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Industry Perspective

Smart Grid Technology Adoption in Canada

MaRS

Natural Resources Canada | Ressources naturelles Canada

Canada

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Executive Summary

This report is produced by MaRS Discovery District (MaRS) with funding provided from Natural Resources Canada. Its objective is to provide insight into the opportunities and challenges of smart grid (SG) technology adoption across Canada, informed by interviews with 29 Canadian public and private utilities, associations and system operators, which the report refers to as “energy service providers.” Any mention of “utilities, associations or systems operators” is a reference to that unique subset of organizations interviewed, rather than all interviewees.

The Canadian energy sector is diverse, and energy service providers offer a range of technical expertise and abilities. It is important to recognize the differences between energy service providers and to acknowledge that the variance in their capabilities is necessitated by Canada’s unique landscape and people.

The report finds that energy service providers face numerous barriers to innovation and technological adoption. These barriers include:

1. **A difficulty investing in advancements beyond core operations and spending little time on SG technology adoption.**
2. **A lack of strategic foresight, training and personnel focused on innovation.**
3. **An inability to align the appropriate stakeholders to make a business case for investing in SG technology to regulators or the board.**
4. **A perception that the regulatory environment is more rigid and hindering than it actually is.**
5. **A lack of customer understanding and difficulty providing customers with value.**

Addressing these hurdles requires a focused effort from those in the policy and regulatory spheres, as well as from energy service providers. The following five recommendations aim to help energy service providers, regulators and policy-makers to address the gaps in—and misperceptions about—approaches to technological adoption, market trends and traditional relationships.

1. **Evaluate current and future investments and validate them against a corporate innovation strategy.**
2. **Embrace a long-term view of sector trends, ensuring that operations and projects align with the future of the market.**
3. **Treat innovation projects differently from proven technology projects.**
4. **Recognize that the ability to innovate relies on a realistic understanding of the regulatory environment and a willingness to openly engage with the regulator.**
5. **Identify novel ways of understanding customers and best addressing their needs.**

Introduction – Canada's Energy Transition

Canadian energy markets, much like the rest of Canada, are defined by their diversity. This makes market integration and cooperation one of Canada's biggest opportunities and one of its biggest challenges. It is important to understand the nuances and diversity of the Canadian energy landscape to contextualize smart grid technology adoption in Canada.

Each province and territory has its own unique energy ownership and regulatory structure. While Canadian electricity markets are regulated by the provinces and territories they are located in, reliability is coordinated at a North American level and requires cooperation between regulatory bodies in Canada and the United States, such as the North American Electric Reliability Corporation and the US Federal Energy Regulatory Commission. Any energy projects that span multiple provinces, territories or borders, or that involve an energy source of national importance, such as nuclear power, are reviewed and monitored by the Canada Energy Regulator and the Impact Assessment Agency of Canada.

Despite Canada's reliance on the oil and gas sector as a major source of economic growth, it has a fairly carbon-free generation mix, relying heavily on both hydro and nuclear power.[1] But there remain some immediate challenges to maintaining, monitoring and further reducing greenhouse gas emissions. For example, the lifetimes of a number of Canada's nuclear plants are coming to an end in the next 20 years, which will result in a significant shift to Canada's power generation profile. In the next five years, 10 major nuclear reactors will be shut down in Ontario[2]—some for major components replacement,[3] while others will end commercial operations altogether.[4] New generation capacity must be met by either existing generation sources or the development of new ones. Table 1 outlines some of the planned closures of nuclear generating stations across Canada, which will have a significant effect on the clean-generating capacity of Canadian nuclear sites.

This shift may result in a new carbon-light approach to Canadian energy production, facilitated through wide-scale adoption of new SG technologies and distributed energy resources (DERs). Alternatively, it may force Canada to rely more heavily on carbon-heavy production techniques.

Energy consumption in Canada is expected to plateau in 2040,[5] adding another hurdle to the country's energy sector innovation journey. Despite the forecasted demand plateau, as electricity production from coal, oil and gas declines the demand on renewable energy is expected to increase, as shown in Figure 1.[6] In addition, prices for renewables continue to decrease as consumers and governments become increasingly aligned with international and national policies and frameworks on climate change. Smart grid adoption will support and increase the efficiency and use cases for renewables, and support the increase in demand from renewable generation.

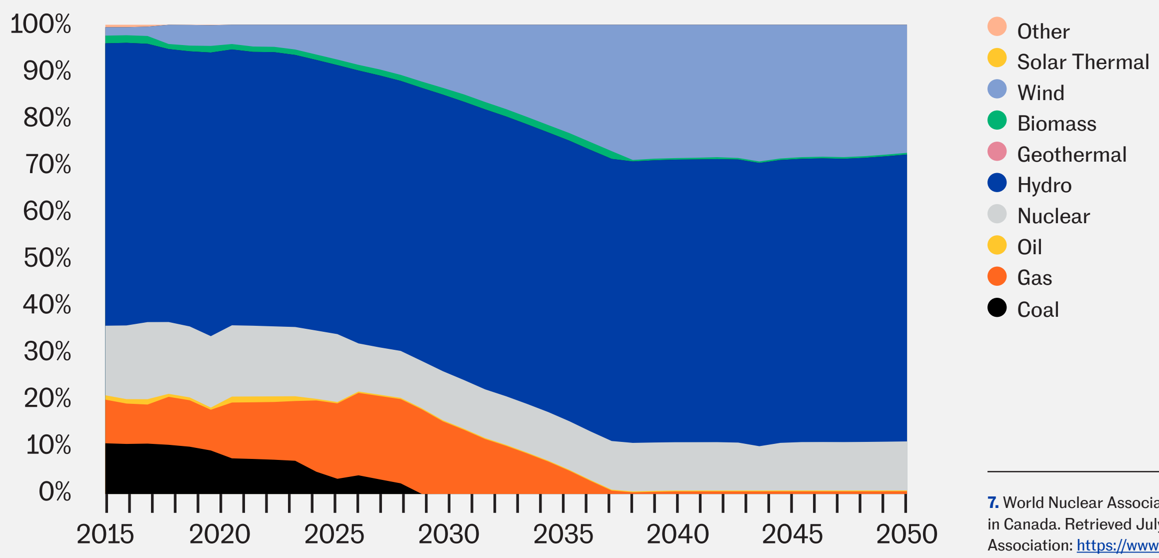
1. Canada Energy Regulator. (2018, August). Provincial and Territorial Energy Profiles – Canada. Retrieved September 3rd, 2019 from Canada Energy Regulator: https://www.cer-rec.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/cda-eng.html **2.** Ontario Power Generation. Darlington Refurbishment Performance Update Q2 2019. Retrieved August 20, 2019 from Ontario Power Generation: https://www.opg.com/strengthening-the-economy/our-projects/darlington-refurbishment/ **3.** Dunn, S. (2018, November). Bruce Power's Unit 6 Refurbishment to Start in 2020. *The Owen Sound Sun Times*. Retrieved August 20, 2019 from The Owen Sound Sun Times: https://www.owensoundsuntimes.com/news/local-news/bruce-powers-unit-6-refurbishment-to-start-in-2020 **4.** Ontario Power Generation. The Future of Pickering Generating Station. Retrieved August 20, 2019 from Ontario Power Generation: https://www.opg.com/powering-ontario/our-generation/nuclear/pickering-nuclear-generation-station/future-of-pickering/ **5.** Klukas, M. Energy Insights – The Energy Landscape in Canada & ASEAN. Retrieved June 3, 2019 from Canadian-ASEAN Business Council: https://www.canasean.com/energy-insights-the-energy-landscape-in-canada-asean/ **6.** BloombergNEF. New Energy Outlook, 2019. Retrieved July 24, 2019 from BloombergNEF: https://www.bnef.com/core/insights/20917/view

