ELECTRO FEDERATION CANADA

Electri-*fyi*: Exploring Electrification Trends and Opportunities in Canada

The Canadian electrical industry is facing a period of dynamic change that is creating a multitude of business challenges and opportunities. Complex and interconnected trends in the economic, technological, social, regulatory and environmental spheres are re-shaping how energy is generated, distributed, sold and used—ushering in an exciting new era of **electrification**.

This transformation provides opportunities throughout the electrical industry on both the demand and supply side of the equation: from electrified transportation and energy-efficient products, to a more sustainable, reliable and socially-conscious energy infrastructure.

Electrification Defined

Electrification has been making headlines recently and is a topic of much discussion among electricity producers, manufacturers, suppliers, regulators and analysts. Energy market shifts, evolving consumer expectations, policy changes and greenhouse gas (GHG) emission reduction targets are among the key factors driving greater interest in electricity as a power source.

Any meaningful analysis of electrification and its implications begins with a working definition of the term:

Electrification is the process of converting a machine or system to operate using electricity, when it previously used another form of energy, e.g. propane, oil, gas or kinetic.

The transition to electricity offers increased supply grid flexibility and efficiency and is set to revolutionize how energy is used for urban planning, rural development and industrialization. The potential for efficient electrification is significant. Although our nation's electricity is largely emissions-free, only 20% of our energy use comes from electricity. This offers tremendous opportunity for the electrification of end-use applications in residential, commercial, industrial and transportation sectors.

Electrification Summit

As part of its continuing mandate to advance Canada's electrical industry, Electro-Federation Canada (EFC) partnered with the Canadian Electricity Association (CEA) in February 2019 to present the Electri-*fyi* Summit. Held at the Plug'n Drive Electric Vehicle Discovery Centre in Toronto, the full-day event brought experts together to explore various facets of electrification.

Experts from Natural Resources Canada (NRCan), the Independent Electricity System Operator (IESO), Plug'n Drive, Ontario Power Generation (OPG) and ABB Canada presented a range of trends driving the electrification movement, as well as implications for companies that generate and deliver energy—and those who manufacture, distribute, market and sell electrical products that support the widespread distribution and use of power in our society. Summit attendees also had an opportunity to broaden their scope and understanding of electrification, by reviewing four possible future scenarios and exploring associated market demands, regulatory implications and early signposts (*see Appendix for a summary of each scenario*).

This whitepaper builds on discussions from the Electri-*fyi* Summit, summarizing the event's key insights, along with additional research to provide an overview of the following aspects of electrification:

- its definition, dimensions and drivers
- energy landscape in Canada and abroad
- its impact on transportation (special focus), residential, commercial and industrial sectors
- business opportunities for electrical industry companies

The main objective of this whitepaper is to provoke reflection on what electrification means for your business: how it will affect your operation; the product and service opportunities that may arise; and how to adapt to stay competitive.

ENERGY DEMAND IS ON THE RISE

Electrification is a game changer. It is changing how we power our societies, produce our goods and services, and how we live, work…and move.

Energy Demand: Key Drivers

There are three significant drivers elevating energy demand on a global scale. These include: Urbanization, the Fourth Industrial Revolution and e-Mobility.

NEARLY 55% OF THE WORLD'S POPULATION LIVES IN CITIES, AND THAT NUMBER IS EXPECTED TO INCREASE TO 68% BY 2050.

1. Urbanization

The global shift of populations from rural to urban areas has accelerated in recent decades, significantly increasing the demand for electricity as a clean, affordable and efficient source of energy. According to the United Nations, the urban population of the world has grown from 751 million in 1950 to 4.2 billion in 2018.[1] Today, nearly 55% of the world's population lives in cities, and that number is expected to increase to 68% by 2050. This continual shift in where humans reside, combined with the overall growth of the world's population, could add another 2.5 billion to urban areas by 2050.

This urbanization trend is expected to lead to a dramatic rise in per-capita electricity use. Currently, cities account for 75% of global energy consumption and 80% of global CO_2 emissions. As cities continue to grow in size, their populations will become increasingly vulnerable to the impacts of climate change, such as frequent storms and rising sea levels.

THE FOURTH INDUSTRIAL REVOLUTION BUILDS ON THE TREND OF DIGITALIZATION TO EXPONENTIALLY ENHANCE THE VELOCITY, SCOPE AND IMPACT OF PRODUCTION

Electrification is a viable way to lower CO_2 emissions and promote urban resilience. However, significant supply grid investment will be necessary to support electricity demand and consumption requirements. Market reforms and government policies will also be required to help advance electrification.

The Conference Board of Canada estimates that $347.5 billion will be needed between 2011 to 2030 to maintain the reliability of Canada's electricity infrastructure.[2] There will also be a greater need for distributed energy resource technologies such as smart meters and battery storage, as electrification begins to transform commercial, residential and industrial sectors. The transportation sector will be most impacted by urbanization, spurring sustainable public transit and electric vehicles (most electric vehicle purchases take place in urban and suburban areas).

2. The Fourth Industrial Revolution

The ways in which modern economies produce goods and provide services are undergoing dramatic transformation. This shift has been dubbed the 'Fourth Industrial Revolution'. Coming on the heels of the world's first three industrial revolutions powered by, respectively, steam, oil and computing, the Fourth Industrial Revolution builds on the trend of digitalization to exponentially enhance the velocity, scope and impact of production.

This revolution is largely characterized by the advent of emerging technology breakthroughs in artificial intelligence, robotics, machine learning, blockchain, IoT, 3D printing, nanotechnology, energy storage and other areas. The combination and integration of these powerful digital technologies is enhancing the ability for businesses to innovate more quickly, operate more efficiently, expand and tailor their offerings, reach more markets, promote employee collaboration and provide better customer service.[3] With a lens on the electrical market, advancements in these technologies can help drive demand for equipment that connects to renewable energy systems such as solar photovoltaics, wave generators, fuel cells and energy storage batteries.

[1] https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

[2] https://www.conferenceboard.ca/temp/17cb73b5-a146-489a-97b0-97115936847c/12-221_SheddingLight_RPT.PDF

[3] https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

3. e-mobility

Electric vehicles (EVs) are poised for significant growth in the coming decades, largely driven by factors related to product superiority, environmental benefit and market opportunity.

EVs offer a number of performance advantages over internal combustion engine vehicles: they have better acceleration, require less maintenance and are more durable. EVs also help reduce greenhouse gas (GHG) emissions, which is increasingly critical in our warming world.

