CANADA'S ENERGY TRANSFORMATION - EVOLUTION OR REVOLUTION?

A Discussion Paper for Canadian Policymakers, Utilities, Regulators and Key Stakeholders on Managing Risk and Creating Opportunities as We Build Low-emission Energy Systems

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QUEST

POLLUTION PROBE
CLEAN AIR. CLEAN WATER.

ACKNOWLEDGEMENTS

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Pollution Probe is a Canadian charitable environmental organization (established in 1969) that is a leading agent of change at the intersection of communities, health and environment. Its approach is to define environmental problems through research, to promote understanding through education and to press for practical solutions through advocacy. Pollution Probe seeks to improve the health and well-being of Canadians by advancing policy that achieves positive and tangible environmental change.

QUEST is a national non-government organization that works to accelerate the adoption of efficient and integrated community-scale energy systems in Canada by informing, inspiring, and connecting decision-makers. QUEST undertakes research, communicates best practices, convenes government, utility, private-sector and community leaders, and works directly with local authorities to implement on-the-ground solutions. QUEST grounds all its activities in the "Smart Energy Community"—a concept that encapsulates the ideal end state of the organization's work.

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Climate change policy drives energy change

Climate change requires a shift to both a lower use of energy (efficiency and conservation) and a lower GHG emissions (renewables) from the fuels we use at affordable prices for all.

- o New materials, codes and standards and programs for efficiency + renewable electricity and fuels

Where you stand depends on where you sit

All provinces and territories want to reduce GHG emissions, but each have differences in access to clean energy, market size, and policies. That means their plans to get to there will vary.

- o Legacy hydro, access to other markets in Canada and the USA, crown ownership, policy orientation on putting a price on carbon all determine how a jurisdiction will manage change.

The pace of innovation has accelerated

New technologies (storage, demand management) and new business models leads to lower costs and greater value from renewables. A tipping point where clean costs less than fossil is nigh – in many cases only 5-10 years away. Energy users are moving there and policymakers, utilities and regulators need to avoid falling behind

- o Distributed Energy Resources (distributed generation, energy storage, demand response, energy efficiency, microgrids) are all becoming more cost effective and valuable when they work together and support new business models for efficiency and integration.

We need to understand the implications – now

Our laws and regulatory systems were not designed to deal with the pace of change now underway. We need places where collaboration and innovation can flourish, knowledge is shared and applied – much more quickly.

- o Sandboxes with performance-based oversight, partnership with technology and business model innovators, and regulator reporting on lessons learned for feedback and new testing.

EXECUTIVE SUMMARY

Innovation is up-ending our world in ways never dreamed of only a decade ago, and how we produce, manage and use energy is a major part of it. Driven by climate change imperatives to lower greenhouse gas emissions, public and private investment in key low emissions energy resources is leading to a rise in use, and a drop in cost.

The magnitude and speed of change is astounding. While wind and solar has attracted most of the interest, primarily due to price reductions of 66% for wind and 70% for solar since 2009 (see Appendix A), there has been increased interest in many new and innovative clean clean energy technologies.

In the past the usefulness of some renewable resources has been hampered by a lack of cost-effective ways to store the energy they produce when the wind isn't blowing, or the sun isn't shining. However, the cost of storage for all uses is falling as the demand for low-cost electric vehicle batteries rises. Lower-cost storage also means renewables become even more valuable. Other technologies, such as hydrogen and renewable natural gas (methane), are potential game-changers if they can accelerate cost reductions as well.

Meanwhile, the pace of change is accelerating. The cost of wind, solar and batteries has dropped faster than expected, and some authorities (McKinsey, Jan. 2019 - see Appendix A) see a tipping point where the combination of renewables and storage will be less expensive than traditional energy supplies is nigh (over the next 5 to 10 years). In Canada, the diversity of energy resources, markets and policies means the timing and impacts will vary.

Technologies that improve the management and use of energy are also emerging. They can make our electricity systems more resilient and reliable, give customers more choice in how to meet their energy needs, and offer energy savings to improve affordability.

On the other hand, we also have a growing interest in using more electricity in non-traditional ways. For example, electricity for transportation and, in many parts of Canada, for space heating are examples. These opposites of demand reduction (efficiency) and growth (electrification) introduce another level of uncertainty into planning for future supplies. The management of these trends and the pace of change will likely determine whether we face an energy evolution or revolution.

Energy leaders in Canada agree that the rise of technologies for energy efficiency, renewable and other local supplies of energy, energy storage and management, and microgrids offer positive results for energy users. These technologies are referred to as Distributed Energy Resources, or DER. They also offer opportunities for new business ventures and growth in jobs. This is particularly important for Indigenous communities where new business ventures and jobs help meet reconciliation and sustainability objectives.

However, these same technologies are also seen as the ones that offer the greatest risk of disrupting current regulated utility business models. This risk is highest where customers are able to invest enough to dramatically reduce or shift energy use or even become self-sufficient. The challenge is that those with the means are able to reap the benefits while those left behind still have to pay. Part of that risk comes when past investments become obsolete or stranded because their costs haven't been fully recovered from rates, and there are fewer users left to pay the remaining bill.

This Discussion Paper argues that impacts from DER on the rest of a utility are at best not well understood. Our hope for a smooth evolution over many years may be dimming for many utilities. Depending on factors such as availability of legacy resources, size of market, jurisdictional policy preferences, and profitability of the utility, the best outcome may be a managed revolution.

This Discussion Paper taps the knowledge of policy, utility and regulatory experts to understand what would make for good energy policies. They called for a long-term vision of the energy future. They suggested that the strategies, tactics and energy plans to achieve the vision need to be integrated with climate change requirements. They called for collaboration and plans to better understand how innovation works in their jurisdiction. Some pilots, and more nimble utilities, are building the knowledge now. We need to speed up the process, share the lessons quickly and apply them broadly.

As this Discussion Paper examined the implications of a transition to lower emission energy supplies and a new balance between distributed and central power resources, we explored the views of the experts on how well the current legislative regulatory frameworks could adapt. In some cases, they thought their framework could, but in many parts of Canada the view was that they could not.

They said technologies such as storage, with multiple purposes and values, were unheard of and unthought of when their frameworks were originally developed. Definitions for the monopoly sales of electricity did not anticipate en masse sales at commercial vehicle charging stations. The frameworks were also built for a time when new ideas and technologies were prudently adopted only after many others had tried it – being risk-averse was expected. In short, many experts see their regulatory frameworks as not being fully adaptable to the current pace and types of innovation.

A number of jurisdictions globally are now exploring the concept of "sandboxes" to address the discrepancy between normal utilities' investments and operations and those for new DER. The general idea is to create a place where innovation can occur under a different sort of regulatory oversight. A sandbox within part of a utility would be able to quickly test and change new technologies and programs. It could study impacts on the whole system. Requirements for detailed prior approval could be replaced by principles such as "low risk of adverse impacts on those outside the sandbox".

The model for a Canadian Energy Utility Sandbox would likely be different depending upon different policy requirements, energy resource availability, and market design, but should include the following:

- A place inside a utility (a location, feeder or operational activity) where:
  - current costs and revenues (business as usual assumptions) could be benchmarked
  - innovative technologies and activities could be tested, measured and reported upon
  - detailed project spending approvals could be replaced by performance outcome
    metrics such as cost to customers, reliability and transparency
- Utilities would be encouraged to seek new technologies, ideas on a partnership or competitive basis
- The cost of innovation could be supported by the utility owners, government grants or incentives, and when part of an energy policy and legal framework, shared with ratepayers

The Discussion Paper concludes on five areas for further exploration, including how to:

- Build a long-term vision
- Anticipate, learn and respond faster
- Address obsolescence risks
- Enhance efficiency but also plan for increased electrification
- Build a new balance between central and distributed power systems

This Discussion Paper is the first step in Pollution Probe and QUEST's continuing program to support the evolution of processes and practices in the energy sector to deploy new technologies business and regulatory models in a manner that benefits everyone and helps in the transition to a low emissions energy system.

WE HOPE TO CONTINUE THESE CONVERSATIONS IN 2019-2020.

INTRODUCTION

Energy markets in Canada are as varied as the country's landscape. Transcending these differences is a powerful trend that is creating fissures in energy markets across the globe. This new energy paradigm has its sights set on the balance between centralized and decentralized energy systems, assumptions about future energy consumption, and low-carbon or zero carbon fuels. With no guarantee of a seamless transition into this future, uncertainties are creating risks for energy systems, policy-makers, regulators and consumers. Through a literature review and a series of targeted interviews with energy sector stakeholders from across Canada and abroad, our work has classified the uniqueness of each jurisdiction while exploring the various commonalities between stakeholder experience to produce a detailed examination of the factors that advance or inhibit the achievements of a lower emissions strategy, and the rebalancing of energy systems.

We talked to more than 40 energy experts in governments, utilities and regulatory bodies and they all agreed that there were great benefits coming from innovations, but they also saw dangers. This Discussion Paper addresses some of the immediate risks we face, but it is only an introduction to the work that is required. We learned that there are gaps in knowledge about the pace of change and the implications of transforming to the energy systems of tomorrow. These are not only gaps in knowledge of research that exists, but also significant room for learning both within and between organizations in the smart energy sector.

SECTION ONE: ACCELERATING CHANGE EVERYWHERE ALL THE TIME

INNOVATION

We are in a situation where just about any global industry in the world today is grappling with unprecedented technology-driven disruption and upheaval. Innovation is everywhere, all the time, and moving at a speed of discovery and adoption that is adding both hope and uncertainty to all aspects of our lives. It is also at the heart of change in how we produce, transform, transmit, distribute and use energy.

The 2018 Generation Energy Report published by the Government of Canada states it well, "An energy transition is underway – and will continue to roll out over the course of a generation, roughly between now and 2040. It is the greatest shift of this kind the world has seen in generations."[1]

Smart Energy Communities are moving forward with a goal to seamlessly integrate local, renewable, and conventional energy sources to affordably, cleanly, and efficiently meet its energy needs and making impressive strides. We know how to use energy more efficiently and use less of it. We know how to build and renovate buildings so they need less energy. We are seeing a sharp rise in the use and a drop in the price of renewable resources and cleaner fuels.

As these innovative technologies become convenient and inexpensive, their attractiveness is irresistible. When irresistible attraction becomes real, adoption accelerates. The price reductions and innovative features are emerging more quickly than forecast. This is introducing rapid change into systems built for prudence, not speed.

In the past prudence worked well because our energy systems were built with lengthy and well-understood lifespans. The type of investments required to adapt the infrastructure of today for the energy systems of tomorrow are evolving. When they will become economic varies by jurisdiction. How they will impact the existing infrastructure is still largely unknown. Building that knowledge is a new priority, and a new form of prudence.

Canada has impressive energy diversity. There are large surpluses of clean electricity in areas that built hydro many decades ago. Ontario and New Brunswick benefit from clean electricity from nuclear power. The legacy coal plants in areas where coal was once local and cheap are now polluting and a source of intense CO_2 emissions. Remote parts of the country still rely on diesel, wind is growing across the country and interest in solar is increasing. Natural gas generation is inexpensive in Western Canada where supplies are plentiful, but expensive in Atlantic Canada where inexpensive supplies are gone.

This diversity makes broad assumptions about the impact of innovation in Canada difficult, and broad conclusions hazardous. But this Discussion Paper suggests the trends are immutable, the tipping point for clean solutions outbidding at least some traditional supplies is close, and the consequences are not well understood. We don't understand exactly what benefits the new technologies bring in every case. Our experience in integrating intermittent renewables is measured in years not decades. Storage is only just emerging as a solution, but how to properly assess its benefits and price its value remains a puzzle.

This Discussion Paper suggests the pace of change is such that we need to build the experience and knowledge to answer these questions within the next five to ten years at most. When low emission solutions are also lower cost solutions, decisions on when to replace current infrastructure, what to build for new infrastructure, and how to pay for it all come to the forefront. These are the critical decisions of our times.

Prudence suggests policies must be developed and implemented, plans drawn up, evidence gathered, hearings held, rulings made, decisions implemented, projects initiated, and years later new energy systems are put into service. But we do not actually know how much time we have, so, we have to start now, because in these exhilarating, accelerating times, the future has a way of arriving more quickly than prudence might prefer.

[1] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/CoucilReport_july4_EN_Web.pdf

THE DRIVE TO USE LESS AND EMBRACE LOWER-EMISSION ENERGY RESOURCES

All levels of government across Canada have made real commitments to take action on climate change. The Government of Canada's $2 billion Low Carbon Economy Fund has offered significant investments in tackling the issue.[2] We are also seeing the rise of one-window agencies to deliver a range of efficiency programs. And it's not just the programs. Codes and standards for appliances and buildings are becoming more stringent. Materials are being improved for insulation value and ease of installation, and managing our energy use has never been easier.

Energy efficiency and conservation are changing the way we think about energy. Efficiency is a low cost resource that is critical to energy planning processes. Not only is it often the cheapest fuel source, it helps lower energy bills which offers benefits across industrial, commercial, residential sectors and even has an impact on energy poverty offering relief from high energy bills to low income families. Using less energy or using it more efficiency is also always the most impactful way to reduce GHG emissions.

Innovation has made tremendous strides in reducing the cost of clean electricity resources such as wind and solar. There's been a 66% drop in the cost of wind over the past decade, and a 70% drop in the cost of solar (see Appendix A). Considering wind alone, it is already the lowest cost source of energy in many parts of Canada. Solar is still behind, but prices for solar cells continue to fall. Meanwhile the rise in production of batteries for electric vehicles (EV) is driving the cost of batteries (storage) down for all users. The combination of the two - lower cost electricity generation and lower cost storage are key drivers of change.

Technology to gather data and help make decisions on when to heat or cool is becoming pervasive. The cost of management is declining and the value for energy systems as a whole is rising. Together, renewable energy and efficiency and energy management is the core of what is known as Distributed Energy Resources or DER.

THE INVASION OF DISTRIBUTED ENERGY RESOURCES

DER are technologies and approaches that can replace the highly centralized supply infrastructure that has characterized the North American energy system for much of its history. These technologies are "distributed" in so far as they are not centralized. They are typically installed or managed behind a local distribution utility meter.

They are "energy" to the extent that they are intended to manage the availability of energy to customers' premises, and they are "resources" to the extent that they can include localized generation assets such as cogeneration plants and solar installations; storage assets of all kinds, including electric vehicles; demand management strategies intended to reduce consumption, especially at system peaks; and also varieties of consumer configurations, for example the development of microgrids.[3]

MANAGING DEMAND WHILE GROWING DEMAND

With electricity being generated from clean fuel sources, there are emerging policies to expand the use of electricity in non-traditional uses. In most parts of Canada non-traditional uses include space heating and transportation. Electrification will grow the need for electricity supplies, although how much more we will need will depend upon how quickly we adopt the new uses, how successful we are in adopting the innovative measures to reduce energy use,

[2] https://www.canada.ca/en/environment-climate-change/services/climate-change/low-carbon-economy-fund.html

[3] Adapted from https://mowatcentre.ca/wp-content/uploads/publications/141_emerging_energy_trends.pdf

and the role of attractive alternatives such as renewable natural gas or hydrogen. Current electrification initiatives include rebates and financing for high efficiency heat pumps and goals for the uptake of electric vehicles (EVs) and EV infrastructure.

Clean electricity and clean alternatives will need to reach a new balance. Today, on average, electricity is roughly 20% of energy use, whereas natural gas is 30-35% and transportation fuels are 34-35%. Policy options to clean up transportation and natural gas supplies through Renewable Fuel Standards are in place in some parts of Canada. The benefit of using the existing pipeline infrastructure for renewable resources, such as methane from sustainable biomass supplies, or for clean energy sourced hydrogen supplies, is significant.

Nevertheless, the trend and momentum are clear. More and more we will be replacing natural gas and diesel/gasoline with heat pumps and electric vehicles. To fully implement electrification would require a massive expansion in electricity production and in electricity networks. However, the timing of the expansion and the size of the increase are difficult to predict. Electrification on its own may not be the most effective course of action in all circumstances, and alternatives that reduce emissions from the natural gas system are also likely to be needed. Energy policies, strategies and plans need to identify the best course of action in the short, medium and long term that takes into account the growing cost-effectiveness of DER. As we noted at the beginning of this section, though, we don't have the luxury of waiting

Appendix A provides additional analysis and detailed references to the issues related to DER, innovation, and the pace of change.

SECTION TWO: INNOVATION THAT WILL HELP AND HURT

TECHNOLOGIES THAT BENEFIT ENERGY USERS

In the preparation of this Discussion Paper we asked governments, regulators and utilities which emerging technologies they thought would have the greatest benefits for energy users. Many of the benefits they see will come from the DER outlined in the preceding section.

There was a strong consensus that the development of low emission energy resources – especially as they become cost-competitive – would be of significant benefit for all. Some of those technologies, such as solar, also lend themselves to self-generation, and that is seen as benefiting individuals, although the real system-wide costs and benefits associated with self-generation are still not well understood.

Related to the rise of low-cost renewables are the benefits seen in the rise of low-cost storage. The two technologies come hand in hand. The rise of electric vehicles was also seen as a benefit, not only for the lower carbon footprint, but also for the opportunity to use the batteries to help fill in demand outside of peaks and even supply electricity to the grid during times of peak.

The benefits they see from the development of sensing, controlling and decision-making technologies to help us manage energy systems large and small go well beyond those associated with electric vehicles. The benefits identified include options to reduce the absolute amount of energy use (efficiency), and the development of new rate designs (incentives) to better match the real-time flows of variable energy resources and encourage or automatically facilitate the shifting of energy use to avoid the extra cost of providing energy at times of peak demand. New forms of intelligent energy technologies also offer the benefit of adjusting demand based upon actual and predicted weather conditions including variances in daylight hours.

The officials we interviewed point out that technologies for managing heating and cooling are now very competitive in many parts of Canada. Research and development on cold climate air source heat pumps could accelerate adoption and remove the need for other energy resources or electric coils for backup. Highly efficient natural gas heat pumps were also identified as a benefit to energy users in parts of Canada that have access to inexpensive natural gas. Existing homes could benefit from new highly efficient cladding materials that can be installed with minimal disruption and lower costs. We also heard that it is important to recognize that when it comes to energy users, the value of new technology goes beyond its immediate function. Devices that improve comfort as well as efficiency could result in rapid adoption and reduce energy use in ways that cannot be foreseen.

The officials believe that the combination of low-cost renewable and storage technologies with sophisticated management technologies creates new value for distributed energy systems. The varieties of systems that are separate, or can be separated from, central power systems are many. At one end of the spectrum some individuals may go off grid entirely. At the other end, utilities are already looking at the advantages of systems to be grid connected, and through the integration of local renewables and batteries they become sources of supply for the grid or for the local community.

Pilots to test these concepts under Canadian conditions are now underway.[4,5] Some applications of new technologies to measure energy use are already being used in places that have had advanced meter infrastructure (AMI) in place for some time. The Green Button standard to share energy use is one example of a customer friendly application. There are many other examples of the advantages from making energy data available.[6]

Finally, the officials identified a broad category of technologies that can improve reliability in energy systems at a lower cost than traditional approaches. This category includes better forecasting of failures, development of subsystems (including batteries) that can be isolated from failures in a larger system and adapt to flexibility in generation from renewables.

They see storage as being increasingly useful for industrial and commercial customers to maintain reliability, and as costs decrease storage solutions could be spread to residential customers.

[4] https://www.nspower.ca/en/home/community/blog/testing-battery-storage-in-elmsdale.aspx

[5] https://www.newswire.ca/news-releases/government-of-canada-invests-to-help-make-canada-a-world-leader-in-clean-technologies-805263412.html

[6] https://questcanada.org/project/atlantic-canada-energy-data-roadmap/

THE RISE OF NON-REGULATED ENERGY SECTOR TECHNOLOGIES AND BUSINESS MODELS

Finally, the officials we talked to think the rise of parties offering services outside of the regulated utility sector (third-parties) was largely a benefit, although it also presents challenges that will be discussed further in the next section. Much of the activity by third-parties comes from the development of technologies and information gathered behind a meter to manage energy use. Many officials saw competition by such third-party private developers as a key component and a driver of innovation.

Although only a handful of jurisdictions report they subsidize smart thermostats, the makers of the devices are already selling them widely as a way to painlessly manage heating and cooling.

Device manufacturers are also building programs to reward their customers if they agree to have their energy use shifted or reduced at key points of peak demand. The makers of the devices can then package these offers into a deal for energy reduction to the utility.[7]

This example is just one of many where a third-party is offering something new. Many officials think it is a good thing to look at energy as a service and have third-parties make investments and take risks outside the regulated utility space. This is particularly true for large building contracts where third-party organizations offer innovative financing models for the private and public sector. One of these models that has emerged is an Energy as a Service (EaaS) agreement.

[7] ibid

Under this agreement a building owner pays for an energy saving service similar to how they pay a utility bill. The EaaS corporation in turn identifies efficiency investments, locates funding to cover the cost of the projects, installs, operates and owns the equipment, and verify the savings. A fee per unit of energy saved is charged at a rate below the utility rate.[8] This could include EV charging networks, which in some jurisdictions are considered competitive activities.