Table 1: Planned Closure of Canadian Nuclear Facilities

Reactor	MWe Net	Operator	First Power	Planned Close, or License To
Pickering A1	515	Ontario Power Generation	1971 / 2005	2022
Pickering A4	515	Ontario Power Generation	1972 / 2003	2022
Pickering B5	516	Ontario Power Generation	1982	2024
Pickering B6	516	Ontario Power Generation	1983	2024
Pickering B7	516	Ontario Power Generation	1984	2024
Pickering B8	516	Ontario Power Generation	1986	2024
Bruce A1	750	Bruce Power	1977/2012	2035
Bruce A2	750	Bruce Power	1976/2012	2035
Bruce A3	750	Bruce Power	1977/2004	2036
Bruce A4	750	Bruce Power	1978/2003	2036
Bruce B5	825	Bruce Power	1984	–
Bruce B6	825	Bruce Power	1984	–
Bruce B7	825	Bruce Power	1986	–
Bruce B8	825	Bruce Power	1987	–
Darlington 1	881	Ontario Power Generation	1990	2025
Darlington 2	881	Ontario Power Generation	1990	2025
Darlington 3	881	Ontario Power Generation	1992	2025
Darlington 4	881	Ontario Power Generation	1993	2025
Point Lepreau 1	635	New Brunswick Power	1982/2012	2037
Total Operating (19)	**13,553**			

Source: *World Nuclear Association*[7]

Figure 1: Energy Generation in Canada



Source: *BloombergNEF: New Energy Outlook 2019*[8]

7. World Nuclear Association. (2019, January). Nuclear Power in Canada. Retrieved July 19th, 2019 from World Nuclear Association: https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/canada-nuclear-power.aspx
8. BloombergNEF. Supra note vi, at 116.

Ambitions of the Canadian Energy Sector

Another factor to consider when forecasting Canada's energy transition are the goals of energy service providers in Canada, who are looking to be national and global leaders in clean, renewable and resilient energy production, transmission and distribution.

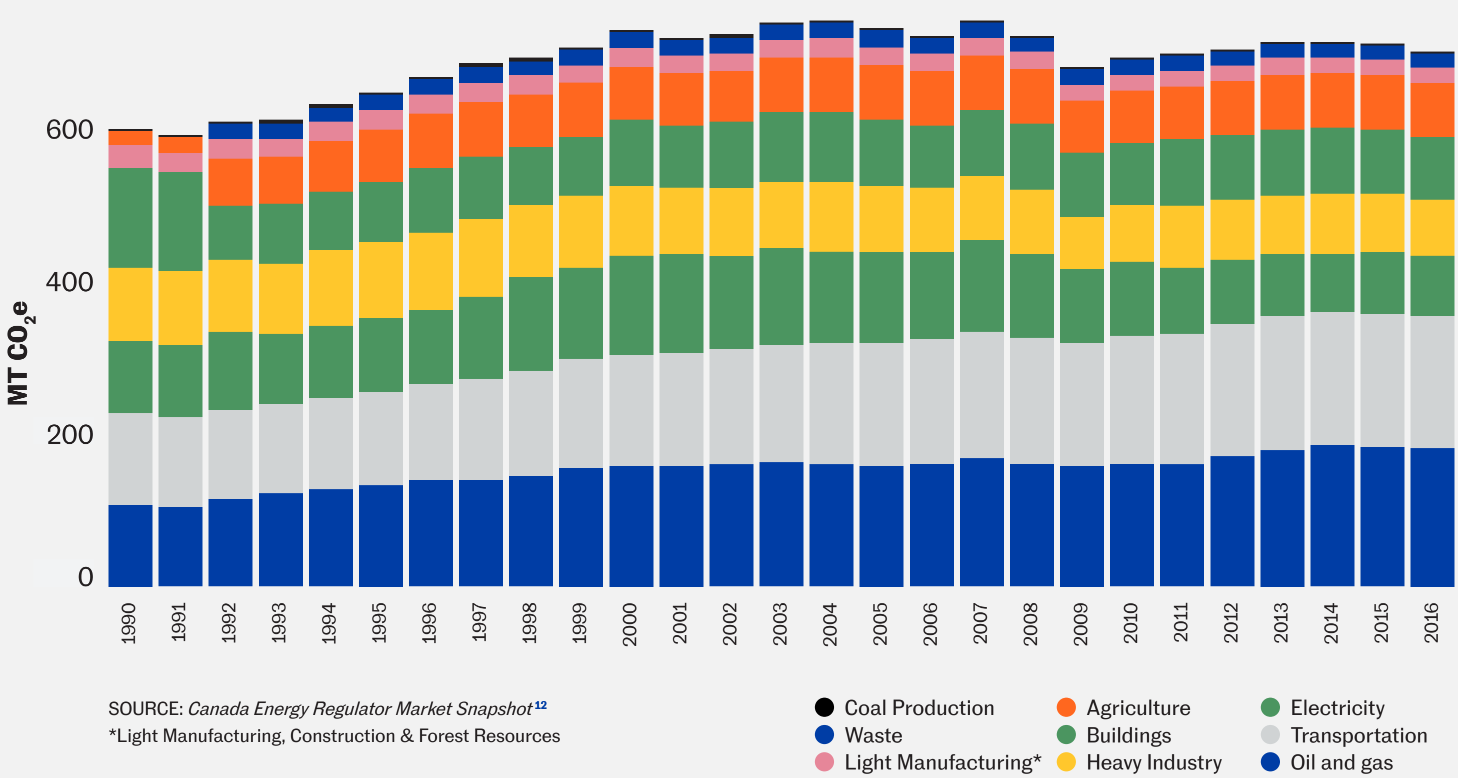
The goals and ambitions of energy service providers are motivated by broader industry trends that include: the shift to decarbonization, improving operational efficiencies and grid modernization, and the focus on provision of better services to customers.

Decarbonization

In 2015, Canada signed the Paris Agreement[9] and promised to reduce emissions with the goal of maintaining a global average temperature rise of no greater than two degrees Celsius.[10] The following year, Canada announced the Pan-Canadian Framework on Clean Growth and Climate Change.[11] It set forward an ambitious target to reduce greenhouse gas (GHG) emissions by 30% below 2005 levels by 2030. Canada's emissions profile has continued to remain stagnant overall rather than decrease (as shown in Figure 2).

9. Government of Canada. (2016, January). The Paris Agreement. Retrieved June 7, 2019 from Government of Canada: https://www.canada.ca/en/environment-climate-change/services/climate-change/paris-agreement.html **10.** Ibid. **11.** Government of Canada. (2019, March). Pan-Canadian Framework on Clean Growth and Climate Change. Retrieved July 10, 2019 from Government of Canada: https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html **12.** Canada Energy Regulator. (2019, January). Market Snapshot: Canada's Historical GHG Emissions – Update. Retrieved September 3rd, 2019 from Canada Energy Regulator: https://www.cer-rec.gc.ca/nrg/ntgrtd/mrkt/snpsht/2019/01-03cndhstrclghgmssn-eng.html

Figure 2: Greenhouse Gas Emission Profiles by Sector



SOURCE: *Canada Energy Regulator Market Snapshot*[12]
*Light Manufacturing, Construction & Forest Resources

Operational Efficiencies and Grid Modernization

Electricity production generated approximately 12% of the emissions produced by Canada, but this figure is expected to decrease to almost zero by 2036.[13] As governments change and voter bases polarize, energy service providers are also subject to regular changes in regulatory and political appetites for innovative ideas and new technologies. These issues are exacerbated by the fragmented structure of electricity markets in Canada and the limited interconnection or communication between provinces and territories.[14] Utilities are beginning to seek unique partnerships and explore new technologies that will increase their operational efficiencies from generation to distribution.