During the Electri-*fyi* Summit, Plug'n Drive noted that EVs reduce GHG emissions by as much as 90%. Further to this, Bloomberg New Energy Finance (Bloomberg NEF) estimates that by 2040, electrified buses and cars will displace a combined 7.3 million barrels of transportation fuel per day.[4]

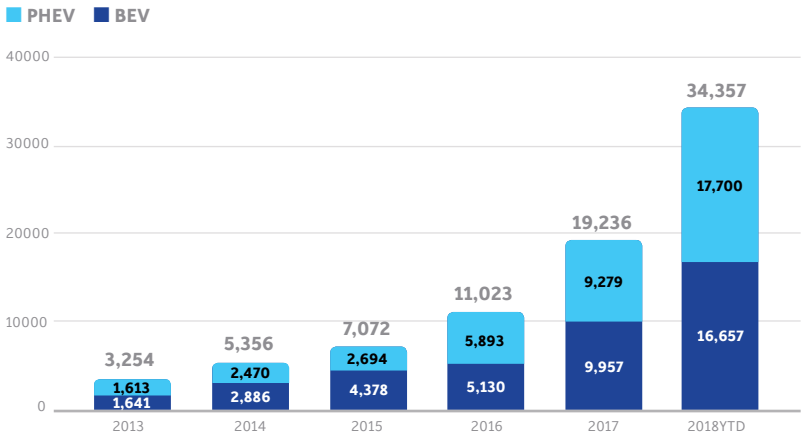
Consumers are taking note of these trends and realizing the potential of electric transportation. In Canada, nearly 35,000 battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) were sold as of September 2018, an increase of 178% from the full year before. This number is expected to climb further with the onset of new federal incentives that took effect in early May.

On a global scale, Bloomberg NEF claims that the number of EVs on the road by the end of the decade will triple—soaring from 3.13 million to 13 million.[5] The growth of EVs in the market will be closely tied to technology developments, availability and access—all of which continue to present tremendous opportunities in the market. Among European countries pursuing electrification most aggressively is Norway, which is aiming to achieve a fully electric-powered society by 2050. Its plan includes phasing out internal combustion engine vehicles by 2025. In fact, as of this year, EVs beat out gas vehicles in their percentage of total market share.

The evolution of battery storage

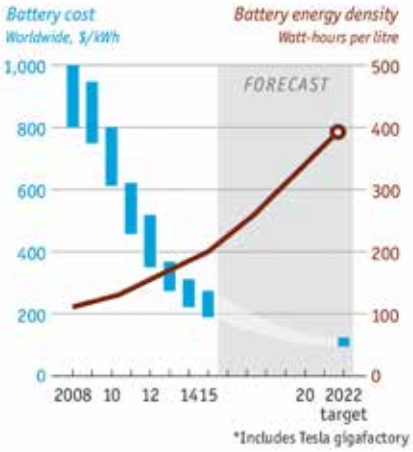
Manufacturing is scaling up quickly to meet the demand for lithium-ion batteries for EVs. In fact, manufacturing capacity is at around 131 GWh per year, based on battery plants announced and those that are under construction. This is set to jump to over 400 GWh by 2021, with 73% of the global capacity concentrated in China.

Exhibit 1: Electric Vehicles Sales Q3 2018, Canada



Source: https://www.fleetcarma.com/electric-vehicles-sales-update-q3-2018-canada/

Exhibit 2: Growth of Lithium-ion Battery Power



Source: https: www.economist.com/graphic-detail/2017/08/14/the-growth-of-lithium-ion-battery-power

[4] https://about.bnef.com/electric-vehicle-outlook/

[5] https://www.bloomberg.com/news/articles/2018-05-30/electric-vehicles-on-the-road-are-set-to-triple-in-two-years

Bloomberg NEF also recently announced that more than $620 billion will be invested in energy storage technology between 2018 and 2040.[6] Innovations in energy storage technology have led its prices to sharply fall, as shown in Exhibit 2. At the same time, the average energy density of EV batteries is also improving by around 5-7% per year. Some players in this space are aiming to bring battery costs down to less than half of today's costs and as low as $80/kWh.[7]

Advancing EV infrastructure

The International Energy Agency's (IEA) Global EV Outlook 2018 indicates that in 2017, the number of EV chargers worldwide totaled almost 3.5 million: nearly 3 million are in homes and workplaces, and 430,000 are in public spaces.[8] In Canada, Plug'n Drive estimates there are more than 5,000 public charging stations, 500 of which are Level 3 fast chargers. This segment is expected to grow substantially as more EVs debut on Canadian roads.

Auto industry activity accelerating

Coinciding with increasing consumer demands and cognizant of the brand value of 'going green', most carmakers are making aggressive plans to electrify their vehicles over the next ten years. Ford will invest $11 billion to develop 40 electrified vehicles by 2022; GM plans to launch at least 20 EV models by 2023; and Toyota intends to add 10 new battery electric vehicles worldwide by early 2020, and will have electric options throughout its entire lineup by 2025. Due to this intensifying EV activity, there are now than 40 models on the road in Canada, from compacts to midsized cars to SUVs.

[6] https://www.bloomberg.com/news/articles/2018-11-06/the-battery-boom-will-draw-1-2-trillion-in-investment-by-2040

[7] https://www.globenewswire.com/news-release/2019/03/14/1752966/0/en/Worldwide-Lithium-Ion-Battery-Cathodes-Market-Report-2019-Market-is-a-7-Billion-Market-in-2018-and-is-Expected-to-Reach-58-8-Billion-by-2024.html

[8] https://webstore.iea.org/global-ev-outlook-2018

Energy Demand Outlook: Global, National, Provincial

The onset of electrification has an immense impact on energy requirements worldwide, as well as in Canada.

Global: The International Energy Agency (IEA) projects that global energy demand is expected to grow by about 27% between 2017 and 2040 due to an extra 1.7 billion people on the planet and rising incomes.[9] IEA also indicates that a much stronger push for electric mobility, electric heating and electricity access could lead to, and even surpass, a 90% increase in electrical power demand by 2040.

Canada: Closer to home, gross energy demand is also expected to rise. The National Energy Board (NEB) projects total end-use energy demand (i.e. all types of energy used in residential, commercial, industrial and transportation sectors) to grow by 1.3% each year[10]. While gross demand is on the incline per capita, the overall net demand for electricity is expected to decline because of the increased adoption of new energy-efficient technologies in lighting, heating, etc. NEB projects that Canadians will use 15% less total energy and 30% less fossil fuels by 2040[11]. This assumption is based on new technology costs improving, advancements in energy-efficient products and services, and federal policies supporting the use of alternative forms of energy.

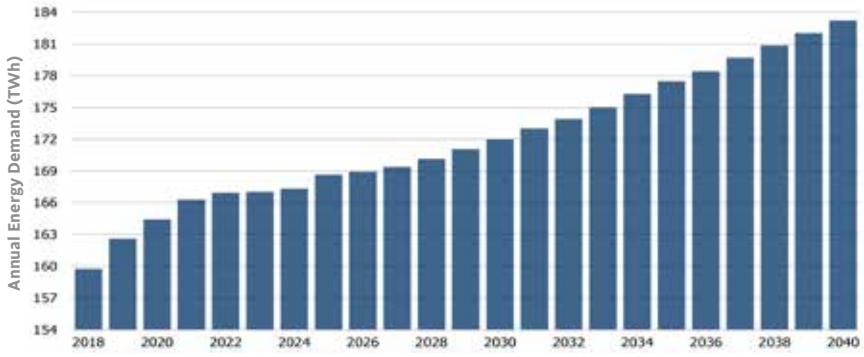
Provinces: The outlook for energy demand by province vastly differs depending on the local economy, adoption of electric mobility and heating, the degree of digitization, and the level of urbanization.

During the Electri-*fyi* Summit, IESO shared projections for energy demand in Ontario, echoing NEB's assumptions that demand will increase in the coming decades.