Through our examination of experience outside Canada we also noted that targeted energy efficiency measures have been used to avoid key infrastructure upgrades and maintenance in some locations. These measures may be referred to as Geotargeting or a Non-Wires Alternative. An example of this practice in use is New York's Brooklyn-Queens Demand Management (BQDM) Project. It aimed to offset an anticipated $1.2 billon capacity upgrade of two sub-transmission feeders by reducing peak load demand by 52 MW, 41 MW of which were to come from customer-side applications.[9] With a budget of $200 million, Con Edison proposed to reduce demand through energy efficiency measures, demand side management, distributed generation and other measures.[10]

Meanwhile the energy consultancy firm Navigant predicts spending on energy efficiency will grow at a steady pace over the next ten years, driven in part by improvements to the resource alongside business models and technologies that continue to evolve.[11]

[8] https://aceee.org/sites/default/files/eo-energy-as-service.pdf
[9] http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=45800
https://www.utilitydive.com/news/despite-failures-coned-targets-more-energy-savings-from-non-wires-pioneer/547725/
[10] ibid
[11] https://www.utilitydive.com/news/der-integration-to-fuel-energy-efficiency-growth-reports-find/549782/

OPPORTUNITIES FOR RECONCILIATION WITH INDIGENOUS PEOPLES

Innovation in our energy systems is also seen by officials as an opportunity to help Indigenous communities develop new energy and economic opportunities in their communities. Some thought that there was a poor track record of helping Indigenous people to benefit from energy projects in the past, but that was changing. There was a general consensus that a more positive approach being taken on DER projects is part of that change, and part of reconciliation.

A number of provinces have or have had programs to develop renewable resources and efficiency upgrades. For example, Indigenous groups in Nova Scotia built more than 23 MW of wind projects under the Province's Community Feed in Tariff (COMFIT) program.[12] Similarly, every band-owned building in the province received an energy audit conducted by locally trained auditors from the communities.

In 2016, New Brunswick Power invited Indigenous groups to be part of a program called Community Renewable Energy-First Nations Opportunity, which is the first phase of the government's Locally-Owned Renewable Energy Small Scale (LORESS) Program.[13] In Saskatchewan the First Nations Power Authority is working with Indigenous communities to identify potential projects, and they have support of SaskPower. In British Columbia, the Clean BC plan commits the government to work in collaboration with Indigenous peoples to access new clean economy opportunities and help communities adapt to the impacts of climate change.[14]

[12] https://energy.novascotia.ca/sites/default/files/files/Copy%20of%20DRAFT%20Comfit%20Status%20as%20of%20January%202019(2).pdf

[13] Community Renewable Energy – First Nations Opportunity, which is the first phase of the government's Locally-Owned Renewable Energy Small Scale (LORESS) Program

[14] https://news.gov.bc.ca/files/CleanBC_HighlightsReport_120318.pdf pg 4.

TECHNOLOGIES THAT MAY HURT (SOMEONE) – RISKS TO MANAGE

We also asked officials across Canada, and in several other jurisdictions, which technologies provided the greatest threat to the existing energy systems. Not surprisingly, many of the same technologies, business models and ideas that provided benefits, also brought the greatest risks - though they felt those risks could be mitigated. They also thought the main risks are the ones that introduce uncertainty to a sector that prides itself on being a safe place to invest.

PACE OF ADOPTION

The uncertainty is largely a question of how quickly technologies will continue down the cost curve and how quickly businesses and customers will understand the benefits and adopt the technology. Everyone recognized that the speed of change is accelerating, and they also thought the falling cost of technologies brought new challenges to existing as well as future investments.

OLD INVESTMENTS, NEW VALUE OR STRANDED ASSETS

Canada's energy sector is of enormous importance to our economy. It accounts for about 10% of our GDP with a range of $50 to $100 billion a year in new capital investment over the past decade.[15] Although much of that relates to the extraction of oil and gas, a great deal of it also relates to electricity generation, transmission and distribution as well as the distribution of natural gas.

[15] https://www.nrcan.gc.ca/energy/facts/energy-economy/20062#L7

Each of these investments has an expected useful life. Each year energy users pay rates that include a share of those investments that represents the decrease in the useful life for that year on an accounting schedule approved by regulators. If the expectations about the useful life prove to be wrong, and a new technology replaces it before the accounting schedule is complete, the asset is said to be stranded – no longer useful, but still sitting on the books and needing to be paid for. For energy officials that risk varies depending on the kind of investments that have been made.

Appendix B provides an overview of legacy generation and fuels.

RISKS TO ENERGY SYSTEMS

Energy officials are concerned that as more technologies are connected to each other, the risks to the entire system rise. This risk was outlined in a 2017 article in the *Electric Power Research Institute Journal*.[16] The article notes security is important throughout the grid, and with DER security can be easily overlooked. The challenge is as the number of parties involved increases, the responsibility for security spreads, the possibility of complete knowledge is reduced, and the risk of a security failure rises. Officials are also concerned about the risks and implications of moving from the resilience and diversity offered by multiple energy systems (electricity, natural gas, diesel/furnace oil and propane delivery) to a single system of electricity. The view is that these implications can likely be managed, but need to be assessed and taken into account when establishing new energy policy directions.

[16] http://eprijournal.com/securing-the-grids-edge/

IMPACTS ON BUSINESS MODELS

Most energy officials we talked to also expressed concern about the potential for third-parties using new technologies to attract customers from the regulated utilities to the detriment of the other customers who remain on the system. The risk is one of scale. A few customers trying to generate their own electricity presents only a small challenge. A significant number of customers with access to attractive loan arrangements who decide to self-generate and self-supply through solar roofs and batteries, particularly if they are large customers, means there is less revenue coming in to cover the cost of all the investments made.

Ironically, a significant rise in efficiency upgrades presents a similar challenge, particularly if large customers such as commercial, industrial and institutional customers take wide-spread and major steps to upgrade their buildings and the systems used for heating and cooling. In the USA a late 2017 study suggested energy savings potential in the sector at 10% from upgrades to HVAC alone.[17]

The result is a raise in rates for those left behind, which could push them to consider their options as well. This threat of a shrinking customer base causing higher costs and more shrinkage is commonly referred to as a "utility death spiral". Right now, it is impossible to estimate how large a risk it could be, but the risk is already being felt in the United States. The consulting firm Accenture reported in February 2019 that a survey showed 95% of utilities executives agree that the risk of electricity energy users going largely off the grid and only using it as an occasional backup will increase significantly in the next two years.[18] In Canada, many officials expressed concern that the risk could emerge quickly and that the legislative regulatory frameworks may not be able to respond quickly enough.

[17] https://www.energy.gov/sites/prod/files/2017/12/f46/bto-DOE-Comm-HVAC-Report-12-21-17.pdf

[18] https://newsroom.accenture.com/news/most-utilities-executives-agree-risk-of-consumers-going-largely-off-grid-will-increase-significantly-in-next-two-years-according-to-research-from-accenture.htm

They note that the legislated regulatory frameworks were set in different times for different conditions. The frameworks implicitly assumed that decisions on investments could be planned well in advance and that the lifespan of those investments was well understood. All investments were to have defensible businesses cases and be prudent in minimizing risks for the customers who would pay for them. The frameworks also assumed limited and specified competition on generation and retail rather than full competition.

Faced with new technologies and new uncertainties new risks emerge. At the very least, energy officials are concerned about how those uncertainties may affect the climate for investment. It should be noted that some energy officials see government ownership as a mitigating factor that will help them avoid these risks. They reason that their government owners will protect them. However, there is a risk that this belief will result in them not being prepared for innovations that are politically popular, and underestimate the pressure on governments to open up access to beneficial technologies and business models.

ENERGY AFFORDABILITY

Underlying the challenges to the current business models is a concern about energy affordability. It is part of the utility death spiral noted earlier. For those who already have stresses in paying bills, paying more because they can't afford to invest in alternatives presents a very significant challenge. There is also an element of equity in new rate designs. Without proper price signals and practical ways to use them by unsophisticated customers, the adoption of DER may shift system costs to customers who, again, cannot afford them.

OBSERVATIONS FOR DISCUSSION

While some jurisdictions thought there might be more room for third-party competition in some aspects of DER such as storage or EV charging, none of the energy regulators, policymakers or utility leaders, suggested we completely remove regulatory oversight of the sector and open it generally to competition.

This is likely due to a belief that even if the rules allowed for competition, in many of Canada's smaller markets it may not arrive.[19] Without many players, regulated monopolies could be replaced by a series of unregulated oligopolies. As a result, made in Canada solutions will likely be required to enable more rapid, flexible, and adaptive decision-making. Decision-making that will also need to remain largely predictable to foster the investments needed while keeping energy costs affordable. It will also need to develop firm plans to address the potential costs due to obsolescence and a shrinking customer base.

[19] https://energy.novascotia.ca/sites/default/files/Case%20studies%20web3.pdf

SECTION THREE:
ENERGY MARKETS – WHERE YOU STAND DEPENDS ON WHERE YOU SIT

HISTORY

Canada's electricity technologies and markets grew like those around the world. Nearly 150 years ago the first arc light was turned on in front of a hotel in Winnipeg.[20] As electricity lighting supplanted gas lighting new technologies were developed to eliminate human effort (vacuuming instead of sweeping and automatic washers instead of hand washing). Industrial opportunities such as smelting also arose. As these new demands emerged, many provinces created government-owned organizations (crown corporations) to meet these needs, often through the development of hydroelectricity.

The opportunities from hydropower were so large as to overwhelm even the large ambitions for industry in Canada. As a result, many of the hydroelectric dams and transmission systems were built based upon sales to adjacent jurisdictions to the south. Those sales in return helped provide revenues to the government owners or helped reduce costs for the provincial energy users.

FACTORS THAT DRIVE POLICY, MARKET AND DECARBONIZATION STRATEGIES

Before we can understand how to adapt, manage and prepare for all the changes coming it is important to acknowledge that in this dynamic transformation that is underway, not everyone is starting from the same place. Not everyone has the same sense of urgency on reaching the destination and not everyone has the same sense of how to get to there. That diversity is real, it is historic, and it recognizes the different access to resources and markets each jurisdiction has.

The diversity shows in how each jurisdiction addresses many key energy policy objectives. For example, jurisdictions may differ in the following areas:

- **Reliability** - Reliability is important, but at what cost?
- **Affordability** - How does the emphasis on the importance of affordability rise and fall depending upon recent events?
- **Pace** - What are the different starting and end points to the speed of transformation to lower or zero carbon energy systems?
- **Competition** - How much of the operations or developments in the current regulated utilities should be open to competition to allow for innovation or reduce costs, at the same time protecting customers and the energy system?
- **Efficiency/Conservation** - How is the priority for efficiency and conservation decided? Considerations include: avoiding new investments, freeing up supplies for exports in new markets, alignment with carbon reduction and affordability for lower income energy users.
- **Market Models** - Should there be changes in the market model, either explicitly as in Alberta's move to create a capacity market, or implicitly through internal reviews in multiple jurisdictions as they look at the rise of distributed energy technologies and systems.
- **Fuel Emissions** - What is the emphasis on lowering or reducing emissions in the fuel we use (such as natural gas)?
- **Electrification** - What is the speed of pursuing a much greater use of electricity through electrification of uses normally supplied by fossil fuels (space heating and transportation)?

ELECTRIC UTILITY OWNERSHIP AND EXPORTS

Electric utilities in Canada vary by their dependence on large crown corporations to produce, transmit and distribute electricity to their customers. Today, British Columbia, Saskatchewan, Manitoba, Québec and New Brunswick still depend upon crown-corporations, although they all have varying degrees of private and municipal

[20] https://electricity.ca/learn/history-of-electricity/

generators and distributors. In the territories, Yukon Energy Company, Northwest Territories Power Corporation and Qulliq Energy Corporation, are all crown corporations with dominant generation, transmission and distribution.

In Nova Scotia and Prince Edward Island there is no crown-owned dominate electricity utility and the main generators and distributors are privately owned. In Newfoundland and Labrador the main distribution utility is private while a crown corporation owns most of the generation and transmission, with responsibility for remote community generation and distribution. In Alberta generation is private, but Calgary and Edmonton have municipally owned distribution companies.

Ontario is more mixed. Ontario Power Generation, a crown-owned generation company, generates around half of all the electricity in the province, with the remaining electricity supplied by independent power producers under contract. Hydro One, a minority government-owned utility, operates the transmission system and acts as the distributor to non-incorporated areas. Approximately 70 municipally-owned local distribution companies operate within franchise areas.

Many provinces have strong north-south connections. British Columbia, Manitoba, Ontario and Québec all export electricity to the US. There are more limited connections between the provinces.

ELECTRIC MARKET DESIGN

Markets in Canada can be classified generally on how tightly the various sectors of the business are integrated or separated, and then how much competition there is within each of those sectors.

It is noted that natural gas markets in Canada are largely separated into transmission and distribution systems. For the end use of natural gas the transmission and distribution systems are largely monopolies within a franchise area. However, Canadian electricity markets vary widely from one province or territory to another.

The following Table classifies each jurisdiction in Canada for electricity markets. We can then reclassify each jurisdiction and place them on a matrix showing the degree of integration and competition.

Table 1 – Degree of Network Integration and Competitiveness in Canadian Electricity Markets[21]

Jurisdiction	Electricity Networks	Electricity Market
Alberta	Separated	Competitive
British Columbia	Partly Integrated	Non-competitive
Manitoba	Highly Integrated	Non-competitive
New Brunswick	Partly Integrated	Non-competitive
Newfoundland and Labrador	Partly Integrated	Non-competitive
Northwest Territories	Partly Integrated	Non-competitive
Nova Scotia	Highly Integrated	Limited competition
Nunavut	Highly Integrated	Non-competitive
Ontario	Separated	Limited competition
Prince Edward Island	Partly Integrated	Limited competition
Québec	Highly Integrated	Non-competitive
Saskatchewan	Highly Integrated	Non-competitive
Yukon	Partly Integrated	Limited competition

[21] For definitions see Appendix A

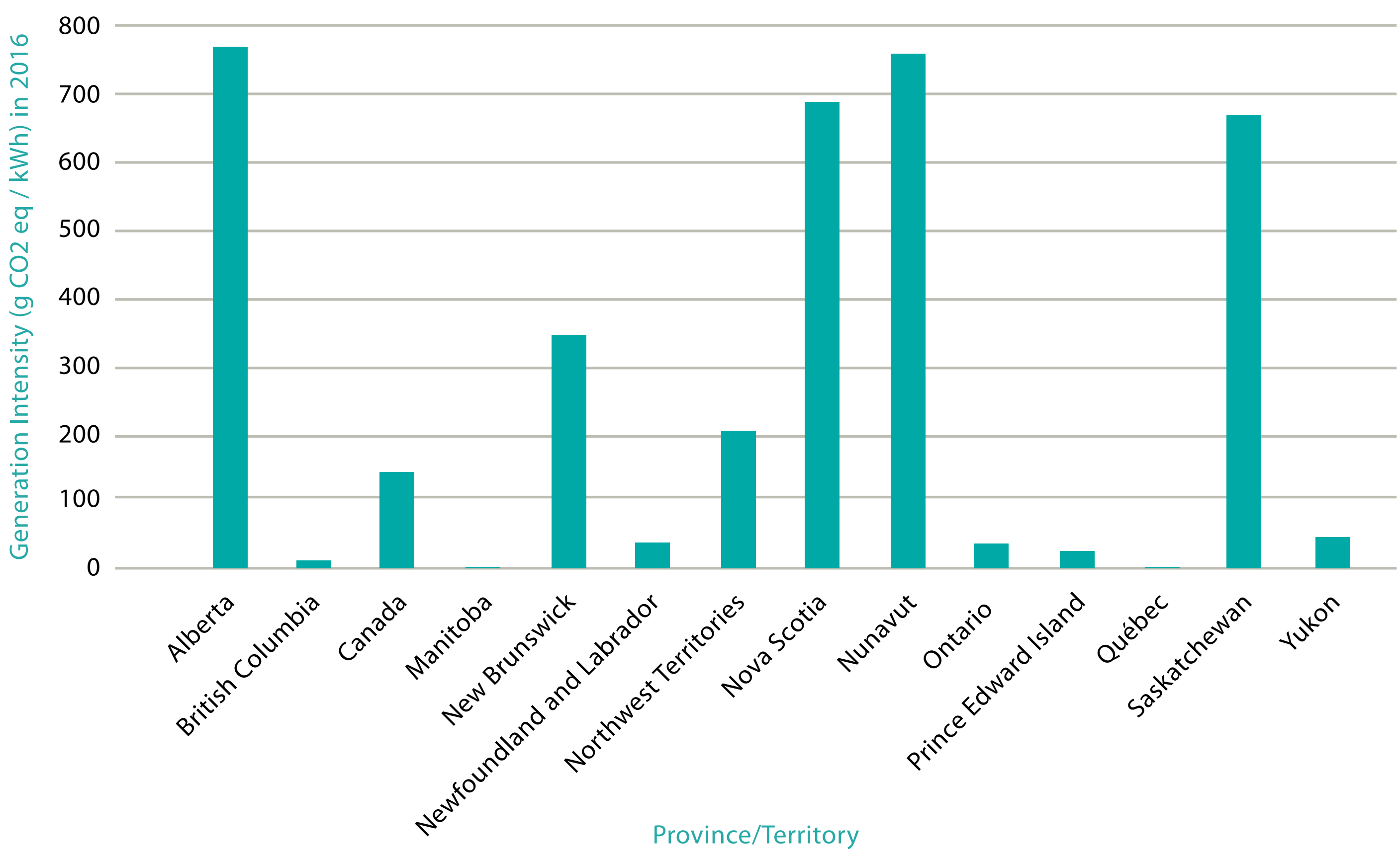
RESOURCES AND CARBON INTENSITY DEGREE OF CURRENT AND NEAR-TERM DECARBONIZATION

As much of the electricity in Canada is produced from zero carbon sources (Hydroelectricity, nuclear, biomass, and new renewables such as wind and solar), Canada as a whole has a relatively low electricity emissions footprint. However, there is considerable variance between various jurisdictions.

The highest carbon electricity jurisdiction is Nunavut where almost all electricity comes from diesel-fueled power plants in each community.

The lowest carbon electricity jurisdiction is Québec, with Newfoundland potentially set to take the title when the Muskrat Falls Hydroelectric facility comes into operations next year. The benefits from Muskrat Falls power flowing into the Maritimes is expected to help Nova Scotia make a major reduction in emissions in 2020/21, with the potential to help New Brunswick and Prince Edward Island as well. The chart below shows the difference in carbon intensity in Canadian electricity jurisdictions as of 2016, the most recent numbers available.

Figure 1 – Generation Intensity (g CO2 eq / kWh) in 2016 in Canadian Jurisdictions[22]



[22] https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html

LEGACY INVESTMENTS

Legacy infrastructure investments and their remaining useful life (and their remaining accounting life - which may not be the same) also play a role in setting the scene for provincial and territorial energy policies. The longer the life remaining on assets that may be most impacted by emerging cost-effective DER, the greater the risk they will be supplanted, and energy users may be required to pay the remaining costs.

MARKET SIZE

Market size is impacted not only by a jurisdictions' own size, but also by its connection with other markets (ranging from isolated off-grid communities to well-connected provinces such as Québec and Ontario. Large size markets with good connections impact perspectives on opportunities for competition and the level of willingness to develop market solutions in public policies.

CARBON PRICING

There are a variety of positions across Canada on the value of carbon pricing. At least at the time of the development of the Pan-Canadian Framework on Clean Growth and Climate Change, there was broad agreement for putting a price on carbon as a tool to help transform energy markets. However, that consensus has dissolved as a specific framework on how to put a price into effect has emerged. A legal challenge to federal authority to impose a pricing regime is underway at the time of the writing of this Discussion Paper. Policy preferences on climate change action may also be impacted by the availability of fossil fuel resources in a province that are available for development.

See Appendix C for more details on jurisdiction markets and designs.

OBSERVATIONS FOR DISCUSSION

Generally speaking, provinces with legacy hydro, domestic surplus supplies of energy serving or seeking export markets, and the presence of crown corporations where government and utility objectives are fully aligned, have similar policy orientations. They are all moving toward finding new uses for electricity in a province (electrification), there is a view that efficiency at home opens more opportunities to sell elsewhere and secure greater revenues and a there is a preference for government or utility solutions.

On the other hand, provinces and territories that have legacy infrastructure that serves a legacy fossil-fueled system are more focused on the cost of transformation and the need for efficiency to mitigate costs for energy users.

SECTION FOUR:
SETTING POLICY – THE GOOD, THE BAD AND THE UGLY

In our survey of policymakers, regulators and utility leaders in Canada and internationally, we were able to capture a focused list of broad and specific advice on where to start when designing energy policies for a lower emission, more distributed energy future. The advice offered is summarized below starting with the thing's policymakers should do.

THE GOOD

First and foremost, the advice is to set long-term policies and goals. This includes creating a long-term vision of the energy system of the future. Within that vision, there should be roadmaps for cleaner energy technologies in each subsector (e.g. EVs) with flexibility built in. Those roadmaps and plans should be broader than just creating cleaner energy systems. The advice is that they should also consider efficient systems and affordable systems. In fact, policymakers should think about the "energy system" as a whole and not as separate areas. For example consider:

- peak demand rather than just energy;
- the impact on energy poverty;
- different benefits from DER investments to each unique location within a market;
- electrification policies within the context of the cost to energy ratepayers and the existing infrastructure – especially the role of natural gas infrastructure; and,
- investments that have already been made and pace change accordingly.