Trends toward technologies that increase the reliability and efficiency of electricity production, transmission, distribution and storage are essential components of the transition to cleaner, more cost-effective and less GHG-intensive forms of electricity. As climate change begins to take a larger toll on communities within Canada, utilities are motivating a shift toward smarter, cleaner and more reliable energy generation, transmission and behind-the-meter technologies. The focus on grid reliability is paralleled by the integration of renewables, energy storage and analytics, which will seek to improve the efficiency of generation, transmission and distribution.[15] The Canadian Energy Regulator has predicted that generation within Canada will have to grow by 27% by 2035. Traditional sources of generation, such as nuclear and hydro generation, are forecasted to have reduced generation capacity, with renewables and natural gas generation facilities showing the largest increases in generation capacity.[16]

Customer Service

Consumers within Canada are demanding more accountability and transparency when it comes to their electricity prices, putting pressure on utilities to install and implement new technologies and pricing mechanisms. Canadians are beginning to think differently about their relationships with their electricity providers and are exploring new communication and generation technologies such as the Internet of Things and Distributed Energy Resources, such as solar.[17] There are significant directives pushing both policy and consumers toward cleaner technologies, with an increasing focus on environmental protection and sustainability. [18] Two-way generation and customer-focused business models add new layers of complexity for utilities that are used to focusing primarily on upstream generation. Utilities are thinking more strategically about how to engage with and offer value to their customer base.

Despite the changing energy production landscape and customer demands, most pricing models and physical infrastructure remain the same as 10 years prior. The majority of newly built grid infrastructure can be attributed to sprawling suburban populations.[19] Utilities are responding to these trends through the experimentation in and adoption of new technologies. However, many are experiencing difficulties in keeping up with consumer trends and rapidly advancing technologies, both of which have implications on the grid and the relationships utilities hold with their customers.

For more information on the Canadian energy landscape, please see the MaRS Advanced Energy Centre's Market Information Report: Canada.[20]

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13. BloombergNEF. Supra note vi, at 116. **14.** International Energy Agency. (2016). Energy Policies of IEA Countries: Canada 2015 Review. Retrieved July 8, 2019 from International Energy Agency: https://www.iea.org/publications/freepublications/publication/EnergyPoliciesofIEACountriesCanada2015Review.pdf **15.** SmartGrid Canada. What is Smartgrid? Retrieved July 18, 2019 from SmartGrid Canada: http://www.sgcanada.org/what-is-smartgrid **16.** Canadian Electricity Association. (2014, April). Vision 2050: The Future of Canada's Electricity System. Retrieved August 4, 2019 from Canadian Electricity Association: https://electricity.ca/wp-content/uploads/2014/03/Vision2050.pdf **17.** IndEco. (2013, January). Smart Grid Consumer Engagement. https://www.indeco.com/pdfs/smart-grid-consumer-engagement.pdf. Retrieved August 3rd, 2019. **18.** Government of Canada. Supra note xii. **19.** Gass, P., Echeverria, D., and Asadollahi, A. (2017, September). Cities and Smart Grids in Canada. Retrieved July 6, 2019 from International Institute for Sustainable Development: https://www.iisd.org/sites/default/files/publications/cities-smart-grids-canada.pdf **20.** Hickey, M., and Lam, I. (2018, October). Market Information Report: Canada: Prepared for Power Forward Challenge. Retrieved August 15th, 2019 from MaRS: https://www.marsdd.com/wp-content/uploads/2019/01/AEC_MARKET-INFORMATION-REPORT_CANADA_2018_F.pdf

How to Read this Report

The objective of this report is to summarize the qualitative trends and challenges related to smart grid technology adoption within the Canadian electricity sector, and to offer potential pathways to overcome those challenges. Further, recognizing the diversity in Canada's energy sector, the report aims to inform regulatory agencies, utilities, industry and research bodies about the challenges—as well as the opportunities—that Canada's energy providers are currently facing with regards to smart grid technology adoption.

MaRS interviewed a range of energy service providers and identified five key challenges they face. The interviews MaRS conducted included a diverse range of participants, from large generators and distributors to small-scale integrated utilities and systems operators. MaRS then developed recommendations to help energy service providers, regulators and policy-makers across Canada begin to move forward.

The Report is Divided Into Three Sections.

1. Methodology

This section provides the reader with an overview of the methodology used by MaRS, including interviews with Canadian utilities and energy service providers. It contains definitions of SG technologies and divides these technologies into a three-horizon model of technological advancement, categorizing them as foundational, incremental or forward looking.

2. Insights

This section provides insight into the number of current and future SG projects undertaken by the interviewees, the various maturity levels of the projects, and the technologies with the highest rates of adoption at the time of interview.

3. Challenges and Recommendations

This section summarizes the challenges in smart grid adoption as identified through primary and secondary research. It also provides recommendations and outlines opportunities where energy service providers and policy-makers can begin to address gaps in their innovation agendas, strategic outlooks and current focuses.

Methodology

MaRS conducted a series of interviews with 29 Canadian utilities, associations and power providers from December 2018 through to March 2019. (For a list of organizations interviewed please refer to the Interviewee Profile). This interview process, combined with secondary research, informed the challenges and recommendations discussed throughout this report. Each interview surfaced details on specific SG projects that were either in operation or in the pipeline at the time of interview, as well as thematic insights into the challenges and opportunities Canadian energy service providers face in implementing these technologies. To maintain anonymity, all insights generated on the successes, barriers and improvements to SG adoption and implementation have been aggregated and quotes have been made anonymous.

Smart Grid Definitions

The following are definitions and descriptions of the smart grid technologies discussed in the interview process and throughout this report. These definitions aim to standardize the language around the types of technologies energy providers are using.

Definition: A smart grid, with clean generation and energy storage, has distributed and autonomous monitoring, analysis and control, and is enabled by the following technologies.

1. Advanced Metering Infrastructure

Automated meter-reading capability enables utilities to read customers' meters remotely, which reduces both meter operations costs and meter reading errors that result from manual meter readings. Additionally, with advanced metering infrastructure (AMI), utilities are able to receive readings over shorter time intervals (for example, hourly, instead of monthly), providing greater detail about customers' energy consumption. Advanced metering infrastructure also allows utilities to detect outages, tampering and theft.

2. Demand Response

Demand response capability refers to the capacity of operator to adjust the demand for electricity at a given moment, using real-time data. Demand response is focused on the behavioural changes of customers at peak demand times, increasing the cost of energy use with the aim of reducing the overall peak load. Demand response depends on having reliable customer data and employing new or dynamic rate options and behind-the-meter technologies that can signal customers to reduce their energy demand.

3. Distributed Energy Resources

Distributed energy resources (DERs) are electricity-producing resources or controllable loads that are directly connected to either a local distribution system or a host facility within the local distribution system. Examples of DERs include solar panels, combined heat and power plants, electricity storage, small natural gas-fuelled generators, electric vehicles and controllable loads. These resources are typically smaller in scale than traditional generation facilities.[21]

4. Distributed Energy Resources Monitoring and Control

Advanced monitoring and forecasting and control systems can help to make DERs more predictable and reliable—for example, by mitigating issues such as voltage sag, which is associated with intermittent renewable generation. These systems leverage power electronics to improve inverter efficiency, optimize voltage output for maximum power tracking and handle

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21. IESO. Ontario's Power System: Distributed Energy Resources. Retrieved August 15th, 2019 from IESO: http://www.ieso.ca/en/Learn/Ontario-Power-System/A-Smarter-Grid/Distributed-Energy-Resources harmonics issues. Additionally, they may include an enhanced ability to predict or automate demand response resources.

5. Electric Vehicle Integration and Control

Electric vehicle integration and control strategies can both mitigate issues for grid operation and provide value to end-users. For example, smart chargers can help to manage the additional energy consumption of electric vehicles on constrained grids by charging the vehicles at night when energy demand and prices are low. This serves to both reduce pressure on the grid and save consumers money (when time-of-use rates are used). In some cases, electric vehicle control strategies would operate batteries as distributed energy storage devices by supplying electricity back to the grid during peak hours.