As gross demand rises, IESO claims that the net-level demand for electricity will decline due, in part, to economic change, distributed/embedded generation and growing conservation efforts—particularly, energy-efficient devices and equipment that are in use in residential, commercial and industrial applications. This projection coincides with the significant decrease in net electricity demand Ontario has seen in past years (2005-2017). See Exhibit 4.

The momentum for our industry's energy-efficient products is building, and this need will become an increasingly-important factor in developing Canada's sustainable future.

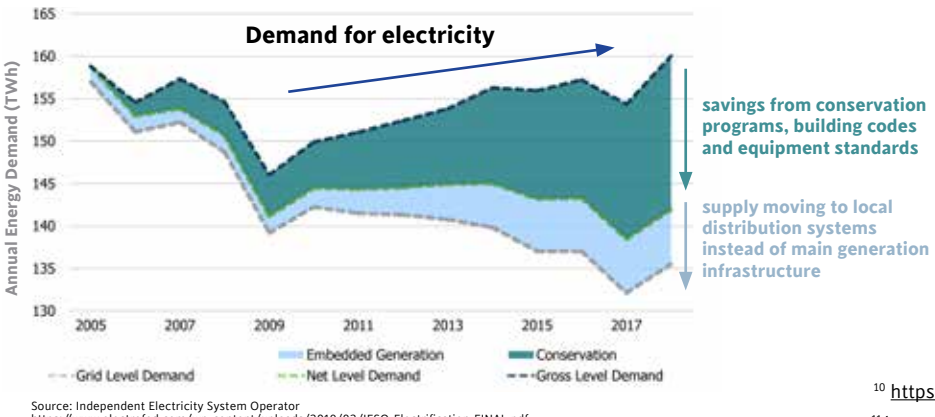
Exhibit 3: Forecasted Growth in Gross Demand, Ontario



Source: Independent Electricity System Operator
https://www.electrofed.com/wp-content/uploads/2019/02/IESO-Electrification-FINAL.pdf

Exhibit 4: Net Electricity Demand, Ontario

Net electricity demand declining from impacts of conservation, economic change, distributed generation



Source: Independent Electricity System Operator
https://www.electrofed.com/wp-content/uploads/2019/02/IESO-Electrification-FINAL.pdf

GLOSSARY

Embedded generation: *represents electricity-producing resources that are directly connected to a local distribution system or to a host facility within the local distribution system, also referred to as Distributed Energy Resources (DERs).*

Gross demand: *represents provincial electricity demand, including naturally-occurring conservation. Excludes impacts from conservation programs, building codes, equipment standards and embedded generation.*

Net demand: *represents gross demand along with energy and capacity savings impacts from conservation programs, building codes and equipment standards. Excludes impacts from embedded generation.*

[9] World Energy Outlook 2018

[10] https://electricity.ca/wp-content/uploads/2014/03/Vision2050.pdf

[11] https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2018/2018nrgftr-eng.pdf

THE ENERGY REVOLUTION

THE ONE-WAY ENERGY-ONLY GRID IS EVOLVING INTO A BI-DIRECTIONAL ENERGY AND IT GRID.

AS MORE PRODUCTS BECOME DIGITALIZED AND CONNECTED WITH DATA-GENERATING DEVICES, MORE DEMAND WILL BE PLACED ON ELECTRICAL GRIDS.

An energy revolution is underway. A series of overarching energy megatrends have emerged that are significantly driving the electrification movement. The Energy Revolution includes three flagship drivers: Decentralization, Digitalization and Decarbonization. The overall dynamics of these developments influence each other in a virtuous cycle.

1. Decentralization
Traditionally, electric power has flowed in one direction—from the power plant to the consumer.

Over the last few decades in Canada, several factors have challenged the conventional one-way grid model, namely: the deregulation of power companies, technical advances in renewables, and government subsidies for green power. As a result, the one-way energy-only grid is evolving into a **bi-directional energy and IT grid**.

The rise of renewables in the energy mix has created variable demand on the grid. The rise in EVs, and the accompanying innovations in batteries and charging stations, are also impacting the traditional grid.

At the same time, the global demand for electricity is swelling, largely due to rising internet access, the global proliferation of web-enabled mobile devices and power-hungry data and crypto-currency mining centres.

The next-generation interconnected grid includes consumers and other players as active elements of the system and is characterized by a rise in distributed energy generation, storage, transmission and consumption, enabled through grid-edge technologies such as microgrids, co-generation, smart meters, solar panels and wind farms.

2. Digitalization
The conversion of data into digital form now produces 2.5 quintillion bytes of data each day! This number is expected to rise with advancements in the Internet of Things (IoT) and web-enabled devices such as sensors, controls, electronics and appliances. As more products become digitalized and connected with data-generating devices, more demand will be placed on electrical grids.

At the same time, digitalization is transforming the ways in which electric utilities and related businesses operate. Generally, power grids in mature economies are aging and require replacement. As digitalization ushers in smart metering, smart sensors, automation and other digital network technologies, electrical companies must modernize and innovate.

3. Decarbonization
Climate change is at the nucleus of electrification and is increasingly becoming viewed as the defining issue of our time. Greenhouse gases in the earth's atmosphere are causing the rise of the earth's average global temperature. The United Nations' Intergovernmental Panel on Climate Change (UN IPCC) suggests we must limit temperature increases to 1.5°C per year in order to mitigate the adverse effects of global warming. Carbon dioxide makes up close to two-thirds of all GHG, mostly the product of burning fossil fuels. The UN IPCC states that global net GHG of CO_2 must fall by approximately 45% from 2010 levels by 2030. As a result, more countries are expected to transition from a fossil fuel-dominated power sector to a more sustainable system involving mainly renewable energies.

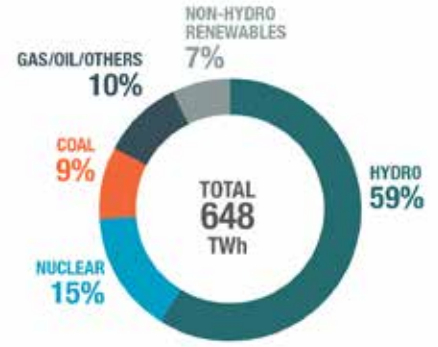
Enter…electricity. As a clean, renewable and abundant source of power, electricity will play a major role in global decarbonization efforts. Importantly, electricity from renewable sources is often available in great abundance and surplus can be stored, allowing other sectors to electrify end-use applications and decarbonize. Decentralized grids also provide expanded opportunities to different players in the electricity system.

ELECTRIFICATION WILL LOWER SYSTEM-WIDE CARBON EMISSIONS IN THE RANGE OF 20% TO 50% BY 2050

Clean Electricity in Canada

According to NEB, more than 80% of Canada's electricity is generated from non-GHG emitting sources, making Canada the second cleanest energy producer in the Organisation for Economic Co-operation and Development (OECD). No other sector in Canada has reduced GHGs more than electricity generation—it has achieved a 39% reduction since 2001.