Within that broader framework there was also advice on priorities. Many believe energy policies should start with efficiency and conservation, then move to lower carbon and fossil fuels than can be decarbonized (renewable natural gas, hydrogen).

Second, there was consistent advice to support innovation, particularly at a pilot scale in places where innovation and the pace of implementation can flourish.

There was also a running theme about developing energy policies based upon the needs of energy users and what they want from the system. Different users will want different things, and policy will need to allow for these differences. It was suggested that allowing energy users to choose from reasonable alternatives builds public support for the system. Building broad public support and broad political support were also seen as important attributes of a consistent and enduring energy policy and investment framework. It is noted that some of those surveyed see choice as competition and an outcome from opening markets. Others see choice as a possibility even within a regulated environment.

SETTING LONG-TERM GOALS

Many jurisdictions around the world have established long-term goals and targets but putting those targets into laws that will frame regulatory decisions and plans is an important next step. To help achieve those goals, it helps to have credible options on how to move toward them. In a number of provinces, there are legislated targets to reach incremental renewable electricity requirements, for example in Alberta, Nova Scotia and New Brunswick. But in the United States, jurisdictions are beginning to adopt legally-binding end dates for the use of fossil fuels in electrical generation. For example, in the Spring of 2019, New Mexico joined California and Hawaii in setting such dates and Minnesota, Washington, New York and Illinois have introduced similar legislation.[23]

Managing change includes communication with energy users. The advice we heard was that users will need to be brought along through the transition so they can understand the changes and how it will benefit them.

It all comes down to understanding innovation benefits from a customer and a system perspective. That includes considering the balance between risks and benefits for the utilities and for energy users. The role of third-party competition, and how much the sector can be opened to competition while ensuring the balance between risk and benefits, also needs to be considered.

And finally, there was recognition that change will impact the people who work in the energy sector today. The advice was to build policies and strategies that consider the workers who will be left behind and make plans for their transition today.

[23] https://www.utilitydive.com/news/threes-company-new-mexico-joins-california-hawaii-in-approving-100-clea/550390/

THE BAD

We also asked the energy leaders to provide their views on the things that should not be done when developing energy policies and legislated energy regulatory frameworks. Sometimes it was simply the opposite of what should be done, for example:

- Don't consider energy and climate change objectives in isolation.
- Don't think about only short-term outcomes and impacts.
- Don't be too prescriptive in how to achieve broad outcomes.
- Don't assume you know what the energy users want, or think there is only one kind of energy user.

But some of the advice on areas to avoid or be careful about are different. For example there is a caution that governments should not force too rapid a change – market forces may dictate the pace of change, but governments should be careful when they take charge in setting the pace.

> Consistency was noted as an important underlying value for energy policy. Caution was raised that it is important not to create market uncertainty through rapid policy swings, particularly with respect to carbon pricing.

The advice also suggested that energy policy not inhibit lower cost solutions or lead to investment decisions based solely on outcomes from pilots that were subsidized. Understanding what will happen at scale is important.

AND THE UGLY

Finally, there was a series of issues where government failures could result in poor energy policies and policy implementation. For example, a failure to put policy into law can be a flaw, especially when a specific outcome is required by the policy. A failure to think policies through was also identified. Examples include failure to understand system impacts from program initiatives (e.g. encourage heat pumps without understanding what a rapid take up would do to grid and capacity issues), or failure to plan for large industrial impacts.

INTERNATIONAL EXPERIENCE

All of this advice has deep experience behind it. There are examples where good policies led to good outcomes and bad policies led to near disaster. Sometimes it is easier to develop and implement strong energy policy and be more objective about failures by looking at other parts of the world. Australia's challenges in transforming their coal-based power systems and opening the floodgates to DER while adopting, and then rapidly disavowing, climate change tools is an example.

AUSTRALIA'S EXPERIENCE

Australia is a country with energy abundance and electricity challenges. Much of their power is generated from locally abundant coal that is burned in aging power plants. A number of states have encouraged growth of solar without building a grid to match. As the system struggles with the mismatch, energy and climate change policy in Australia is under continuous re-invention or denial. A recently published book (Blackout by Mathew Warren – January 2019) chronicles the history and events that led up to a September 2016 power failure where the entire state of South Australia, including the capital Adelaide. It details the complex history of rapid changes in energy and climate change policies, the growth of solar rooftop PV to a level not seen anywhere else, and the closure of aging coal plants without a plan to replace the energy. Even a potential solution of using Australia's abundant supplies of natural gas is stymied by long-term export contracts. The combination of short-term political solutions (often to address electricity prices) and aging energy infrastructure promises more trouble ahead. Six times in the past decade Australia has tried to get a national plan for climate and energy, but each time the plan was reversed. The author has played many insider roles in the Australian energy sector and builds a compelling case for a less politicized, more carefully planned and integrated approach to setting Australia on a path to a sustainable energy future.

Also consider the UK example, where a Parliamentary report on a failure to be aggressive on upgrading the efficiency of buildings revealed the danger in setting goals, but failing to follow through on them.[24]

As another international example, in the spring of 2018 the International Renewable Energy Agency (IRENA) reported a series of key findings for good energy policy, including advice on the integration of renewables[25,26]. The advice was very similar to the advice offered by Canadian experts.

- Renewable energy policies must focus on **end-use sectors**, not just power generation.
- The use of renewables for **heating and cooling** requires greater policy attention, including dedicated targets, technology mandates, financial incentives, generation-based incentives, and carbon or energy taxes.
- Policies in the **transport sector** require further development, including integrated policies to decarbonise energy carriers and fuels, vehicles and infrastructure.
- Policies in the **power sector** must evolve further to address new challenges.
- Measures are needed to support the integration of **variable renewable energy**, considering the specific characteristics of solar and wind power.
- Achieving the energy transition requires **holistic policies** that consider factors beyond the energy sector itself.

[24] https://www.carbonbrief.org/uk-homes-shockingly-unprepared-for-climate-change-says-ccc?utm_campaign=RevueCBWeeklyBriefing&utm_medium=email&utm_source=Revue%20newsletter

[25] https://www.irena.org/publications/2018/Apr/Renewable-energy-policies-in-a-time-of-transition

[26] https://irena.org/publications/2019/Feb/Innovation-landscape-for-a-renewable-powered-future

SECTION FIVE:
SETTING THE STAGE FOR
A NEW ENERGY ERA

Canada's legislated energy regulatory frameworks are the energy policies a province or territory put into law. They have particular importance for energy providers and users when the relationship is monopolistic. When there is little or no choice, the legislated regulatory frameworks describe the process to establish the price of energy to users (rates), as well as other important issues such as reliability, the obligations of a utility to provide service, and a rate of return to the utility for their investments (capital).

The model is well established, well understood and well designed to minimize risk to energy users (paying too much for investments not needed) and risk to the utility (if they do a good job running their business and make prudent investments they are assured they will get their costs covered by their customers and a reasonable profit). To varying degrees, it is often an adversarial environment where regulators listen to competing evidence to make a final determination.

The regulatory processes can also be conciliative where stakeholders come to a consensus and present a solution back to the regulator for final determination.

In either case it is a world best understood by experts and representatives. It is not a comfortable world for players not well versed in the language of energy. Nevertheless, the energy system exists to provide energy services to the users. The regulatory process therefore must consider the needs of users, and these users need to be brought along on the journey.

From a perspective of change, Canadian regulatory models are designed to resist new technologies and approaches that are not well tested and backed by evidence of the benefits. The argument for maintaining this conservative approach is largely founded on the principles of risk and reward. Regulated utilities are rewarded by their investors for being risk-averse. The investors want predictable returns. Regulators resist the idea that utilities should innovate but bear no risk if the innovation fails. Everyone then becomes risk-averse.

Yet, there remains a recognition that the energy world is shifting. The question then becomes how existing energy policies and the related legislated regulatory frameworks should change. To answer that question, we asked energy leaders in Canada whether the current system actually needed to change, or could it be flexible and adaptive to the challenges it now faces from lower emission requirements and emerging DER technologies and third-party interventions.

CANADIAN EXPERIENCE AND ADVICE

Many of Canada's energy system players are comfortable with what they have. They see the current system as being predictable, capable of attracting investment at a reasonable cost and delivering reliable energy at fair prices.

But when it comes to managing the kinds of change now coming forward, Canada's energy regulators, policymakers and utility leaders are almost unanimous in their view that our legislative regulatory frameworks are not flexible enough and don't easily adapt to change.

Even when they thought it could, it was qualified. Yes, they are flexible and adaptive today, but not for the future. Yes, they can change, but not fast enough. Yes, there is flexibility in the regulatory framework, but guidance is needed on how to balance the different interests.

How quickly the frameworks allow for decision-making is a significant issue. In one case it was observed that the current framework may have significant latitude but when left to regulatory processes manage to change, most are conservative and lengthy.

There is a risk that even after there have been detailed reviews, the solution gets hung up on need for technical changes to the law. Some regulatory frameworks have difficulty evaluating the rapidly changing costs and values of technologies. A nimbler system would be more forward looking rather than retrospective – especially when timeframe from research to filing to decision to implementation takes years. Identifying value of the innovation is a related issue. "We don't understand the value of this" is another way of putting it.

Some make the simple observation that some new technologies present ideas that just didn't exist when the legislative frameworks were drawn up decades ago. The frameworks did not anticipate some aspects of DER, innovation and investment. The idea of storing energy in low-cost batteries distributed around the system is a good example. Is storage a source of supply? Is it a way to manage the cost of intermittent renewables? Is it a way to help reduce peak demand? Or is it all of these things and thus hard to fit in just one box? Storage and electric vehicles also present new consequences that are not yet well understood, and how to manage all this is not clear in many legislative frameworks. As third-parties continue to promote these technologies, and end users continue to adopt them, answering questions will become important.

Efficiency is another area of DER where some legislative frameworks fail. While Nova Scotia explicitly recognizes the value of comparing investments in efficiency against investments in generation, most regulatory frameworks do not. There is a growing interest in reducing energy use as a first step through innovative programs, financing and rate designs. But regulatory systems depend upon utilities to bring forward good cases, and without certainty utilities are reluctant to take the risk to propose innovation.

Some utilities want fewer restrictions on innovation. They need more direction on how to deal with the implications from change (shorter investment paybacks reduce risk of future stranded assets). They need a new balance on risk and benefit sharing for innovation, including a determination on how much should be taken on by customers. Governments need to set clearer direction and do it through legislation. Doing so reduces, but does not eliminate the risk of new political decision-making, and change.

Some of the energy experts we spoke with called for legislative frameworks to require the regulatory system to pay more attention to integrated planning and act faster. But it was also recognized that there has to be a balance between the need for speed and the intrinsic value of caution, prudence and full stakeholder input. The two needs, speed and prudence, may not be inherently contradictory if certain areas and actions can be designed for speed, while other aspects of the regulatory sector can be built for caution and safety. Determining factors may include degree and magnitude of risk and length of time for the investment to be paid off. Smaller investments with taxpayer support could be subject to different approaches than larger investments to be fully risked by ratepayers.

CAN THE CURRENT SYSTEM ENCOURAGE INNOVATION AND RISK-TAKING?

The energy experts we surveyed responded to this question from the perspective of their legislated regulatory framework. However, the advice provided had broad applicability. For example, even when they thought their system could encourage innovation and risk-taking, they thought the roles of the players needed to be better understood. They also expressed a need for more clarity on when and why there should be customer funded (rate-based) risk investments. Lastly, they thought it might be better to look at specific projects and pilots to understand the scope and merit of placing such innovation risks on ratepayers and off of utilities.

Even when the thinking was that the system can be flexible, there was concern that the process can be complex, daunting and have little take-up. This point to the opportunity for better engagement in the system that is more efficient and effective. In our analysis we noted some differences in views about how flexible the systems were between jurisdictions with government-owned utilities and those without. The jurisdictions with crown corporations tended to be more comfortable with the flexibility of their legislated regulatory frameworks, but this view was not consistently expressed.

CAN THE CURRENT SYSTEM ADDRESS ISSUES SUCH AS THE NEW RATE DESIGNS, WAYS TO COMPENSATE SHAREHOLDERS, AND STANDARD ASSETS?

The general view is that the current system can manage innovative rate designs, but the introduction of new methods to reward good performance could face stakeholder challenges or political blockages. Also as noted earlier, different jurisdictions have different views about the level of risk they face in having assets becoming stranded, and so there are varying views on whether the regulatory frameworks can manage that risk.

Those that saw risk suggest there should be more clarity in policy and legislation on what should be done. In general, the view was that getting rates right is important – principles include matching rates with costs, using rates to promote flexibility and meeting different user needs with different solutions were noted. They believe rate design plays a major role in transitioning to new DER systems.[27]

GENERAL ADVICE ON THE WAY FORWARD

Finally, there was a good deal of thought on how to proceed with innovation and the legislated regulatory frameworks. We asked energy experts for their thoughts on what should be done, what should not be done and where we should exercise caution.

There was a general agreement that we should be looking for simplicity, promote agility and beware of adding more complexity. In fact, in some cases the advice was to find areas where we can just let go, to enable rather than impose innovation.

There was also a general view that we should be understanding the consequences of our interventions before we intervene. Sometimes the advice on this was general such as make sure you perform risk analysis, build in reviews and check-ins and be careful not to use single lens policy frameworks. But, sometimes that caution had a specific area of concern such as being careful about understanding the need for capacity as well as energy, especially when creating a system that will have more peaks and valleys, and even more importantly when they are coincident with neighbouring markets.

THE ROLE FOR REGIONAL ENERGY POLICY AND REGULATION

So far this Discussion Paper has outlined the challenges facing each individual jurisdiction as they plan for change. But it also needs to be understood that there are options, opportunities and complexities that may come from regional cooperation. Opportunities to take advantage of clean energy surpluses are enhanced if the surpluses can reach other Canadian markets. Regional cooperation can remove the barriers for such exchanges and the federal government can help build the infrastructure also required.

In early 2019, Atlantic Canada announced they were examining the advantages and costs of a regional system operator model where costs are shared on a larger scale. Premiers agreed to engage with the federal government to seek partnership in a regional transmission system, clean energy infrastructure, smart systems and electrification.[28]

Only a few weeks later, federal political leaders joined their provincial counterparts in Atlantic Canada to announce

[27] https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/solving-the-rate-puzzle-the-future-of-electricity-rate-design

[28] https://www.cap-cpma.ca/images/Newsroom/Final-CAP-Communique-EN.pdf

they would develop a Clean Power Roadmap for Atlantic Canada. The roadmap is to outline a collective vision for how jurisdictions can collaborate over the coming decades to build a clean power network across the region by creating a system-wide plan that will provide economic and environmental benefits. The Roadmap will inform how governments invest in electricity infrastructure across the region. This includes transmission interconnections, next-generation renewable energy technologies such as tidal energy, smart grids and energy storage, and EV charging networks — all areas where governments are continuing to invest. The development of the Roadmap will be overseen by an Atlantic Clean Power Planning Committee, consisting of senior officials, working with utilities.[29]

In Western Canada governments are also pursuing regional initiatives as well, but perhaps without the same degree of enthusiasm, or at least not yet.[30] Meanwhile, in Central Canada, Ontario signed an agreement in 2017 to buy electricity from Quebec.[31] Ultimately, the economics of DER and the pace of reducing the carbon content of the electricity systems will be affected by the degree of cooperation among jurisdictions with a surplus of clean electricity and those with deficits.

LEADERSHIP FOR CHANGE

We asked energy policymakers, regulators and utility leaders who should take a leadership role in regulatory development. Most saw this as a government role, but some thought improvements and suggestions for change should come from those who see the opportunities, know their customers best and feel the challenges the best - the utilities.

The responsibility of the utility to present solid cases for change was flagged as a potential risk, especially if the utility fails to make a good case. The systems are flexible enough to allow a utility to try again. If they go back to the drawing board, they can build a better case they can resubmit. But what if they don't resubmit? Who stands up to say you must try again? There are advocates for businesses and ratepayers, but who advocates for change? Do we need explicit opportunities in the legislated regulatory frameworks to discuss innovation? Should there be a requirement for plans to address innovation?

> Everyone has a role is advocating for innovation, but not everyone is stepping up. Utilities are often uncomfortable going outside what is safe and predictable, regulators work within principles of minimizing risk to ratepayers and governments swing between activism (sometimes with vision, often for political gains) and benign neglect. Also, some view that innovation truly belongs to the unregulated private sectors.

All these views suggest leadership doesn't come naturally to any of the potential leaders. This Discussion Paper identifies the issues and could provide a foundation for dialogue among the parties and their stakeholders.

REGULATORY SANDBOXES

The idea of maintaining a sophisticated regulatory system while also providing a defined and flexible place to test innovative concepts originated in the Finance Technology sectors (FinTech).

Like the energy sector, the financial sector has developed technology to enable new methods of delivering services and new business models to cover such costs profitably. Their solution was called a regulatory sandbox - a special place with a different kind of oversight for new ideas.

As of the winter of 2019, Australia was consulting on the use of such an idea for energy systems.[32] In Ontario the idea of a sandbox was adopted by the Ontario Energy Board (OEB) as a concept that could be applied to pilots.[33]

[29] https://www.canada.ca/en/atlantic-canada-opportunities/news/2019/03/atlantic-growth-strategy-maps-atlantic-canadas-clean-energy-future.html
[30] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/clean/RECSI_WR-SPM_eng.pdf
[31] https://www.theglobeandmail.com/news/national/ontario-to-buy-hydroelectricity-from-quebec-in-bid-to-cut-emissions/article32466166/
[32] https://www.aemc.gov.au/sites/default/files/2018-12/Regulatory%20sandbox%20Consultation%20paper.pdf
[33] https://www.oeb.ca/sites/default/files/Report-of-the-Advisory-Committee-on-Innovation-20181122.pdf

In the United Kingdom the regulator, the Office of Gas and Electricity Markets (OFGEM), has run two rounds of the regulatory sandbox process since launching the service in February 2017. It has compiled and published its insights from running these processes:[34] The insights include the following:

– It is not always clear to innovators what they can and cannot do. OFGEM originally imagined that the sandbox requests would be made by innovators who were looking to run a trial, but were being blocked by a specific rule that they were aware of. OFGEM found that, in practice, many innovators needed help navigating the regulatory framework and that many projects could go ahead without needing a sandbox.
– If an innovative proposition is not possible, it is usually because of a complex mix of requirements including industry norms, systems, charging arrangements, codes and licenses.
– Innovators are focused on launching businesses, not trials. OFGEM's regulatory sandbox is designed to facilitate time limited trials, however it found that most innovators wanted to launch enduring businesses and are less focused on trials. For OFGEM, it is important that the relaxation of the rules is temporary as it differentiates a sandbox from a permanent rule change.

PERFORMANCE BASED REGULATION

Performance Based Regulation (PBR) is a concept that is more focused on the end result than how it is achieved. In the utility sector the key elements of PBR have very specific meaning. They include Performance Incentive Mechanisms and Multi-year Rate Plans. In a 2016 report by the energy consultancy group Synapse, they noted, "PBR's appeal lies chiefly in its ability to strengthen utility performance incentives relative to traditional cost-of-service regulation (COSR). Some forms of PBR can streamline regulation and provide utilities with greater operating flexibility. Ideally, the benefits of better performance are shared by the utility and its customers."[35]

Some aspects of PBR are already implemented in Canada. Ontario has long used PBR principles in its regulatory framework. Nova Scotia examined PBR from a Canadian perspective in 2014[36] and established a legal requirement for the regulator to set Performance Standards for reliability. It also implemented a form of a multi-year rate plan in 2015 when it allowed the utility to file for a rate increase, then froze rates for four years. But it did not implement another key part of PBR - performance incentives which are difficult to establish for an integrated utility when it is building new generation and transmission. Other Canadian experience suggests PBR may be more suitable for smaller and distribution-level utilities.

BUILDING A PERFORMANCE BASED UTILITY

For 100 years, the Town of Summerside had its own electric utility that was regulated by the Province of Prince Edward Island. As part of the arrangement to separate rural parts of the town from the new City of Summerside, the province agreed to leave regulatory oversight for the utility with the new City Council. The only conditions were that:

– Rates charged to customers could not be higher than the utility for the rest of the province.
– Financial Statements were to be filed annually.
– Reliability needs to be at a level typical of utility services

As a result of the outcomes-based regulation, Summerside Municipal Services Director, Greg Gaudet says "We are able to look at innovative ways that make us more efficient in cost and expenses. We are still regulated but at arms-length, which allows for flexibility." It also allows for a speed of decision-making that is unique in Canadian terms. "Our process is to go to local council within a month and if we can make an economic case than it is pretty well approved. It usually takes a maximum 2-3 months to take advantage of opportunities as they arise." Gaudet recognizes there is a risk that council may make the wrong decisions. However, he says that risk is borne by the taxpayer and ultimately the value of the utility assets that could be sold.

[34] https://www.ofgem.gov.uk/system/files/docs/2018/10/insights_from_running_the_regulatory_sandbox.pdf

[35] http://www.synapse-energy.com/sites/default/files/performance-based-reg-high-der-future.pdf

[36] https://energy.novascotia.ca/sites/default/files/Case%20studies%20web3.pdf

[37] https://energy.novascotia.ca/sites/default/files/Our-Electricity-Future.pdf

BUILDING A PERFORMANCE BASED UTILITY (CONT'D)

Within this framework for nimble action, Summerside has built an enviable reputation for innovation. It gets 46% of its electricity from wind and it is moving aggressively on other forms of DER. In particular, "Instead of chasing consumer load, we are trying to control consumer load," says Gaudet. "We are shifting demand, filling up underneath peak and achieving more sales from the same infrastructure". Today Summerside has been an early adopter of using hot water heaters to manage loads and are now looking to use heat pumps to do the same as they promote fuel switching from oil to electric heat. All of this not as pilots, but as permanent core infrastructure.