6. Energy Storage

Energy storage system integration and control technologies enable seamless integration with the grid by minimizing disturbances while maximizing the value of the system. Energy storage systems are used to mitigate the impacts of intermittent resources on the grid, defer the need of upgrades in capacity-constrained areas, and provide ancillary services. Integration and control systems may include sensors, protective hardware, communications equipment and control software.

7. Microgrids (Automated Islanding and Reconnection)

Automated islanding and reconnection is able to sense conditions on the grid and microgrid, enabling it to detect when to disconnect (isolate) the microgrid from the macro grid at the interconnection to operate independently and when to reconnect with the grid to operate in parallel. This capability can provide greater reliability for both the grid and the microgrid. In addition, the microgrid can operate under different conditions when islanded in order to protect equipment and maintain operation of critical loads.

8. New Rate Options

New utility price structures, enabled by smart metering and data collection from smart grid assets, allow for variable rates to be offered based on time of use, critical peaks and usage of assets such as electric vehicles. They allow utilities to manage customer consumption with price incentives and to reduce demand during peak usage hours.

9. Self-Healing Grid

A self-healing grid utilizes sensors, controls, switches and communication systems to detect fault location and perform isolation and service restoration. In the event of a fault, a self-healing grid reconfigures feeder circuits to isolate a fault and deliver power to the un-faulted sections of feeder by transferring their load to un-faulted feeders. Self-healing grids enable a much faster restoration of power to customers by performing switching operations automatically instead of dispatching a field crew to carry out manual operations.

10. Voltage and Voltage Ampere Reactive (VAR) Control

Automated voltage and reactive power controls are used to improve the power factor of feeders, reduce line losses and better manage voltage levels along feeders.

Three-Horizon Model of Smart Grid Technology

MaRS further categorized the above 10 technologies into a three-horizon model[22] of technological advancement and adoption, as shown in Figure 3. These technologies are categorized based on their relative advancement and use within the subset of energy service providers interviewed. The three categories in the three-horizon model are as follows.

1. Horizon 1
Foundational Technologies include advanced metering infrastructure, demand response, new rate options and self-healing grid, which are based on data collection and communications structures, and are essential for the optimization of current assets.

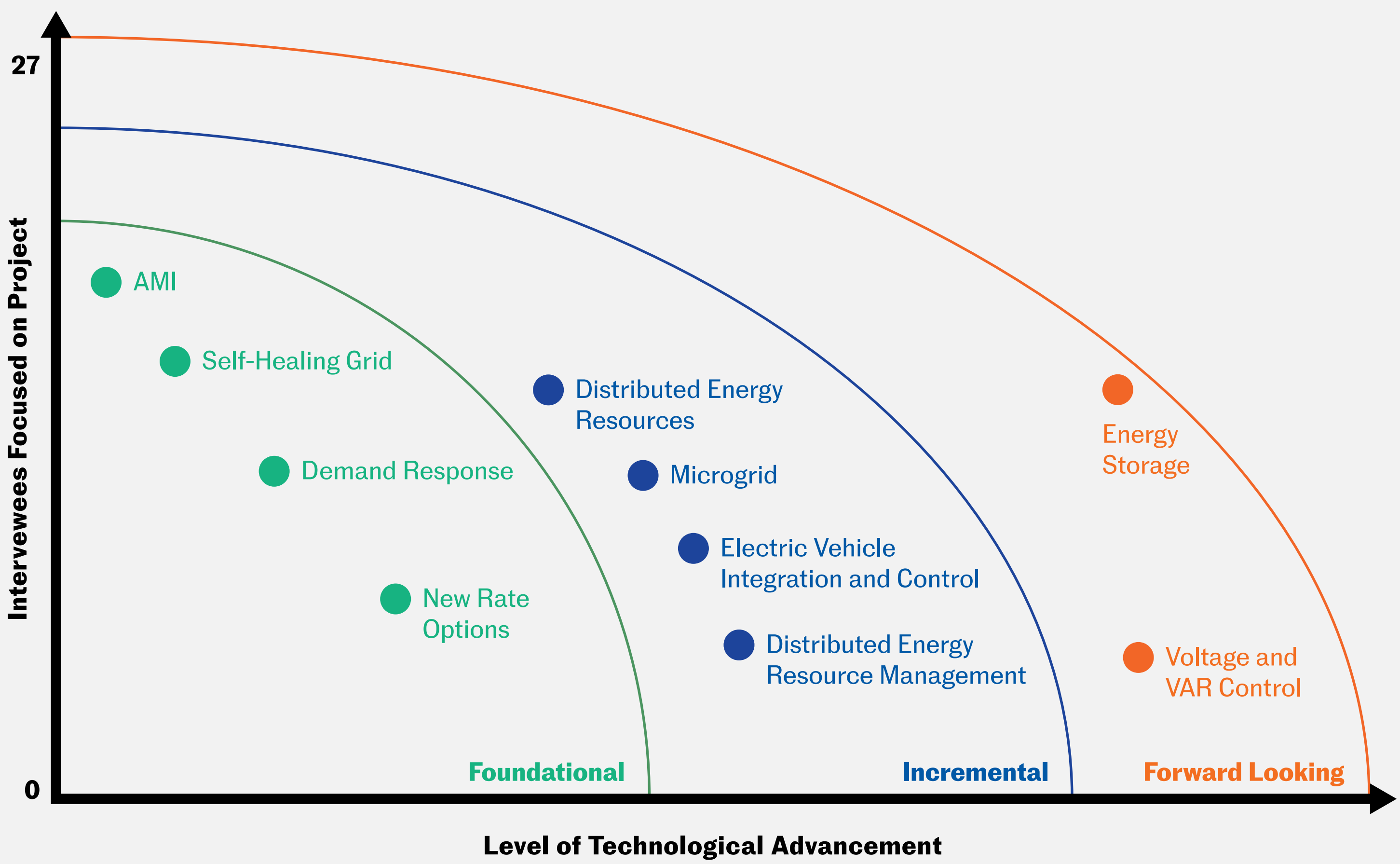
2. Horizon 2
Incremental Technologies include electric vehicles, DERs, distributed energy resource monitoring and control, and microgrids. These technologies are relatively advanced, but are comparatively new to the energy landscape and are not used or deployed to their full potential.

3. Horizon 3
Forward-looking Technologies include Voltage and VAR Control and energy storage, which position energy service providers to respond to and solve sector-wide problems likely to surface in the future.

Some technologies span both the incremental and forward-looking ranges, but are currently only being adopted in an incremental way. These are technologies such as DERs/distributed energy resource monitoring and control, and electric vehicles, which could offer significant advantages beyond what they are currently being used for. There are also dependencies between horizons, such that technologies in Horizon 2 depend on the development and scaling of technologies in Horizon 1.

22. The three-horizon model allows for the categorization of technologies based on their current state in the market, as well as their current level of adoption and use within an organization's business. The three horizons—foundational, incremental and forward looking—explain how a technology is used within an organization to optimize existing structures (foundational), expand business models within the organization's current market range (incremental), and finally expand into new markets and untraditional areas of focus for an organization (forward looking).

Figure 3: Three-Horizon Model of Smart Grid Technology



Interviewee Profile

The following list comprises the 29 energy service providers interviewed for this report as divided by region. For a full list of the questions asked in these interviews, see Appendix A.