Exhibit 5: Electricity Generation in Canada by Source, 2016



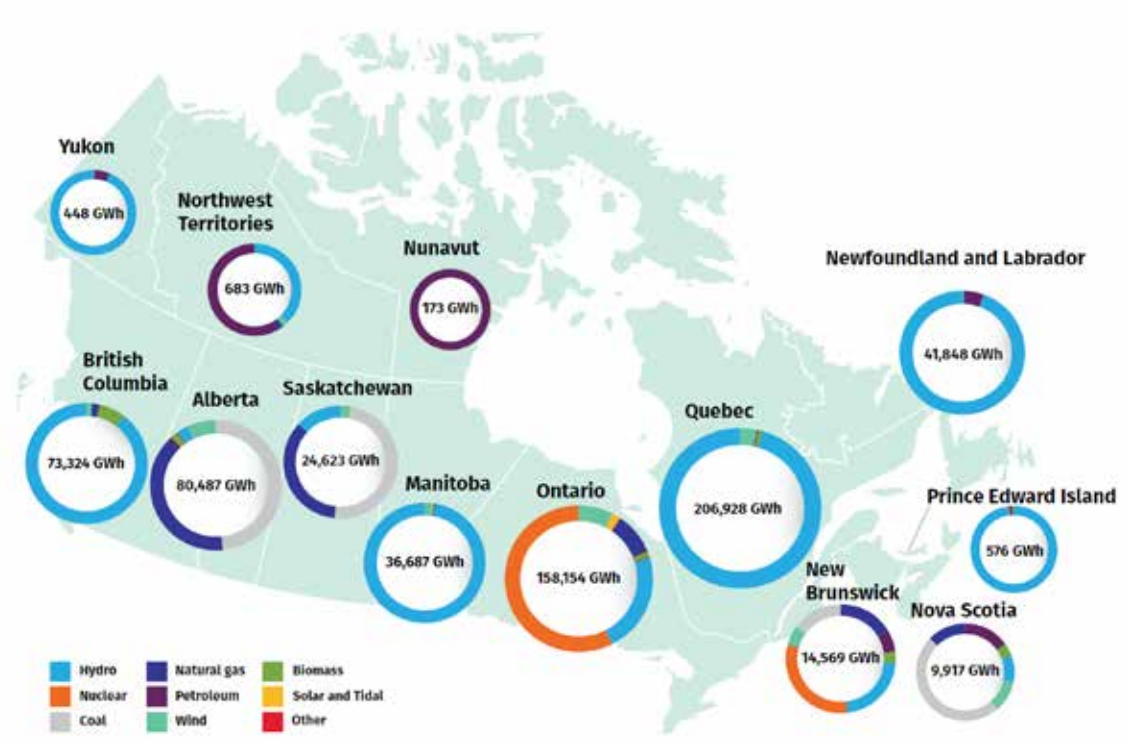
Source: NRCan
https: www.nrcan.gc.ca/energy/facts/electricity/20068

This effort is largely driven by the government's Pan-Canadian Framework on Clean Growth and Climate Change, which strives to develop a strong electricity system nationwide. Recent federal carbon tax policy includes measures such as: renewable power, EV infrastructure, expansion of clean energy to remote and rural communities, and electricity grid integration for the purpose of decarbonization.

While Canada has made significant inroads with sustainable energy generation, several jurisdictions are still reliant on fossil fuels and are facing a major transition. See Exhibit 6.

Provinces and territories will be required to implement policies to help phase out coal and diesel fuels – it is promising to know that some progress is already underway. See Exhibit 7 on the following page.

Exhibit 6: Electricity Generation by Province/Territory



Source: NRCan
https: www.electrofed.com/wp-content/uploads/2019/02/NRCan.pdf

THERE IS SIGNIFICANT POTENTIAL FOR EFFICIENT ELECTRIFICATION BY END-USE APPLICATIONS—MANY OF WHICH DIRECTLY IMPACT OUR INDUSTRY.

Interestingly, while Canada's electricity is largely emissions-free, only 20% of our actual energy use comes from electricity, according to NRCan—pointing to a significant opportunity for electrification in residential, commercial, industrial and transportation sectors. There is significant potential for efficient electrification by end-use applications—many of which directly impact our industry (e.g. heating and cooling applications that currently run on non-electrical sources).

The successful transition to end-use electrification will be evident when all of the bars in Exhibit 8 appear in blue.

Electrification in Canada is highly important to the decarbonization of these end-use applications. A study by the Electric Power Research Institute (EPRI) projects that U.S. customers will increase their reliance on electrical end uses. By 2050, electricity is expected to make up 47% of final energy, which is a measure of energy consumed across all fuel types at the end use. Cost declines and state-level policies will further drive the growth of renewables, with wind and solar increasing the most rapidly. EPRI predicts that electrification will lower system-wide carbon emissions in the range of 20% to 50% by 2050. Realizing the benefits of electrification will depend on greater investment in grid modernization and continued innovation in electric technologies to reduce costs and improve performance.[12]

Global action is progressing quickly—and Canada is stepping up its game in the movement towards electrification.

Exhibit 7: Provincial Energy Investments

Source: Natural Resources Canada

Territories collective efforts to reduce use of diesel (e.g. Old Crow solar, YK, Inuvik Wind, NWT, Iqaluit, NU)

British Columbia will make industries clean by using clean energy (e.g. electrification of gas production)

Alberta phasing out coal-fired electricity (supported with the Renewable Electricity Program)

Saskatchewan's target of 50% renewable energy generation by 2030

Manitoba's Keeyask + electricity partnership with Saskatchewan (e.g. Birtle-Tantallon line)

Ontario's storage and smart grid investments, building on coal-phase out

Quebec's electric vehicle and building efficiency initiatives

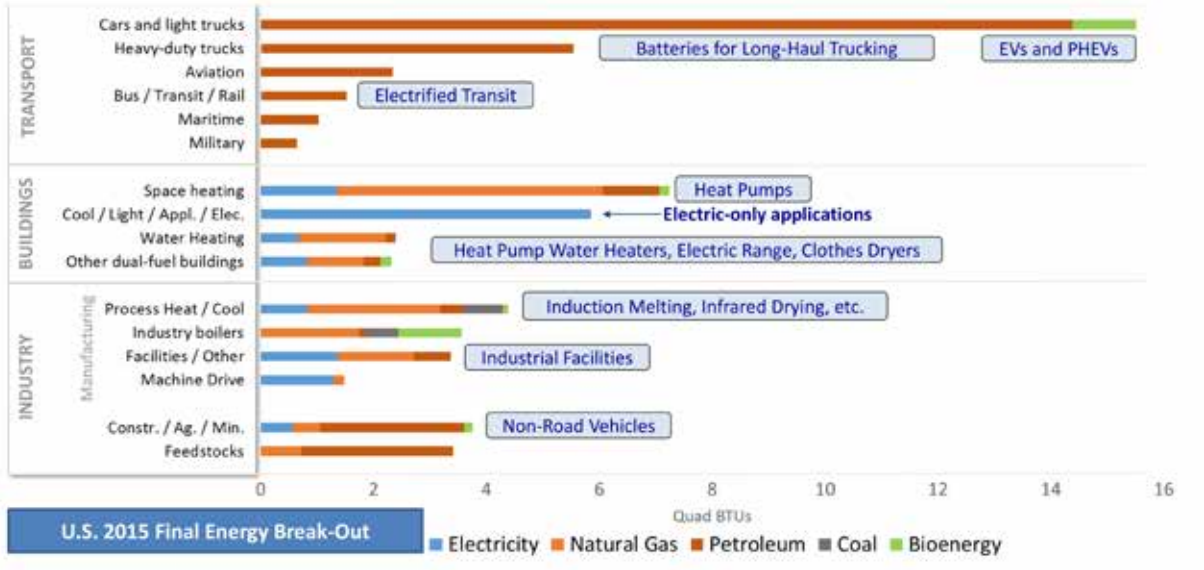
New Brunswick Smart Grid research initiative (i.e. Smart Grid Innovation Network)