In other parts of Canada, the concept of setting performance standards rather than detailed oversight has been tested in smaller utilities, sometimes by design and sometimes by default. In the Maritimes some smaller utilities were left behind when the moves to consolidation in the sector were underway in the last century.[38,39,40]

Today both Summerside Electric on Prince Edward Island and Saint John Energy in New Brunswick have been early adopters of DER techniques and have been recognized for their success. Although both utilities save money by not having to defend plans at regulatory hearings, the major benefit for innovation is being able to act faster when testing ideas and adopting new technologies.

INTERNATIONAL EXPERIENCE AND ADVICE

From an international perspective there have been a multitude of initiatives to look at how utilities can transition to become more focused on DER. In particular, the Rocky Mountain Institute of Colorado in the United States has played a leading role as advisor to New York's Reforming the Energy Vision (REV) initiative. It has also published papers on reform that outlines principles and areas for action.[41] They include elements of PBR, suggestions for new approaches on the treatment of capital and operational expenses, and the retirement of uneconomic assets as well as new revenues and services for utilities. In California industry and regulators are exploring ways to align revenues and DER investments.[42]

In setting the stage for a new era, the international advice suggests approaches that resonate with an existing Canadian practice - opening up a dialogue with stakeholders.

In Hawaii, where DER transformation is already well underway, they have created a set of regulatory workshops to advance a more collaborative process among stakeholders and a reduced utility role to more quickly facilitate the power sector's transformation.[43]

In another example, a diverse group of national not-for-profit organizations and industry thought leaders in the United States are helping change state regulatory processes for the power sector. That group is called Renovate and it has been convened by the Smart Electric Power Alliance (SEPA) and launched in partnership with other leading electric industry and stakeholder groups.[44] The initiative's vision is to enable the evolution of state regulatory processes and practices in order to address the scalable deployment of innovative technologies and business operating models that support the transition to a clean and modern energy grid.[45] Another organization that is focused on the evolution of technology and innovative business practices is Smart Grid.[46]

[38] https://www.nbpower.com/en/about-us/history
[39] https://www.nspower.ca/en/home/about-us/who-we-are/our-history.aspx
[40] https://www.maritimeelectric.com/about-us/profile/history-of-maritime-electric/

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[44] https://sepapower.org/knowledge/industry-leaders-collaborate-to-launch-new-regulatory-innovation-initiative/
[45] ibid
[46] http://www.whatissmartgrid.org

CONCLUSIONS AND POTENTIAL MODELS

In summary, the advice is clear - we need to become nimbler in decision-making to address pace of innovation that is leading to lower cost solutions more rapidly than before. We need to make at least some parts of decision-making simpler and easier to understand. We need to be careful about the risks that come from investments requiring long payback periods, and we need to ensure that risks and benefits are equitably shared. We need better planning, including explicit plans for innovation and how to address the value and challenges of DER.

Our regulatory frameworks need to evaluate investments based upon price trends, encourage pilots, and bring experience from pilots into the mainstream more rapidly. We should consider a simpler, performance outcome regulatory model and oversight for utilities exploring benefits of DER. We should ensure we document and share outcomes and we should provide a framework that enables innovation to be explored with contributions from utilities, governments and, where directed by legislated regulatory frameworks, contributions from customers.

From this advice, several key attributes of having a regulatory framework that encourages innovation emerge. Each jurisdiction should consider the:

– relevant examples of nimble low-cost innovation in Canada;
– nature and purpose of the regulatory oversight that needs to be in place;
– principles for public benefit, with an emphasis on protecting customers and ensuring innovation benefits everyone; and,
– elements that can be adapted from the experience of others in the energy and other fields

> If speed of decision-making is a key factor in accelerating innovation, the lightly regulated municipal utilities may have attributes to help us find a way forward. The challenge is how to enable larger utilities (especially those who are responsible for many parts of the energy system such as generation and transmission as well as having an obligation to serve), act like their smaller, nimbler cousins.

One answer could be to break them up into smaller pieces – an approach taken in many countries with large markets – but in many Canadian provinces and territories markets are small and the costs of a breakup can be high. In addition, a breakup takes time to execute and time to heal. Given the pace of change we face, it’s time we probably don’t have.

Another answer might be to examine the benefits of operating parts of a utility as if it were separate, even as it legally remains whole. There are many examples of creating new operating arrangements inside an organization where costs are kept segregated, including the division between regulated and unregulated activities.

We suggest that utilities such as those in Summerside, Prince Edward Island and Saint John, New Brunswick are good examples to build from. They are both innovative, close to their customers and recognized nationally for their advances in implementing DER technologies and methodologies. They are also lightly regulated and held to account at a high level of performance-based standards on keeping rates below benchmarks, maintaining high degrees of reliability and being transparent in their financial reporting. These elements would be fundamental to continued accountability.

We know that innovation has a general public benefit. It has been recognized through investments by the Government of Canada and the provinces and territories. It is now time to reinforce and support a culture of learning, collaboration and sharing those experiences and lessons learned. The energy policy and legislated regulatory frameworks across Canada should support this culture to support accountability, transparency and the advancement of knowledge.

CANADIAN ENERGY UTILITY SANDBOXES (CEUS)

This approach would be fully consistent with the concept of a sandbox. Our conclusion is that the concept of segregating or sandboxing part of a utility has merit. Given the diversity of utilities and market designs across Canada, the model would need to be adapted to the needs of each jurisdiction. Consistent with our support for a culture of sharing and learning, the development of Canadian Energy Utility Sandboxes (CEUS) should be a well-documented process with regular sharing of outcomes.

CANADIAN ENERGY UTILITY SANDBOX (CEUS)

In Canada a virtual utility DER sandbox (Canadian Energy Utility Sandbox - CEUS) would be designed and implemented differently in each jurisdiction. The design would be adapted to the different policy requirements, energy resource availability, and market design, but could include the following elements:

- A place inside a utility (a location, feeder or operational activity) where:
  - current costs and revenues (and business as usual growth) could be benchmarked;
  - innovative technologies and activities related to DER could be implemented, measured and reported upon; and,
  - detailed project spending approvals would be replaced by performance outcome metrics such as cost to other customers, reliability and transparency.
- Utilities would be encouraged to seek new technologies and ideas to explore and third-party innovators to partner with.
- New concepts to advance energy efficiency such as demand shifting and energy as a service would be explored.
- The cost of innovation could be supported by the utility owners, government grants or incentives, and ratepayers directed by the energy policy and legislative framework.

The objectives of building a CEUS could include the following:

- building and sharing knowledge quickly;
- replacing detailed project approvals with outcome requirements;
- collaboration with third-parties to advance innovation and support regulatory navigation;
- testing and learning about system impacts as well as technology and program impacts; and,
- protecting energy users and spreading benefits.

By taking this approach, it would mirror some of the objectives and activities already taking place on a pilot basis. However, establishing a sandbox inside of a utility on a longer-term basis should streamline future projects, improve accountability and test benefits and challenges more comprehensively. By making it a more permanent part of a utility, a more iterative approach could be taken on learning. Rather than being stuck with the original business case approval, the CEUS model should enable the application of knowledge gained as the project progresses and allow for swapping out technologies, buying services or moving the innovation into another direction, without having to go back to the regulator.

We would suggest that the CEUS concept could result in a separately regulated part of an existing utility. It would be able to approach the regulator with a well-defined concept of innovation to take place within a specific geographic or operational part of the utility (the sandbox). Within this sandbox the utility would be allowed to operate, or fund innovation by third-parties, with different elements of risk and benefit sharing.

The CEUS concept for DER also suggests the utilities should be encouraged to work closely with third-party innovators and service-providers, either as partners or through competitive processes. While this is already happening in some places, what is now part of an isolated good practice could be extended more broadly and frequently.

In order to meet the requirement to accelerate testing and learning, sandbox approval processes would likely need performance-based metrics on matters such as rate-impacts, reliability and profits if they are in the private sector. It would also test the strengths and weaknesses of PBR models in general. All learning would be shared. A decision to extend PBR to other distribution-level activities or to the more complex issues of generation and transmission would be left for a later day.

The type of innovations to be explored and their costs would likely need public investments to help cover costs and reduce burdens on customers. Finally, in the interest of transparency, there would be a need to document successes and failures and share them. Perhaps the new virtual energy information agency being established by the Government of Canada could be a hub for sharing this knowledge.

SECTION SIX: CLOSING OBSERVATIONS AND NEXT STEPS

FIVE OBSERVATIONS FOR CONSIDERATION

Throughout this paper we have illustrated the need for more responsive, flexible and adaptable approaches to enable the benefits and address the challenges and risks associated with innovation. Within that overall observation, this Discussion Paper suggests stakeholders consider the following:

1. BUILD A LONG-TERM VISION

We need to build consensus on a long-term vision of where we want to go. It will change as new information arises (and we need access to more timely policy-related energy information), but agreement on the direction of change will help us get there with some degree of stability. That agreement will also help regulators and utilities make their plans. Multi-stakeholder initiatives to share knowledge and explain the importance of stability are suggested. Good practice suggests development of firm goals and general timelines while letting markets and energy users dictate the pace. Good practice also suggests a framework that starts with efficiency, then renewables and then lower-carbon fuels.

2. ANTICIPATE AND RESPOND FASTER

We need to become nimbler in decision-making to address pace of innovation and changing consumer demands that are leading to lower cost solutions more rapidly than before. Our regulatory frameworks need to evaluate investments based upon price trends, encourage innovation, identify opportunities for third-parties, consider a simpler, performance outcome regulatory model/oversight, for distribution utilities and segments, and document and share outcomes. They need to ensure there is a plan for innovation. Our utilities need to build evidence on those price trends, shorten timeframes for investment proposals and bring their experience and that of third-parties from innovation into the mainstream more rapidly. A Canadian Energy Utility Sandbox model could help meet these needs.

3. ADDRESS RISKS FROM OBSOLESCE AND CUSTOMER DEPARTURES

We need to ensure we have plans in place to address the implications of obsolete investments in infrastructure and generation – particularly fossil fuel generation and in some cases transmission that becomes uneconomic due to distributed generation. The challenge is addressing investments that are obsolete because of regulatory and/or policy change, and/or technology. The uncertainty surrounding such matters drives up the cost of financing for all utility projects.

Providing certainty on amortization will improve planning, lower cost of investment, and enhance opportunities to accelerate retirements. This would result in utilities having less push back on early retirements – especially when the alternatives are lower than both capital and operating costs of legacy investments. We also need to address challenges from lower-cost alternative sources of energy, mass commercial and institutional building efficiency savings, and their attraction for customers with access to capital. In both cases, obsolescence and a loss of customers to alternative supplies leaves remaining customers with higher costs and raises dangers of unaffordability.

4. ENHANCE EFFICIENCY, BUT ALSO PLAN FOR ELECTRIFICATION

We need to pursue all reasonable and economic efforts to reduce our use of energy while integrating such reductions with plans for electrification. Planned properly, energy efficiency measures can provide room for the growth of electrification. Poor planning could result in stops and starts resulting in instability, higher costs and utility death spirals. Putting efficiency agencies into a "negawatt model" for regulatory processes while establishing integrated plans that look at affordability, reliability and the transition to more energy use from electricity would be helpful. Making such plans flexible with regular updates would be necessary. The regulatory frameworks would need to require that this be done.

5. BUILD A NEW BALANCE BETWEEN CENTRAL AND DISTRIBUTED POWER SYSTEMS

Distributed energy systems can be seen as systems that do not depend upon distant energy resources. Their growth is assured as storage and renewable energy system costs continue to fall. But not everyone can have a rooftop solar system to meet their needs. And mass deployment of new resources, electric vehicles and batteries will evolve over time. Further, there is an opportunity to integrate Canadian markets better to take advantage of existing power systems and supplies. Each jurisdiction may have its own optimal balance, but planning should also consider optimal regional balances that benefit all. The Government of Canada can play a large role in facilitating a lower carbon agenda by helping lower the cost of connecting Canadian markets.

NEXT STEPS

The transformation of our energy system has begun. This Discussion Paper is the first step in documenting what is taking place across Canada and our vision of supporting its evolution. This includes the processes and practices to deploy new technologies, develop robust and adaptive policy and regulatory frameworks and business models in a manner that benefits everyone and helps in the transformation to a low emissions energy system.

Building on this Discussion Paper, QUEST and Pollution Probe plan to work with stakeholders to develop jurisidction or region specific roadmaps that balances the need for quicker innovation with prudent regulation, identifies risk-sharing opportunities, and gathers and incorporates input from energy users. Visioning would likely include many of the observations made in this Discussion Paper, but would also need to consider:

– how the particular policy, regulatory and business environment in each jurisdiction sets priorities, direction, and timetables;
– best practices in innovation in comparable jurisdictions and review them for relevance and potential applicability;
– the purpose of regulatory oversight for various utility activities and investments, how it relates to innovation, and what needs to change to enable more innovation; and,
– the principles of regulating for the public benefit, and ensuring service to all energy users.

We hope to continue these conversations in 2019-2020.

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APPENDIX A: BACKGROUND TO ENERGY INNOVATION

From the perspective of this Discussion Paper, innovation includes new technologies, programs, ideas and requirements that enable investments in efficiency to reduce the energy we need, lower or eliminate the carbon emissions from the energy we use, maintain the reliability of our energy supplies and delivery systems, exploit opportunities to better manage the value of our energy, and do this in a manner that is affordable to energy users while opening opportunities for Indigenous peoples to participate as part of a process of reconciliation.

The various costs and benefits may be complex, but at its heart, innovation is about simplicity. Innovation is everywhere. Apple wasn't the first to combine a phone with a camera, and a connection to the internet. But it was the first to make that connection so attractive and simple to use. Others quickly followed and within a decade 76% of Canadians had a smartphone.[47] From virtually zero to almost everyone.

The same is true for retail in the world of Amazon, batteries in the world of Tesla, transportation in the world of Uber and Lyft, accommodations in the world of AirBnB. Long-established markets, business models and regulated sectors are being upended, reinvented and eagerly embraced by customers everywhere. The world of energy is not immune.

Innovation is everywhere, all the time, at a speed of discovery and adoption that is adding both hope and uncertainty to all who produce, transform and use energy in Canada and around the world. Most adoption by energy customers comes from the perception that the "something new" is better than before. The "better than before" could be in the form of features, convenience or cost. But there is another form of better as well – the ability to deliver energy with a low or even zero carbon footprint.

Almost everyone sees great value to technologies that allow us to reduce the amount of energy we use and lower the carbon content of what we do use. If technologies can also be convenient and inexpensive when they deliver the value, the attraction is irresistible. When irresistible attraction becomes real, adoption accelerates.

Innovation includes new ideas and methods, as well as changes to existing products or services and even regulatory practices. That means program and research dollars as well as policies and regulation are also part of innovation and helping to drive adoption.

As a result, we are on the cusp of a real paradigm shift: investments in innovation have created technologies and the potential for new models for businesses that not only could help us to do things differently, increasingly they are also a lower-cost way to do them. The pace of change and adoption is also faster. The price reductions and innovative features are taking place more quickly than earlier forecasted. It has brought us to a point where planning for the next decade is critical.

THE NEED FOR INNOVATION TO ADDRESS CLIMATE CHANGE AND EXTREME WEATHER

The drive to reduce the emissions from our energy use globally is being driven by climate change. The 2015 Paris Agreement calls for keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to actually limit the temperature increase to 1.5 degrees Celsius.[48]

Canada's efforts to reduce emissions to meet our Paris Agreement commitments are documented in the Pan-Canadian Framework on Clean Growth and Climate Change.[49] The Pan-Canadian Framework goes beyond reducing emissions and includes commitments to grow the economy and build resilience to the changing climate.

[47] https://mobilesyrup.com/2017/11/14/76-percent-canadians-owned-smartphone-2016-statscan-survey/

[48] https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

[49] https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

But while we develop the technologies, policies and programs to stem the rise, climate change is already changing climate conditions. From droughts, to floods and fires, around the world energy systems are causing, adapting and responding to new fragile ecosystems, changes in energy needs, and are being forced to become more resilient.

RESPONSIBILITY FOR THE ENERGY POLICIES AND PROGRAMS THAT DRIVE INNOVATION

Under Canada's constitution each province and territory in Canada is responsible for its own energy systems and rules under Section 92(10) and 92A (1) of the Constitution Act, 1987.[50] As a result, there are 13 different energy policies, ownership and market models, and legislated regulatory frameworks. The policies and legislated requirements vary widely but often they are focusing on the need for lower or zero carbon sources and resources and to be more efficient in our use of energy.

USING LESS ENERGY

Efficiency has been defined as the energy we don't use,[51] and often the lowest cost resource we have. Using less helps with energy affordability. It is especially helpful for those on low incomes facing high energy bills. It makes good sense from a conservation ethic. And, if we use less energy from fossil fuels, we will lower our carbon footprint and the GHG emissions that are a cause of climate change.

Climate change is the reason why funding for efficiency programs across Canada is on the rise. The exact amount is currently undocumented as many provinces do not track spending by the utilities and the information is fragmented. Efficiency Canada hopes to collect information in this area later this year. Included in the count will be significant contributions from the federal $2 billion Low Carbon Economy Fund which supports a variety of initiatives and has experienced significant uptake to support efficiency programs.[52]

EFFICIENCY NOVA SCOTIA

Nova Scotia has been exploring models to deliver efficiency and conservation programs for more than a decade. From utility programs and a government agency to an independent agency and then an independent efficiency utility, the Province has been the organizational test-bed for Canada.

The current structure – an efficiency utility was partially modeled on experience in Vermont. But it remains a unique Canadian construct. The Statute requires the electricity utility to undertake cost-effective electricity efficiency and conservation activities that are reasonably available in an effort to reduce costs for its customers by contracting with the efficiency utility – Efficiency Nova Scotia. The contract must be approved by the province's Utility and Review Board.

The definition of cost-effective activities is evolving but the law also requires the Board to take into account their affordability. As a result of the change in law in 2014, ENS has had regular reviews and public accountability for its plans and outcomes. For 2018 it achieved a savings of 159.4 GWh at actual cost of $33.94 million. That cost is a little more than 2.5% of an electricity bill. In addition to ratepayer funding ENS receives funds from the Province and the Government of Canada for non-electricity activities including programs to support low-income homeowners.[53]

New concepts and approaches are helping to put energy efficiency in the forefront of energy policy decisions. Most provinces have now established one-window agencies to deliver a range of efficiency programs. British Columbia, Alberta, Manitoba and Québec have joined PEI in delivering government run agencies, while Efficiency Nova Scotia continues to pioneer an independent utility franchise model.[54] New Brunswick has chosen to have the electricity utility to be responsible for all forms of energy efficiency. Each jurisdiction picks a model that fits best for its government, utilities and stakeholders.

[50] https://laws-lois.justice.gc.ca/eng/Const//page-4.html#docCont
[51] https://www.nrcan.gc.ca/20380
[52] https://www.canada.ca/en/environment-climate-change/services/climate-change/low-carbon-economy-fund.html
[53] https://www.efficiencyns.ca/
[54] https://nslegislature.ca/legc/bills/62nd_1st/1st_read/b041.htm

Acting to reduce energy use often comes at a price. In the long run the spending usually pays off in the form of savings that are greater than the cost of the improvements.

However, that upfront investment usually requires upfront spending (capital), and often that capital is borrowed and has to be financed. A number of provinces and municipalities have explored new ways to make capital available for efficiency projects. The concept is known as Property Assessed Clean Energy (PACE)

These new approaches lower the risk and cost of the capital by making energy upgrade loans directly linked to the property's municipal tax obligations. Another benefit to the property owner is that when the property is sold the outstanding balance on the loan and the guarantee of repayment (lien against the property) are seamlessly transferred to the new owner.

From a cash-flow perspective the loan costs (interest and loan payback payments) are designed to match the savings on energy bills. Federal Budget 2019 created a one-time grant of $1.01 billion to the Federation of Canadian Municipalities for community efficiency upgrade and innovative financing programs.[55] Other forms of financing provided by Energy Service Companies (ESCO's) have been available for sometime, while Green Bonds and business models that take over responsibility for then infrastructure and sell energy as a service (EaaS) are emerging.[56]

Sometimes it is not just about reducing the amount of energy we use, it's also about when we use it. That's because we don't use the same amount every hour of the day, or the same amount in different seasons. However, we do we need to have the capacity to provide the energy we need when we need it. In a traditional utility approach, that means a significant investment in electricity generating capacity that stands by, waiting to serve. Today we are increasingly able to shift demand and reduce the need at peak times, saving the need to invest in generation that is rarely used.

Where the infrastructure exists to meter energy use in real time it is possible to create incentives such as rates to encourage energy users to change their behaviour and flatten demand by reducing peaks and filling in the valleys. The result is better value from the system's existing resources, and savings for all. How much value and what there might be in the way of pitfalls in a particular jurisdiction needs more experience and experimentation.

