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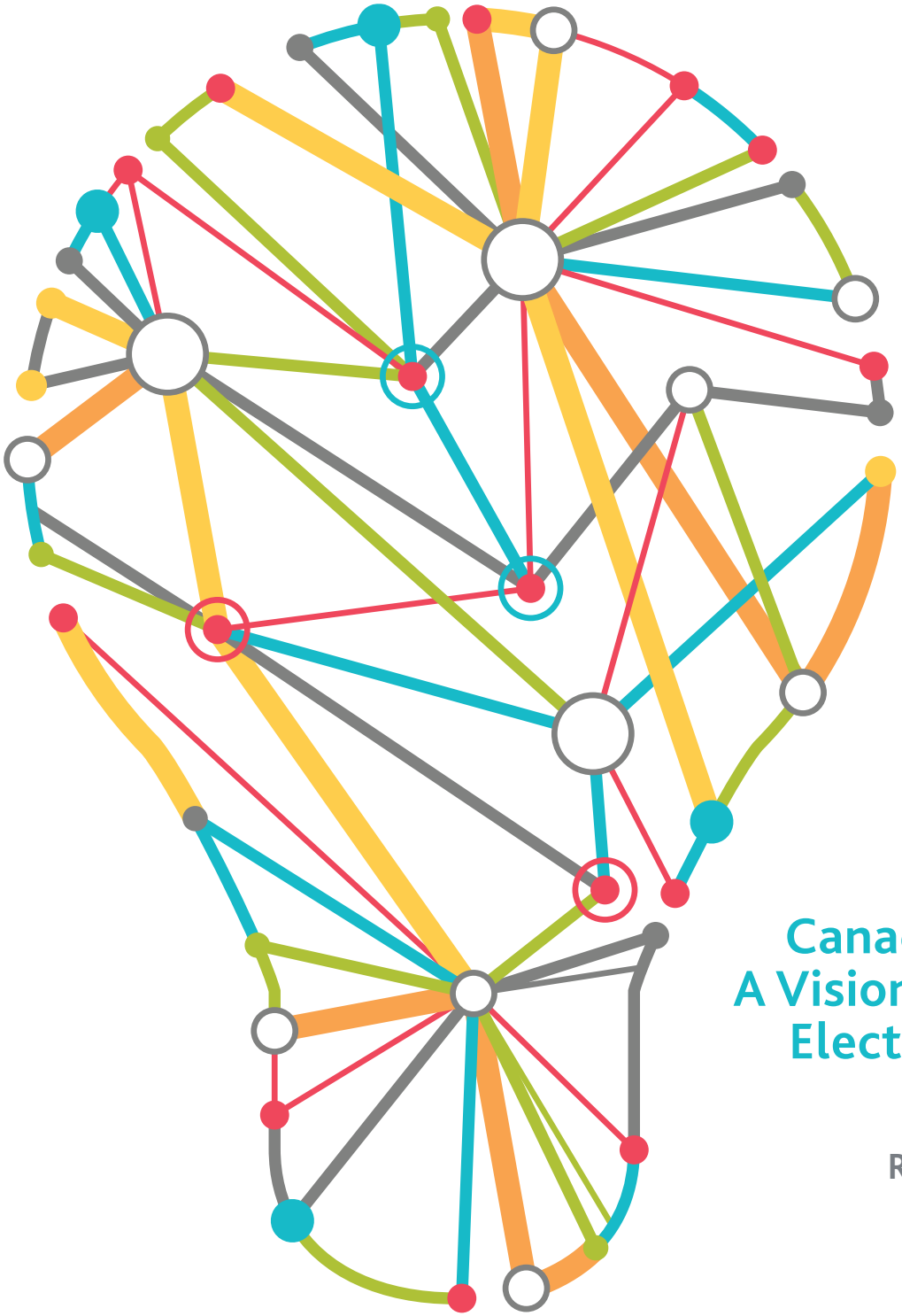

Canada's Advantage: A Vision for Renewable Electricity in Canada

Canadian Council on Renewable Electricity

November 2016

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ABOUT

The Canadian Council on Renewable Electricity educates and engages Canadians about the opportunity to expand the production and use of renewable electricity across the country. The Council works to build public support for increased development of our abundant renewable electricity resources in order to further decarbonize North America's energy system. The founding members of the Council are the Canadian Hydropower Association, Canadian Solar Industries Association, Canadian Wind Energy Association, and Marine Renewables Canada. To learn more, visit www.renewableelectricity.ca.

Acknowledgements

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Canada is a global leader in using renewable electricity to power our homes, businesses and economy. With more than 65 per cent of our electricity coming from renewable energy, we are a leader amongst the G7 group of countries.

Executive Summary

In this document, the Canadian Council on Renewable Electricity outlines its vision for the future of renewable electricity in Canada.

The successful Paris climate change negotiations in December 2015 marked a turning point: the world is committed to addressing climate change. Canada has set a target of reducing economy-wide emissions by 30 per cent below 2005 levels by 2030, and it also recognizes scientific findings that global reductions of at least 80 per cent will be required by 2050 to limit climate change. Achieving such deep reductions in Canada will not be easy, especially given significant emissions from its transportation and oil sectors. Such a transition will require a combination of decisive early action as well as enduring and widespread support from ordinary Canadians to maintain momentum. We will need an unprecedented level of cooperation across sectors and governments while maintaining the integrity of our federal system and the role of the provinces, territories and First Nations and Indigenous communities.

Yet this new global resolve to address climate change also presents very significant opportunities for Canada–both at home and abroad. Canada has a relatively clean electricity system, with 80 per cent of its electricity generated from non-emitting sources–including 65 per cent from renewable energy. Our clean electricity resources can provide the foundation both for needed emission reductions and economic growth.

An early embrace of this opportunity offers clear advantages. First, much of Canada's electricity infrastructure is aging, and so is in need of replacement in any case. Second, early action can provide Canada with valuable lessons that it can leverage to assist other countries who will be facing similar challenges. As a large country with diverse geographical needs and resources, Canada can become a leader in clean technology, upstream and downstream electricity storage, the smart grid, and the broader electrification of the economy. Not only will we be able to provide clean electricity to assist the United States in achieving its own targets, we will also be able to export our technology and services throughout the world.

Modeling work and analysis from the Deep Decarbonization Pathways Project (DDPP) finds that economy-wide reductions of 30-50 per cent (compared to the 2005 baseline) are achievable with current technologies, such as energy efficiency measures, clean electricity, and switching from fossil fuels to clean power for buildings—provided implementation begins immediately. But reductions beyond 50 per cent, in contrast, would require substantial innovation to enable large scale adoption of electrification technologies in sectors where electricity has not traditionally played a major role, such as heavy transport, oil and gas and various industries. Put differently, for Canada to achieve its greenhouse gas (GHG) reduction targets, we will need to make our electricity system even cleaner–eventually achieving 100 per cent non-emitting electricity–while also expanding power generation to support the electrification of the economy, notably in transportation, industry and buildings.

In order to achieve a largely decarbonized economy and capture the substantial associated advantages, we recommend that Canada take action in the following three areas:

1. **Aim for a zero-carbon electricity grid by 2050.** Implement policies to ensure the phase-out of practically all emitting generation sources by 2050 and the sustained growth of the share of generation produced by renewable sources.

2. **An electrified economy.** The federal, provincial and territorial governments should commit to increasing the use of electricity in our energy system to over 50 per cent of all energy used in Canada by 2050. Aim for 100 per cent zero carbon buildings by 2050, set ambitious targets for the electrification of transportation and strongly support the electrification of industry through research and development (R&D) support, subsidies and regulation.

3. **A renewable energy export strategy.** Federal, provincial and territorial governments should prioritize the development of a renewable energy export strategy, including work on streamlining of cross-border transmission projects, and removal of any policy barriers.

Our clean electricity resources can provide the foundation both for needed emission reductions and economic growth.

Introduction

The Council's first publication, Powering Climate Prosperity (2015), called for three forms of action to support climate change mitigation: energy efficiency, clean electricity generation, and broad electrification. Building on this earlier work, this document advances a vision for the future of renewable electricity in Canada.[1]

In the pages to follow we detail the growing importance of renewable electricity, discuss key trends in electricity and energy in Canada and globally, and illustrate how Canada has distinct advantages and opportunities related to renewable electricity. We also offer recommendations for policy makers.

1 ENERGY EFFICIENCY

2 CLEAN ELECTRICITY GENERATION

3 BROAD ELECTRIFICATION

Canada has distinct advantages and opportunities related to renewable electricity.

[1] In this report, renewable electricity is understood to include any source of electricity that is naturally replenished. In particular, renewable electricity sources include wind, solar, marine, hydroelectric power (of all sizes), geothermal, and biomass.

I. Canada's Energy System: What Path to 2050?

Canada's energy system encompasses the production of all forms of energy, its transportation, transformation, storage, and use. It includes, for example, the extraction of oil and its transportation and refining to produce gasoline for the engines of our cars. The power plants and power lines that produce and transport electricity from renewable resources like water, wind or the sun and non-renewable resources like fossil fuels (coal, oil or natural gas) are important components of our power system.

The energy needed to run Canada's economy—to heat and light our homes and businesses, transport people and goods by road, rail, air and sea, and to power our manufacturing plants—is still largely coming from fossil fuels. In fact, fossil fuels represent approximately 80 per cent of all the energy used in Canada[2] and are the main source of greenhouse gas (GHG) emissions. Primary electricity (renewables and nuclear) represents the majority of the remaining 20 per cent of the energy used in Canada, and does not produce GHG emissions[3].

As we will see in this report, in order for Canada to achieve its GHG emissions reduction targets our country needs to reduce the role of fossil fuels in all sectors of our economy. We must decarbonize the electricity sector by strongly growing electricity generation from non-emitting sources of electricity while progressively retiring high-emitting power plants. In the other sectors, we must make a sustained effort to replace fossil fuels with clean electricity as the main source of energy; in other words, we need to electrify the economy with clean and renewable electricity.

In the coming decades, in the absence of new policy measures (i.e. in a business-as-usual scenario), Canada's energy system will continue to increase the quantity of fossil fuels used and associated GHG emissions. Alternatively, if we are serious about achieving GHG emission reductions, new policy measures will be needed to drive increased energy efficiency, accelerated electrification of the economy, strong growth of renewable power generation, reduced use of fossil fuels and reduced GHG emissions.