Alberta

1. Alberta Electric System Operator
2. Alberta Federation of Rural Electrification Associations
3. Blue Mountain Power Co-op
4. City of Lethbridge

British Columbia

5. FortisBC Alternative Energy Services

Manitoba

6. Manitoba Hydro

Nova Scotia

7. Emera Energy
8. Nova Scotia Power

Ontario

9. Alectra Utilities
10. Cornerstone Hydro Electric Concepts
11. Essex Powerlines Corporation
12. Festival Hydro
13. HCE Energy (a Hamilton Utilities Corporation company)
14. Hydro One
15. InnPower
16. Lakeland Holding Ltd.
17. London Hydro
18. Niagara-on-the-Lake Hydro
19. Oakville Hydro
20. Sault Ste. Marie PUC Distribution
21. Spark Power Corp.
22. Tillsonburg Hydro
23. Toronto Hydro
24. Utilities Kingston
25. Waterloo North Hydro

Prince Edward Island

26. Summerside Electric

Quebec

27. Hydro-Québec

Saskatchewan

28. SaskPower

Nunavut

29. Qulliq Energy Corporation

These organizations can be further divided by organizational structure, including public (integrated, generator, transmission or distributor), private (integrated, generator, transmission or distributor), system operator, association, or a combination of public and private.

Public

1. Alectra Utilities
2. Blue Mountain Power Co-op
3. City of Lethbridge
4. Essex Powerlines Corporation
5. Festival Hydro
6. Hydro-Québec
7. InnPower
8. Lakeland Holding Ltd.
9. London Hydro
10. Manitoba Hydro
11. Niagara-on-the-Lake Hydro
12. Oakville Hydro
13. Qulliq Energy Corporation
14. SaskPower
15. Summerside Electric
16. Tillsonburg Hydro
17. Toronto Hydro
18. Utilities Kingston
19. Waterloo North Hydro

Private

20. Emera Energy
21. FortisBC Alternative Energy Services
22. Nova Scotia Power
23. Sault St. Marie PUC Distribution Inc.

Public/Private

24. HCE Energy (a Hamilton Utilities Corporation company)
25. Hydro One
26. Spark Power Corp.

Association

27. Alberta Federation of Rural Electrification Associations
28. Cornerstone Hydro Electric Concepts

System Operator

29. Alberta Electric System Operator

These organizations were selected because they represent a range of public and private utilities and associations serving over 9.3 million customers across Canada, or roughly 24% of the entire Canadian population. All organizations interviewed are undertaking some form of SG development. Differences in capabilities between smaller rural organizations, larger urban organizations and those with differentiated or engaged customer bases resulted in a choice sampling of projects, technologies and associated outcomes. There were, however, a number of similarities in the challenges of SG adoption identified between all of the organizations interviewed. The interviewees also identified SG projects that are either current projects (projects that are in the pilot phase) or future projects (projects that are in the pipeline or the ideation phase). Unless noted otherwise, the data in the following section includes both current and future projects.

Insights

This section provides an overview of the SG projects and insights drawn from the interviews. These insights specifically relate to the types and progress of SG adoption across the participating organizations.

Smart Grid Project Breakdown

Figure 4 provides a breakdown of SG projects identified by the 29 organizations interviewed, as of the time of interview (December 2018 to March 2019). It is important to note that the majority of the projects described by the interviewees are current projects, with only 14% of the total number of projects described as future projects (pipeline projects) or projects with unconfirmed timelines. There is a heavy focus on Horizon 1 technologies such as advanced metering infrastructure, self-healing grid and demand response technologies, which together constitute 45% of the total number of both current and future projects mentioned. Interviewees described these technologies as easier to justify to either the regulator or to shareholders due to their ability to manage and augment grid resiliency and efficiency, or in the case of advanced metering infrastructure, to provide some of the necessary structures for the adoption of additional SG technologies.

Advanced SG technologies (Horizons 2 and 3) depend on the development and implementation of back-end data management systems, as well as grid-ready information technology and operational technology (IT/OT) communications structures. Figure 4 also showcases the number of current and future projects under each of the distinct SG categories. The number of advanced metering infrastructure projects being undertaken by this subset of utilities may signal that multiple service providers are still in the process of developing a foundational communication network, which often must precede the adoption of more advanced SG technologies.

The SG initiatives with the highest number of current projects involve advanced metering infrastructure, self-healing grid and demand response. Energy storage, electric vehicles, and voltage and VAR control have the highest rate of future projects, likely due to the high cost of the technologies and their dependence on the development and implementation of foundational SG communication technologies.

Figure 5 segments the different types of SG projects by organization type within the subset of Canadian energy service providers interviewed.The focus on distributed energy resource monitoring and control, demand response and electric vehicles signals that there is significant advancement in the capabilities of some electricity providers' communication structures. However, the focus for many providers remains on some of the more basic SG technologies that enhance operational capabilities, such as communication structures and data collection techniques.

Canadians are faced with widely differing contexts and needs from their local electricity infrastructures. Trends such as the use of electric vehicles in urban hubs such as Vancouver, Calgary or Toronto differ from trends in smaller rural communities. Rural communities have fewer resources to face inclement and often violent weather, extremely lengthy and underserviced connections to the grid, and a higher risk of prolonged outages. The initiatives that have the highest percentage of current projects, as shown in Figure 4, are advanced metering infrastructure, self-healing grids and demand response, initiatives that address the more basic, operational inefficiencies of the systems faced by such communities. The collection of data from these initiatives will go on to inform the most strategic way to implement the more complex technologies (Horizons 2 and 3) in the pipeline of future projects. Those future projects are ones that will result in significant increases in the efficiencies of energy production and distribution, as well as the development of new relationships and structures with customers and the grid as a whole.