Operating in the background is another series of incentives and policies to improve the standards for insulating our buildings and running our appliances more efficiently. Once these practices are widely adopted and the costs have come down, they become requirements and are embedded into codes and standards. Federal efficiency standards apply to products that are imported into Canada or sold across provincial boundaries.[57]

Of particular importance is the work to raise the bar higher for buildings. This work is now underway.[58] The Government of Canada is working with the provinces and territories to update the National Model Building Code with the target of net-zero energy ready buildings by 2030.[59] It is up to each province and territory to determine how much of the model to adopt and when to make it a requirement. Internationally, energy codes and best practices are being documented to give policymakers information on what could be considered for their jurisdiction.[60]

It is also important to look at efficiency from the perspective of technology and business model innovation. As technologies emerge to enable more control over our energy use, demand can be shifted, smoothed and reduced. At scale this is both an enabler on the road to a cleaner energy future, and if not anticipated properly, a potentially disruptive force in the current energy systems. This is discussed further in the sections of this Discussion Paper on DER.

[55] https://budget.gc.ca/2019/docs/plan/chap-02-en.html#Part-2-Affordable-Electricity-Bills-and-a-Clean-Economy

[56] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/Financing%20Report-acc_en.pdf

[57] https://www.nrcan.gc.ca/energy/regulations-codes-standards/6861

[58] https://www.nrc-cnrc.gc.ca/eng/publications/codes_centre/2015_national_building_code.html

[59] https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/federal-actions-clean-growth-economy/homes-buildings.html

[60] https://www.smartcitiesdive.com/news/new-resource-library-helps-cities-boost-buildings-energy-efficiency/549610/

REDUCING THE CARBON EMISSIONS FROM THE ENERGY WE USE

On average, electricity generated in Canada is relatively clean. This primarily is due to a number of provinces and the Yukon and Northwest Territories having access to clean energy from hydro-electric generating plants built many years ago. Other jurisdictions did not have such resources and so they designed strategies based upon what was then, low-cost fossil fuels (coal and natural gas), and in some cases, nuclear power. Today some of those provinces still have access to low-cost and lower-carbon natural gas supplies, while others depend upon high-cost and higher-carbon diesel fuels, and high-carbon intensity coal. In addition, many remote communities in northern Canada rely heavily on diesel for electricity, a fuel source that is both expensive and polluting. Despite the different starting points, and pace of change, all jurisdictions in Canada share a desire to move to a lower carbon emissions energy system.

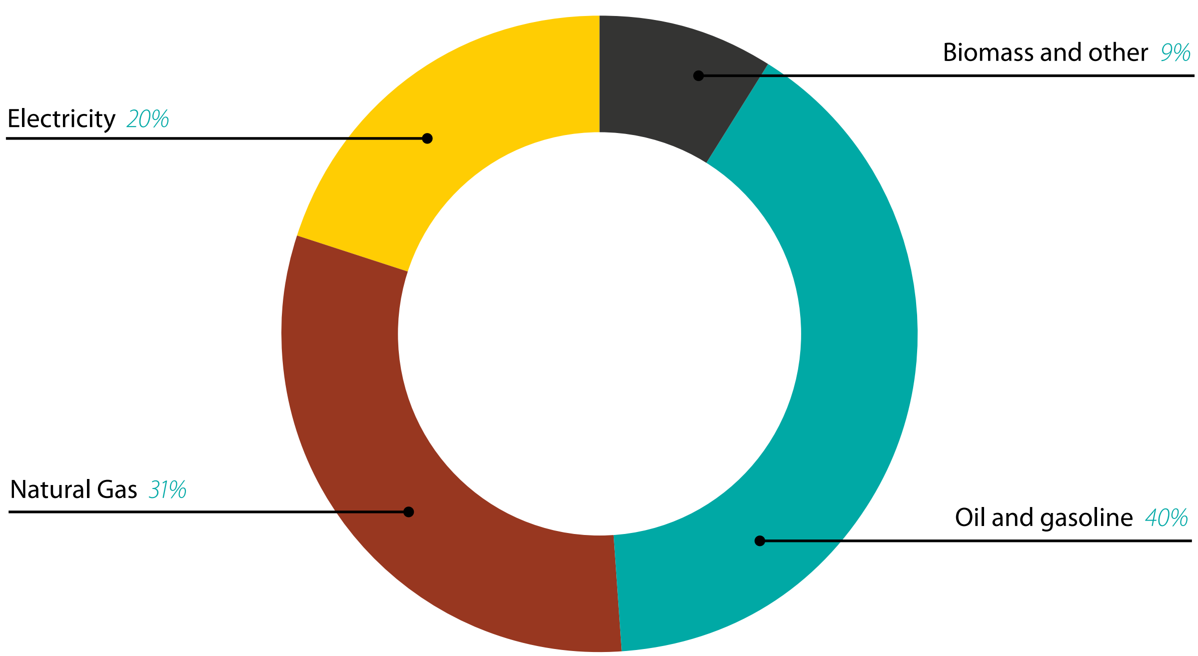
With electricity being generated from clean fuel sources, there are emerging policies to expand the use of electricity in non-traditional uses. In most parts of Canada non-traditional uses include space heating and transportation. Electrification will grow the need for electricity supplies, although how much more we will need will depend upon how quickly we adopt the new uses, how successful we are in adopting the innovative measures to reduce energy use, and whether attractive alternatives such as renewable natural gas or hydrogen emerge at a competitive cost. Current electrification initiatives include rebates and financing for high efficiency heat pumps and goals for the take up of electric vehicles (EVs) and EV infrastructure.

To displace the natural gas and diesel/gasoline would require a massive expansion in electricity production. However, the timing of the expansion and the size of the increase are difficult to predict. Energy policies, strategies and plans need to identify the best course of action in the short, medium and long term that takes into account the growing cost-effectiveness of DER.

For cleaner fuels such as natural gas where the carbon intensity is about half that of oil or coal, there are emerging policies for Renewable Fuel Standards which could use the existing pipeline infrastructure for fuels from renewable resources such as methane from sustainable biomass supplies, or for clean energy sourced hydrogen supplies.

> Today (on average) electricity is roughly 20% of energy use, whereas natural gas is 30-35% and oil and gasoline are around 40%.

Figure – Canada's secondary energy use by fuel type, 2015[61]



[61] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/energy-factbook-oct2-2018%20(1).pdf

TECHNOLOGIES THAT DRIVE INNOVATION

The energy market is changing as new technologies drive innovation in the development, delivery and management of energy. The innovation is building on existing clean energy resources such as hydroelectricity and nuclear power to create new possibilities for lower-cost, lower carbon energy systems, enabling new ways to help energy users reduce their usage while opening the possibility of new unregulated players participating in the market.

LOWER CARBON TECHNOLOGIES — WIND

Cost Reductions for Wind

Wind power is as old as the first windmills and sails. In modern times it has become more cost effective as the blades and turbines of the windmills grew in size. The Canadian Wind Energy Association reports a 2/3 drop in the levelized cost of wind in Canada over the past 10 years.[62] In late 2018, Saskatchewan accepted an all-in price for a 200 MW wind farm $0.042 per kWh including transmission costs. In late 2017 an auction for wind energy in Alberta resulted in the lowest seen in Canada and some of the lowest prices seen anywhere – the average price is $0.037 kWh.[63] Due to the low operational costs of wind and solar, most of the decline in prices comes from lower capital costs, and continued declines are forecast.[64]

Growth of Wind

According to CANWEA, Canada finished 2018 with 12,816 MW of wind energy capacity - enough to power approximately 3.3 million homes, or 6% of our country's electricity demand. On a demand basis Prince Edward Island and Nova Scotia are the leaders at 2% and 12%, respectively, of demand met by wind in 2018, a change from near zero over the course of 10 years.[65]

[62] https://canwea.ca/news-release/2018/10/19/saskpower-contract-award-confirms-the-value-of-wind-energy-as-the-province-moves-to-reduce-greenhouse-gas-emissions-throughout-the-economy/
[63] https://www.alberta.ca/release.cfm?xID=511572D67D28E-C09C-E3E6-BA37A772B4C34AF6
[64] https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/snpsht/2018/11-03cstnstllwnd-eng.html
[65] https://canwea.ca/wind-energy/installed-capacity/

LOWER CARBON TECHNOLOGIES — SOLAR

Cost Reductions for Solar

Even with as rapid as the decline in wind costs has been, the declines seen in solar prices have been truly amazing. The International Energy Agency (IEA) is reporting the capital cost of solar PV technology declining from $14.50 Watts direct current WDC in 2003 to $2.50WDC in 2017. This represents an 83% decline over 14 years. The price decline since 2009 would be 70%.[66]

On a larger utility scale, international prices have seen the same kinds of decline, to the point that in some markets solar PV is able to fully compete on costs. A solar PV installation in Spain was not only recently completed without subsidies, but was also successfully sold to a third party.[67,68] The ability to sell of developed projects is important because it is seen as a sign of market maturity. In Canada, the Alberta government has plans to purchase enough solar to meet more than half the electricity demand of the government.[69]

The IEA report shows installation costs still represent about half the cost of projects (pg. 18) with the solar module about a quarter of the cost.[70] To get further very significant cost reductions, the industry will need to address installation and other soft costs such as permitting (the so-called "balance of system" costs). New builds will likely make a difference.

[66] http://www.ieapvps.org/index.php?id=93&tx_damfrontend_pi1=&tx_damfrontend_pi1%5BcatPlus%5D=&tx_damfrontend_pi1%5BcatEquals%5D=&tx_damfrontend_pi1%5BcatMinus%5D=&tx_damfrontend_pi1%5BcatPlus_Rec%5D=71&tx_damfrontend_pi1%5BcatMinus_Rec%5D=&tx_damfrontend_pi1%5BtreeID%5D=201&tx_damfrontend_pi1%5Bid%5D=93
[67] https://www.pv-magazine.com/2018/12/31/baywa-r-e-completes-and-sells-175-mw-subsidy-free-spanish-pv-plant/
[68] https://spain.solarmarketparity.com/market-parity-watch
[69] https://www.jwnenergy.com/article/2018/10/alberta-looking-solar-power-more-half-government-needs/
[70] http://www.ieapvps.org/index.php?id=93&tx_damfrontend_pi1=&tx_damfrontend_pi1%5BcatPlus%5D=&tx_damfrontend_pi1%5BcatEquals%5D=&tx_damfrontend_pi1%5BcatMinus%5D=&tx_damfrontend_pi1%5BcatPlus_Rec%5D=71&tx_damfrontend_pi1%5BcatMinus_Rec%5D=&tx_damfrontend_pi1%5BtreeID%5D=201&tx_damfrontend_pi1%5Bid%5D=93

Growth of Solar

Residential solar (rooftop)

Multiple sources report the vast majority of solar PV installations so far have been done in Ontario.[71] But as prices decline, the interest in other provinces is picking up. Our survey of energy officials and leaders across Canada notes that new solar programs are being introduced and adopted in many jurisdictions, and that interest in solar PV by energy users across Canada is high. Officials are also interested in understanding the impacts better. All Nova Scotia programs have a requirement for solar projects to measure and report how much and when the arrays are producing electricity to better understand the impact on the grid.

Utility scale solar

Larger solar projects (10 MW or greater) cost less per Watt than their rooftop counterparts. California is the leader in larger-scale solar projects. In the spring of 2018, California hit several records for peak output of utility-scale solar at more than 10.5 GW, as well as for renewable energy overall. However, solar energy frequently exceeds demand and is thus curtailed/wasted.[72] In Texas, utilities signed a power purchase agreement (PPA) for a 255 MW solar PV plant in 2017 for $25/MWh. The average cost for existing coal plants in the US is between $27/MWh and $45/MWh.[73]

In Canada, the National Energy Board (NEB) is forecasting as much as a further 50% decline in the cost of solar over the course of the next decade with a 64% reduction by 2040.[74] They expect costs to decline because of improved manufacturing efficiency, economies of scale and lower installation costs as industry learns from experience.[75]

Nevertheless, solar PV is not the answer for all the renewable questions. Many people live in apartments rather than single-family homes, commercial buildings often don't have enough roof space either, and even solar farms take up space that may have competing uses. But, there's still a great deal of room to grow before those limits are reached.

[71] http://www.iea-pvps.org/index.php?id=479&eID=dam_frontend_push&docID=4061
[72] https://www.pv-magazine.com/2018/05/01/california-blows-through-solar-power-renewable-energy-output-records/
[73] https://www.utilitydive.com/news/texas-muni-signs-cheap-solar-contract-below-25mwh/544509/
[74] https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/snpsht/2018/11-03cstnstllwnd-eng.html
[75] ibid

TECHNOLOGIES THAT CREATE AND MANAGE LOCALIZED CLEANER ENERGY SUPPLIES

DISTRIBUTED ENERGY SOURCES

The modern history of energy has seen constant change on how it is delivered and how we make use of it. This is particularly true of electricity. The original technology could not cost effectively send the electrons very far (original DC technology) so each user needed their own generator. However, new technology soon emerged to solve this problem. Central power plants emerged to connect customers (new AC technology) with distant sources of electricity at a lower cost.

Today, many of those original legacy systems continue to deliver low-cost power (particularly the legacy hydropower plants and their associated transmission systems), but in other cases, the legacy technologies come with high environmental and fuel costs (coal-fired generation plants for example). As a result, cleaner or low or zero carbon technologies emerged.

TYPES OF DISTRIBUTED ENERGY RESOURCES (DER)[76]

Distributed Generation (DG)

Power-generating technologies, including variable renewable energy sources such as solar and wind, as well as gas-fired and diesel-fired generators.

Energy Storage

Storage includes both electricity storage technologies such as batteries or fly wheels, and other forms that allow energy to be used at a later point (such as heat storage). Electric vehicles could be used as a form of energy storage.

Demand Response (DR)

Technologies that allow consumers to alter their consumption patterns based on some signal, such as market prices or grid congestion.

[76] https://mowatcentre.ca/wp-content/uploads/publications/141_emerging_energy_trends.pdf

TYPES OF DISTRIBUTED ENERGY RESOURCES (DER) (CONT'D)

Energy Efficiency
Technologies that reduce overall consumption, such as LED bulbs or more efficient air conditioning.

Microgrids
Microgrids are small localized grids that can operate independently of the larger public grid. By using local sources of energy to serve local loads, microgrids can help in the integration of DG.

With the decline in prices noted earlier, these new renewable technologies are not only competing with fossil fuel supplies, with the help of other technologies and under the right conditions they are allowing for a return to local generation and use. In a comprehensive way, new Distributed Energy Resources (DER) are changing the role of generating, monitoring, storing, shifting, and managing and reducing energy at various levels – in buildings, communities (distribution hubs) and throughout larger utility systems by promoting efficiency and lowering the cost of renewables.

VALUE OF DEMAND RESPONSE

The value of demand response changes as the cost of competing solutions rises or falls, and the technologies that can enable demand response options rise or fall. Value may be for the system as a whole or only for those energy users who directly participate. At the same time the rate structures may inadvertently result in costs for the system. For example, rate designs may assume modest shifting off-peak while experience results in a great deal of shifting to avoid the charges, resulting in a change in revenue assumptions.

Understanding all this is very important. A 2016 research summary[77] by NRCan touched on this dilemma but indicated more information was required. New York's innovative Reforming the Energy Vision (REV) initiative identified a series of benefits to determine the Value of Distributed Energy Resources including the value of the energy itself, the value of being available when needed (capacity), environmental benefits, the locational value if it is located in an area that would have otherwise needed infrastructure upgrades, and system value if it were able to provide technical support such as voltage or frequency regulation.[78]

THE INFRASTRUCTURE FOR A SMART ENERGY FUTURE

Advanced Meter Infrastructure (AMI) technology has been with us for many years. British Columbia and Ontario were leaders in their adoption in Canada. These so-called smart meters can read energy use on frequent intervals which enables more detailed energy system information for operations and planning. The technology enables sophisticated time-of-use rate designs. The most advanced meters and associated infrastructure allow for two-way communications that enable the utility to offer the option to control energy use (heating and cooling). This two-way communication, decision-making and energy management is enabled by AMI and its ability to communicate with DER in real time at virtually zero operational cost.

The ability of a utility to manage customer energy use through attractive rate designs also offers potential benefits to all customers if such management tools result in lower high-cost peak demand. The rise of electric vehicles presents a whole new set of potential benefits. In one case Honda developed a program which uses the vehicle's built-in communication to selectively charge during times of high renewable generation and when electricity prices are at their lowest. A charging session can be interrupted automatically during an electricity peak period, resuming when the price drops.[79]

Recently the Government of Canada announced a series of pilots to explore Smart Grid and energy storage through its Energy Innovation Program. It is providing approximately $68 million for research, development and demonstration projects.[80]

In addition to utility control options, there are widespread and cost-effective technologies that allow energy users to control, shift and manage energy, including their own generation. Technologies can also gather data and create information to enable decisions by users automatically.

[77] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/pubs/Smart%20Zone%20Planning%20with%20Variable%20Renewable%20Generation%20EN%20VR%20FINAL.pdf

[78] https://nyrevconnect.com/rev-briefings/value-der-pricing-distributed-resources/

[79] https://www.forbes.com/sites/sebastianblanco/2018/07/31/honda-smartcharge-reward-charging-electric-vehicle/#7d9ad04f679f

[80] https://www.nrcan.gc.ca/energy/funding/21146

The data can also enable new business models where third parties can help identify these opportunities, offer financing and their own management systems. In some cases, the utility is left on the sidelines while the third-party is seen as the helpful intermediaries. As technology evolves and self-generation, storage and management becomes more cost-effective, utilities run the risk of losing a significant number of their customers entirely.

STORAGE/BATTERIES

Perhaps the greatest enabler in the DER future is the rise of cost-effective energy storage. The importance of storage was highlighted by almost every jurisdiction during our interviews. Storage overcomes the problem presented by electricity which normally must be used immediately. Chemical energy sources such as petroleum, coal and even biomass can readily be stored until required. Electricity can be converted into another energy resource (electrical energy becomes chemical energy when it is stored in a battery or potential gravitational energy when it is used to pump water to higher ground), but until recently the cost of doing so was quite expensive. With cost reductions, storage of electrical energy becomes more practical and electricity becomes even more useful.

Cost Reductions in Storage

Storage prices are now dropping much faster than anyone expected. Major players in Asia, Europe and the United States are all scaling up lithium-ion manufacturing to serve EV and other power applications. With higher demand comes economies of scale and other efficiencies. No surprise, then, that battery-pack costs were at almost $1,000 USD per kilowatt-hour in 2010, and were down to less than $230 USD per kilowatt-hour in 2016.[81] In December 2018, Bloomberg New Energy Finance published the results of its ninth battery price survey showing the volume weighted average battery pack fell in prices by 85% from 2010-2018, reaching an average of $176/kWh.[82]

Growing Use — Storage at the Utility Scale

California utility regulators have approved Pacific Gas & Electric's proposal to build the two largest battery systems in the world. The decision marks a landmark development in California's quest to decarbonize its electrical system by shifting from natural gas to non-emitting sources for flexible power.[83] The S&P Global Market Intelligence reports new records in battery production – and are forecasting a 10 times increase in production over the next decade.[84]

THE ROLE OF ELECTRIC VEHICLES

Rise in Use

Edison Electric Institute (EEI) reports that the American stock of EVs (i.e. the number of EVs on the road) is projected to reach 18.7 million in 2030, up from slightly more than 1 million at the end of 2018. This is about 7% of the 259 million vehicles (cars and light trucks) expected to be on U.S. roads in 2030. It took 8 years to sell 1 million EVs. EEI predicts the next 1 million EVs will be on the road in less than 3 years, by early 2021.[85] In the United Kingdom it is anticipated that EVs will reach price equivalency by the mid 2020s with sales overtaking that of petrol and diesel by the late 2030s.[86]

The Government of British Columbia has made the electrification of vehicles a major component of its plan to electrify the province in order to reduce greenhouse gas emissions. The plan operates calls for 30% of all sales of new light duty cars and trucks will be ZEVs by 2030 and rise to 100% by 2040".[87]

In Canada as a whole, the NEB forecasts price parity for electric vehicles by 2030 if supports and technology developments increase.[88]

Canada's federal Budget 2019-20 set a target to sell 100% zero-emission vehicles by 2040, with sales goals of 10 % by 2025 and 30 % by 2030 along the way.[89] It will help realize that goal through $5,000 federal purchase incentives for electric battery or hydrogen vehicles. In addition, businesses purchasing electric plug-in hybrids

[81] https://www.mckinsey.com/business-functions/sustainability/our-insights/battery-storage-the-next-disruptive-technology-in-the-power-sector
[82] https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/?sf99803286=1
[83] https://www.greentechmedia.com/articles/read/pges-recording-breaking-battery-proposal-wins-loses#gs.19i8n9
[84] https://www.spglobal.com/marketintelligence/en/news-insights/trending/9GIYsd7qF8tNpiopwH7KSg2
[85] http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20EV%20Forecast%20Report_Nov2018.pdf
[86] https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/383/38302.htm
[87] https://www.cleanenergybc.org/reports-publications/electrification-of-british-columbia
[88] http://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2018/2018nrgftr-eng.pdf
[88] https://budget.gc.ca/2019/docs/plan/chap-02-en.html#Part-2-Affordable-Electricity-Bills-and-a-Clean-Economy

and hydrogen fueled vehicles will receive tax advantages which allow for immediate write off of vehicle costs up to $55,000.[90]

EVs are an important new technology for many reasons. From an energy perspective they would displace at least some fossil fuel transportation uses. They also represent an opportunity to act as DER. Not only can technology manage to time battery charging from the grid to periods of low demand, but it can also enable an EV to send electricity from their batteries to the grid in periods of high demand.