[2] Percentage of final energy use, based on 2013 revised data from Statistics Canada Table 2.1 in publication 57-003.

[3] Electricity produced using the power of water, wind or sun is considered to be a primary source of energy because it does not need any fossil fuel to be generated.


In order for Canada to achieve its GHG emissions reduction targets our country needs to reduce the role of fossil fuels in all sectors of our economy.

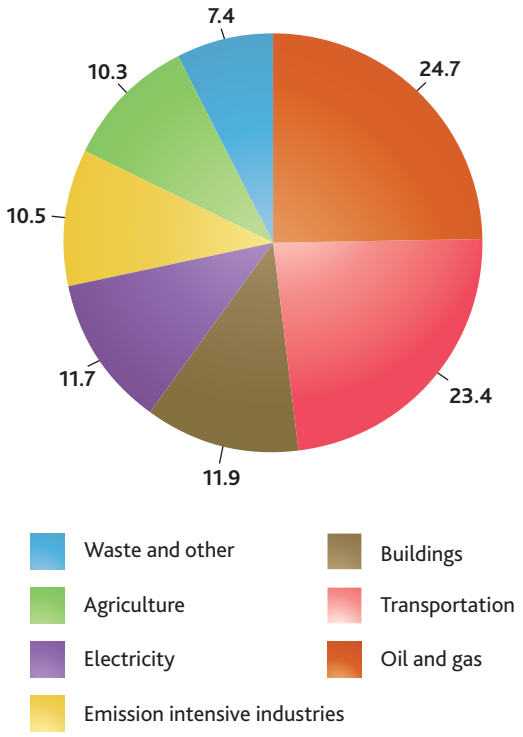
To understand these two potential future paths for Canada, we need to consider three things: the current energy mix, how business as usual will lead to increased GHG emissions, and the scenarios and factors that will lead to decarbonization in the alternative – including the recent encouraging momentum towards decarbonization. These considerations and factors will clarify the stakes and the choice that is before us as a country.

A. NOTABLE FEATURES OF CANADA'S ENERGY MIX

As mentioned above, the energy used in Canada is still dominated by fossil fuels. Our country is also a very large producer and exporter of fossil fuels. More specifically, Canada has the world's third largest proven oil reserves–97 per cent of which are in the oil sands–and the world's 15th largest proven natural gas and coal reserves.[4] It takes a lot of energy to extract and refine Canada's hydrocarbons and these activities cause significant GHG emissions. Only a fraction of these emissions is attributable to the oil and gas we use in Canada: the rest corresponds to the emissions produced by the extraction, processing and transportation of the oil and gas that Canada exports. As a result of the large size of Canada's oil and gas industry, this sector produces nearly 25 per cent of Canada's total GHG emissions. The second largest sector in terms of emissions, transportation, is responsible for 23 per cent of the total. Buildings (heating) and electricity generation each produce approximately 12 per cent of the total (Figure 1).

In contrast to the overall energy system, Canada's current electricity generation mix is relatively clean, with 80 per cent of electricity generated from non-emitting resources, including 65 per cent from renewables, of which hydropower is responsible for approximately 60 per cent of the total.[5] Canada also has vast undeveloped hydropower, wind, solar and marine energy resources in all regions of the country, making it possible to greatly increase clean power generation to support the rapid electrification of the economy.

Figure 1: GHG emissions by Sector of the Economy (per cent)



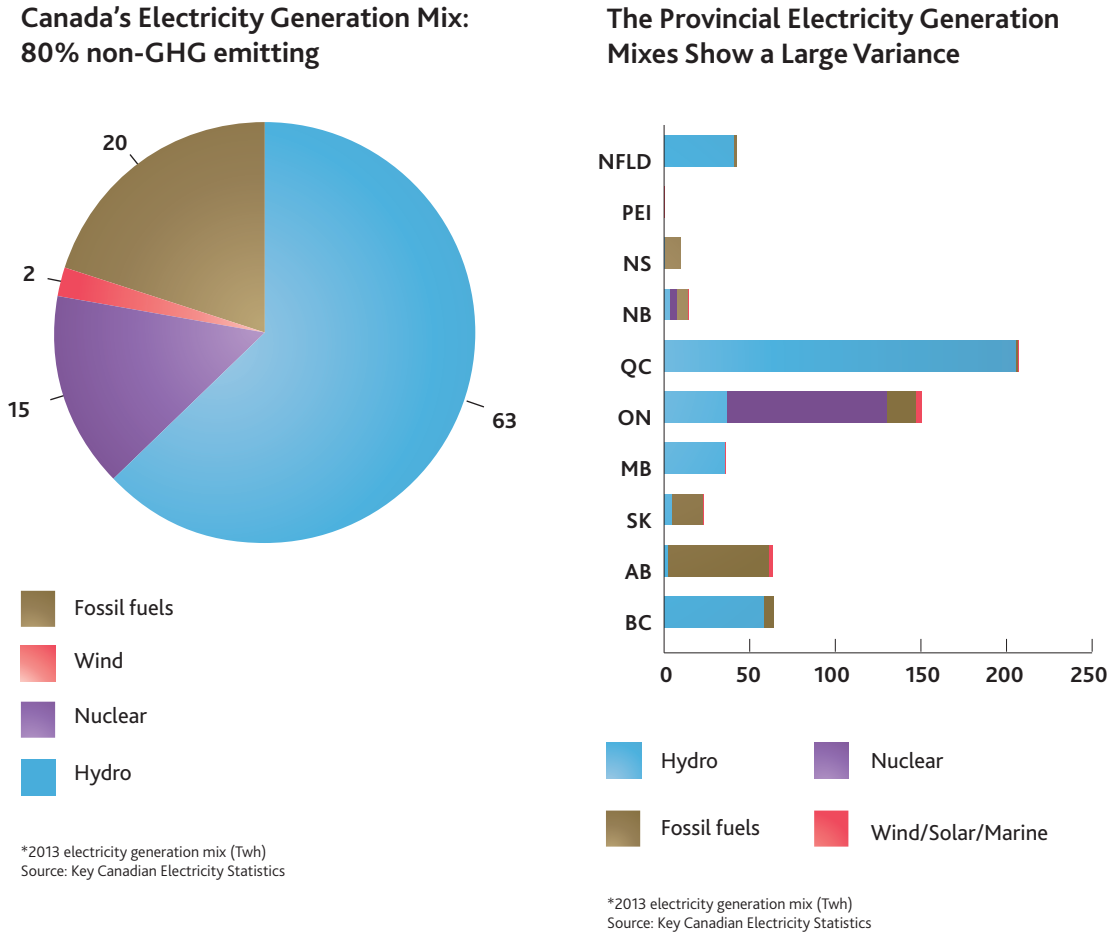
*2013 GHG emissions
Source: Environment Canada

[4] "Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040," National Energy Review Board, January 2016 (report summarized on webpage): http://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016/index-eng.html#fn5.

[5] These are rounded numbers. See: http://www.nrcan.gc.ca/energy/electricity-infrastructure/about-electricity/7359.

In the United States, by contrast, roughly one-third of electricity is from non-emitting sources, mostly nuclear.[6] The United States also enjoys significant undeveloped renewable power resources, but not as much as Canada on a per capita basis. Canada's clean electricity profile is an advantage. Still, despite the fact that the average electron is clean in Canada, there are quite significant differences in electricity generation profiles among the provinces (Figure 2), as well as limited interprovincial transmission linkages. For example, while British Columbia, Quebec, Manitoba and Newfoundland rely mostly on hydropower, in 2012 Alberta, Saskatchewan and Nova Scotia generated 85 per cent, 74 per cent and 90 per cent of their power from coal and gas resources, respectively.[7]

Figure 2: Electricity generation mix



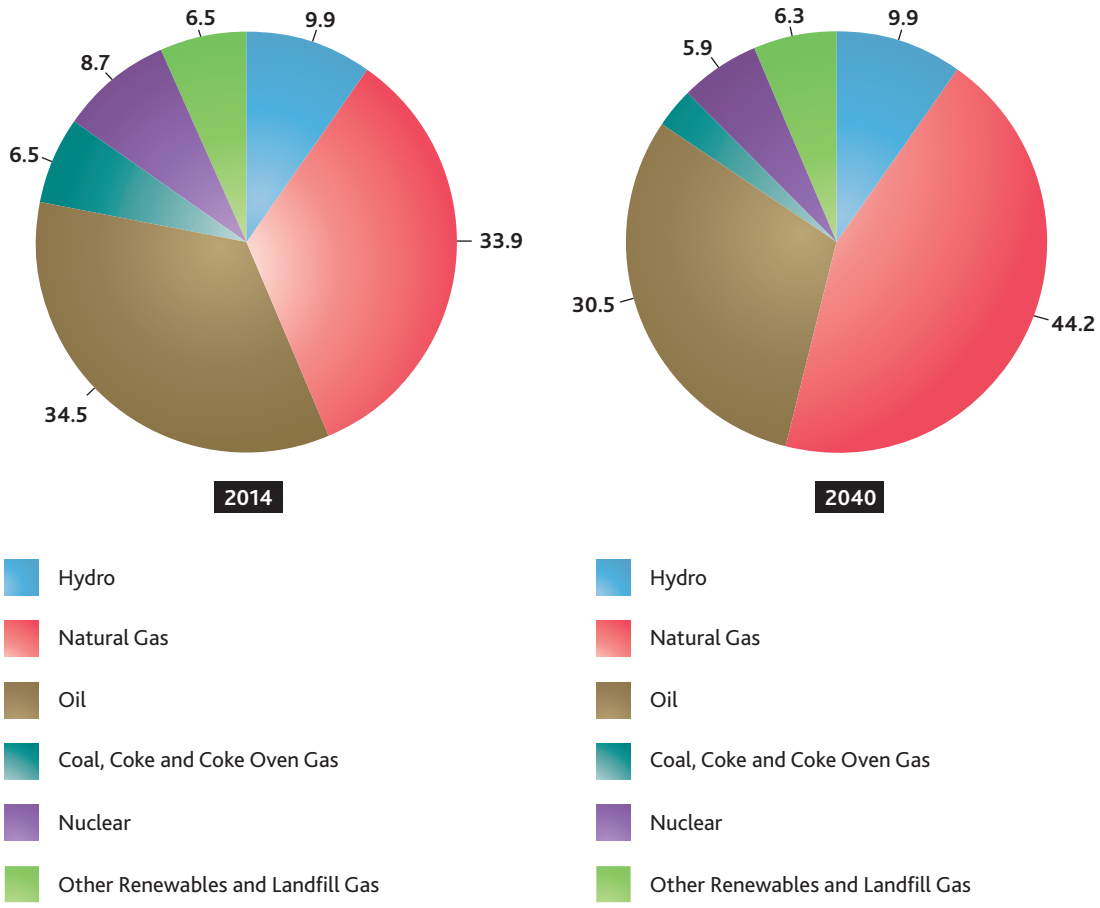
[6] See: "Carbon dioxide emissions from electricity generation in 2015 were lowest since 1993," U.S. Energy Information Administration, May 13, 2016: http://www.eia.gov/todayinenergy/detail.cfm?id=26232.