Figure 4: Project Distribution by Category and Stage

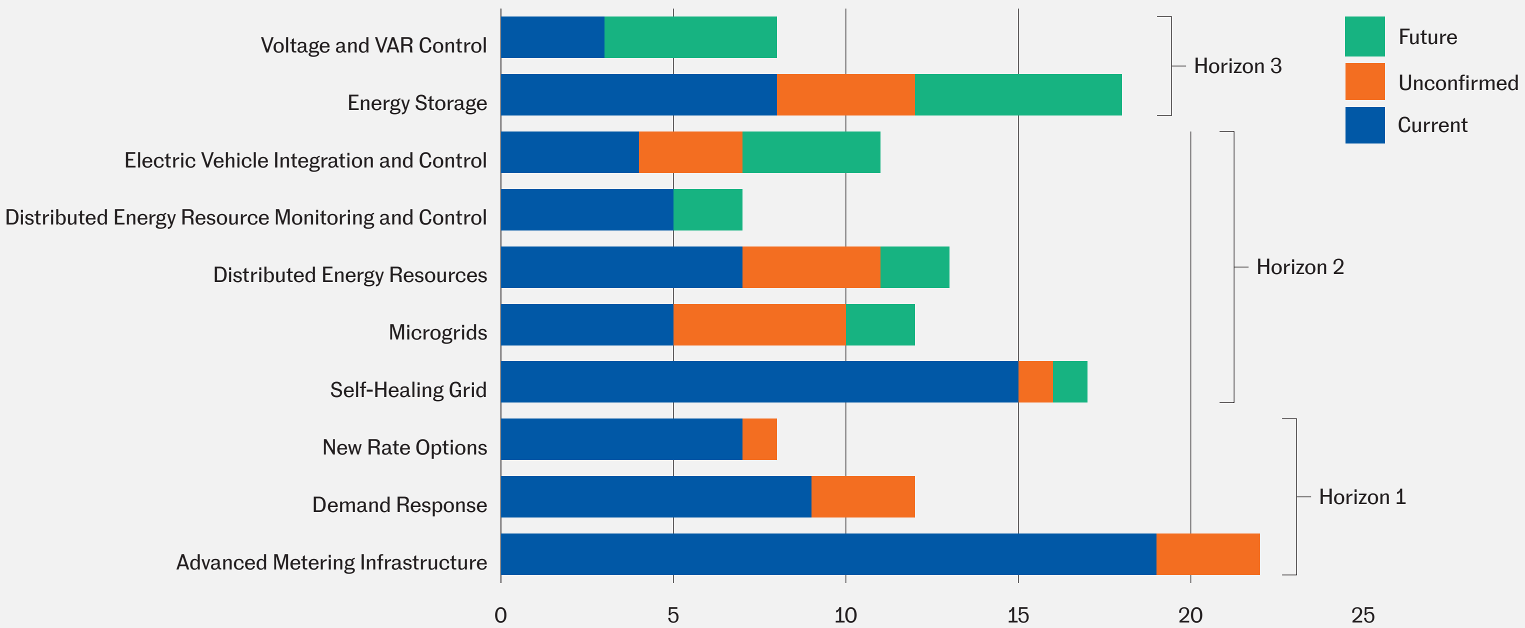
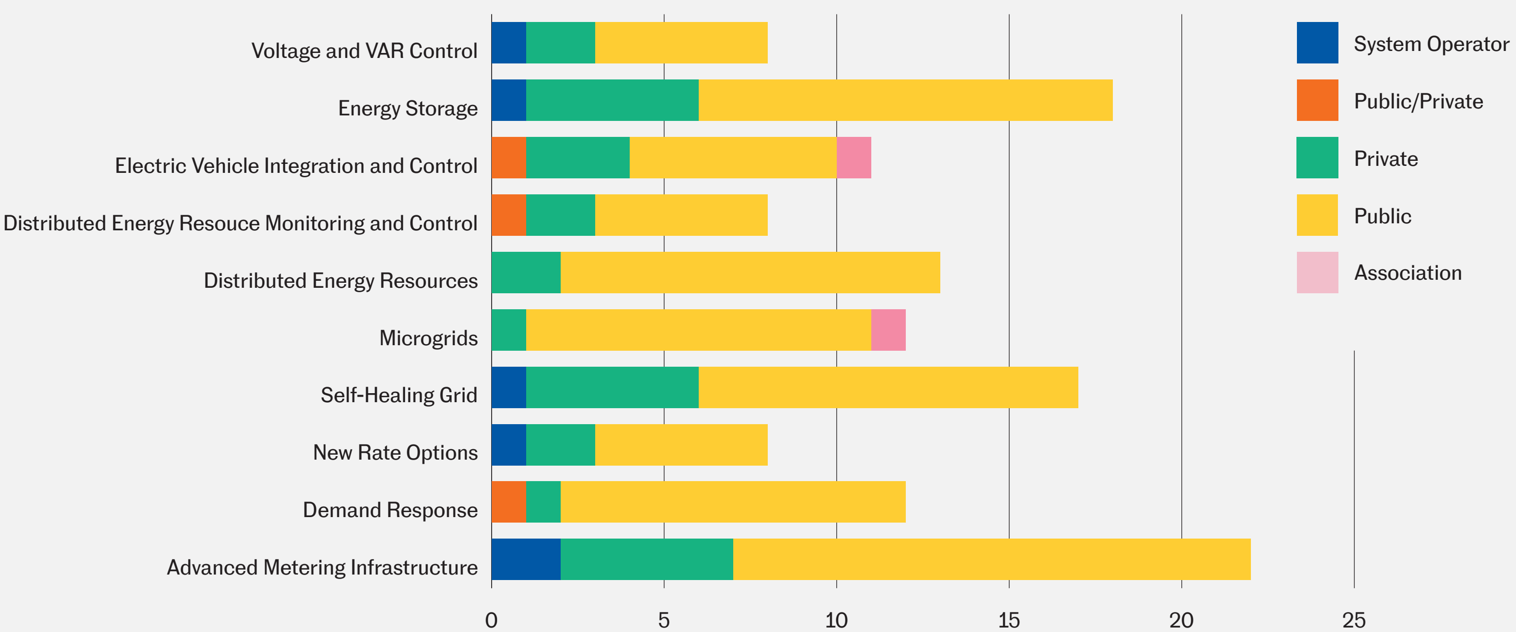


Figure 5: Project Distribution by Organization Type



Challenges and Recommendations

Interviewees recognized the need to innovate in the energy sector and, more specifically, to incorporate smart grid technologies in their operations in order to: focus on decarbonization, increase operational efficiencies, modernize the grid and provide value to customers. Despite this recognition, Canadian utilities are not adopting technologies at the same pace as other markets around the world.[23] Advanced energy projects being adopted in the US, Japan and Korea, such as fuel cell power plants that convert natural gas or hydrogen into electricity, are many years ahead of Canada.[24]

Through the interviews, five key challenges were identified that impede the ability of the sector to adopt innovative technologies. Each challenge is accompanied by a recommendation to be considered by utilities, regulators and policy-makers.

Challenge No. 1: Thinking Beyond Core Operations

Utilities are spending most of their time on core operations and foundational SG technologies

"Our day-to-day operations are not data driven, we have people that have experience with our daily operations, and they know what works. We are planning to get better at that over the next five or 10 years, beginning to focus on data."

Utilities are spending most of their time and resources on foundational SG technologies, as shown in Figure 4. The high costs of building and replacing infrastructure and the need for repairs to legacy grid components reduce the appetite for large-scale technological adoption. Rather than adopt new technologies and shift toward new business models, many interviewees noted that they are focused on justifying their current expenditures on legacy infrastructure. Some major utilities have decades-old components of their operating systems, preventing the adoption and use of new technology, specifically when it comes to data collection and use.

Interviewees noted that advanced metering infrastructure is being adopted at a higher rate than other technologies due to its ability to save on costs associated with in-person inspections and improve and streamline data collection. Smaller utilities in particular are having the most difficulty in allocating both human and financial capital in implementing SG initiatives outside of foundational technologies such as advanced metering infrastructure. A number of utilities noted that their innovation arms are small and are often siloed from the rest of their organization. While larger utilities are less burdened by a lack of resources, they too are more focused on core operations than on advancing SG technology adoption. The motivations behind adopting or piloting an SG technology may simply not fit the innovation agenda of some utilities that feel the need to focus predominantly on their core operational procedures.

Moving away from core operations can be difficult for utilities; however, there are examples of utilities successfully diversifying their investments. NextEra Energy, a public utility in the US, is leveraging its core operations in a unique way to diversify its production portfolio and find revenue models beyond its traditional generating technologies.[25] NextEra has positioned

23. World Bank. (2016). World Development Report 2016: Digital Dividends. Retrieved July 18, 2019 from World Bank: http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf
24. World Nuclear Association. Supra note vii, at 201.
25. BloombergNEF. Utility Company Profiles: Strategy and Data. Retrieved July 18, 2019 from BloombergNEF: https://www.bnef.com/core/insights/15657/view

itself as a leader by investing more capital into its competitive arm than its utility arm, leveraging both a favourable regulatory environment and its ability rate base new renewable projects. NextEra also leverages scale for more accommodating contracts with service providers. By centralizing investment into its core operations and leveraging its purchasing power, NextEra has been able to diversify its generation assets from wind and solar to natural gas through acquisitions, giving it a larger audience for customer-service pilots and expanding its electric customer base.[26]

Recommendation No. 1: Intentional and Aligned Investments

Evaluate current and future investments and validate them against a corporate innovation strategy

The disconnect between utilities' operational priorities and innovation priorities leads to ineffective innovation strategies. Such strategies are often not aligned with a broader corporate innovation strategy or are not reflective of the changing market. Designing an innovation agenda to match a corporate strategy that is aligned with the future of the industry will enable utilities to benchmark their current investments and projects against their future needs. This is exemplified by the fact that the majority of the energy service providers interviewed had current projects focused on piloting foundational SG technology (Figures 3 and 4).

The investment in foundational projects is a step in the right direction for many energy service providers. However, if utilities are looking to invest in more progressive technology, they must be strategic and intentional, mapping new SG investments onto a forward-looking corporate strategy. The utilities that do not plan strategically for technological adoption or innovation will lack the resources and expertise to use the technology they invest in to its fullest extent. For example, some utilities reported having data sitting in their operational data store that was not actually being analyzed or used to drive decision making. This problem was the result of a lack of the information technology infrastructure needed to process and catalogue the data in an effective manner, and/or a lack of direction in how to garner insights from the data collected.

