefly about the reasons for your ratings in question #5.

1. Battery and other storage systems
2. Climate change concerns
3. Conservation and demand management (CDM)
4. Cost-cutting and rate reduction
5. Distributed generation
6. Electric vehicles
7. Extreme weather
8. LDC consolidation
9. Prosumers and other new competitors
10. Shifting customer preferences
11. Smart grid and smart technologies

7. In light of the most important factors you identified in question #5, what do you think should be done to encourage an ideal future for the industry?
8. How do you think [the cost to renew Ontario's electricity distribution infrastructure] should be addressed?
9. What do you think are the best ways for LDCs to meet the needs of Ontario's new energy consumer into the future?
10. How many LDCs do you predict will exist in Ontario in the year 2030?
11. Looking forward to the year 2030, what will emerge as the dominant process for restructuring Ontario's electricity distribution system? (Please use the 'Comments' box to tell us why you think so.)

• Consolidation
• Diversification
• Specialization
• Privatization

APPENDIX B [1/4]

Research Study Participant Consent Letter

RYERSON UNIVERSITY

Yeates School of Graduate Studies

Participant Consent Letter

The LDC of the future:
Expert insights on challenges, opportunities, and the drivers of change in Ontario's electricity distribution industry

You are being invited to participate in a research study. Please read this consent form so that you understand what your participation will involve. Before you consent to participate, please ask any questions to be sure you understand what your participation will involve.

INVESTIGATORS: This research study is being conducted by Nabila Alibhai (graduate student in Environmental Applied Science & Management, Yeates School of Graduate Studies), jointly supervised by Dr. Dan McGillivray from the Centre for Urban Energy (CUE) and Dr. Michal Bardecki from the Department of Geography at Ryerson University.

If you have any questions or concerns about the research, please feel free to contact:
Dr. Dan McGillivray, dan.mcgillivray@ryerson.ca, (416) 979-5000 ext. 2976
Dr. Michal Bardecki, bardecki@ryerson.ca, (416) 979-5000 ext. 6175
Ms. Nabila Alibhai, nabila.alibhai@ryerson.ca

PURPOSE OF THE STUDY: The objective of the study is to explore key drivers of change in Ontario's electricity distribution industry in order to identify some of the major challenges and opportunities that LDCs are facing today. This study has been designed to complement the objective of the conference, **"The LDC of the Future,"** taking place on Wednesday, July 3, 2015 at the Mattamy Athletic Centre of Ryerson University (60 Carlton Street, Toronto, Ontario, M5B 1J1). Approximately 100 participants are being recruited for this study, and are wholly comprised of the industry experts invited to the conference. Results of this study will contribute to a graduate thesis for the Master of Applied Science (M.A.Sc.) in Environmental Applied Science & Management.

WHAT PARTICIPATION MEANS: If you volunteer for this study, you will be asked to:

Complete **two 10-minute online surveys** with up to 15 closed and open-ended questions per survey. In total, you can expect to devote between **20-30 minutes over two weeks (June 2-14, 2015)** to participate in this study. There is no requirement for additional preparation to

APPENDIX B cont. [2/4]

Research Study Participant Consent Letter

complete the surveys. Results from this study will be anonymized and aggregated to ensure confidentiality is maintained in data collection and reporting, and that participants cannot be inadvertently identified. Anonymized research data will continue to be made available to interested participants after the culmination of this study.

A link to access the Pre-Conference Survey will be sent to you electronically from the Centre for Urban Energy on **Tuesday, June 2, 2015**, and may be completed online at your convenience any time prior to **Thursday, June 4, 2015 at 11:45pm**.A paper version of the same survey will also be made available to you at the conference.

Results from the Pre-Conference Survey will be analyzed and aggregated, and findings will be provided to all participants in the Post-Conference Survey in the week of June 8-12, 2015. Your link to access the Post-Conference Survey will also be sent to you electronically from the Centre for Urban Energy, and will cover the same topics as the first survey. At this point, you are free to maintain or change your responses. The Post-Conference Survey will also take approximately **10 minutes** to complete, and may be done so online at your convenience any time prior to **Sunday, June 14, 2015 at 11:45 pm**.

The Pre-Conference Survey will include a short Respondent Profile to collect data on participants' occupations and age ranges. This information will be used to establish a baseline for the study and frame the analysis of responses. You can choose whether or not to answer these questions without any impact on your participation in this research study or the conference. The purpose for collecting demographic information is to enhance the insights of this research study by investigating whether there is any correlation between age, occupational background, and responses. Demographic characteristics will only be reported where clear patterns and trends exist in a group of respondents in order to protect individual participant identities.