[7] *Vision 2050: The Future of Canada's Electricity System*, Canadian Electricity Association: http://www.electricity.ca/media/Vision2050/Vision2050.pdf, p. 16.

B. BUSINESS-AS-USUAL SCENARIO: INCREASED GHG EMISSIONS

As a base case analysis for the future energy mix of the Canadian economy, the 2016 update from Canada's National Energy Board (NEB) provides detailed scenarios on the 2040 energy mix.[8] None of the scenarios considered by the NEB take into account the potential impact of Canada's commitment to the Paris Agreement, nor do they consider some recent federal and provincial policy changes.[9] The NEB's update is useful therefore as a business-as-usual (BAU) illustration of how Canada's energy system might develop in the absence of significant new climate and environmental policies. It is striking to note that in this BAU scenario, the share of fossil fuels in Canada's primary energy demand will grow from 75 per cent today to 78 per cent in 2040 (Figure 3).

Figure 3: NEB base case scenario for Canada's primary energy demand in 2014 and 2040 (per cent)



Source: NEB, Canada's Energy Future 2016, figure 4.7

[8] "Canada's Energy Future," as above.

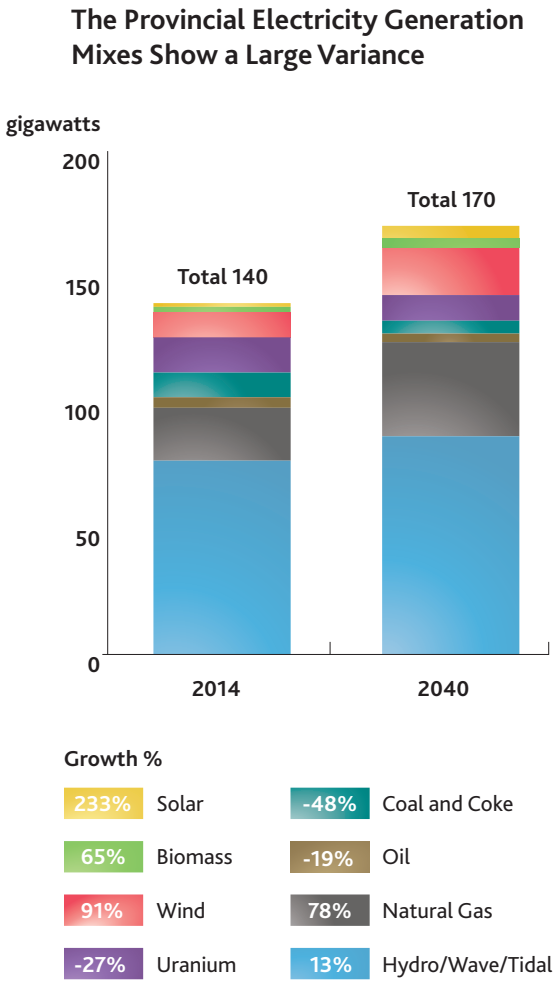
[9] According to the NEB "it only reports on policies and programs that are law, or near law at the time of analysis;" however it also recognizes that "these policy developments will be critical factors in Canada's energy and environmental future, and the possible addition of climate policy developments beyond those just announced will represent a considerable uncertainty for long-term energy projections;" "Canada's Energy Future," as above.

As illustrated in Figure 3, the primary fuel mix in 2040 would still be strongly dominated by natural gas and oil, providing almost 75 per cent of the total energy in 2040. The scenario assumes gas would increase substantially and there would be limited additional electrification of transport and industrial energy use. GHG intensity (emissions per unit of energy) for Canada's fossil fuel mix would decline by 12 per cent compared to its 2005 GHG intensity, but because of the growth in overall energy demand, total energy related GHG emissions would still increase by 13 per cent compared to 2005.[10] In absolute terms, under business-as-usual as highlighted by the NEB base case scenario, Canada would increase emissions by 55 megatonnes (MT), instead of reducing them by 190 MT to meet its 30 per cent GHG reduction commitment by 2030 (relative to 2005), an excess of 245 MT.[11]

In summary, in a business-as-usual scenario, 2040 GHG emissions are much higher than they are today which demonstrates that strong policy measures are needed to reverse the trend toward higher emissions.

The charts in Figures 4 show how the power generation mix evolves under the NEB's BAU scenario. It shows growth for hydro and marine, wind, biomass and solar. It also shows strong declines for coal and oil. The largest absolute addition, however, is from natural gas, which starts from a higher base than solar and wind. In this scenario, the estimated GHG intensity of the fuel mix for power generation would decline by only 5 per cent from around 160 kilograms per megawatt hour (kg/MWh) to 150 kg/MWh and total emissions from the electricity sector increase as the growth in generation exceeds the small reduction in emission intensity.

Figure 4: Evolution of Canada's electricity generation capacity (gigawatts) under NEB base case scenario



Source: NEB, Canada's Energy Future 2016, figure 8.2 and 8.4

[10] The NEB does run various alternative scenarios with different oil/gas prices and export options but they have little impact on the general conclusions.

[11] All data from this paragraph derived from "Canada's Energy Future," as above.

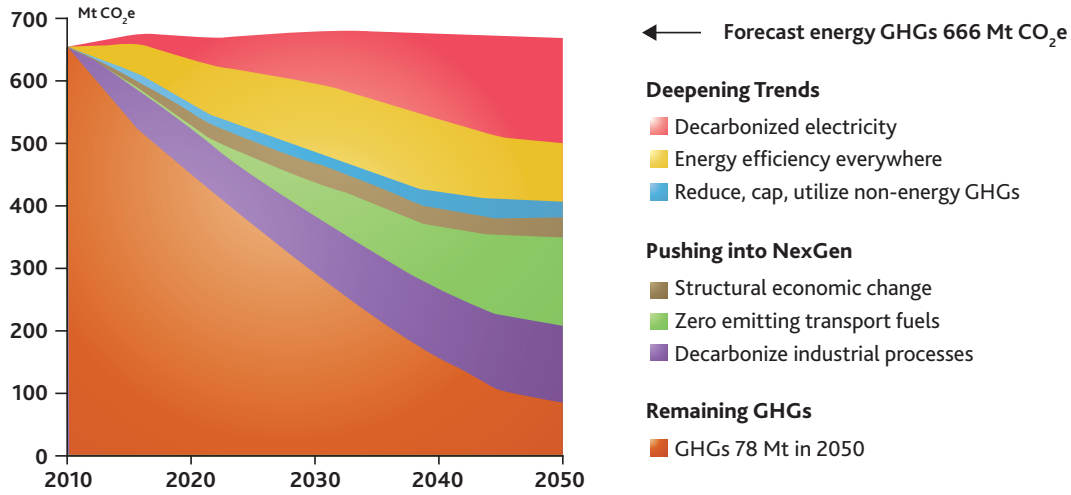
C. DECARBONIZATION SCENARIO

How might the future evolve if we are serious about achieving GHG reductions? A number of alternative scenarios to the NEB have been put forward which show decarbonization pathways that are in line with Canada's international climate change commitments. The Deep Decarbonization Pathways Project (DDPP) Canada provides one such decarbonization analysis.[12]

The DDPP's deep decarbonization scenario describes how Canada could achieve an 88 per cent reduction compared to 2005 to reach 78 MT of energy-related emissions in 2050. The report identifies a base case showing how this could be achieved through fast rollout of existing technologies, development of new generation technologies (especially for industrial and oil and gas emissions) and some structural economic adjustment away from high emitting sectors (Figure 5).

Enhanced energy productivity, clean electricity and electrification are the main potential drivers for achieving this substantial reduction. Reducing emissions from power generation to almost zero would be a major direct reduction. Secondly, replacing fossil fuels with electricity as the energy source for transportation (e.g. through adoption of electric vehicles), industries and buildings can also achieve major emissions reductions. The total contribution of clean electricity plus electrification is estimated to be between 55 per cent to as much as 70 per cent of the total reduction. To put this in perspective, efficiency measures–the next largest individual reduction lever–would contribute only 15 per cent of the reduction.

Figure 5: Deep Decarbonization Pathways to 2 Degrees Celsius



[12] *Pathways to Deep Decarbonization in Canada*, Sustainable Development Solutions Network (SDSN) and Institute for Sustainable Development and International Relations (IDDRI), 2015. The DDPP is an initiative of the United Nations SDSN and IDDRI in which 16 country teams representing 75 per cent of global greenhouse gases (GHGs) and 85 per cent of the total world economy explore national deep decarbonization pathways. The focus is to achieve 1.7 tons per capita emissions by 2050 (78 MT in total) which is consistent with a 66 per cent per cent probability of limiting global average temperature increases to 2°C; see *ibid*., p. 7.

D. BUSINESS-AS-USUAL VERSUS DECARBONIZATION: A CHOICE TO MAKE

By examining the NEB base case and the detailed analysis of the DDPP, we can draw three key conclusions for decarbonization prospects in Canada:

1. **Current trends will result in increased GHG emissions.** While a continuation of current trends and policies would reduce GHG intensity a little bit over time, total GHG emissions would nevertheless increase with the increase in overall energy use.