Prince Edward Island's wind and distributed energy expansion

Nova Scotia's energy efficiency and renewable electricity targets

Newfoundland and Labrador's commitment to energy efficiency and clean energy at Muskrat Falls

Exhibit 8: Potential Electrification by End-use Application

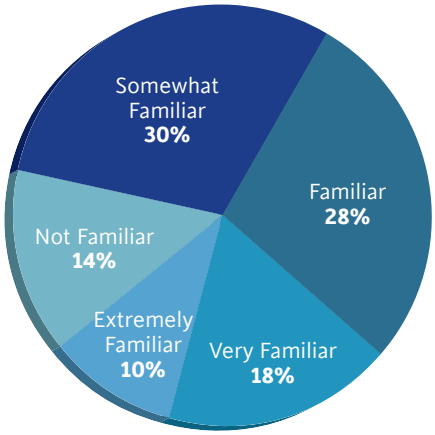


Source: Ontario Power Generation
https: www.electrofed.com/wp-content/uploads/2019/02/OPG-Presentation.pdf

[12] http://mydocs.epri.com/docs/PublicMeetingMaterials/ee/000000003002013582.pdf

INDUSTRY OPPORTUNITIES

Exhibit 9: EFC Manufacturer Survey Question: *How familiar are you with electrification and its potential impacts?*



OVER HALF OF ALL RESPONDENTS SAID THEY ARE FAMILIAR-TO-EXTREMELY FAMILIAR WITH THE POTENTIAL IMPACTS THAT ELECTRIFICATION MAY HAVE ON THEIR SEGMENT AND HAVE ENGAGED IN INTERNAL DISCUSSIONS TO ASSESS OPPORTUNITIES

Electrification is poised to dramatically shift how electricity is generated, transmitted, used and sold. Driven by a variety of economic, environmental, technological and regulatory factors, this complex global trend is reshaping electricity systems and the businesses operating in this space. The dynamics and opportunities of electrification covered in this whitepaper provide useful insights on what direction this movement is heading in, and how our industry can evolve to embrace changes during these electrifying times.

Awareness among members is strong

Before we delve into several outlined opportunities for members, it is important to take note of our industry's attitudes towards and understanding of electrification. EFC conducted a survey with manufacturer members earlier this year and collected close to 60 member company responses, representing nearly half of EFC's total manufacturer membership.

Survey responses indicated that opportunities associated with electrification are not going unnoticed. Over half of all respondents said they are familiar-to-extremely familiar with the potential impacts that electrification may have on their segment, and have engaged in internal discussions to assess opportunities. Electrification plans are in progress: 46% of those who have discussed impacts have an electrification strategy in place; 29% are in the process of developing a strategy within a year. Most of these respondents were in the following product segments: wire & cable, lighting, wiring supplies, automation & control, and transformers.

With strategies in play, let's explore some of the opportunities that members might consider in step with the electrification movement.

Gross energy demand will remain high

As we explored earlier, global energy demand is on the rise. Our national demand for energy is also expected to increase, and while this trend will differ for each province, it serves as a good measure to understand how national and provincial developments will impact your business.

Currently, only 20% of Canada's energy use comes from electricity—and we know that Canada's electricity grid is one of the cleanest in the world. The movement towards electrification will result in the increased reliance on electricity to power cars, homes and businesses.

Our industry has an opportunity to introduce new products and services to the market for a range of electrification applications; we can elevate traditional offerings such as wire and cable, lighting, transformers, distribution equipment, automation products and other product segments, to support the development of smart cities, intelligent buildings, Industry 4.0, data centres and indoor farming.

e-Mobility is also a growing sector for our market due to the projected expansion of EVs and the advancement of battery storage technology. In fact, 86% of EFC manufacturer members who took part in the industry survey, believe that Transportation will be the segment most impacted by electrification. Demand will rise for products such as batteries, wire, plugs, receptacles, connectors, feeder circuits, power-conversion equipment, socket outlets, couplers and submeters.

Industry members and smart products to assist in net energy demand reductions

One of the key contributors to the falling net demand for electricity, is the adoption of smart, energy-efficient products in all markets. Our industry has made significant inroads in producing leading-edge products such as LED lighting, sensors and controls, automation equipment and others, that heighten energy savings.

MODERNIZING THE GRID IS ESSENTIAL. MANY ELECTRICAL SYSTEMS USED IN GRID INFRASTRUCTURES TODAY ARE APPROACHING, AND EVEN EXCEEDING, THE END OF THEIR USEFUL 25-TO-40-YEAR SERVICE LIFE.

Supplying the 'next-generation grid'

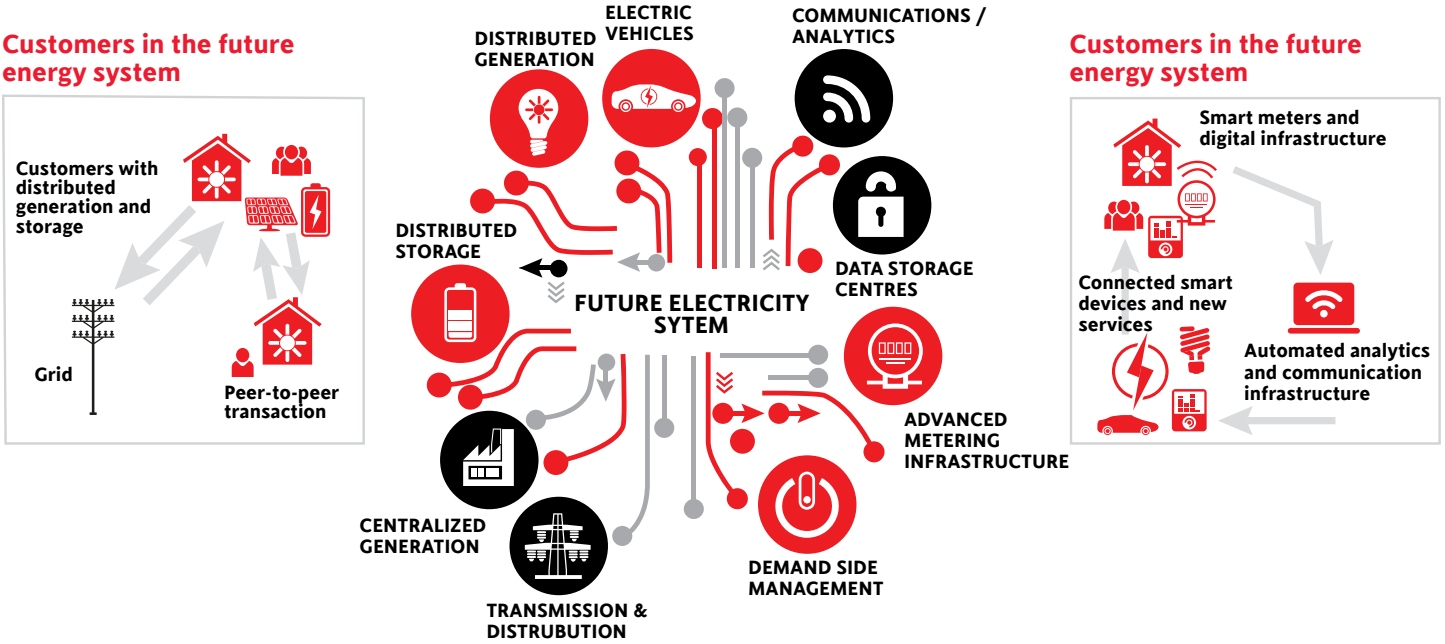
Within the energy sector, utilities are searching for ways to decentralize how power is generated, transmitted and distributed. Our industry plays an important role in this realm—our products support grid development for capacity requirements. Many electrical systems employed in grid infrastructures today are approaching, and even exceeding, the end of their useful 25-to-40-year service life. Modernizing the grid is essential to support new demands for flexibility and performance. CEA forecasts that capital expenditures in new electrical infrastructures are to exceed $350 billion over the next 20 years, and total North American expenditures are forecasted at ten times that amount.[13]