Challenge No. 2: Lack of Strategic Foresight

Utilities do not plan for scale because of a lack of strategic foresight, training and personnel focused on innovation

Utilities often find themselves piloting new technologies, but are unsuccessful at implementing them at scale due to internal cultural barriers and a lack of process or personnel. All the utilities interviewed were piloting some form of SG technology; however, few had substantial plans to actively integrate this new technology into their operations upon success. Utilities view pilot projects as a method to better understand the economics of new technologies, but often have no plans for adopting these technologies, thereby uniquely positioning themselves as late adopters rather than prime movers. This mentality ends up setting Canadian utilities back years from their competitors and reinforces Canada's "first to be third" attitude toward technological adoption.

"We understand that because it was sort of an early adoption pilot project, there's really no positive business case for the configuration that we've installed currently, but the hope is that the lessons learned would allow us to make decisions around where it's appropriate to have more storage on our system…"

By adopting new technologies later, or after numerous other pilots have already been completed, utilities passively de-risk these technologies and benefit from proven use cases, making purchase plans easier to justify to their stakeholders.

"…we benefit from being late adopters in that a lot of the lessons learned are out there, and a lot of the data manipulation opportunities that earlier adopters would have not known what to do with are easily accessible for us."

While waiting for technologies to be proven, however, energy service providers are preventing customers and consumers from benefiting from better services, higher rates of energy efficiency and lower costs associated with their energy use. The late adoption of technology signals a broader challenge that must be overcome within many Canadian utilities, namely the lack of future planning and strategy. The absence of planning reduces the visibility that energy service providers have into the future of the market, as well as the resource need, both human and financial, necessary for the adoption of unique or new technologies.

Recommendation No. 2: Align Operations with Long-Term Market Trends

Embrace a long-term view of sector trends, ensuring that operations and projects align with the future of the market

The goals of government funding for pilot projects need to extend beyond

26. Ibid.

short life-cycle projects and align to the future needs of the energy industry. Actively incentivizing pilot technologies without identifying the barriers to the development and scale of those technologies decreases the likelihood of full-scale adoption. When incentive structures are limited in time and scope—and are focused on data gathering rather than actual use and adoption cases—utilities enter into a cyclical pattern of arrested innovation, which incentivizes them to adopt certain new technologies for a short period of time, while maintaining a long-term baseline energy production, distribution and transmission profile.

British Columbia's Clean Energy Act[27] is an example of legislation that incentivizes both industry and consumers to take the leading charge in energy efficiency and clean energy production and adoption. By reducing the overall cost of consumer goods, such as cars and retrofits for homes, and incentivizing the construction of clean energy infrastructure, the BC government is actively reducing the risk of technology adoption beyond the pilot phase. Funders of SG technology projects need to ensure that they are promoting the transition from pilot to scale when feasible or when there is value identified.

The problem of funding SG projects, some interviewees noted, is rooted in the fact that many energy service providers have a lack of foresight or understanding of the future of their market. The lack of strategic planning and investment is a signal that utilities assume that the grid will remain the same in the future as it is now. This assumption underscores the difficulties energy service providers are having in attempting to communicate the benefits, possible savings, efficiencies and choices built into a new grid architecture.

"Nobody has come up with a reference grid architecture for the future of smart grid technology. People have ideas of what the grid might look like 20 years from now, 30 years from now, but to actually invest in a technology or infrastructure which is going to be around for 20 or 30 years, you need to have a reference grid architecture."

Utilities need to focus on developing clear objectives so they are better equipped to communicate their needs, and they must base their technological adoption and procurement strategies on future trends. The inability for a utility to anchor in and de-risk its investments can lead to a breakdown of communication and a potential loss of perceived value of a technology or innovation at all levels of stakeholders, from those in the policy and regulatory spheres to shareholders and customers. Utilities must have clear and defined objectives when piloting new technologies and must identify a plan and/or process to scale.

Challenge No. 3: Making the Business Case

Utilities often struggle in making the business case for investing in smart grid technology to the regulator and the board

"...The tech isn't the problem, it is the implementation and the business models which pose the problems."

Making the business case for investment into a new technology is difficult for Canadian utilities. Smart grid technology can be expensive, and technologies such as energy storage or DERs are new to the utility landscape and often have not been fully explored by regulators. Further, the benefits of some of the more advanced SG technologies, such as microgrids or energy storage, are accrued across the value chain, making it difficult for one stakeholder who will only gain a portion of that value (like a non-integrated utility focused on distribution or transmission) to justify the investment or share in the value generated.

Beyond the difficulty in justifying investment in SG technology, most funding for these projects originates from retained dividends and/or federal or provincial initiatives. Utilities often find that sound business cases for investment into new areas or projects can only be created through funding from government initiatives or from deferred earnings (such as shareholders choosing to defer dividend payouts and reinvest back into the company).[28] While this is a well-understood approach to innovation, it limits utilities' ability to grow. This method forces utilities to be frugal when it comes to making investments into the grid—often forgoing more complex infrastructure improvements for simpler ones that are easier to justify and defend to their shareholders.

Canadian utilities have been anchored in the asset-driven business model for almost a century. While this model allows for equity investments into their rate base, it does not provide nuanced or creative ways to seek a return or higher rate of capital growth, and therefore liquid capital. By treating the adoption of innovative technology like the implementation of proven technology, utilities minimize risk at the expense of reducing overall innovative capacity.

27. Province of British Columbia. (2018, December). CleanBC: Our Nature. Our Power. Our Future. Retrieved July 22, 2019 from Province of British Columbia: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf **28.** Navigant. (2015, January). Ontario Smart Grid Assessment and Roadmap. Retrieved July 22, 2019 from OntarioEnergyReport.ca: https://www.ontarioenergyreport.ca/pdfs/Navigant-Smart-Grid-Assessment-and-Roadmap-Final-Report-.pdf

Recommendation No. 3: Differentiate Innovation Projects

Treat innovation projects differently from proven technology projects

Collaboration with other stakeholders who may find value in a new technology will help build the business case for that project or technology. Interviewees identified the shift to more distributed energy production as a major opportunity for new partnerships and service models, allowing utilities to remain relevant even as their traditional roles become outdated. Unique approaches to procurement and adoption will allow for value to be added to utilities' current business models, while also preparing them for the future of the energy industry. For example, a number of utilities interviewed are partnering with telecommunications organizations to develop IT infrastructure that will enable new businesses in the future.

Beyond partnerships, energy service providers commonly engage with new technologies along their traditional lines of procurement, often through a formal request for proposal (RFP) process if they are looking to acquire or buy new technologies or services. However, the RFP process does not necessarily allow utilities to question their own data or allow for a collaborative or iterative approach to technological development—and may actually set them up for failure. Less formal mechanisms of engagement, such as requests for information or strategic partnerships with solution providers or academic/research institutions, can provide added value to a utility's adoption of a new technology, while also enabling energy ecosystem stakeholders.

Regulators must also recognize that new technologies and new investments are not "asset-heavy" investments and therefore require new regulatory approaches to succeed. New technologies will be focused on monitoring, data analysis and technological integration. Regulatory regimes must also change and adapt, recognizing that a utility's return on large-scale assets will no longer be a sufficient incentive to ensure the reliable and resilient provision of electricity and services to the grid.

Challenge #4: Regulatory Perception

Utilities perceive regulation to be stifling to innovation

Many of the utilities interviewed perceive the regulatory environment to be restrictive and hindering to innovation or, at minimum, see it as limiting the speed at which they can adopt new technologies.

"Our regulatory climate is not overly enabling to investment in new technology..."