2. **Cleaning the electricity supply and increased electrification together have the potential to contribute 55-70 per cent of the total 2050 emissions reduction target in the DDPP's deep decarbonization scenario.** These two measures, if applied broadly and aggressively, are the two main avenues by which Canada has a chance of reaching this target.

3. **Achieving deep decarbonization by 2050 will involve major challenges.** A large reduction of 30-50 per cent compared to the 2005 baseline would require a major effort, but much of it is achievable with current technologies, such as clean electricity and energy efficiency–provided implementation begins immediately. Reductions beyond 50 per cent, in contrast, represent a major challenge that would require substantial innovation and large scale adoption of new technologies in transport, oil and gas and industries.

In summary, an acceleration and expansion of renewable electricity will accomplish two objectives of broad importance for the country. First, it will serve as the single largest emission reduction lever in Canada. Second, it will be the main driver for decarbonization of personal transport as well as an important contributor for decarbonization of buildings and industry. Put simply: an acceleration and expansion of renewable electricity provides the foundation for Canada to achieve deep emission reductions.

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E. CANADA'S NEW MOMENTUM TOWARDS DECARBONIZATION

In 2009, the Group of Eight (G8) industrialized economies, including Canada, agreed that they "should collectively cut emissions by 80 per cent by 2050."[13] While laudable, the agreement did not have any discernible impact in Canada. Over the last few years, however, the Canadian policy and business context for decarbonization has changed rapidly at the federal, provincial, municipal and even household levels–and these recent developments lend more credence to a decarbonization scenario.

Most notably, as part of the Vancouver Declaration of March 2016, the Prime Minister and Premiers (collectively the First Ministers) together recognized the need to mobilize all Canadians to address climate change and seize the opportunity for clean growth.[14] In the Declaration, the First Ministers agreed to: increase the level of ambition in GHG reductions; promote clean economic growth to create jobs; deliver mitigation actions; increase action on adaptation and climate resilience; and enhance cooperation both domestically and in North America.[15] In addition, the federal government committed, among its own early actions, to investing in "green infrastructure," "foster development of regional plans for clean electricity transmission," and to "advancing the electrification of vehicle transportation."[16]

Building on the Declaration, the 2016 federal budget provided for "almost $2.9 billion over five years, starting in 2016-17, to address climate change and air pollution issues," notably including "2.5 million over two years, starting in 2016-17, to Natural Resources Canada to facilitate regional dialogues and studies that identify the most promising electricity infrastructure projects with the potential to achieve significant greenhouse gas reductions."[17]

Such momentum is also evident at the household level, where more and more individual consumers are participating in micro-generation efforts, and offering their own renewable energy back to the grid.

F. IMPLICATIONS

While Canada is endowed with substantial renewable energy resources, we must now develop and expand these resources much further. If the recent business and policy momentum towards decarbonization can be sustained over many years–if we embrace and pursue this enormous potential–Canada will be able to achieve substantial, economy-wide carbon reductions and fully capitalize on our renewable electricity advantage.[18] The next section discusses in greater detail the role of electrification in supporting decarbonization across the entire Canadian economy.

[13] "G8 agrees to climate targets despite differences with developing nations," *The Guardian*, July 8, 2009: https://www.theguardian.com/world/2009/jul/08/g8-climate-carbon-emission-targets.

[14] "Vancouver declaration on clean growth and climate change," March 3, 2016: http://www.scics.gc.ca/english/conferences.asp?a=viewdocument&id=2401. Also notably, Ontario is committed to reducing GHG emissions by 37 per cent below 1990 levels by 2030, and 80 per cent by 2050, see: https://news.ontario.ca/ene/en/2015/05/ontario-first-province-in-canada-to-set-2030-greenhouse-gas-pollution-reduction-target.html; and Quebec is committed to a reduction target of 37.5 per cent below 1990 levels by 2030: http://www.newswire.ca/news-releases/quebec-adopts-the-most-ambitious-greenhouse-gas-reduction-target-in-canada-555931051.html.

[15] "Vancouver declaration," see footnote 14

[16] "Vancouver declaration," see footnote 14

[17] "Chapter 4 – a Clean Growth Economy," *Budget 2016*, Government of Canada: http://www.budget.gc.ca/2016/docs/plan/ch4-en.html.

[18] For useful background and additional context, see Anthony Swift, "Paris Climate Agreement explained: What's next for Canada?" Natural Resources Defense Council, December 12, 2015: https://www.nrdc.org/experts/anthony-swift/paris-climate-agreement-explained-whats-next-canada.

II. Growth in Electrification

Long-term decarbonization objectives can only be reached with both full decarbonization of electricity supply and strong GHG emission reductions in oil and gas and energy end-use sectors including buildings, industry, and transport. Full decarbonization of the electricity supply can be achieved by aggressively expanding clean electricity like wind, hydro, solar, marine, and other renewables. This challenge– although substantial–can be addressed by combining existing and already widely deployed technologies with the right political will and regulatory framework. In contrast, decarbonization of other sectors will not only require political will and supporting regulations, but also adoption of new technologies and changes in existing processes and practices across a wide number of actors.

Table 1 shows the extent of the challenge and key decarbonization levers that need to be adopted for each of the main sectors:

Table 1: Decarbonization challenges and levers by sector

Sector	Proportion of 2050 DDPP reference case energy emissions (%)	Technological Challenge	Key decarbonization levers
Buildings	12	Relatively low	**Electrification** Energy efficiency
Transport	36	Medium/High	**Electrification** Energy efficiency Biofuels
Industry	17	High	**Electrification** CCS
Oil and gas	30	High	CCS Multiple measures related to efficiency, electrification, in-situ steam generation

Electrification will be the primary driver for achieving required substantial GHG emission reductions in the building, industry and transportation sectors and should be a primary objective. What electrification means for each of these three sectors is discussed in more detail below.

A. BUILDINGS

Around 70 per cent of the energy used in commercial and residential buildings is used for heating, generating substantial emissions.[19] Better insulation has already led to a substantial decrease in heat intensity for new buildings, with approximately a 40 per cent reduction for residential heat intensity between 1990 and 2012.[20] The reduction trend is expected to continue, although at a slower pace. With these low heating loads, electric and solar thermal heating, potentially in combination with heat pumps, are becoming economic options and will allow buildings to reach close to zero emissions by 2050, with all energy needs in residential and commercial buildings powered by electricity.

The key challenge for buildings is the existing building stock, which has existing heating infrastructure and is not as efficiently insulated.

B. TRANSPORT

By 2050, transport will be, by far, the largest GHG emitter in Canada under the DDPP reference case scenario. Fortunately, recent technological improvements–mostly in battery technology–have made electric vehicles (EVs) a viable alternative to the internal combustion engine vehicle. EVs may have lower GHG emissions than gasoline-powered cars even in areas with relatively GHG-intensive electricity supply. For example, an average car driver will reduce lifecycle GHG emissions when switching to a similar battery EV in all states of the United States.[21] In Canada, with relatively low emissions in its GHG profile, the switch from gasoline to EVs will see even larger potential GHG reductions.

At present, EVs still only represent less than 1 per cent of new vehicle sales, but this modest showing is about to change. Battery costs have already come down 60 per cent over the last 5 years and will continue to decline, further making full electric cars increasingly competitive.[22] Bloomberg New Energy Finance predicts that by 2022 the total cost of ownership for an EV will be lower than a traditional car (at US$70-dollar oil) at which point EV sales will really start to take off (Figure 6). Major car manufacturers are already preparing for these changes with almost all major manufacturers introducing new EV models.

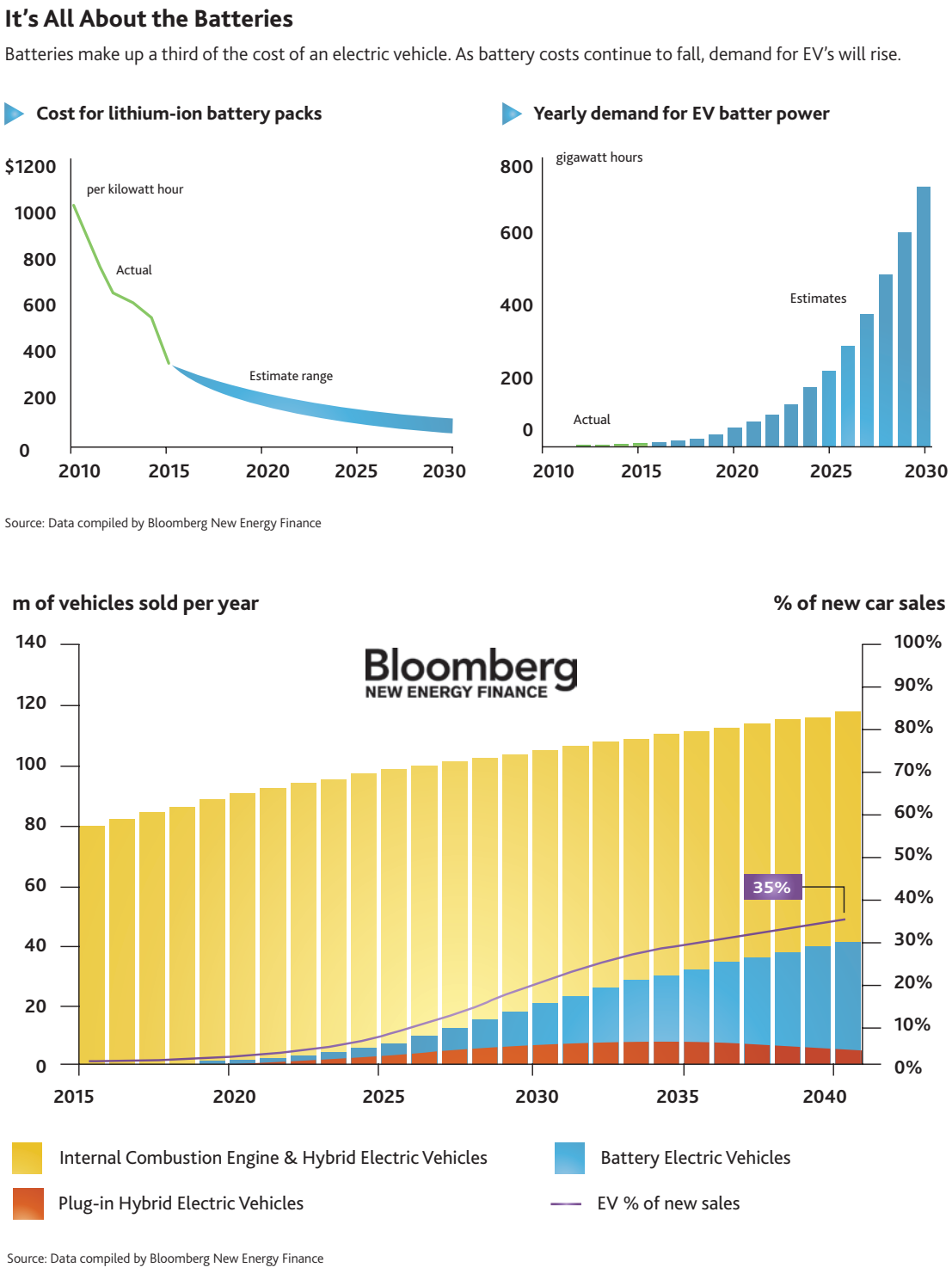
[19] "Solar Thermal,"Natural Resources Canada: http://www.nrcan.gc.ca/energy/renewable-electricity/solar-thermal/7301.