Investments in new electricity systems, particularly in renewable technologies such as solar, wind, geothermal and battery storage, are providing new avenues for consumers to produce, consume, store and share electricity.

Exhibit 10 offers an overview of the varying degrees of innovation our market can help serve.

At the EFC-CEA Electri-*fyi* Summit, participants discussed how advancements in new technologies, and the compatibility between them, are leading to the emergence of a new subset of consumers known as "Prosumers", spurring a phenomenon known as 'energy interdependence' within communities. As a result, consumers are engaging in a 'transactive energy' culture, in which they will produce their own electricity using renewable resources, consume what is required, and then store and share/sell excessive electricity back to the grid or to fellow community members. This model offers consumers greater control over greener choices for their energy systems and promotes self-sufficiency – a key factor that could open up clean electricity access to remote and northern communities in Canada.[14]

Exhibit 10: The Future of Electricity - New Technologies Transforming the Grid



[13] Canadian Electricity Association (CEA), Electric Utility Innovation: Toward Vision 2050, 2015: https://cea-ksiu6qbsd.netdna-ssl.com/wp-content/uploads/2017/05/ElectricUtilityInnovation-2.pdf

[14] NRCan estimates that 200+ remote communities remain heavily reliant on diesel-powered generators (NRCan's Remote Communities Database, 2017, Renewable Energy and Electricity Division, Ottawa).

The new infrastructure must support a more energy-efficient and customer-centric framework. This is an opportunity for electrical manufacturers and distributors to heighten collaborative efforts with utilities, so that together, we can return to the drawing board to map out a reliable, scalable electricity system that will keep pace with changing times.

As the role of the consumer expands, the future electricity system will also need to evolve to support an automated and analytical infrastructure for distributed generation and storage, demand side management, electric transportation and other key services. Designers, engineers, manufacturers, distributors and allies will see tremendous opportunities. WEForum estimates that electrification, combined with the decentralization and digitalization of energy, will create more than $2.4 trillion of economic value in 10 years.[15]

With the impending advancement of electrification in urban and rural communities, and the economic benefits of an electrified infrastructure, projections for energy demand and consumption continue to be closely monitored by analysts to ensure our electricity system remains reliable, scalable and green. Our industry is a major player in attaining these goals.

FUTURE PATHWAYS: A LOOK AT FOUR SCENARIOS

The electrification topic is vast and covers a wide range of possibilities. Industry partners came together at the Electri-*fyi* Summit for an exploratory discussion about four distinctly-different paths for the future of electrification in Canada, developed by the Canadian Electricity Association's National Emerging Issues Committee. The scenarios are not predictions; rather, they are situations that are designed to explore a wide range of potential outcomes and opportunities – and may be used as a framework for members to evaluate their strategic priorities in light of future electricity requirements.

Electrification Scenarios

1. **Off the grid:** Consumers self-generate energy in a safe, reliable, cost-effective manner with distributed energy technologies.
2. **Closer to home:** Distributed energy technologies are advancing and transforming consumers' electricity systems, which are part of a value proposition offered by new market entrants and utilities.
3. **Green electricity system with large-scale renewables:** a low-cost, green electricity system emerges based on large-scale renewables and storage, along with innovations in advanced information technology.
4. **Power to the nation:** the federal government introduces a Canadian energy strategy that emphasizes electrification and the creation of an integrated national electricity grid.

The group discussions of these scenarios led to compelling insights on the key considerations, obstacles and enablers of electrification in Canada. To learn more, see Appendix for group notes from the Summit.

You are encouraged to review the scenarios and map out how your organization might be impacted and seek opportunities from the plausible scenarios. The mapping of Canada's electricity system is taking shape—we have an opportunity to reimagine our energy infrastructure and to pave a path for our industry to be a more significant player in this space.

Off the grid

Closer to home

Large-scale renewables

Power to the nation

[15] The Future of Electricity: New Technologies Transforming the Grid Edge: http://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf

APPENDIX

ELECTRO FEDERATION CANADA EFC

Scenario 1: Off the Grid

Picture This: Energy-conscious customers are self-generating energy in a safe, reliable and cost-effective manner with distributed energy technologies. These users are, at times, outraged as utilities fail to adapt to their new competitive environment. Utilities fail to provide value-added services to customers and fail to facilitate the transition among customers, partners and others. In the face of angry ratepayers – and voters – governments elect to sideline utilities and accelerate the transition through pro-distributed-energy and climate policies. With a number of additional technology shifts, utilities find themselves left behind with stranded assets and a mess of financial, regulatory and legal issues.

Strategic Issues: This scenario addresses what could drive a very rapid increase in distributed energy and the migration of customers to move off grid. A rapid increase in self-generated energy could severely undermine the existing role of the grid and the long-term sustainability of traditional utilities. No more discussion required for the billions needed to replace aging infrastructure, as it's no longer needed. Utilities have been through a perfect storm and have been relegated to playing the role of supplier of last resort.

Recap:

- Steep changes in distributed energy technologies
- Customers are engaged in energy issues, and are, at times, enraged as utilities fail to adapt, fail to provide value-added services to customers and fail to facilitate the transition among customers, partners and others
- Governments sideline utilities and accelerate the transition through pro-distributed-energy and climate policy
- Additional shifts in technology leave the utilities behind with stranded assets and a mess of financial, regulatory and legal issues
- A rapid increase in self-generated energy could severely undermine the existing role of the grid and the long-term sustainability of traditional utilities