Competing federal and provincial interests can present barriers to the adoption of new technologies and/or new innovative approaches to solving industry challenges. Regulators can also lag behind current market trends, making it difficult for utilities to understand how a regulator may react to a new technology. The inherently political nature of the electricity sector also adds difficulty in a utility's ability to predict and understand where policy is heading in the future and whether new technologies or incentive structures will remain in place.

"When the IESO [Independent Electricity System Operator] and the Province of Ontario passed regulations to install smart meters, we saw where the landscape was shifting, and so we started to make an investment into automation, real-time monitoring, and sort of nudge our way into self-healing networks."

Some energy service providers keep projects in the pipeline until there is more clarity from the regulator or independent system operators on how a technology will be managed.[29] Utilities also emphasized the fact that they are operating with a dual mandate of ensuring the timeliness of projects that must address the future needs of energy service providers, while also enhancing customer value in the short term from currently funded projects. This is keeping some utilities focused on current projects rather than addressing future trends.

"We're always interested in increasing customer value and it makes a lot more sense to consider the existing projects, because they already have support from the Ministry of Energy."

Recommendation No. 4: Engage the Regulator

Recognize that the ability to innovate relies on a realistic understanding of the regulatory environment and a willingness to openly engage with the regulator

Throughout the interviews, regulators were described as restrictive and hindering the utilities' ability to innovate. Utilities must work with regulators and policy-makers to identify and leverage industry trends. The purpose of these governmental organizations is to manage the safety and security of the

29. IESO. Stakeholder Engagements: Non-Emitting Resources Subcommittee. Retrieved July 8, 2019 from IESO: http://www.ieso.ca/Market-Renewal/Stakeholder-Engagements/Non-Emitting-Resources-Subcommittee industry, increase investor confidence and review new technologies. While some utilities interviewed identified that they are working together with the regulator, many view the regulator as a hindrance to innovation, rather than a valuable partner. Collaboration should align with broader energy-sector trends and enable the development of smart grid technologies.

Some utilities in Canada are beginning to develop unregulated arms to support projects that cannot be rate based. These utilities are able to explore new business models and opportunities that would otherwise be difficult to approve through the traditional regulated arm of the utility, and in many cases can be a symptom of perceived regulatory rigidity. These new business arms are a valid way of exploring new technologies and should not be overlooked by the Canadian energy sector.

Challenge No. 5: Getting to Know the Customer

Utilities need to dedicate more time and effort to better understand their customers and provide increased value

Utility customers increasingly want to take control of their energy usage and explore new home and personal technologies. The accelerated interconnectedness of devices and the proliferation of app-based relationships have utilities reconsidering their customer interaction models.[30] As new service models emerge around the world, Canadians are increasingly aware that their relationships with large organizations are slow to change. Today's consumers are more concerned about the sustainability of their purchases. They desire personalized user experiences and expect the protection and safeguarding of their personal data. To consumers, these requests are not mutually exclusive; however, to some service providers, these demands are hard to realize in tandem with their current business models.

Energy service providers, from generation to distribution and transmission, often have not defined their customers and are not traditionally accustomed to providing their customers with choices. Due to the inadequacy of advanced in-house data analysis techniques, utilities offerings are often less flexible than the demands from their customer bases. The business case for investing in customer insights can be difficult to make, as the costs of IT/OT are high and are usually passed down to ratepayers.

"Utilities are business-to-customer focused, but in a very different way. They're not used to giving customers choices, so there is a ton of learning for us, of how we engage with customers for new energy choices."

A number of utilities noted that the high costs of technologies associated with data gathering and cleaning make it difficult to justify investment unless there is a direct link between the value of the technology and the customer.

Recommendation No. 5: Develop New Relationships with the Customer

Identify novel ways of understanding customers and best addressing their needs

The majority of interviewees expressed that they prioritize customers in their decision-making processes. However, they also noted that they find it difficult to understand what their customers truly need. Utilities must actively identify and define their customers, and engage with customers directly to ensure that they understand their priorities.

The utilities that actively shift their focus toward understanding their consumers will be best positioned to adopt the technologies that provide the most value to their customers. Beyond the traditional customer distinctions—commercial and industrial (C&I), residential, and municipalities, universities, schools and hospitals (MUSH)—utilities will need to develop customer insights that enable them to track and identify trends at a more micro level.

Different customer segments will offer new and unique opportunities for utilities. For example, C&I customers are at the forefront of looking for nuanced ways to reduce their demand on the grid. By engaging and leveraging the C&I customer base to adopt and pilot new technologies, utilities can offset large amounts of grid infrastructure refurbishment costs through improvements in the longevity, durability and reliability of the grid, as well as reductions in the rate hikes needed to facilitate investment. These partnerships can provide utilities with an easier business case for testing new technologies and will help meet the demands of C&I customer bases. This is just one way utilities can develop a more insightful relationship with a customer. Ultimately, utilities need to curate their approach and identify unique and nuanced ways to engage with and understand all of their customer segments.

30. Smith, S. (2018). 2019 Power and Utilities Industry Outlook. Retrieved July 13, 2019 from Deloitte: https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/power-and-utilities-industry-outlook.html

Conclusion

Canada's electricity sector is necessarily diverse and it faces numerous challenges to innovation and technological adoption. These challenges have been outlined in this report based on interviews with a cross-section of service providers. Addressing these challenges requires a focused effort from the policy and regulatory spheres, as well as from utilities. The recommendations in this report aim to address the gaps in—and misperceptions about—approaches to technological adoption, market trends and traditional relationships.

Our five recommendations are:

1. **Evaluate current and future investments and validate them against a corporate innovation strategy.**
2. **Embrace a long-term view of sector trends, ensuring that operations and projects align with the future of the market.**
3. **Treat innovation projects differently from proven technology projects.**
4. **Recognize that the ability to innovate relies on a realistic understanding of the regulatory environment and a willingness to openly engage with the regulator.**
5. **Identify novel ways of understanding customers and best addressing their needs.**

Innovation and technological adoption must be intentional and strategic, recognizing the nuances of both the technology and the end customer. Canadian utilities, regulators and policy professionals have a unique opportunity to overcome the barriers to the adoption and scaling of technology through iterative collaboration, better communication and co-investment into solutions.

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This report was completed in line with the MaRS vision of promoting the adoption of innovative, new technologies, and supporting collaborative innovation within Canada and internationally.

The information in this report is general in nature and provided as a summary of interviews. This report is meant for informational purposes – to aid in the understanding of challenges to innovation faced by the electricity sector in Canada.

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Appendix A: Interview Questions

The following list highlights the questions asked in the interviews with energy service providers across Canada.

Project Identification

1. Do you have a current or future project in any of the following areas?

- ○ Advanced metering infrastructure
- ○ Demand response
- ○ Distributed energy resources
- ○ Distributed energy resources monitoring and control
- ○ Electric vehicle integration and control
- ○ Energy storage
- ○ Microgrids (automated islanding and reconnection)
- ○ New rate options
- ○ Self-healing grid
- ○ Voltage and VAR (reactive power) control
- ○ Other?

Project Description, Project Goals and Partnerships

1. What is the focus of the project?

2. What is the objective of the project?

a) Is it to test a technology, a business model or other?

3. What year was the project begun or is it planned to begin?

a) If the project has already begun, what is the stage of the project—in progress, planning, other?

4. Are you looking for partners in this project? If so, what types of partners are you looking for (e.g. venture, academic, another utility etc.)?

5. Who are your project partners/suppliers?

a) How did you find them?

b) Were there any challenges in finding them?

6. What were the key learnings from the project?

7. What challenges did you, or do you expect to, encounter?

8. Has the project helped to inform your business case development?

9. How have you measured, or how do you plan to measure, project success?

10. Do you have any plans to integrate current projects/pilots?

11. Do you have any past projects/pilots you are transitioning to scale?