[20] *Pathways* to Deep Decarbonization, as above, p. 28.

[21] Cleaner Cars from Cradle to Grave (2015)," Union of Concerned Scientists: http://www.ucsusa.org/clean-vehicles/electric-vehicles/life-cycle-ev-emissions#.VwTGEFL97IV.

[22] See chart 'It's All About the Batteries,' in Tom Randall, "Here's How Electric Cars Will Cause the Next Oil Crisis," Bloomberg, February 25, 2016: http://www.bloomberg.com/features/2016-ev-oil-crisis/.

Figure 6: Electric Vehicle Trends[23]



Source: Data compiled by Bloomberg New Energy Finance

Source: Data compiled by Bloomberg New Energy Finance

[23] For the chart on the top, see the chart 'It's All About the Batteries,' in Tom Randall, "Here's How Electric Cars Will Cause the Next Oil Crisis," ibid.; for the chart on the bottom, see "Electric Vehicles to be 35 per cent of Global New Car Sales by 2040;" Bloomberg New Energy Finance, February 25, 2016.

Incremental efficiency gains for traditional combustion engine vehicles and use of biofuels can both also provide significant contributions to GHG emission reductions, especially in the short term and for freight transport. In the long term, however, electrification is likely to be the dominant trend for road transportation, with the possible exception of heavy long-distance road vehicles that may predominantly use biofuels.

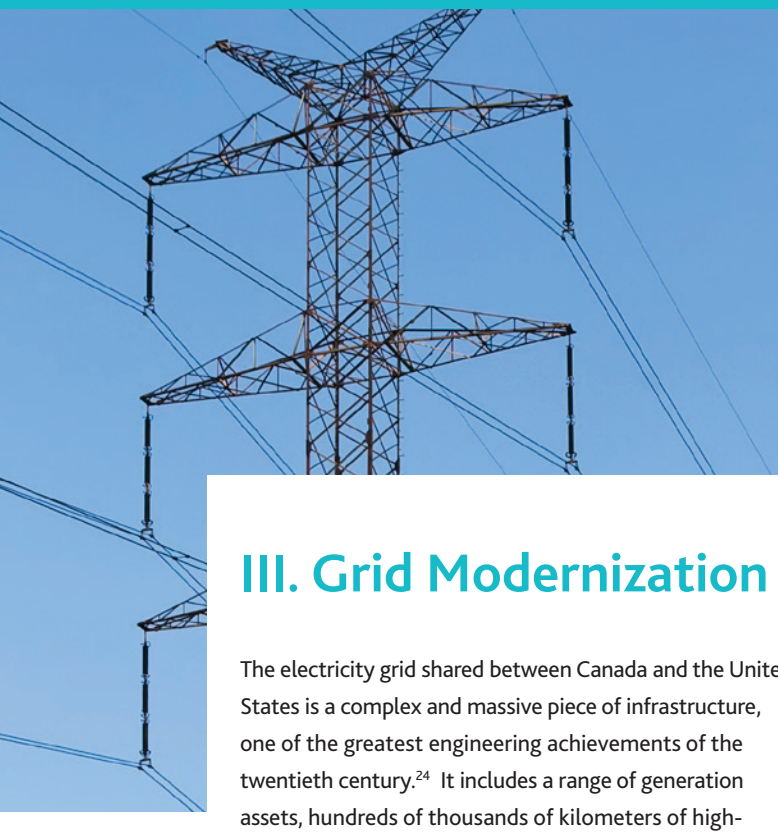
To reach the objective of an 80 per cent reduction by 2050, EV adoption rates in Canada will need to far exceed the adoption rates illustrated in Figure 6, likely requiring all passenger vehicles sold after 2040 to be electric so that by 2050 transport can be almost fully decarbonized.

C. INDUSTRY

Many industrial processes use heat. To generate this heat, factories typically burn fossil fuels–the source of most industry related GHG emissions. In principle, these emissions can be reduced dramatically by a combination of energy efficiency measures, biomass, electrification, carbon capture and storage (CCS) and a number of smaller measures. Electrification via the use of heat pumps and electric boilers will certainly be one of the most substantial GHG reduction measures, especially in light industries. The DDPP project estimates the market share of electric boilers in industrial heat generation to increase from 7 per cent in the BAU reference case to 40 per cent in 2050 which would, under this scenario, be responsible for over 50 per cent of the total non-oil and gas GHG emission reductions.

Broad electrification in industry is necessary and desirable across industries, but implementation challenges will be substantial. Implementation will often require process changes and process innovations (especially when replacing steam or very high temperatures), but such changes are likely to see slow adoption. Also, the cost of electric heating might be high in some cases, which can be an obstacle for traded goods. Therefore, to advance electrification in industry it is important to analyze each industrial sector individually and understand the extent to which this large potential opportunity can be implemented. A top-down analysis can only go so far; ultimately sector-by-sector abatement progress will require close collaboration with experts in those sectors.

Electrification will be the primary driver for achieving required substantial GHG emission reductions in the building, industry and transportation sectors and should be a primary objective.



III. Grid Modernization and Evolution

The electricity grid shared between Canada and the United States is a complex and massive piece of infrastructure, one of the greatest engineering achievements of the twentieth century.[24] It includes a range of generation assets, hundreds of thousands of kilometers of high-voltage transmission lines, and distribution wires that step down power for use by consumers.

But the grid is limited in two important respects. First, its infrastructure is aging. On the Canadian side alone, the Conference Board of Canada estimated in 2012 that by 2030, almost $350 billion in new investment would be required just to maintain existing electricity capacity, with most of Canada's non-hydro assets needing renewal or replacement by 2050.[25] Second, the current grid was built under yesterday's assumptions, not tomorrow's needs. The grid of the future–a so-called smart grid–will need to support EVs, micro-generation, the variability of some forms of power, improved demand response capabilities, improved asset use, problem detection and mitigation, and perhaps most of all, greater consumer empowerment and choice. The need to replace aging infrastructure is clearly an opportunity to shape the grid of the future.

A. THE SHAPE OF THE FUTURE SMART GRID

A smart grid involves changes and additions to the grid including smart meters, expanded distributed generation and energy storage, household appliances capable of communicating with the grid, and transmission and distribution enhancements.[26] On the transmission side, high voltage direct current (HVDC) transmission is a key innovation that allows for efficient delivery of clean generation over long distances to the demand centre. Lastly, communities and buildings are implementing their own forms of distributed generation, alongside innovative demand response and energy efficiency initiatives.

The need to replace aging infrastructure is clearly an opportunity to shape the grid of the future.

[24] As the U.S National Academy of Engineering has suggested. see: https://www.nae.edu/Publications/Bridge/TheElectricityGrid/18627.aspx.

[25] More precisely, "[i]nvestment in electricity infrastructure in Canada from 2011 to 2030 will total an estimated $347.5 billion, in current dollars," see "Shedding Light on the Economic Impact of Investing in Electricity Infrastructure," Conference Board of Canada, 2012. p. 1, http://www.conferenceboard.ca/e-library/abstract.aspx?did=4673.

[26] See e.g., *Smart Grid: A Pragmatic Approach,* Canadian Electricity Association: http://www.electricity.ca/media/SmartGrid/SmartGridpaperEN.pdf.

Through such upgrades and improvements, many ordinary Canadians will be more empowered and engaged in how they power their lives. Their household appliances will be more economical. Their electric-powered vehicles will serve as a highly distributed form of storage throughout the grid. They may elect to generate additional power on their own, for instance from a small scale solar or wind power installation (or both). Moreover, they could offer surplus power back to the grid, thereby transforming what was historically a one-way relationship into two-way electron flows. In addition, their EVs will also be capable of taking surplus power–either from their own source of micro-generation or the grid's surplus power–and store it in the form of batteries. Thus in the grid of the future, consumers, localized micro-generation, centralized sources of generation and electric vehicles will all work synergistically to optimize electricity resources and how they are managed.

B. SMART GRID AND RENEWABLES: A VIRTUOUS CIRCLE

Renewable power is not only a key factor in driving the need for a smart grid, but also in making a better grid possible. There are three important points to highlight here. First, while there can be challenges in integrating variable and localized generation with the grid of yesterday, jurisdictions around the world have already proven that they can aggressively add variable resources without compromising system reliability, provided sufficient investments are made to adapt the grid.[27] Second, Canada has a critical advantage over many other jurisdictions to help smooth over variability issues: substantial hydropower resources. Electricity grids have always required storage and flexible resources, and hydro power is the only large scale, dispatchable non-emitting resource that can both store electricity and very rapidly ramp up and down (increase or reduce its supply) in response to changing requirements.[28] Third, in the grid of the future, additional localized power from renewables–variable or not –will serve to strengthen grid resilience, by providing a highly distributed form of back-up or alternative power. In response to the devastation and power outages of Hurricane Sandy, New York State has recognized that distributed generation needs to be a key element of its resilience strategy: even if one part of the grid goes down altogether, power can still be generated from other sources.[29]

Renewable power is not only a key factor in driving the need for a smart grid, but also in making a better grid possible.