POTENTIAL GAME CHANGERS

NATURAL GAS

Canada's current energy sector includes a variety of sources and fuels. Natural gas is one of the most important in the space heating part of the sector.[91] The development of this resource has been accompanied by a significant investment in the natural gas system. Finding ways to use this infrastructure for clean gaseous fuels would be a significant benefit to industry and the ratepayers who are paying for the investments. Hydrogen and renewable natural gas (methane from renewable resources such as biomass) are the most promising as they are both technically feasible today, although we need more innovation in the technology to produce them.

HYDROGEN

Hydrogen is potentially an ideal solution for a lower carbon world. If we can find a cost-effective way to produce it we can solve a great number of clean energy problems. First of all, it is plentiful – it is the H in H_2O – and second, it is very environmentally useful. For example, hydrogen can be used in fuel cells to generate power using a chemical reaction rather than combustion, producing only water and heat as by-products. It can be used in cars, houses, for portable power, and in many more applications. It can also be transported through pipelines.

But, making pure hydrogen is the tricky bit. It doesn't typically exist by itself in nature and must be produced from compounds that contain it. It can take a lot of energy to free it up. That energy can come from diverse resources including fossil fuels such as natural gas. But to become a truly clean fuel we would need to use renewable energy sources, such as wind, solar, and hydroelectric power.[92] The challenge is to produce, store and transport hydrogen at a cost that can compete with other clean sources, and that has been a problem.

Canada pioneered the development of hydrogen fuel cells for more than 30 years ago through British Columbia's Ballard Power. Today the hydrogen gas sector is focused on infrastructure for supplying light and medium duty vehicles for transportation uses.[93] British Columbia and Québec have pilot projects underway.[94]

Recently, New Brunswick Power made a $13 million-dollar investment into an American company with the hope of developing the world's first hydrogen-powered distributed electricity grid.[95,96] In the UK, a gas company is looking to convert a gas network to hydrogen.[97]

Nevertheless, as a technology that has held out promise for a long while, the economics have proved elusive. There is still great uncertainty about its ultimate capabilities and potential applications. There is a debate over when, or even if ever, extracting hydrogen from renewable resources will become cost-effective.

The question is whether a situation will emerge such that renewable resources including wind, solar and hydro-electricity will have a price low enough to make the conversion economically viable and whether the efficiency of the electrolysis process can be increased.[98]

RENEWABLE NATURAL GAS

Equally exciting is the potential for renewable natural gas (RNG). Canada is working with industry on a new RNG technology developed by G4 Insights Inc. to convert forestry residue into pipeline-grade RNG to be distributed through existing natural gas pipelines in Canada. In

[90] ibid
[91] http://www.cga.ca/publications/
[92] https://www.energy.gov/eere/fuelcells/hydrogen-production
[93] http://www.chfca.ca/media/CHFC%20Sector%20Profile%202018%20-%20Final%20Report.pdf
[94] http://www.ballard.com/about-ballard/our-history
[95] https://www.joiscientific.com/overview/
[96] https://www.nbpower.com/media/1489057/nb-power-and-joi-scientific_02222019_final.pdf
[97] https://www.theccc.org.uk/wp-content/uploads/2018/11/Hydrogen-in-a-low-carbon-economy.pdf
[98] https://energypost.eu/renewable-hydrogen-already-cost-competitive-says-new-research/

addition, Canada's natural gas utilities have set a target of 5% of renewable-blended natural gas in the pipeline distribution system by 2025 and 10% by 2030.[99]

More generally, renewable natural gas is part of a larger effort to obtain energy and other useful products from biomass. Bioenergy for heating and electricity production already plays a significant role in Canada's renewable energy sector and currently supplies 6% of Canada's secondary energy by fuel type in 2014.[100]

The use of biomass waste and from sustainable forest products shows promise both as a feedstock for electricity as well as through conversion technologies that can produce renewable gases. Today many of the uses of biomass for electricity are linked to forest products industries that have access to low cost feedstocks (waste). Low-cost energy production from sustainable resources using high standard forest harvesting practices remain an attractive goal in some provinces.

In Canada, British Columbia is leading on RNG. The government's CleanBC Plan intends to make residential and industrial natural gas consumption cleaner by putting in place a minimum requirement of 15% to come from renewable gas by 2030.[101]

Nevertheless, like hydrogen, renewable natural gas is categorized in this Discussion Paper as a potential game changer because it is not clear at this point whether there are enough resources that can be made available in a sustainable and price-competitive manner to make a big difference within the next decade.

NEAR-TERM IMPORTANT THERMAL TECHNOLOGIES

Although probably not game changers, there are important technologies that will add to the portfolio of possibilities for lower carbon, particularly those for heating and cooling that are already economically viable in some situations today.

GEOTHERMAL

In some parts of Canada, it is possibly to drill down into the earth to tap sources of energy for heating, and if the energy supplies are hot enough, they can also be used to actually generate electricity. The government of Canada recently announced $25.6 million for a 5 MW project in Saskatchewan, which is described as the first of its kind.[102]

DISTRICT ENERGY

District energy systems which use renewable fuels (e.g. sustainably harvested or waste biomass) enable a more efficient use of energy as well as a renewable system. Even when used in conjunction with natural gas, a District Energy system is more efficient and may the fuel sources may evolve to renewable gas sources.

A recently released report on district energy in Canada[103] notes that more than half of Canada's roughly 200 systems are in Ontario and British Columbia. They provide a range of services, with 66% providing heating only while 20% provide both heating and cooling and the balance also produce electricity. More than half serve a single customer, often education institutions, governments and utilities.

Canadian district energy systems use a wide variety of fuels including gaseous and liquid fossil fuels, biomass, geoexchange, heat recovery from industrial processes, energy extracted from waste-water effluent, sea and lake water for cooling, municipal solid waste, and solar energy delivering annual thermal energy of approximately 5.5 million MWh representing about 2.2% of the total building

[99] https://www.nrcan.gc.ca/19445
[100] http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/39140.pdf
[101] https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf P.65

[102] https://pm.gc.ca/eng/news/2019/01/11/prime-minister-announces-support-canadas-first-geothermal-power-facility
[103] https://www.sfu.ca/content/dam/sfu/ceedc/publications/facilities/CEEDC%20-%20District%20Energy%20Report%202019.pdf

energy use for space heating, cooling, and water heating in Canada. Compared to the average emission factor for fossil fuel-based systems, the use of renewable energy avoided 5.5% of the GHGs that would have otherwise been emitted.[104]

DISTRICT COOLING FROM OCEANS, LAKES AND RIVERS

District or building system cooling using water from the ocean has been used in several projects adjacent to Halifax Harbour with the most recent system now under construction.[105] In Toronto cold water from Lake Ontario also has a long and growing history. Recently Enwave received funding to expand its district cooling project.[106]

LONGER-TERM POTENTIAL TECHNOLOGIES

If electricity does become the dominant energy source for new uses in buildings and transportation, we will need more of it, and the low-cost wind and solar may hit a ceiling in terms of land use. There may also be limitations on how much further we can develop Canada's hydroelectricity supplies. In that case we may well need to turn to the oceans for energy from offshore wind, waves, and tidal currents.

In addition, there are technologies being explored that could develop nuclear power on a more economical scale without creating the problems with waste. These kinds of technological approaches have been pursued for many years. In fact, at one point in the 1950s it was said that the day was coming when electricity from nuclear power was going to be so plentiful we won't even bother to meter it. That day may yet come, but it certainly illustrates the danger of predicting when a technology will become pervasive and inexpensive.

[104] ibid

[105] https://canada.constructconnect.com/dcn/news/labour/2018/12/engineer-looks-sea-heating-cooling-halifaxs-queens-marque

[106] http://enwave.com/news/enwave/enwave-receives-funding-to-expand-environmentally-friendly-deep-lake-cooling-system/

THE PACE OF CHANGE

The pace of change is accelerating and tipping points are nigh. In much of the world the past couple of decades have been focused on building support for the development of new energy technologies through special rates and research grants. Policy and regulations assumed the amount of energy procured would be relatively low and thus the implications were more of interest than concern. In some places generous support resulted in more rapid uptake than expected, and consequences for the stability of the electricity system ensued.

TECHNOLOGY AND ITS APPLICATIONS

To make matters even more interesting is the advance of technologies with applications well outside the energy sector but with great implications for the energy sector. Among them are the rise of the 5G telecommunications systems that allow for very efficient data transfer, at speeds up to 10x that of 4G, to and from many sensors and devices.

This will likely be the backbone for many new energy management systems in our lives. The first auction for licences that could support 5G communications technologies in Canada started in spring of 2019.[107] In the USA 5G systems started in Chicago and Minneapolis in April 2019.[108]

Blockchain

Also promising is the ability to securely transfer information about transactions using blockchain technology. Blockchain uses decentralized records that are chained to each other chronologically and encrypted so that all changes are visible in the record and can be authenticated by other users versions of that blockchain.[109] It could become the way energy trading could take place on a distributed and micro-level. With low cost transactions there may be significant value in sharing energy in communities and taking advantage of different needs at different times.

[107] https://www.itbusiness.ca/news/government-set-to-launch-600-mhz-spectrum-auction-for-5g-cellular-network-on-tuesday/109331

[108] https://www.verizon.com/about/news/customers-chicago-and-minneapolis-are-first-world-get-5g-enabled-smartphones-connected-5g

[109] https://www.ey.com/Publication/vwLUAssets/ey-overview-of-blockchain-for-energy-and-commodity-trading/%24File/ey-overview-of-blockchain-for-energy-and-commodity-trading.pdf

For example, a Harvard Business Review article[110] outlines how a factory could sell a few minutes of unused power during a down time to another factory that needs additional power. Trading in this way could provide efficiency benefits for grid operators. In another even more micro example, an EV could send its surplus into a micro-grid and another vehicle might use the electricity to charge its battery. Normally, small-scale transaction system costs are too high to make it worthwhile. Blockchain could change that, with far-reaching consequences.

Advanced Meter Infrastructure (AMI)

The rise in information from the energy data created through smart meters and other forms of AMI is also creating an opportunity to increase accountability and the performance of efficiency programs. California has just begun programs that build on real data and real change in energy use patterns rather than traditional modeling efforts.[111]

REACHING THE TIPPING POINT

These technologies are emerging, but as noted earlier, many key DER technologies are already within range of being, or soon to become, cost effective. As a result, we are beginning to reach a tipping point where these resources converge to make them cost-competitive under a wider range of circumstances.

A recent McKinsey Report stated that many countries will reach a tipping point where new-build solar or wind capacity is cost-competitive with the fuel cost of existing conventional plants in the coming five years.[112] Similarly, as the cost of batteries continues to decline, within the next 5-10 years many countries will reach the point at which the total cost of ownership for electric vehicles are more economic than internal combustion engine vehicles. This is true for passenger cars but also for most truck segments.[113]

5 to 10 years to a tipping point. A lifetime away for some things. Just around the corner for energy planning. Getting the timing exactly right is likely impossible. There are too many uncertainties. But the possibility of 5 years or 7 rather than 10 or even 20 at a pace dictated by third-parties and left to customers as to when they will be adopted on a mass scale should be a very sobering thought for market investments and regulatory frameworks.

Finally, it is also important to note that the value from falling prices is not just coming from new generation. The structure of DER investments allows for relatively short terms and faster paybacks leading to technology refreshes sooner than later. Rather than 40 to 50 years of useful life seen for fossil fuel plants, and an amortization schedule to match, the costs of DER are amortized over the life of a power purchase agreement that is often for only 20 years.

That means investments in the early part of this decade will start to be replaced shortly after the end of the next. As a result, early generation renewables such as wind or solar will be replaced by lower cost technology in the late 2020s and early to mid-2030s which will help make the electricity system of the future even more affordable and competitive.

[110] https://hbr.org/2017/03/how-utilities-are-using-blockchain-to-modernize-the-grid
[111] https://www.greentechmedia.com/articles/read/new-programs-test-californias-pay-for-performance-efficiency-paradigm#gs.3rcr84
[112] https://www.mckinsey.com/~/media/McKinsey/Industries/Oil%20and%20Gas/Our%20Insights/Global%20Energy%20Perspective%202019/McKinsey-Energy-Insights-Global-Energy-Perspective-2019_Reference-Case-Summary.ashx
[113] ibid

APPENDIX B:
LEGACY GENERATION AND FUELS

LEGACY HYDROELECTRIC GENERATION

Many of the huge investments in the energy utility space are in generating systems for hydroelectricity. Those who are fortunate enough to have those resources are relatively confident their investments would withstand the challenges of new technologies. In fact, the crown corporations and their provincial owners thought the general rise in the need for renewable electricity presented opportunities for stronger sales and revenues that could be used to the benefit of their province and its people.

Although few of the hydro systems were explicitly designed to serve as storage and help balance systems that include more intermittent renewables, they can do so. The operation of Norway's hydro storage and Germany's wind and solar systems shows how this symbiotic relationship can work.[114]

A part of Canada's legacy clean power system is the massive transmission systems that bring the electricity from remote sites in the northern parts of the country to the south and on to the United States. Transmission infrastructure is expected to last for decades. There may be a risk that they don't, but that risk is the same as that for the associated power plants – relatively low.

However, there is some risk to both new and existing markets in the United States. For some groups it's not just about the cost of clean power, it's also about the source, and they favour local renewable energy supplies over imported sources. For example, the Northern Pass Project to sell Hydro Québec power to Massachusetts through New Hampshire recently failed due to opposition in New Hampshire and is now under appeal.[115] The replacement Clean Energy Connect Project[116] to bring Hydro Québec electricity through Maine is not a done deal yet either.

[114] http://jointdeclaration.org/wp-content/uploads/2013/06/Norway-key-role-energy-transition_web.pdf
[115] http://www.northernpass.us/index.htm
[116] https://www.necleanenergyconnect.org

LEGACY FOSSIL FUEL – COAL

Coal remains a key source of energy globally. After two years of decline, global coal demand grew by 1% in 2017 to 7585 MT as stronger global economic growth increased both industrial output and electricity use. Driven by strong coal power generation in China and India, coal demand is expected to grow again in 2018.[117] In Canada there is no growth, only declines, with Ontario shutting down its plants, and Alberta planning to shut down its plants by 2030. There are no firm plans to shut down all plants in the rest of Canada.

Canada's Coal-fired Electricity Regulations are expected to cause the early retirement of most coal-fired plants at or before their end of life or by 2029 due to performance requirements that would likely be only achievable with uneconomic technology.[118] In some cases provinces have reached agreements to modify the application of the regulations. Rather than closing as many plants as the accounting rules would require, Nova Scotia has negotiated an agreement to reach emission reductions equivalent to the federal rules[119] by using the plants mainly during periods of peak demand.

Saskatchewan is committed to having at least 40% of the province's electricity generation capacity to be from non-emitting energy sources by 2030. As of now, the province is at about 25%.[120] There is an option to equip coal plants with clean technologies such as carbon capture and storage (CCS). However, that technology requires a place to store the carbon captured. An investigation into the geology of a site near a relatively new coal plant in Nova Scotia that could have been used for storage, proved inconclusive.[121] SaskPower has built a CCS plant at the Boundary Dam site

[117] https://www.iea.org/coal2018/
[118] https://www.canada.ca/en/environment-climate-change/news/2018/02/proposed_amendmentstocoal-firedelectricityregulationsandproposed.html
[119] https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/agreements/equivalency/canada-nova-scotia-greenhouse-gas-emissions.html
[120] https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/agreements/equivalency/canada-saskatchewan-greenhouse-gas-electricity-producers.html
[121] https://www.nrcan.gc.ca/energy/funding/current-funding-programs/eii/16057

with a $240 million contribution from the Government of Canada,[122] but no decision has been made to expand the concept.

One of the challenges here is that large capital-intensive projects such as CCS require significant public investments to test concepts and new approaches as well as a very long lead time for proving concepts, meeting regulatory approvals and then raise large amounts of capital to build a project that can benefit from economies of scale. With the 2030 deadline looming, there is little time left to manage all that.

All this means, in the absence of further arrangements before or after 2029, some plants in New Brunswick, Nova Scotia and Saskatchewan run the risk of forced retirements before being fully amortized, leaving utilities and their customers potentially on the hook.

LEGACY FOSSIL FUEL – NATURAL GAS

In many parts of the world natural gas has proved to be a reliable and cost-effective way to produce electricity. It can also be highly efficient when built with combined cycle technologies that generate electricity from a gas turbine, capture the waste heat from that first cycle, and then use it to drive a steam turbine to deliver additional electricity in a second cycle.[123]

More recently natural gas plants have been designed to manage peak loads.[124] In both cases their cost-effectiveness depends upon access to plentiful supplies of low-cost natural gas. It also depends upon the economics of making large investments in technologies that may only operate part-time. The cost-effectiveness of peaker technologies and even new combined cycle natural gas plants under some circumstances is already being challenged by batteries.[125,126,127] Thus the risk of obsolescence is present for some natural gas plants as well.

[122] https://www.pembina.org/reports/canada-ccs-activities-table.pdf
[123] https://www.ge.com/power/resources/knowledge-base/combined-cycle-power-plant-how-it-works
[124] https://www.ge.com/power/transform/article.transform.articles.2018.oct.storage-threat-to-peaker-plants
[125] ibid
[126] https://www.bloomberg.com/news/articles/2019-01-24/pg-e-may-be-selling-california-assets-nobody-wants-in-20-years?
[127] https://www.navigantresearch.com/reports/how-utilities-can-look-beyond-natural-gas-with-cost-effective-solar-plus-storage-strategies

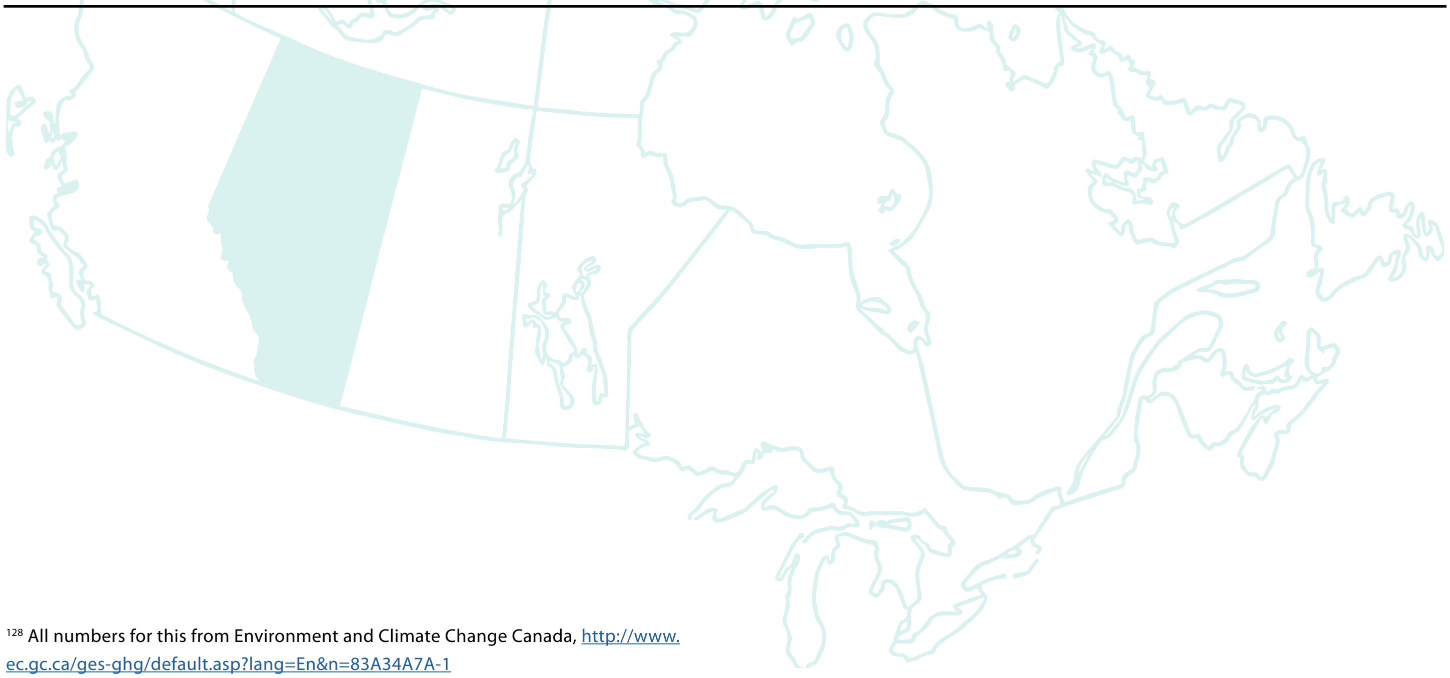
APPENDIX C:
JURISDICTIONAL PROFILES

DEFINITIONS

Area	Definition	Description
Electricity networks	Highly Integrated	Generation, transmission, distribution is generally owned by a single utility
	Partly Integrated	There may be a variety of utilities, and elements of transmission, distribution and generation are conducted by a variety of players, but there remains at least one major integrated utility that owns generation, transmission and distribution
	Separated	Transmission, distribution is generally owned by separate utilities
Electricity markets	Non-competitive	Limited competition by IPPs, and they only sell to monopoly utility
	Limited Competition	A limited wholesale market where distribution utilities can choose their own sources of electricity, in addition to supply from the monopoly
	Competitive	Wholesale and retail sales are common and are procured on a competitive basis

ALBERTA

Area	Definition	Description
Regulatory oversight	Alberta Utilities Commission	Alberta Utilities Commission regulates regulated retail and networks rates.
Electricity networks	Separated	The electricity network is split up with private ownership of the transmission network and municipal ownership of the distribution networks. The Alberta Electric System Operator (AESO) is the independent system operator for Alberta. AltaLink, a private company, operates most of the transmission system, and municipal distributors and others operate the distribution systems.
Electricity market	Competitive	Five major private utilities compete in the wholesale electricity market: TransCanada, TransAlta, ATCO, ENMAX, and Capital Power.
Natural gas	Integrated	ATCO Gas, a private company, is Alberta's largest natural gas distributor. AltaGas Utilities, a private company, distributes natural gas mostly in northern Alberta.
Retail	Competitive	Customers may choose retailers for electricity and natural gas. Customers who don't sign a contract are served by a Regulated Retailer (such as municipally owned Epcor and ENMAX).
Energy efficiency	Centralized	Energy Efficiency Alberta, a government agency, is funded by a government grant stemming from the provincial carbon levy.
Distributed energy resources	Net metering	Residential solar program that sells at market price or retail offset. Good uptake in the program with close to 19 MW installed. Energy Efficiency Alberta is offering rebates on new solar system installations. AMI is not yet fully in the province with challenges in approval from the regulator.
Electricity carbon intensity[128]	High 760 g CO2eq / kWh (2016)	Coal continues to be a large part of the generation mix. There has been a recent push for new wind and solar projects.
Clean energy policy targets		The government has set the following targets: - to phase out coal by 2030 - supply 30% of electricity from renewable sources by 2030.