1. What customer behaviours will be required to drive the widespread adoption of this scenario? **What barriers could prevent the behavioural shifts from happening?**	• Energy users – anger, dissatisfaction with current system • New system will need to address key challenges/pains – and build consumer confidence • Willingness to invest the time to install/deploy/learn (knowledge) and money for cost for equipment • Drive to build a sense of community and responsibility • Complexity of systems could cause reliability concerns and drive adoption down • Product availability will be paramount • Cost uncertainties • Access to reliable channel of installers, service technicians
2. Within this scenario, how will technology impact the following: **a. Product requirements? (new and existing)** **b. Grid requirements? (generation, distribution, transmission)**	• Cost-effective, simple, reliable, integrated solutions required A. High-capacity generation required – DC products, batteries/energy storage – Redundancy of solar, wind, energy storage systems – Scalable grids (micro, nano) B. Bi-directional – Sharing network – Some distribution wires – No transmission lines required
3. What new services/channels will be required to support this scenario? What gaps exist today that new entrants might fill?	• Energy broker/facilitator • Integrator • Energy-trading platform • Energy consultants to recommend system • Private maintenance/repair technicians – capital investment • Insurance (new business streams) • Recycling batteries
4. What are the economic/ price barriers to this scenario?	• Reasonable payback – for residents (costs must be less than they currently pay); businesses (less than three years' ROI) • How will it affect the resale value of homes?
5. What government regulations will need to be in place for this scenario to be effective? (short term, long term)	• Allow individuals to resell unused electricity to community (breakdown of monopolies) – regulations for this process • Standards for equipment, safety, application/installation and power quality • Pricing standards (including for peer-to-peer rates)
6. What are some early signs of adoption we should see to indicate this scenario is progressing?	• Increased sales of DER products • Decreased electricity demand – decreased reliance on utilities • Onset of new trades/channel players: energy broker/facilitator, integrator, consultants • Builders adding new communities

Scenario 2: Closer to Home

Picture This: Emerging technologies are providing energy-conscious consumers with new options, while forcing markets to adapt to change in order to remain competitive with new entrants. Specifically, distributed energy technologies (e.g. energy storage/ batteries, solar panels, etc.) are advancing and transforming consumers' electricity systems – these technologies are part of a value proposition offered to consumers by new market entrants and utilities.

Strategic Issues: This scenario looks at the impacts and opportunities that may arise if a greater degree of customer control and autonomy are achieved in a dynamic, market-driven world, where utilities act as 'system orchestrators' – connecting smart competitors, smart customers and an array of smart and sustainable energy products and services. If utilities are able to adapt, the grid is not only sustained, it plays a central role in supporting the transition to distributed energy.

Recap:

- Distributed technology-based value propositions offered by new market entrants and utilities
- Technology creates customer options and forces utilities to adapt
- Existing utility systems and expertise are leveraged to help deliver solutions
- Policy and regulation support a smooth, manageable transition to this scenario, ensuring the overall safety and protection of consumers
- Utilities adapt, compete and act as system orchestrators to deliver sustainable solutions

1. What customer behaviours will be required to drive the widespread adoption of this scenario? **What barriers could prevent the behavioural shifts from happening?**	• Main driver will be the cost/benefit proposition for the consumer – the ROI needs to be appealing; this will be based primarily on financial costs, but will include the value society places on 'quality of life' benefits, i.e. climate, air and water quality • Perception of reliability. As an example, we have a lot of history and comfort with the lifecycle of a traditional fossil-fueled vehicle. There is a not enough evidence and history yet to have the same comfort level with an EV. • Consumer comfort. Consumers have different tolerance levels with respect to change and its perceived inherent risks. As an example, being on the grid today is comfortable. It is reliable and service issues and outages are addressed promptly by the utilities. Moving off the grid provides unknowns for the consumer with respect to quality of power and predictability of support when service issues occur. • There needs to be a fair pricing structure. Consumers cannot be disadvantaged due to the region they reside in, or the level and speed of adoption by the market. • There will be a challenge for utilities to continue their service level for existing customers and to support the infrastructure with a portion of their revenue stream lost due to customers opting out.
2. Within this scenario, how will technology impact the following: **a. Product requirements? (new and existing)** **b. Grid requirements? (generation, distribution, transmission)**	• Storage technology will need to continue to advance • The consumer needs access to storage. Availability needs be on a flexible scale based on usage needs – both daily and seasonally. • The grid will require power quality standards with multiple services accessing and manage potential issues like harmonics. • There will be interconnection challenges to the grid.
3. What new services/channels will be required to support this scenario? What gaps exist today that new entrants might fill?	• Management tools to communicate between providers to provide real-time buying and selling of power instantaneously – an energy "stock market" • Service requirement for consumers and facilities (residential and commercial) to jump on and off the grid. An example is a new home owner who buys an off-grid home and wants to connect, or vice versa. • Creation of connection service providers for consumers to access or get removed from the grid. • A challenge will be for the utility to compete against new service providers with potentially reduced revenue due to client decline and continue its obligation to support the current network.
4. What are the economic/ price barriers to this scenario?	• Supporting current infrastructure with less revenue due to clients opting out for alternative energy sources and services • There needs to be a high return on investment value for service providers to build networks, products and services • There needs to be a high return on investment value for consumers to opt in • Government incentives to seed infrastructure investment and product purchases (EV car incentives in B.C. and Quebec would be a current example)
5. What government regulations will need to be in place for this scenario to be effective? (short term, long term)	• Regulations for trading power for consumers and service providers • Municipal requirements for infrastructure (e.g. building code requiring a percentage of new parking spots that are EV charging-enabled) • Rules regarding the quality of power fed into the grid from different sources • Regulations for entering and exiting connection to the grid
6. What are some early signs of adoption we should see to indicate this scenario is progressing?	• Decreased consumption on the grid • "Visual" – more EV stations, solar panels, wind turbines, etc. • Change in the number of customers for the utility • Equipment pricing trends – adoption will decrease equipment costs based on economies of scale and competition

Scenario 3: Building a Green Electricity System with Large-scale Renewables

Picture This: A low-cost, green electricity system emerges based on large-scale renewables and storage, along with innovations in advanced information technology. Dispatchable power from renewables undercuts both natural gas and distributed energy in economic terms, while maintaining efficiency, reliability and stability. Customers have choices and place high value on price and reliability in this market-driven world – a world that is politically, economically and environmentally sustainable with supportive customers, low and stable power costs, and declining GHG emissions. The growth of renewables and the electrification of transportation support policies to reduce emissions. Some jurisdictions will rely on baseload nuclear and hydro to underpin their zero-emitting electric systems that will be used to electrify the broader economy.

Strategic Issues: This scenario addresses the question of whether there is a sustainable role for the traditional, large-scale grid. Can a push to large-scale renewables along with economic storage provide low-cost, reliable power that can compete with distributed energy and reinforce the central role of the grid?