[27] See e.g., *Renewable Energy Integration in Power Grids: Technology Brief*, International Renewable Energy Agency and Energy Technology Systems Analysis Programme, International Energy Agency, 2015: http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP_Tech_Brief_Power_Grid_Integration_2015.pdf.

[28] For a related discussion see "Hydropower," in Renewable Energy Technologies: Cost Analysis Series, Volume 1: Power Sector, Issue 3/5, IRENA WorkingPaper, International Renewable Energy Agency, http://www.irena.org/documentdownloads/publications/re_technologies_cost_analysis-hydropower.pdf, p. 4.

[29] For a concise overview of the initiative, including efforts to enable microgrids to boost resilience, see "Reforming the Energy Vision," New York State white paper, March 2016: https://www.ny.gov/sites/ny.gov/files/atoms/files/WhitePaperREVMarch2016.pdf.

C. GREATER OPTIMIZATION

The grid of the future will also see improved efficiency, coordination, and resource optimization, and it will empower consumers to make a direct contribution to GHG emission reductions. Canada will need to tailor infrastructure decisions on the grid to suit specific geographic conditions, and there will continue to be a mix of centralized and distributed technologies. Northern communities will be able to replace highly polluting and expensive diesel power–flown in to some locations at prohibitive cost–with cleaner and cheaper renewables.[30] Large scale hydroelectric power will serve as an upstream storage (and flexible) resource, while more localized technologies will feature emerging solutions for downstream storage, including flywheels, batteries, and compressed air technologies. A combination of significant additional upstream and downstream storage capabilities in Canada will further strengthen our capability to optimize clean electricity among the provinces–and to offer abundant, clean electricity into the United States.

As an example of such cross-border optimization, Minnesota Power and Manitoba Hydro recently signed an innovative long term power purchase agreement, starting in 2020, that will enable Minnesota Power to send wind power northward to be stored by Manitoba Hydro through its hydroelectric stations. The agreement will enable Minnesota Power to "maximize the value of its wind resources" and reduce "its dependence on carbon-based generation."[31] Yet many other similar opportunities have yet to be tapped. As mentioned earlier, the 2016 federal budget set aside $2.5 million, starting in 2016-17, "to facilitate regional dialogues and studies that identify the most promising electricity infrastructure projects with the potential to achieve significant greenhouse gas reductions."[32] The funding, while modest, should help identify the range of ways in which Canada can take full advantage of our clean power resources.

The grid of the future will also see improved efficiency, coordination, and resource optimization, and it will empower consumers to make a direct contribution to GHG emission reductions.

[30] See e.g., Kate Kyle, "An off-grid community goes solar, and gets closer to its roots," CBC News, May 28, 2016: http://www.cbc.ca/news/canada/north/colville-lake-solar-power-1.3604310, and "Wind, solar wouldn't cost more than diesel in parts of Nunavut: study," CBC News, June 1, 2016: http://www.cbc.ca/news/canada/north/nunavut-renewable-energy-possible-1.3610340, and "Diavik wind farm case study," http://canwea.ca/communities/case-studies/.

[31] "Manitoba allows Minnesota to 'store' wind energy," Association of Power Producers of Ontario, http://magazine.appro.org/index.php?option=com_ntent&task=view&id=1434&Itemid=1.

[32] "Chapter 4 – a Clean Growth Economy," *Budget 2016*, as above. http://www.budget.gc.ca/2016/docs/plan/ch4-en.html.

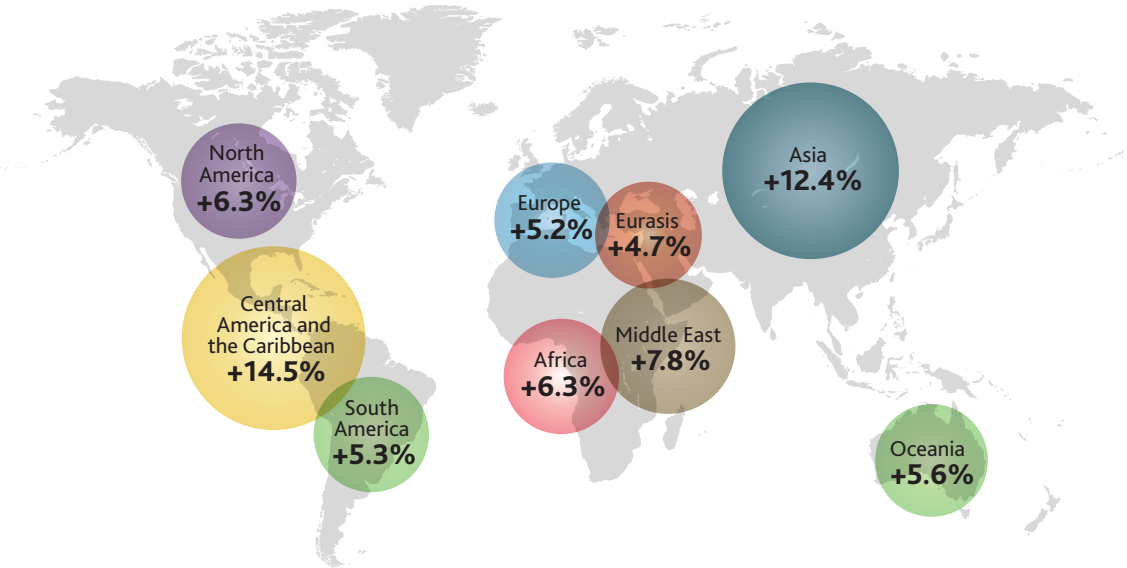
IV. Global Trends Advancing Renewable Energy

Canada has an opportunity to ride the earliest waves of the coming global energy transition. No matter whether one considers investor sentiment, technology and cost trends, or global norms, all of these areas have shifted in favour of renewable energy. For many observers, the momentum is irreversible: renewable energy's day has come (Figure 7).

Figure 7: Renewable power capacity additions and investment by technology (2015)[33]

Renewable Capacity Highlights

Renewable power generation capacity grew 8.3% in 2015, the highest rate ever recorded.

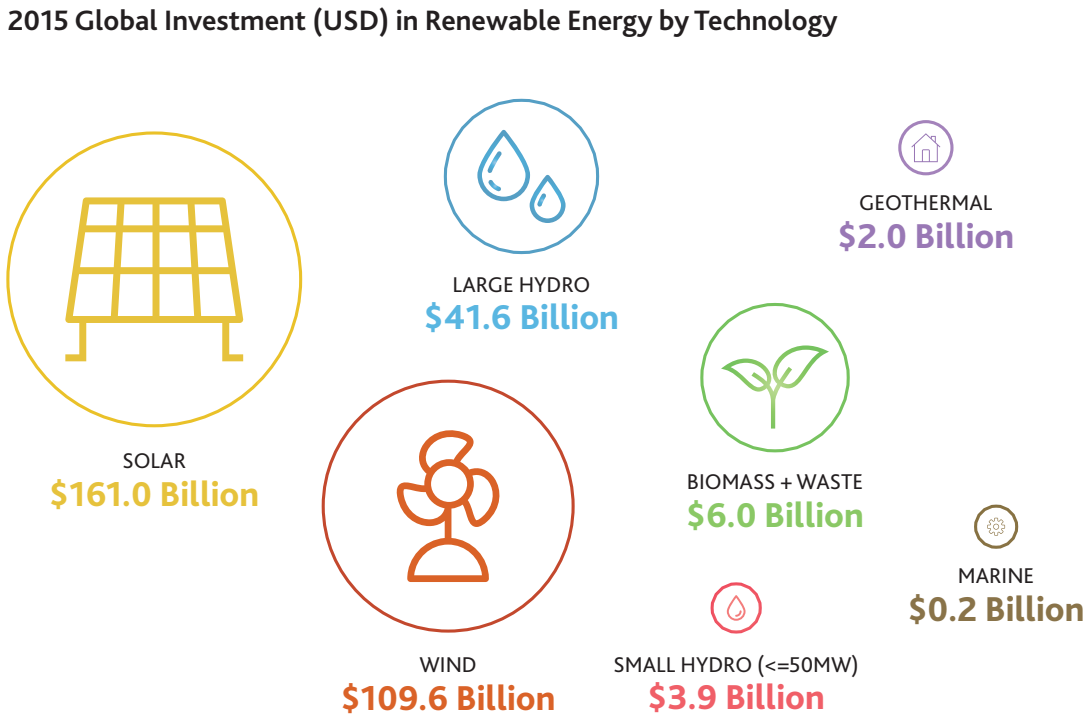


[33] The data in Figure 7 is drawn from "Renewable Capacity Highlights," is from "2015 Sets Record for Renewable Energy, New IRENA Data Shows," IRENA, and "2015 Global Investment (US$) in Renewable Energy by Technology," is from *A Year for the Record Books*, as above, p. 6.

A. NEW RECORDS FOR RENEWABLE ENERGY DEPLOYMENT

In 2015, renewable energy set new records for investment and the growth rate of new capacity.[34] The total investment in renewable energy in 2015 was US$325 billion,[35] higher than ever, despite the difficult global economic environment and despite falling oil and gas prices. For the first time ever, more than half of all added power generation capacity came from renewables, with investments in solar and wind alone far outpacing fossil fuel investments, and more than half of the additions in developing countries, especially China.[36] Investors around the world (Figure 8) are increasingly betting on renewable energy.

Figure 8: Renewable power capacity additions and investment by technology (2015)



The momentum is irreversible: renewable energy's day has come.

[34] "Renewable generation capacity increased by 152 gigawatts (GW) or 8.3 per cent during 2015, the highest annual growth rate on record," see "2015 Sets Record for Renewable Energy, New IRENA Data Shows," IRENA, April 7, 2016: http://www.irena.org/News/Description. aspx?NType=A&menu=cat&PriMenuID=16&CatID=84&News_ID=1446; and "A record US$325 billion was invested in renewable power in 2015," see *A Year for the Record Books, Tracking the Energy Revolution*, Global 2016 edition, February 2016, 2016 Clean Energy Canada: http://cleanenergycanada.org/wp-content/uploads/2016/02/A-Year-for-the-Record-Books_final.pdf, p.5.