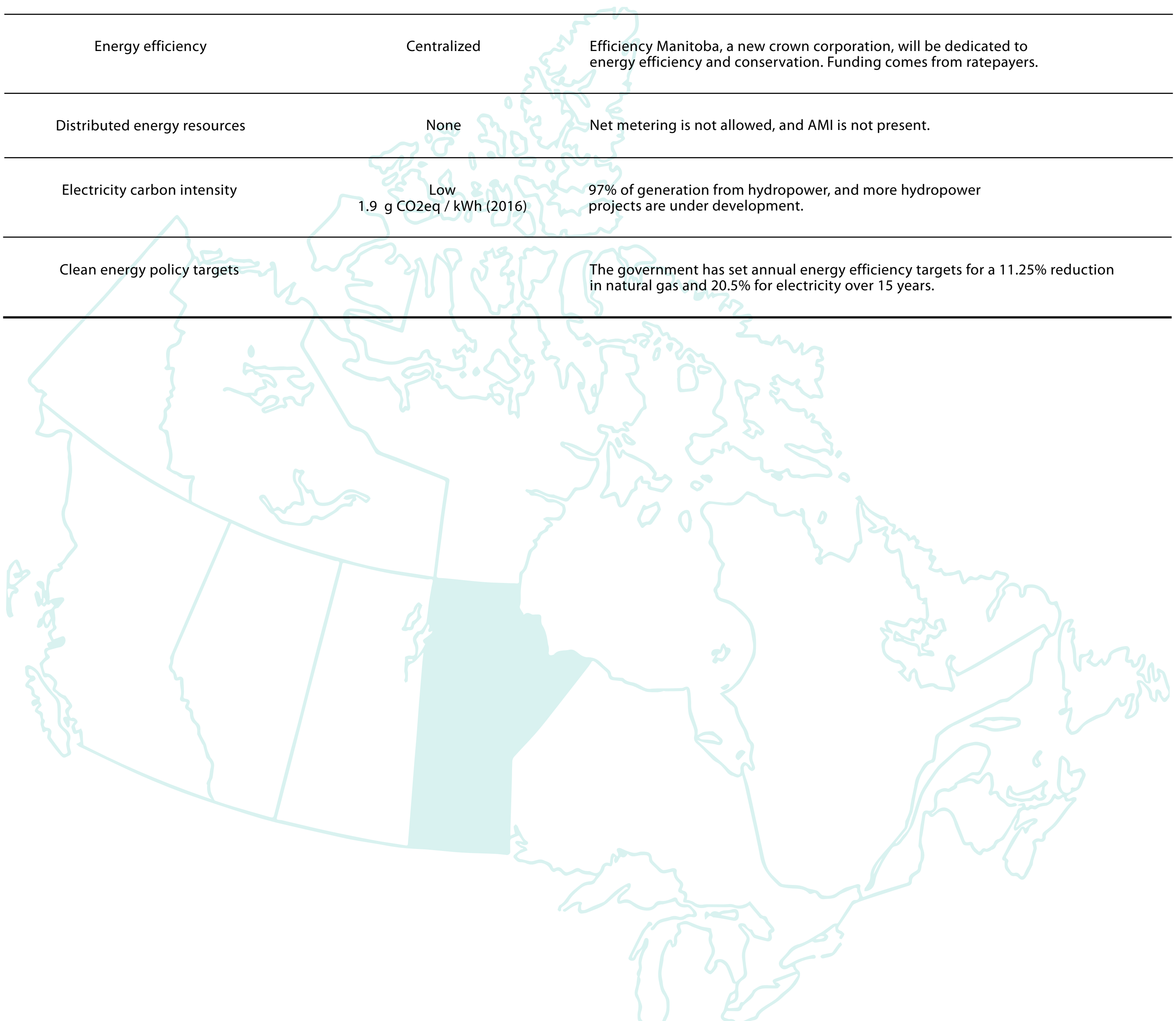
[128] All numbers for this from Environment and Climate Change Canada, http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1

BRITISH COLUMBIA

Area	Definition	Description
Regulatory oversight	BC Utilities Commission	The BC Utilities Commission regulates natural gas and electric utilities, intraprovincial pipelines and basic automobile insurance rates.
Electricity networks	Partly Integrated	BC Hydro, a crown corporation, owns the majority of generation, most of the transmission and distribution. Fortis BC, a private company, owns generation, transmission and distribution assets.
Electricity market	Non-competitive	BC Hydro generates the majority of electricity, and there are a number of IPPs under contract.
Natural gas	Integrated	The majority of customers are served through Fortis BC, with Pacific Northern Gas, a private company, having the franchise in northern BC.
Retail	Non-competitive	BC Hydro supplies electricity to 95% of British Columbians with FortisBC providing electricity service in a franchise area.
Energy efficiency	Centralized	BetterBuildings is a single window to all efficiency programs in the province.
Distributed energy resources	Net metering	Currently, BC Hydro has a surplus of electricity, and policy is geared towards using existing grid resources. Net metering is allowed when nameplate capacity is < 100 kW and AMI is in place.
Electricity carbon intensity	Low 11.1 g CO2eq / kWh (2016) 19.73 g CO2eq/MJ (BC number)	Hydropower provides 98% of BC's electricity, with the exception of off-grid communities and some natural gas backups.
Clean energy policy targets		CleanBC program has the following targets: - reduce emissions from buildings by 40% by 2030 - 60% of homes and 40% of commercial buildings will be heated with clean electricity - 30% of all sales of new light-duty cars and trucks will be zero-emission vehicles by 2030, rising to 100% by 2040 - target of 15% of natural gas to be renewable gas by 2030 - reduce diesel use in off-grid communities.

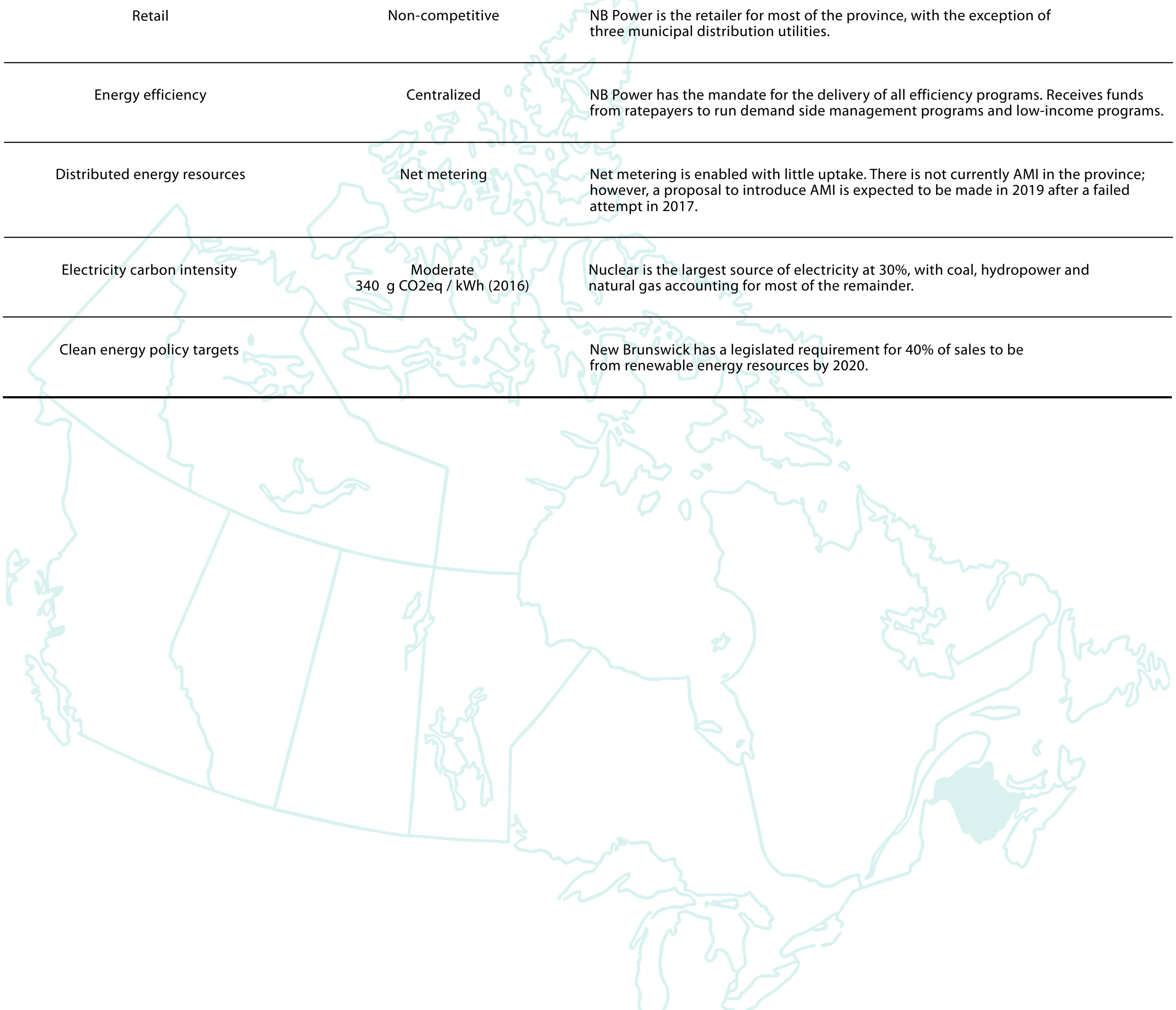
MANITOBA

Area	Definition	Description
Regulatory oversight	Manitoba Public Utilities Board	Manitoba Public Utilities Board regulates rates for both natural gas and electricity.
Electricity networks	Highly Integrated	Generation, transmission, and distribution are owned by Manitoba Hydro, a crown corporation.
Electricity market	Non-competitive	Electricity is almost entirely owned by Manitoba Hydro with the exception of 265 MW of IPP wind.
Natural gas	Integrated	Centra Gas, a subsidiary of Manitoba Hydro, is the sole distributor of natural gas.
Retail	Non-competitive	All electricity sales must go through Manitoba Hydro.
Energy efficiency	Centralized	Efficiency Manitoba, a new crown corporation, will be dedicated to energy efficiency and conservation. Funding comes from ratepayers.
Distributed energy resources	None	Net metering is not allowed, and AMI is not present.
Electricity carbon intensity	Low 1.9 g CO2eq / kWh (2016)	97% of generation from hydropower, and more hydropower projects are under development.
Clean energy policy targets		The government has set annual energy efficiency targets for a 11.25% reduction in natural gas and 20.5% for electricity over 15 years.



NEW BRUNSWICK

Area	Definition	Description
Regulatory oversight	New Brunswick Energy and Utilities Board	The New Brunswick Energy and Utilities Board regulates rates for electricity and natural gas.
Electricity networks	Partly Integrated	New Brunswick Power (NB Power), a crown corporation, owns and operates the transmission infrastructure and most of the distribution with the exception of three municipal distribution utilities.
Electricity market	Non-competitive	The majority of electricity is generated by NB Power with the exception of some IPP wind and private natural gas generation. NB Power operates 13 hydro, nuclear, coal, oil, and, diesel powered stations.
Natural gas	Integrated	Enbridge Gas is the monopoly provider of natural gas.
Retail	Non-competitive	NB Power is the retailer for most of the province, with the exception of three municipal distribution utilities.
Energy efficiency	Centralized	NB Power has the mandate for the delivery of all efficiency programs. Receives funds from ratepayers to run demand side management programs and low-income programs.
Distributed energy resources	Net metering	Net metering is enabled with little uptake. There is not currently AMI in the province; however, a proposal to introduce AMI is expected to be made in 2019 after a failed attempt in 2017.
Electricity carbon intensity	Moderate 340 g CO2eq / kWh (2016)	Nuclear is the largest source of electricity at 30%, with coal, hydropower and natural gas accounting for most of the remainder.
Clean energy policy targets		New Brunswick has a legislated requirement for 40% of sales to be from renewable energy resources by 2020.

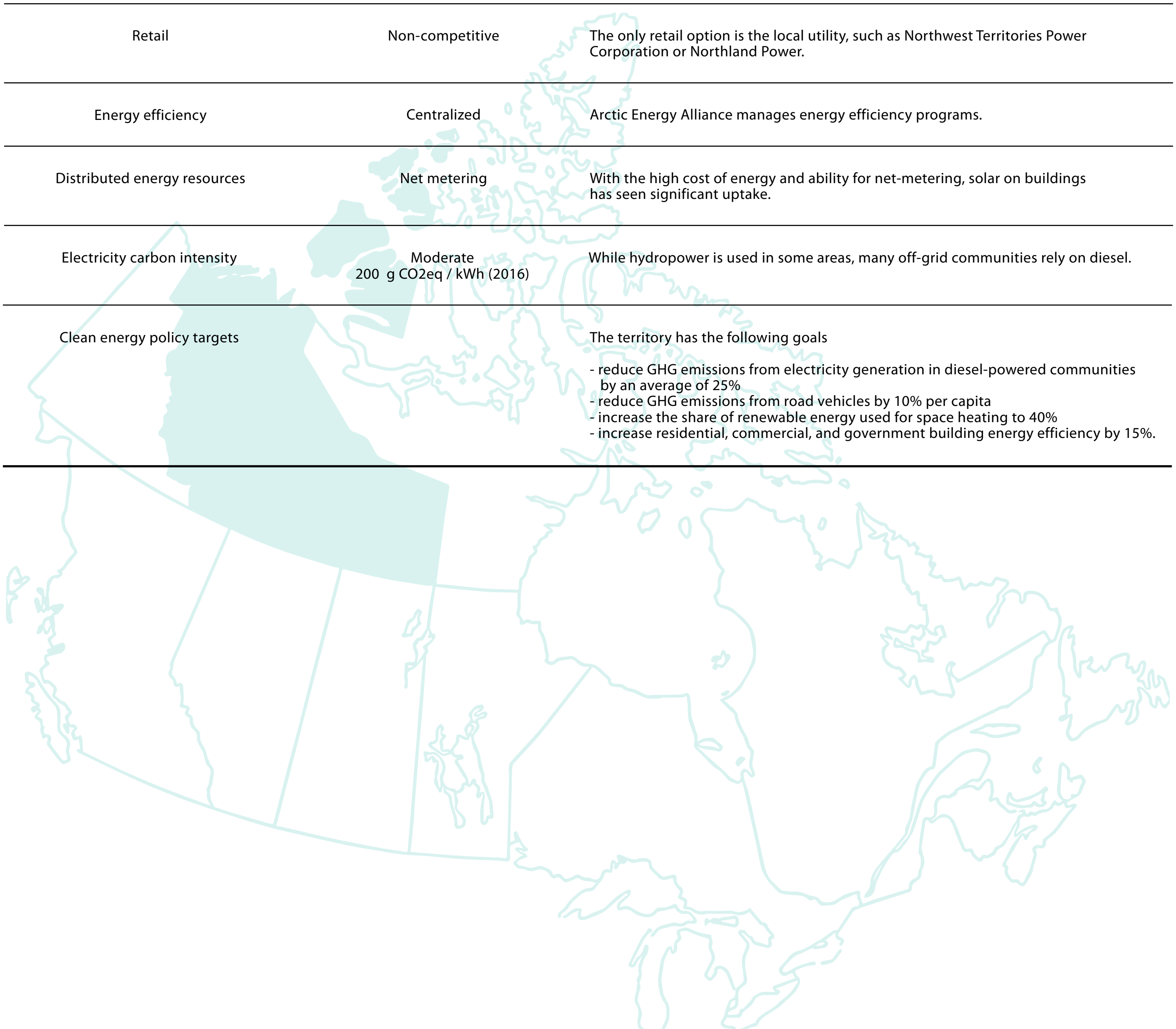


NEWFOUNDLAND AND LABRADOR

Area	Definition	Description
Regulatory oversight	Newfoundland and Labrador Board of Commissioners of Public Utilities	Newfoundland and Labrador Board of Commissioners and Public Utilities regulates customer electricity rates.
Electricity networks	Partly Integrated	There are two large utilities: Newfoundland and Labrador Hydro, a crown corporation, and Newfoundland Power, a subsidiary of Fortis. Newfoundland and Labrador Hydro delivers electricity to industrial and residential and commercial customers in rural areas. Newfoundland Power operates an integrated generation, transmission and distribution system throughout the island portion and serves 87% of all electricity customers.
Electricity market	Non-competitive	Most electricity is generated by Newfoundland and Labrador Hydro. Newfoundland Power and other independent companies also operate generation.
Natural gas	None	
Retail	Non-competitive	The only two retailers are Newfoundland Power and Newfoundland and Labrador Hydro, which operate in different franchises.
Energy efficiency	Dispersed	Efficiency programs are split between utilities and social housing corporations. Programs include a Home Energy Savings Program that targets low income households and an Energy Efficiency Loan program.
Distributed energy resources	None	With a large surplus of centralized energy generation planned, focus on distributed energy generation is minimal with the exception of off-grid communities. There are no plans for AMI in the province or incentives for other developments.
Electricity carbon intensity	Low 37 g CO2eq / kWh (2016)	Large use of hydropower, and this is expected to increase with the completion of the Muskrat Falls project.
Clean energy policy targets		The government is looking to reduce diesel reliance in off-grid communities.

NORTHWEST TERRITORIES

Area	Definition	Description
Regulatory oversight	Northwest Territories Public Utilities Board	NWT Public Utilities Board regulates electricity and natural gas consumer prices.
Electricity networks	Partly Integrated	Northwest Territories Power Corporation, a crown corporation, owns all of the transmission, and the distribution in some remote communities. Northland Power, a private company and a subsidiary of ATCO, distributes and sells power in Yellowknife, Hay River and surrounding communities and in some remote communities.
Electricity market	Non-competitive	Northwest Territories Power Corporation has a monopoly on generation, with the exception of new distributed resources such as solar.
Natural gas	Integrated	Two local gas distributors: Inuvik Gas (private) and Norman Wells Gas (municipal).
Retail	Non-competitive	The only retail option is the local utility, such as Northwest Territories Power Corporation or Northland Power.
Energy efficiency	Centralized	Arctic Energy Alliance manages energy efficiency programs.
Distributed energy resources	Net metering	With the high cost of energy and ability for net-metering, solar on buildings has seen significant uptake.
Electricity carbon intensity	Moderate 200 g CO2eq / kWh (2016)	While hydropower is used in some areas, many off-grid communities rely on diesel.
Clean energy policy targets		The territory has the following goals - reduce GHG emissions from electricity generation in diesel-powered communities by an average of 25% - reduce GHG emissions from road vehicles by 10% per capita - increase the share of renewable energy used for space heating to 40% - increase residential, commercial, and government building energy efficiency by 15%.