Questions will be of two types:

- General demographic and occupation questions;
- Questions seeking your judgment on important issues in the electricity distribution industry.

Sample Questions:

1. What is your age range?
   - 20-39
   - 40-59
   - 60+
2. Are you currently, or have you ever been, an LDC board member?
   - Yes
   - No

APPENDIX B cont. [3/4]

Research Study Participant Consent Letter

9. What do you think are the best ways for LDCs to meet the needs of Ontario's new energy consumer into the future?

<u>POTENTIAL BENEFITS</u>: While not guaranteed, participation in this study has the potential to provide managers and decision-makers of Ontario LDCs with greater insights on the challenges and opportunities in their industry by incorporating valuable perspectives of fellow industry experts. You may not gain any direct benefit from participating in this study.

<u>WHAT ARE THE POTENTIAL RISKS TO YOU AS A PARTICIPANT</u>: Participation in this study involves minimal risk because it will be no greater than what you would encounter in your daily professional activities. The surveys which take place in the context of this study will be directly related to the topics discussed at the conference, **"The LDC of the Future."** Some anxiety or discomfort may result from the nature of the topics covered in the study and discussed at the conference. Any risk of social exposure among industry colleagues will be mitigated by completing the surveys online, in a time and place of your convenience.

Participants may be concerned that their personal identities may become inadvertently exposed by taking part in this study. Provisions put in place to minimize this possibility include separate, encrypted storage arrangements for coded demographic data and question responses and results reported via group trends, patterns, and aggregated data. The choice to participate in this study or not will never affect an existing relationship with Ryerson University, the Centre for Urban Energy, or any staff members of these institutions.

<u>CONFIDENTIALITY</u>: Several measures to maintain the confidentiality of participant identities and responses will be adopted for this study. Demographic data (age range, and place of employment) will be coded and stored in encrypted form separately from survey response data. Real names of participants will be neither asked nor used in published material. Any findings published from this study will only provide grouped and aggregated trends and statistics of participant responses to prevent individual participant identification. Data will remain in secure storage for a maximum period of 5 years. After this time, the data will be destroyed by fully reformatting the portable storage media.

The online surveys are hosted by SurveyMonkey, a websurvey company located in the USA and as such is subject to U.S. laws; in particular the US Patriot Act, which allows authorities access to the records of internet service providers. This survey or questionnaire does not ask for personal identifiers or any information that may be used to identify you. However, if you choose to participate in the survey, you understand that your responses to the survey questions will be stored, and can be accessed, in the USA. The security and privacy policy for the

APPENDIX B cont. [4/4]

Research Study Participant Consent Letter

websurvey company can be found at https://www.surveymonkey.com/mp/policy/privacy-policy/

INCENTIVES FOR PARTICIPATION: Participation in this study is voluntary, therefore no monetary compensation will be provided.

COSTS TO PARTICIPATION: There is no cost to participate in this study.

VOLUNTARY PARTICIPATION AND WITHDRAWAL: Participation in this study is completely voluntary. You can choose whether to be in this study or not. If any question makes you uncomfortable, you can skip that question. You may withdraw from the study at any time, and at any point. Simply close your web browser before submitting your survey, and your data will not be collected. Your choice of whether or not to participate will not influence your future relations with Ryerson University, the Centre for Urban Energy or the investigators (Nabila Alibhai, Dr. Dan McGillivray, Dr. Michal Bardecki) involved in the research. You are not forfeiting any of your legal rights by participating in this study.

FOR QUESTIONS ABOUT THE STUDY NOW OR LATER, PLEASE CONTACT:

Primary Investigator: Nabila Alibhai, nabila.alibhai@ryerson.ca

Supervisor Contacts: Dr. Dan McGillivray, dan.mcgillivray@ryerson.ca, (416) 979-5000 ext. 2976
Dr. Michal Bardecki, bardecki@ryerson.ca, (416) 979-5000 ext. 6175

This study has been reviewed by the Ryerson University Research Ethics Board. If you have questions regarding your rights as a participant in this study please contact:

Research Ethics Board
c/o Office of the Vice President, Research and Innovation
Ryerson University
350 Victoria Street, Toronto, ON, M5B 2K3
416-979-5042
rebchair@ryerson.ca

APPENDIX C [1/2]

Post-Conference Survey ("S2") – Questions

Conference Feedback:

1. Which session(s) did you find most useful?
2. What topics are you interested in exploring further?

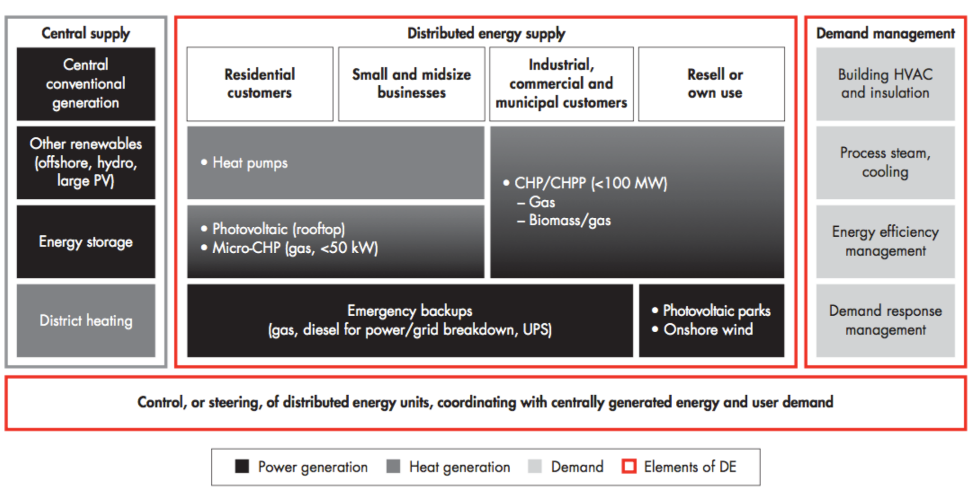
Demographic:

3. Based on the categories outlined in the 2012 Report of the Ontario Distribution Sector Review Panel*, what is the size of your LDC?
4. What is your age range?
5. Are you currently, or have you ever been, an LDC board member?
6. As a participant of the CUE's 'LDC of the Future' conference, what group do you predominantly identify with?

LDC of the Future:

7. The figure* (below) provides a good overview of areas in distributed energy (DE) that could be opportunities for the LDC of the future. Considering all possibilities (i.e., central supply, customer segments, technology applications, demand management), where would you invest?

Figure 1: Distributed energy includes three areas of opportunity: Helping users generate energy, managing their demand and balancing energy supply and demand across the network



Notes: CHP: combined heat and power; CHPP: combined heat and power plant; UPS: uninterrupted power supply; HVAC: heat, ventilation and air-conditioning
Source: Bain analysis

APPENDIX C cont. [2/2]

Post-Conference Survey ("S2") – Questions

8. Considering what you heard at the conference, please rate each driver of change (adjacent) according to your judgement of its likelihood to influence the direction of the industry.
9. In an "ideal future," LDCs will implement Integrated Community Energy Solutions* … Where can the LDC of the future have the most impact in a Smart Energy Community?

> 1. Battery and other storage systems
> 2. Climate change concerns
> 3. Conservation and demand management (CDM)
> 4. Cost-cutting and rate reduction
> 5. Distributed generation
> 6. Electric vehicles
> 7. Extreme weather
> 8. LDC consolidation
> 9. Prosumers* and other new competitors
>   ** producer + consumer, i.e., term to describe consumers who are also producers of electricity*
> 10. Shifting customer preferences
> 11. Smart grid and smart technologies

10. Should ratepayers bear more of the cost of renewing and transforming Ontario's electricity distribution infrastructure (i.e., via raised electricity rates, distribution rates, global adjustment, etc.)?
11. Considering the essential nature of the electricity commodity, is it the job of an LDC to consider issues of social equity in its customer base before making business decisions?
12. In general, do you agree or disagree with the [consolidation] recommendation?
13. What element(s) of the recommendation (adjacent), if any, do you <u>disagree</u> with?
14. Do you think the [relief on taxes pertaining to transfers of electricity assets] will be an effective incentive to encourage LDC consolidation?

> - 8-12
> - regional (geographically contiguous) distribution
> - large enough
> - improved efficiency
> - local community connections
> - agree with all elements

APPENDIX D

S2 Sample Demographics

Professional Association	Conference Population		S2 Sample		
	n	%	*n*	*% of sample*	*% of population*
LDC Management and Operations	27	24	13	31	48
LDC Board of Directors and Municipal Government Representatives	28	25	5	12	43
Academia and Researchers	16	14	13	31	81
Industry (including Consultants)	17	15	7	17	41
Law	5	5	0	0	0
Federal/Provincial Government	6	6	2	5	33
Regulatory and Market Operations	6	6	2	5	33
Other (NGOs, Associations, etc.)	7	5	*2 merged to industry, 2 merged to academia*		
Total	**112**	**100**	**42**	**100**	**37.5**

APPENDIX E

"LDC of the Future" Conference Agenda

8:00am Registration
Continental Breakfast
Networking

8:45 Welcoming Remarks
Video: The Schneider Electric Smart Grid Lab

9:00 Session One
The Challenge - Technology Developments

New and rapidly improving technology – particularly in the form of distributed generation, storage, and conservation – provide consumers with the opportunity of not just reducing their electricity consumption, but of ultimately leaving the grid altogether. Is this a serious threat or an important opportunity for LDCs?