[35] *A Year for the Record Books*, as above, p. 5.

[36] Tom Randall, "Wind and Solar are Crushing Fossil Fuels," Bloomberg, April 6, 2016: http://www.bloomberg.com/news/articles/2016-04-06/wind-and-solar-are-crushing-fossil-fuels.

B. CONSISTENT AND MARKED DECLINE IN RENEWABLE ELECTRICITY PRICES

The cost of several sources of renewable power generation has declined substantially over the past years, driven by advantages of scale and technological improvements that reduce costs and improve efficiency. This decline is especially evident in the price for solar photovolatics (PV), whose global levelized cost of electricity per megawatt hour declined by 61 per cent between 2009 and 2015. [37]

A renewable electricity resource has achieved 'grid parity' when its unsubsidized cost of electricty is similar to prices present in the electricity market to which the resource is connected. Wind and solar are now steadily moving towards grid parity in more and more regions around the world, joining large hydro and geothermal which have traditionally met or exceeded the threshold in many areas. While the recent drop in oil and gas prices will have a delaying effect on the moment at which renewable energy reaches grid parity in some jurisdictions, this drop will not stop the overall momentum, given the overall scale and growth of investment in renewable energy, ongoing innovations in the sector, the increasing adoption of carbon pricing, and the fact that renewables do not have any fuel costs.

C. UNIVERSAL ADOPTION OF THE PARIS AGREEMENT

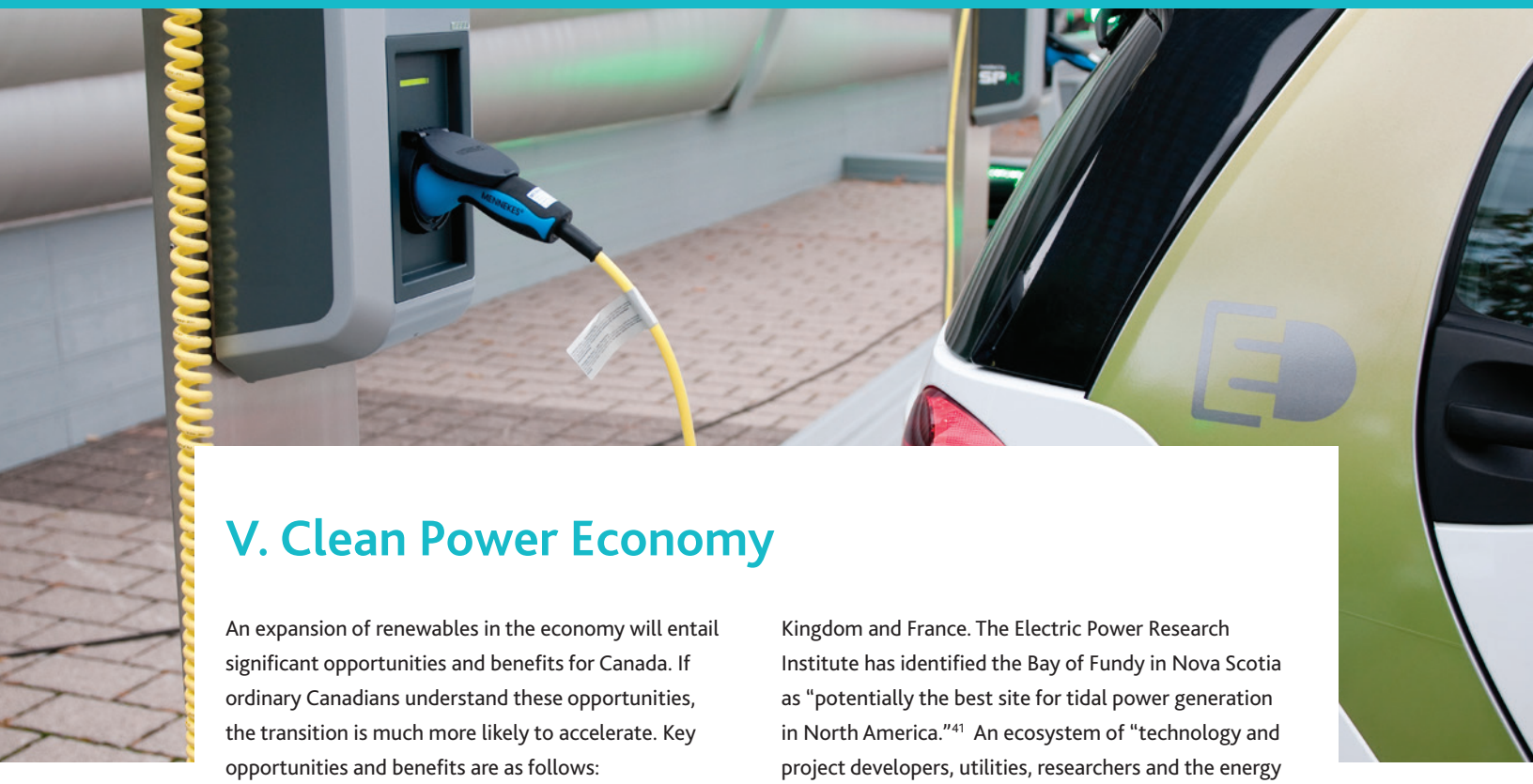
In December 2015 in Paris, a consensus was reached among 196 parties to reduce global GHG emissions. The agreement–which entered into force on November 4 of this year after at least 55 countries (including Canada) comprising at least 55 percent of global greenhouse emissions enacted the agreement–aims for countries to reduce their GHG emissions output "as soon as possible" and to do their best to keep global warming "to well below 2 degrees Celsius." During the negotiations, Canada put forward an Intended Nationally Determined Contribution (INDC) of 30 per cent reduction by 2030 relative to 2005 emissions.

This agreement and the positive reaction from most parties involved can be seen as a strong signal that global norms have now shifted in favor of climate action. In the Canadian context, too, the Vancouver Declaration of March 2016 made it clear that "all governments, Indigenous peoples, as well as civil society, business and individual Canadians, should be mobilized" to face the climate change challenge.[38] Canada, it affirms, "stands at the threshold of building our clean growth economy." [39]

[37] *Global Trends in Renewable Energy Investment 2016*, UNEP and Bloomberg New Energy Finance: http://fs-unep-centre.org/sites/default/files/publications/global-trendsinrenewableenergyinvestment2016lowres_0.pdf, p. 19.

[38] "Vancouver Declaration," as above.

[39] *Ibid*.



V. Clean Power Economy

An expansion of renewables in the economy will entail significant opportunities and benefits for Canada. If ordinary Canadians understand these opportunities, the transition is much more likely to accelerate. Key opportunities and benefits are as follows:

A. COMPETITIVE ADVANTAGE

First, cleaner and expanded electricity production, powered by renewable electricity, will likely see some productivity gains and cost savings–for instance, reduced pollution remediation and health care costs associated with fossil-fueled power–that would contribute to the competitiveness of the economy.[40] Second, as the Canadian economy moves away from fossil fuels, it will be more sheltered from oil price fluctuations and their roller coaster impacts on economic growth, tax revenues, the exchange rate and employment.

Finally, and perhaps most importantly, a Canadian economy that has fully embraced clean electricity is well positioned to export the technologies and services associated with this industry to the world. For example, Canada is one of three early adopters of marine renewables technologies, alongside the United Kingdom and France. The Electric Power Research Institute has identified the Bay of Fundy in Nova Scotia as "potentially the best site for tidal power generation in North America."[41] An ecosystem of "technology and project developers, utilities, researchers and the energy and marine supply chain" has developed around the Bay of Fundy to develop this exciting and powerful energy resource.[42] If the technology achieves commercial maturity in Canada, Canadian companies will be well positioned to export this knowledge to other markets around the world that will be eager for clean energy solutions.

Other emerging renewable energy technologies are already at much later stages of maturity and market growth. In the case of wind, for instance, in 2015 Canada's installed capacity surpassed 11,000 MW, meeting 5 percent of electricity demand in Canada.[43] As for solar, it is the "fastest growing energy source in the world," and is on track to produce at least 1 per cent of electricity in Canada by 2020, "with almost 6,300 MW of installed capacity."[44] As these two technologies expand in Canada, the companies driving their growth here will be able to expand into other markets as well.

[40] See e.g. "Use of coal power costs $300 million a year in health expenses: report," *The Globe and Mail*, March 26, 2013: http://www.theglobeandmail.com/news/national/use-of-coal-power-costs-300-million-a-year-in-health-expenses-report/article10339809/.

[41] "Marine Renewable Energy Research Projects," Offshore Energy Research Association: http://www.oera.ca/marine-renewable-energy/tidal-research-projects/.

[42] See Graham Curren, "Marine Renewable Energy in Canada: Industry overview," July 2015, http://www.marinerenewables.ca/wp-content/uploads/2015/06/NB-Event-MRC-slides-Graham-C.pdf, p. 2.

[43] "Installed Capacity," http://canwea.ca/wind-energy/installed-capacity/.

[44] *Roadmap 2020: Powering Canada's Future with Solar Electricity*, CanSIA:

B. JOBS

Renewable energy provides employment through its entire value chain, including manufacturing, shipping, construction, and operations. As the sector grows, the number of jobs will grow as well. There will also be additional jobs associated with the evolution of the grid, including new storage technologies, micro-grid components, and roles related to renewable electricity integration. According to a recent report by Electricity Human Resources Canada, a "limited deployment" of renewable energy capacity growth would generate "185,000 construction person-years of work and up to 19,000 jobs in operations" for Canada by 2022.[45] Additional capacity to meet "government policy targets" and more significant potential for the industry could create "620,000 person-years of construction employment and accumulate 34,000 jobs in operations," also by 2022.[46] Or by another measure, the Canadian Hydropower Association estimates that hydropower project development by itself could generate "a million jobs" over the next two decades.[47] As promising as these estimates may sound, they do not factor in jobs associated with the manufacturing and assembly of EVs and their components–a potentially large opportunity in Canada associated with cleaner electricity.