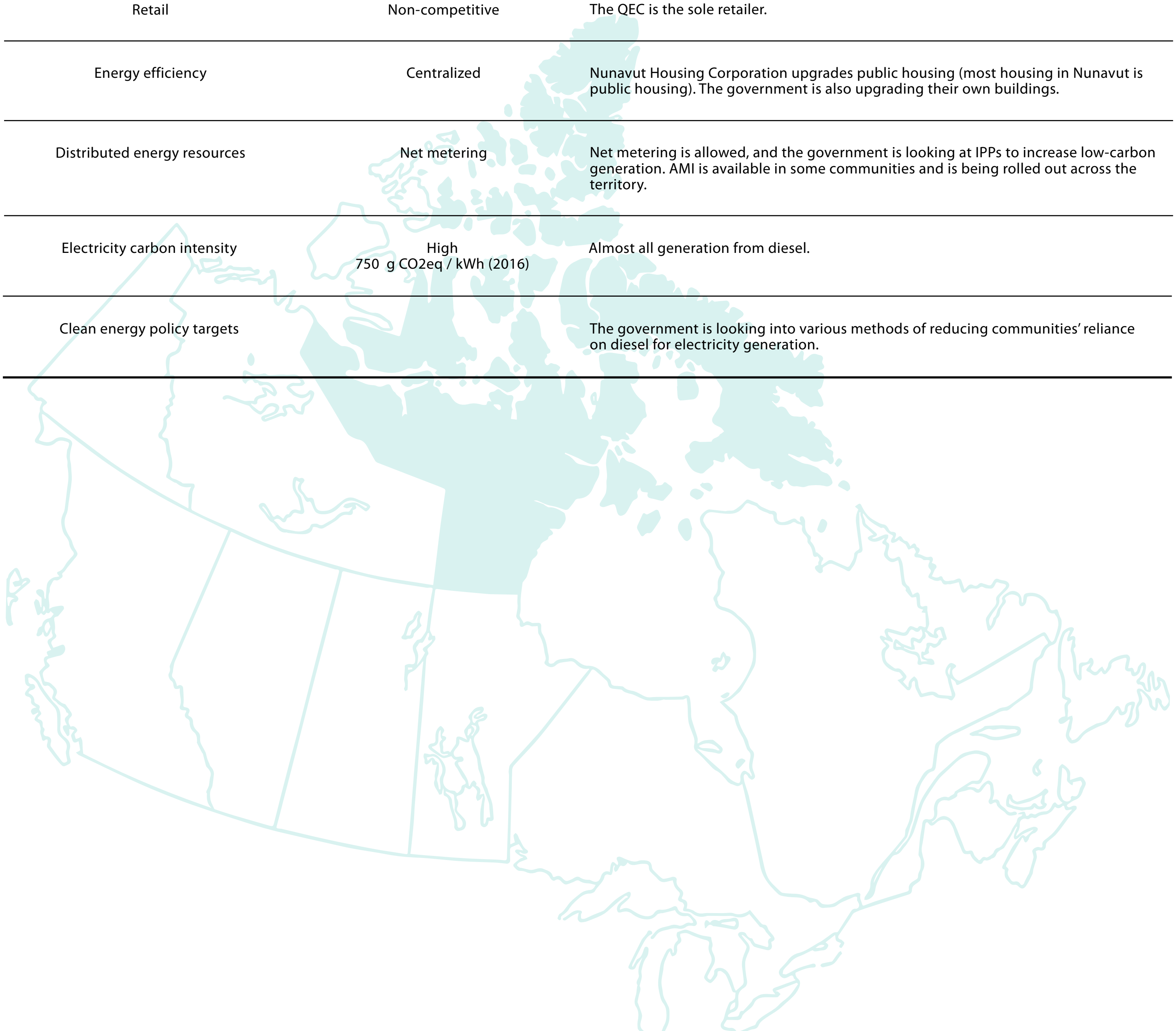


NOVA SCOTIA

Area	Definition	Description
Regulatory oversight	The Nova Scotia Utility and Review Board	The Nova Scotia Utility and Review Board regulates rates and capital investments by utilities for electricity and natural gas.
Electricity networks	Highly Integrated	Nova Scotia Power (NS Power, a private company, and a division of Emera Inc.) is the monopoly provider and operates the transmission and most distribution networks for 97% of the market. Some communities have local their own local distribution utilities.
Electricity market	Limited Competition	Most electricity is generated by NS Power, however there are numerous IPPs who have long-term (20 year) contracts with NS Power with a significant amount of electricity set to come from NL in 2020 (>10%) and some of the municipal utilities generate their own power as well as buy from NS Power or import.
Natural gas	Integrated	Heritage Gas (private, a subsidiary of Algonquin Power – purchase underway) is the monopoly provider.
Retail	Non-competitive	Monopolies for delivery of energy within defined territories, however direct to retail sales from renewable energy IPP's to customers is allowed after the customer pays a tariff to NS Power for the use of their network.
Energy efficiency	Centralized	Single window, independent utility, DSM funding for electricity, program funding for low-income and non-electric homes and businesses
Distributed energy resources	Net Metering	Net energy metering, with a previous FIT program. AMI investment coming in 2019-2021.
Electricity carbon intensity	High 680 g CO_2eq / kWh (2016)	Since 2016 emissions continued to fall as renewables continued to grow. In 2020 there will be very significant reductions in carbon as renewables are now forecast to grow from 25% (2015) to 50-60% in 2020 as power from NL's Muskrat Falls project begins.
Clean energy policy targets		The government has a legislated requirement for renewable resources to supply 40% of electricity consumption by 2020. The government's Electricity Plan suggests virtually no carbon in electricity by the early 2040s, and the Coal Regulation Equivalency Agreement requires the province to meet their own GHG caps on the use of coal out to 2030.

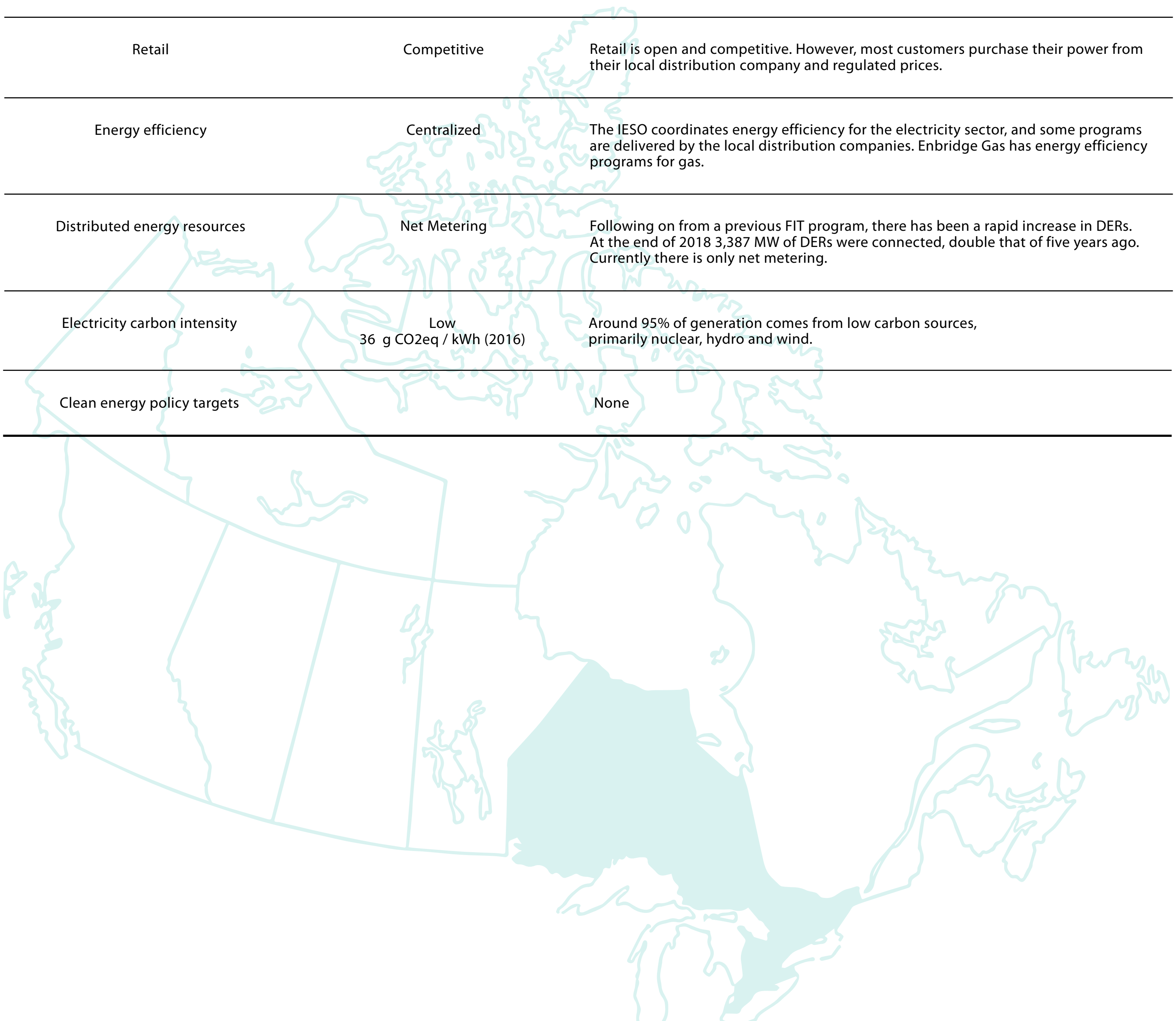
NUNAVUT

Area	Definition	Description
Regulatory oversight	Utility Rates Review Council	Government of Nunavut makes the final decisions on rates, following advice from the Utility Rates Review Council (URRC).
Electricity networks	Highly Integrated	The Qulliq Energy Corporation (QEC), a crown corporation, has a monopoly on generation, transmission, distribution.
Electricity market	Non-competitive	The QEC owns all generation, which is 100% diesel. There are plans to allow independent power producers into the territory.
Natural gas	None	
Retail	Non-competitive	The QEC is the sole retailer.
Energy efficiency	Centralized	Nunavut Housing Corporation upgrades public housing (most housing in Nunavut is public housing). The government is also upgrading their own buildings.
Distributed energy resources	Net metering	Net metering is allowed, and the government is looking at IPPs to increase low-carbon generation. AMI is available in some communities and is being rolled out across the territory.
Electricity carbon intensity	High 750 g CO_2eq / kWh (2016)	Almost all generation from diesel.
Clean energy policy targets		The government is looking into various methods of reducing communities' reliance on diesel for electricity generation.



ONTARIO

Area	Definition	Description
Regulatory oversight	Ontario Energy Board	The Ontario Energy Board regulates network rates and regulated prices for customers on the Regulated Price Plan.
Electricity networks	Separated	Minority government-owned Hydro One operates the transmission system and the distribution system in rural areas. There are around 70 municipally owned local distribution companies that have individual franchises. The system operator is the Independent Electricity System Operator (IESO).
Electricity market	Limited Competition	Ontario Power Generation, a crown corporation, generates around half of all electricity. The remainder is generated by independent power producers under contract to the IESO. The IESO is introducing market reforms with the aim of increasing competition.
Natural gas	Integrated	Centra Gas, a subsidiary of Manitoba Hydro, is the sole distributor of natural gas.
Retail	Competitive	Retail is open and competitive. However, most customers purchase their power from their local distribution company and regulated prices.
Energy efficiency	Centralized	The IESO coordinates energy efficiency for the electricity sector, and some programs are delivered by the local distribution companies. Enbridge Gas has energy efficiency programs for gas.
Distributed energy resources	Net Metering	Following on from a previous FIT program, there has been a rapid increase in DERs. At the end of 2018 3,387 MW of DERs were connected, double that of five years ago. Currently there is only net metering.
Electricity carbon intensity	Low 36 g CO2eq / kWh (2016)	Around 95% of generation comes from low carbon sources, primarily nuclear, hydro and wind.
Clean energy policy targets		None

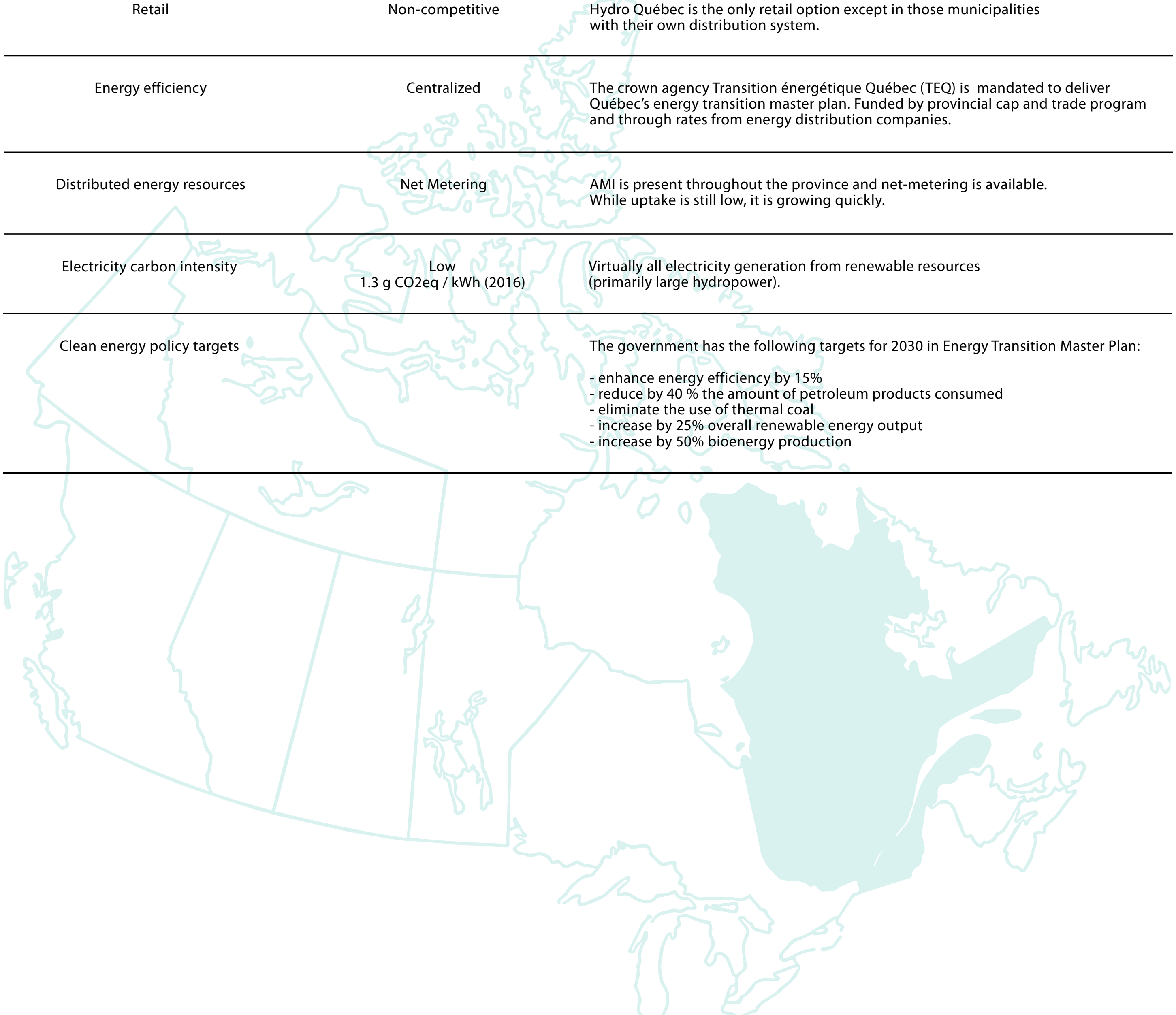


PRINCE EDWARD ISLAND

Area	Definition	Description
Regulatory oversight	PEI Regulatory and Appeals Commission	The PEI Regulatory and Appeals Commission regulates electricity rates.
Electricity networks	Partly Integrated	Maritime Electric, a private company and a subsidiary of Fortis, owns and operates the generation, transmission and distribution of electricity, with the exception of municipally owned Summerside Electric.
Electricity market	Limited Competition	Most electricity is imported from NB Power. Eight wind farms are owned by a small number of independent companies, Summerside Electric, and PEI Energy Corporation, a crown corporation. Summerside Electric operates thermal plants.
Natural gas	None	
Retail	Non-competitive	Maritime Electric is the sole retail operator with the exception of Summerside Electric.
Energy efficiency	Centralized	Efficiency PEI is a crown corporation which applies for funding through the Regulatory and Appeals Commission.
Distributed energy resources	Net metering	Policies are in development to further promote DERs in the province. Net-metering is currently available in the province with minimal uptake.
Electricity carbon intensity	Low 25 g CO2eq / kWh (2016)	Most electricity is imported from New Brunswick.
Clean energy policy targets		The government has the following targets: - increase efficiency by 2% a year by 2020 - increase wind farms in the province.

QUÉBEC

Area	Definition	Description
Regulatory oversight	Regie de l'energie	Regie de l'energie regulates the rates for natural gas and electricity in the province
Electricity networks	Highly Integrated	Hydro Québec, a crown corporation, owns almost all of the generation, all of the transmission and all of the distribution. Some municipal electricity distribution companies.
Electricity market	Non-competitive	With the exception of wind and biomass IPPs and some hydropower plants, Hydro Québec owns all electricity generating assets.
Natural gas	Integrated	Énergir, a private company, is the main sole distributor of natural gas in the province with Gazifère serving the Gatineau region.
Retail	Non-competitive	Hydro Québec is the only retail option except in those municipalities with their own distribution system.
Energy efficiency	Centralized	The crown agency Transition énergétique Québec (TEQ) is mandated to deliver Québec's energy transition master plan. Funded by provincial cap and trade program and through rates from energy distribution companies.
Distributed energy resources	Net Metering	AMI is present throughout the province and net-metering is available. While uptake is still low, it is growing quickly.
Electricity carbon intensity	Low 1.3 g CO2eq / kWh (2016)	Virtually all electricity generation from renewable resources (primarily large hydropower).
Clean energy policy targets		The government has the following targets for 2030 in Energy Transition Master Plan: - enhance energy efficiency by 15% - reduce by 40 % the amount of petroleum products consumed - eliminate the use of thermal coal - increase by 25% overall renewable energy output - increase by 50% bioenergy production



SASKATCHEWAN

Area	Definition	Description
Regulatory oversight	Saskatchewan Rate Review Panel	Final rates for electricity and natural gas are set by the government following a review by the Saskatchewan Rate Review Panel
Electricity networks	Highly Integrated	SaskPower, a crown corporation, owns the transmission, and most distribution. Saskatoon and Swift Current have municipally owned distribution.
Electricity market	Non-competitive	SaskPower generates majority of the electricity in the province. 20% of electricity is generated by independent power producers.
Natural gas	Integrated	SaskEnergy is the crown monopoly provider of natural gas in the province.
Retail	Non-competitive	The only retailer with the exception of a few municipal distribution utilities is SaskPower.
Energy efficiency	Centralized	SaskPower and SaskEnergy operate the electric efficiency and natural gas efficiency programs respectively.
Distributed energy resources	Net metering	Net metering is allowed and AMI is expected to roll out within the next three years. Overall uptake of DERs is minimal. First Nations Power Authority has set asides for community energy projects.
Electricity carbon intensity	High 660 g CO2eq / kWh (2016)	Three-quarters of generation from coal and gas, with the remainder mostly from hydropower.
Clean energy policy targets		The government has a target of reducing greenhouse gas emissions from electricity to 40% below 2005 levels by 2030. SaskPower aims to have up to 50% of generation capacity from renewables by 2030.

YUKON

Area	Definition	Description
Regulatory oversight	Yukon Utilities Board	The Yukon Utilities Board regulates electricity rates. The Yukon Energy Corporation has its capital projects over $3 million reviewed by the Utilities Board.
Electricity networks	Partly Integrated	Yukon Energy Corporation, a crown corporation, operates the transmission infrastructure. ATCO Electric Yukon, privately owned, acts as the distributor for most of the territory.
Electricity market	Limited Competition	Yukon Energy Corporation generates most of the territory's electricity. ATCO Electric Yukon also has some power generation facilities.
Natural gas	None	
Retail	Non-competitive	Small customers purchase power from ATCO Electric Yukon. Yukon Energy Corporation supplies some large customers and mines.
Energy efficiency	Centralized	Energy Branch, Government of Yukon, is responsible for delivering energy efficiency programs.
Distributed energy resources	Standard offer	Yukon has two distributed energy policies: Micro-Generation Policy and Independent Power Production Policy. The Micro-Generation Policy has set rates for electricity exported to the grid.
Electricity carbon intensity	Low 45 g CO2eq / kWh (2016)	Hydropower supplies over 90% of electricity. There are off-grid communities reliant on diesel.
Clean energy policy targets		The government's energy strategy has set the following targets: - increase energy efficiency by 20% by 2020. - increase renewable energy by 20% by 2020. - develop the biomass energy sector.

APPENDIX D:
ORGANIZATIONS CONTACTED

The following are the organizations we surveyed for this paper. Please note that this is not a complete list as some wished to remain anonymous. We would like to thank the representatives for the time in talking to us. All opinions and errors are the authors' alone.

AltaLink
Alberta Energy
ATCO
Australia Energy Regulator
British Columbia Hydro
British Columbia Utility Commission
Efficiency Nova Scotia
Energy Efficiency Alberta
Efficiency PEI
Enbridge Gas
Enmax
First Nations Power Authority
Government of Nunavut
Hydro Ottawa
Hydro Québec
Independent Electricity System Operator
Manitoba Municipal Relations Energy Division
Newfoundland and Labrador Natural Resources
New Brunswick Energy and Mines
New Brunswick Energy and Utilities Board
Northwest Territories Public Utilities Board
Nova Scotia Energy and Mines
Nova Scotia Power
Nova Scotia Utility and Review Board
Ontario Energy Board
Pennsylvania Public Utility Commission
Québec Ministry of Natural Resources
Qulliq Energy Corporation
Regie de l'energie
Rhode Island Public Utility Commission
Saint John Energy
Saskatchewan Rate Review Panel
SaskEnergy
SaskPower
Summerside Electric
Transition énergétique Québec
UK Energy Networks
Yukon Government

PROJECT SUPPORTERS

Natural Resources Canada / Ressources naturelles Canada

Canada