Featuring:
Dan McGillivray
Bala Venkatesh
Sean Conway (Moderator)

9:45 Session Two
The Evidence

LDCs face a challenge in addressing changing customer preferences. The demand for reliable electricity will increase with the continued adoption of high-tech devices and electric vehicles. To keep up, LDCs must bear the cost of renewing aging infrastructure. At the same time, government policies also require LDCs to encourage conservation and distributed generation, which further increases their costs while cutting into their revenues. Customers and businesses alike are also employing new technologies to reduce their demand, resulting in both further reduced revenue for LDCs and new competition for the delivery of electricity services.

The question remains: what are LDCs actually seeing in their networks, in their communities, and on their balance sheets? How has this challenge manifested itself today, and how might it practically affect the LDC of the future?

Featuring:
Mike Matthews
Atul Mahajan
James Keech
Sean Conway (Moderator)

10:45 Networking Break

11:00 Session Three
Financial and Regulatory Implications

New technology presents both financial and regulatory implications for LDCs and their owners. As some consumers reduce their demand, the cost of maintaining existing infrastructure will fall on an increasingly smaller group of consumers, particularly low-income consumers. This raises questions of social justice. Further, declines in revenue create the risk that LDCs and their owners will have to bear the costs of stranded assets, which could seriously affect municipal budgets across the province. Can existing regulatory and policy mechanisms protect LDCs and their owners from the impact of these challenges?
LDCs have operated under a "regulatory bargain," where they are compensated for their obligation to serve their communities by earning a fair return on their investment. Can – and should –this "bargain" protect LDCs from the effects of shifts in consumer expectations and competition? This panel will consider this and other questions, including:

1. Should the provincial government assume responsibility for the costs of stranded assets?
2. Should the regulatory system rely on traditional cost accounting tools – like increasing fixed charges – to address the challenges?
3. Are those traditional regulatory tools effective in the long run?
4. Are they appropriate as a response to technological, policy, and cultural changes?

Featuring:
Karen Taylor
Karen Farbridge
Robert Warren (Moderator)

12:15pm Lunch and Keynote
Future Energy Technologies

Featuring:
Tyler Hamilton

1:30 Session Four
The Owners

This session asks the owners of LDCs (mostly municipalities) for their perceptions of these challenges and how they might be addressed. Key questions for the owners are:

1. Do municipalities regard the challenges to their LDCs as real and pressing?
2. How important is the revenue from LDCs to the finances of municipalities?
3. Do municipalities believe that the provincial government has a responsibility to either protect LDCs from competition or assume the costs of stranded assets?
4. What role do municipalities believe the regulator should play in assisting LDCs to meet these challenges?
5. To what extent, if at all, is the sale of the LDC, the acquisition of another LDC, or a merger with another LDC, a viable option for municipalities to preserve an important source of revenue?

Featuring:
Adrian Foster
Glenna Carr
Jim Hogan
Paul Murphy (Moderator)

2:45 Networking Break

3:00 Session Five
The Path Forward

What are the possible solutions to these challenges? One possible solution is a change to the regulatory model governing LDCs. Such a change might involve a movement away from traditional solutions based on cost recovery methods, and towards one that encourages value creation. Among the questions this session will address are the following:

1. If the regulatory system encourages or requires the development of new business models for LDCs, what would those new models consist of?
2. What should be the role of the regulatory system, and of provincial government policy, in enabling the creation of those new business models?
3. Is consolidation of LDCs into fewer but larger units an adequate solution to these challenges?
4. Is size alone sufficient or are new business models necessary?
5. What can and should be the role of the private sector in enabling LDCs to meet these challenges?

Featuring:
Norm Fraser
Timothy Curtis
Michael Angemeer
Paul Murphy (Moderator)

4:15 Wrap-Up

What have we heard?
What does it mean?
Where do we go from here?

4:45-5:30 Adjournment and Reception

#FutureLDC / @RyersonCUE

Source: (Zade *et al.*, 2015)

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