Recap:

- Market economics drive change
- Large-scale renewables become increasingly cost competitive
- Advances in large-scale battery storage technology makes renewables dispatchable, which displaces natural gas and coal
- Renewed customer trust: cost, reliability and convenience
- Roof-top solar fades: hassle and cost, the elimination of subsidies
- Low-cost green grid emerges that is politically, economically and environmentally sustainable

1. What customer behaviours will be required to drive the widespread adoption of this scenario? **What barriers could prevent the behavioural shifts from happening?**	• **End User:** cost of energy • **People:** older people do not care about where the energy comes from, but younger people (under 30) do – Demographics matter with adoption • Social responsibility by manufacturers and voters will affect behaviour • Barriers: – Storage technology doesn't exist today (limited, if any) – Political uncertainty and incentives from government will not be around when needed – will not last • NIMBYism
2. Within this scenario, how will technology impact the following: **a. Product requirements? (new and existing)** **b. Grid requirements? (generation, distribution, transmission)**	• **Product Requirements:** standardization from manufacturers is important for adoption and currently there is no feasible storage technology • **Grid Requirements:** – Weather resiliency and decentralization for consistent service is needed (e.g. ice storms) – Do we have enough grid interconnectivity? – Utilities have great potential to work together rather than build silos
3. What new services/channels will be required to support this scenario? What gaps exist today that new entrants might fill?	• Channels currently exist (Ontario-centric) • Gap in new technology – storage • Possible opportunity for Integrator services to bridge storage and generation
4. What are the economic/ price barriers to this scenario?	• Overall cost or impact on KWh. Is it feasible? • **Stranded assets:** abandon existing infrastructure before life cycle is over. – Transmission costs for infrastructure were high – possible time to consider change to DC power grid? • **Grid defection:** new technologies and services could remove power generation from the grid altogether (i.e. Suncor removes its co-generation plants to supply its own plant and not public infrastructure. Result is loss of provincial revenue for utilities)
5. What government regulations will need to be in place for this scenario to be effective? (short term, long term)	• Competitiveness in long and short term (government) • Changing government policies (new ideas with every election) • Other countries' regulation impacts – globalization
6. What are some early signs of adoption we should see to indicate this scenario is progressing?	• We are already adopting this strategy today – (e.g. windfarms) • Missing large-scale storage technology • Investment in large-scale storage technology could be a positive sign or indicator • New players in the market due to low cost of green power (e.g. Budweiser and data centres) • Uptake in electrical vehicles + trains + infrastructure could be an early sign post

Scenario 4: Power to the Nation

Picture This: A merging of national issues supports policy intervention, leading to a Canadian Energy Strategy that emphasizes Electrification and the creation of an integrated national electricity grid. The emerging integrated network of networks supports social, Indigenous, environmental and economic objectives. Strategically-distributed facilities create opportunities for Indigenous communities. Low-cost green renewables support environmental objectives. Greenhouse gas (GHG) emissions are in decline. Low-cost electricity enhances growth through investment and competitiveness for a range of industries that are energy or transportation intensive. The push to Electrification supports the penetration of electric vehicles, and the emergence of the national grid allows the efficient integration of renewable energy into the portfolio of generation in the system.

Key Strategic Issues: This scenario addresses the question of whether there might be a path toward national Electrification and the development of a national electricity grid to support an array of social, environmental, economic and political objectives.

Recap:

- Policy decisions drive change
- Convergence of social, Indigenous, environmental and economic issues create support for market intervention
- Canadian Energy Strategy drives electrification and the development of an integrated national grid that matching renewables with hydro storage
- Large-scale, low-cost renewables dominate new generation
- Build out of national grid supports social, Indigenous, environmental and economic objectives

1. What customer behaviours will be required to drive the widespread adoption of this scenario? **What barriers could prevent the behavioural shifts from happening?**	• Consumers taking advantage of government incentive programs (solar, EVs, energy storage) • Affordability and cost certainty drive installation uptake in urban and rural areas (access to all) • High trust in federal government among consumers • With federal government driving programs, pushback from provincial jurisdictions can be expected – could lead to confusion among consumers • Without a strong carbon tax policy defined, consumers could push back on implementation
2. Within this scenario, how will technology impact the following: **a. Product requirements? (new and existing)** **b. Grid requirements? (generation, distribution, transmission)**	• Technology already exists – but access to it is limited, it's varied, and largely inoperable with other systems • Government required to have one solution that controls the national system for all consumers (national system operator) • Heightened needs for energy storage/batteries, wire and cable (wireless systems?), solar, thermal, controls/sensors • One solution needed to integrate systems • Infrastructure upgrades required: transformers, utility distribution equipment, wire and cable • Funding for efficiency in operations • Capital cost
3. What new services/channels will be required to support this scenario? What gaps exist today that new entrants might fill?	• Requires an amalgamation or re-mapping of all provinces – what is their role in this federal system, if any? • Who will supply generation, transmission and distribution (one super utility?) • How will the federal government support funding end-to-end generation and transmission? • If the goal is to reduce carbon footprint, we only need generation and transmission (distribution can remain within each province via utilities or private entities)
4. What are the economic/ price barriers to this scenario?	• The ultimate goal would be to balance pricing for all Canadians (fairness, equity) • How will infrastructure spend be allocated? Split nationally? • Provincial ROI (how do you compensate those provinces who have already invested in infrastructure – as other provinces allocated funds to 'catch up'?) • If the playing field is levelled, what happens to market competitiveness (attracting business investors to locate in a province) – will Ontario lose business?
5. What government regulations will need to be in place for this scenario to be effective? (short term, long term)	• One holistic regulation is required for a federal system – for generation, transmission, distribution, safety • How will provinces be regulated? Is there a role within provinces; if so, how will they be compensated?
6. What are some early signs of adoption we should see to indicate this scenario is progressing?	• Carbon tax (justification of eliminating GHG emissions) – the onset of a natural disaster could speed up a federal ruling • Ontarians and those in other provinces that pay high costs for electricity, begin seeing a drop in cost (Québécois and others begin seeing an increase?) – levelling the playing field – Public revolt over pricing and reliability • Regulations and standards in discussion and begin to be set – feds begin working more closely with provinces (east-west) and less closely with U.S. partners (north-south) • Pilot programs begin to play out (between two provinces to begin with) • Private engagement by different companies in other provinces (private investments) Probability of this Scenario: • Within the next ten years: 0-5% • 10-20 years: 20-50%

Special acknowledgements:
EFC thanks the following industry representatives for supporting the development of this whitepaper and for joining us on this important journey as we explore the promising future that electrification will bring to our nation and to the global arena.

Francis Bradley, Stephen Koch and Julia Muggeridge - *Canadian Electricity Association*
Eric Deschenes and Stephanie Medeiros - *ABB Canada*
Mike Risavy, *Independent Electricity System Operator*
Ron Groves, P*lug'n Drive*
Andrea Brown, *Ontario Power Generation*
Marco Presutti, *Natural Resources Canada*
Sharon Aschaiek, *Higher Ed Communications*

EFC Research Committee members:
Youri Cupidon, *Convectair*
Helene Vaillancourt, *CSA Group*
Jean-Sebastien Bercier, *Desdowd*
Umesh Patel, *Eaton*
Shelly Vaz, *Eaton*
John Kerr, *Kerrwil*
Barbara Tracey, *Leviton Canada*
Ali Julazadeh, *Mersen*
Dave Klarer, *NCS Int'l*
Cara Clairman, *Plug'n Drive*
Dorothy Tully-Petersen, *Priority Wire*
Gary Pounder, *Premise*
Stephane Lettre, *Stelpro*
Josh Cherun, *S&C Electric*
Frances Chan, *Siemens*
Tom Mason, *Sonepar*

ELECTRO FEDERATION CANADA EFC

About Electro-Federation Canada
Electro-Federation Canada (EFC) is a national, not-for-profit industry association that represents over 220 member companies that manufacture, distribute, market and sell a wide range of electrical products. EFC members contribute over $10B to the Canadian economy and employ 40,000 workers in more than 1,200 facilities across the country. EFC empowers the industry with market intelligence, professional development and a voice for advocacy and standards advancement within a safe, collaborative environment. For more information, visit www.electrofed.com.