C. INCREASED ELECTRICITY EXPORTS TO THE UNITED STATES

Canada and the United States exchange electricity back and forth every day via transmission interties across the country. Already Canada is a net electricity exporter to the United States; in 2014, Canada's net trade revenue in electricity exports amounted to $2.3 billion.[48] Canada, the United States and Mexico have agreed collaborate further to reduce emissions in the North American grid,[49] and would also benefit from developing a shared EV infrastructure to tackle transportation emissions on the foundation of this cleaner grid.[50] With the implementation of the U.S Environmental Protection Agency's Clean Power Plan (CPP), American states will be able to count electricity imports from Canadian hydropower and other non-emitting sources towards their emissions reduction targets. A recent analysis by the North American Electric Reliability Council found that Canadian exports to the U.S. could increase "three-fold … as a result of the CPP's implementation, with most of the increase sent to the Midwest states."[51] As the United States places greater importance on climate action, Canadian clean power should be increasingly seen as an important part of the solution. This is why the electricity sector commissioned a report that provides technical guidance to U.S. state policymakers on how to enable clean energy imports from Canada for compliance with the Environmental Protection Agency's (EPA) Clean Power Plan (CPP).[52]

Working together will be much easier than working alone.

Substantial growth of renewable electricity has the potential to provide major opportunities and benefits for the Canadian and North American economy. The vision of a clean economy should be undergirded by supportive policies and regulations to encourage investment, foster innovation and accelerate growth.

[45] *Renewing Futures: Meeting the Human Resources Needs of Canada's Renewable Electricity Industry*, Final Report (2013), p. 2.

[46] Ibid.

[47] "Five Things You Need to Know About Hydropower: Canada's Number One Electricity Source," Canadian Hydropower Association, https://canadahydro.ca/facts/.

[48] "Canada's Electricity Industry," Electricity 101 Slide Deck, Canadian Electricity Association: http://www.electricity.ca/media/Electricity101/Electricity101.pdf, p. 19.

[49] See http://pm.gc.ca/eng/news/2016/06/29/leaders-statement-north-american-cli

[50] On this concept see Jim Burpee and John Haffner, "It's Time for a U.S.-Canada Electric Auto Pact," Policy Innovations, May 28, 2015: http://www.policyinnovations.org/innovators/people/data/john_haffner.

[51] "Market Snapshot: Electricity from Canadian Non-Emitting Sources Qualify Under the U.S. EPA's Final Clean Power Plan," National Energy Board, August 20, 2016: https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/snpsht/2015/08-02lctrct-eng.html.

[52] See http://www.brattle.com/news-and-knowledge/news/report-by-brattle-economists-provides-guidance-on-enabling-canadian-clean-energy-imports-for-clean-power-plan-compliance

D. CLEAN TECHNOLOGY SECTOR IN CANADA

A robust clean technology sector–including but not limited to the renewable energy value chain–has quietly emerged in Canada. In industry reports and policy discussions, a clean technology company is "defined as a company with proprietary technology or know-how that addresses one or more of the markets"[53] illustrated in Figure 8.

Quietly but steadily–and without most Canadians realizing the full extent of its development–the clean technology sector in Canada has already become a success story. Better still, it is strongly positioned for substantial further growth. According to a recent report by Analytica Advisors:

- The sector already has more than "775 technology companies, including many SMEs, operating in ten sectors and in every region of Canada." As a comparison, Canada has "700 firms in the aerospace sector and 450 firms in the automotive sector."[55]
- With respect to revenue, in 2014 Canadian cleantech companies earned "an estimated $11.63 billion," with "export revenue" constituting more than half of this amount, at $6.6 billion, and some "23 percent of export sales coming from non-U.S markets."[56]
- Finally, on the innovation front, cleantech companies in Canada invested "over $1.2 billion in R&D in 2014 and $7.6 billion cumulatively from 2008 to 2014, of which $5.5 billion was from firms with less than $50 million in revenue."[57]

Canadian cleantech companies, including many renewable energy companies and suppliers, are already earning substantial revenues and exporting their technology and services to international markets. And R&D efforts now underway will reap dividends far into the future. The future is bright for the sector.

Figure 9: Canadian Clean Technology Industry Taxonomy[54]

[53] "Synopsis (English)," Press materials for the 2016 Canadian Clean Technology Industry Report, April 22, 2016: http://www.analytica-advisors.com/news/press-materials-2016-canadian-clean-technology-industry-report, page 2.

[54] "Synopsis (English)," Press materials for the 2016 Canadian Clean Technology Industry Report, April 22, 2016: http://www.analytica-advisors.com/news/press-materials-2016-canadian-clean-technology-industry-report, page 2.

[55] Ibid., page 4.

[56] Ibid.

[57] Ibid.

VI. Conclusions and Recommendations

Greenhouse gas emissions reductions of 80 per cent or more will be required by 2050 to achieve the climate objectives agreed upon at COP 21 in Paris in December 2015, since ratified by Canada and entered into force amongst its signatories.

Given the critical role energy production, transmission, distribution and use plays in the generation of GHG emissions, any serious effort to decarbonize Canada's economy must have enhanced energy productivity as the first priority. In addition, there is a broad consensus that any credible climate change plan seeking to meet the level of ambition agreed to in Paris must have at its heart the continued decarbonization of electricity generation—replacing existing fossil fuel generation with zero-carbon power over time, and ultimately producing all electricity with non-emitting sources of generation. Just as importantly, Canada's broader energy system must also increase its reliance on electricity—fuel switching away from fossil sources to clean, renewable power in a variety of energy end uses. It is only by taking these actions together that Canada will be put on a path to achieve the scale of emission reductions needed to meet both our national 2030 target and put our economy on the right trajectory to achieve the much deeper reductions required by 2050—all while creating new and expanded economic and social benefits.

Fortunately, from coast to coast to coast Canada is blessed with abundant and diverse renewable energy resources and can build on a strong foundation to become a global leader in the transition to a low carbon economy. With its diverse mix of renewables—including hydro, marine, solar and wind—we have the opportunity to create an electricity system, and an energy system, dominated by clean, renewable energy. From utility scale to distributed, baseload to variable generation, Canada can deliver a clean, reliable and affordable electricity system to power our future prosperity.

The following recommendations are offered to help Canada decarbonize its electricity system and, through increased electrification of other sectors, the broader energy system in Canada and more broadly in North America:

From coast to coast to coast Canada is blessed with abundant and diverse renewable energy resources and can build on a strong foundation to become a global leader in the transition to a low carbon economy.

A. AIM FOR A ZERO CARBON ELECTRICITY GRID BY 2050

Approximately 80 per cent of Canada's electricity production today is zero carbon. The federal government should seek to enable and facilitate achievement of national targets for electricity generation that move us close to 100 per cent zero-carbon electricity by 2050. Federal, provincial and territorial governments should work together to achieve these targets by:

1. Defining and agreeing upon national targets for non-emitting electricity generation that move Canada towards a zero-emissions electricity supply by 2050. The previous federal government had adopted a target that 90 per cent of Canada's electricity supply should be non-emitting by 2020. While inadequate action to support that objective means that it is no longer achievable, we believe Canada should establish targets that identify the years prior to 2050 in which Canada will see 90 per cent and then 95 per cent of its electricity supply met through zero-emissions generation.

2. Taking steps to significantly reduce pollution from any remaining coal-fired electricity generation in Canada beyond 2030, and establishing federal GHG regulations for electricity generated by natural-gas that become increasingly stringent such that these plants will be required to produce significantly fewer GHG emissions by 2050, while providing flexibility in compliance with the zero emissions target through mechanisms such as allowing the use of offsets.

3. Establishing a national, economy-wide price on greenhouse gas pollution that rises over time, as now committed to by the federal government.

4. Reviewing federal tax laws to ensure they provide incentives for renewable energy investors that are at least equivalent to those provided for investors in other energy sectors.

5. Supporting clean electrification in remote and northern Indigenous communities and industrial facilities.

6. Convening and supporting forums for electricity system planners and operators from across Canada to come together to discuss common challenges related to the transition to a zero carbon electricity grid and identify best practices and priority actions to facilitate low carbon implementation plans.

The federal government should seek to enable and facilitate achievement of national targets for electricity generation that move us close to 100 per cent zero-carbon electricity by 2050.

B. AN ELECTRIFIED ECONOMY

The federal, provincial and territorial governments should commit to increasing the use of electricity in our energy system to over 50 per cent of all energy used in Canada by 2050.[58] To achieve this target, they should cooperatively develop sector-specific strategies that include interim targets to drive fuel-switching from fossil fuels to electricity and to maximize the potential to decarbonize energy used by all forms of transportation, industry and buildings. *The Pathways to Deep Decarbonization in Canada* analysis has shown that meeting the greenhouse gas emission reductions required in 2050 will require increased electrification at the following scale:

1. **Transportation**: Increasing the use of electricity for transportation to meet 10 per cent of energy needs in 2030, and over 30 per cent of energy needs in 2050. By 2050, most of the energy used in transportation should be from non-emitting resources (e.g., electric, hydrogen or biofuels).
2. **Industry**: Increasing industrial use of electricity to meet 45 per cent of energy needs in 2030, and over 50 per cent of energy needs in 2050.
3. **Buildings**: Increasing the use of electricity in buildings (residential and commercial) to meet 80 per cent of energy needs in 2030, and 100 per cent of energy needs in 2050.[59]

C. A RENEWABLE ENERGY EXPORT STRATEGY

Federal and provincial and territorial governments should prioritize the development of a renewable energy export strategy. Key components of such a strategy should include:

1. Educating Canadians about the country's renewable energy potential and how exporting some of that potential is good for Canada and North America, both environmentally and economically.
2. Working with governments on the development of a North American clean electricity strategy, including streamlined permitting processes for cross-border transmission projects.
3. Developing a broad international strategy to address policy barriers and increase the export of renewable electricity technologies, services and products.

Commit to increasing the use of electricity in our energy system to over 50 per cent of all energy used in Canada by 2050.

[58] *Pathways to Deep Decarbonization in Canada*, Sustainable Development Solutions Network (SDSN) and Institute for Sustainable Development and International Relations (IDDRI), 2015.

[59] *Ibid.*

CANADIAN COUNCIL ON RENEWABLE ELECTRICITY

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