CanREA's 2050 Vision

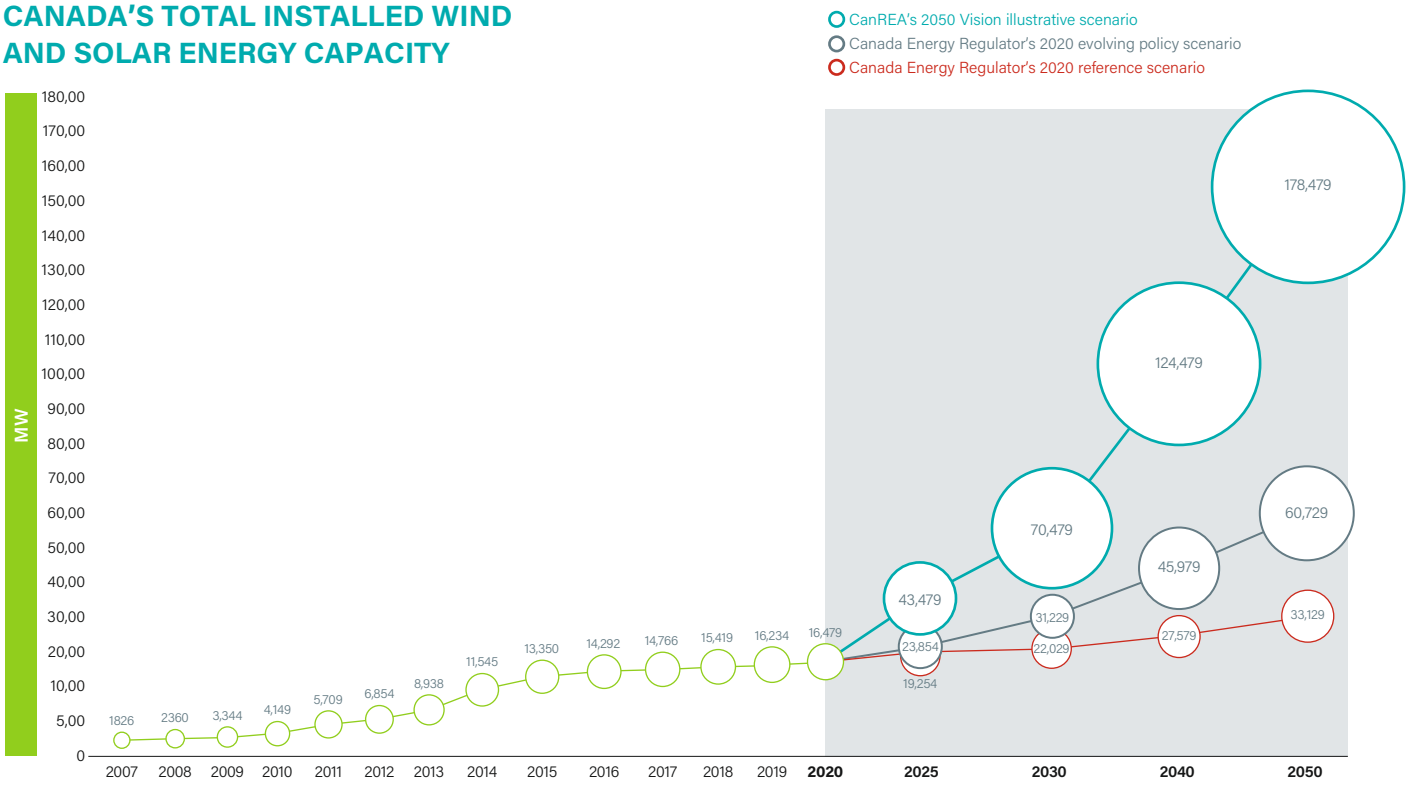
Powering Canada's Journey to Net-Zero

Canadian Renewable Energy Association

WIND. SOLAR. STORAGE.

As Canada sets out on a transformative journey to reach net-zero GHG emissions by 2050, we need a powerful boost from wind energy, solar energy and energy-storage technologies.

CANADA'S TOTAL INSTALLED WIND AND SOLAR ENERGY CAPACITY



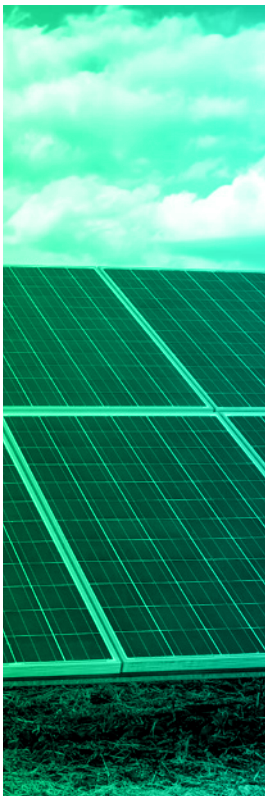
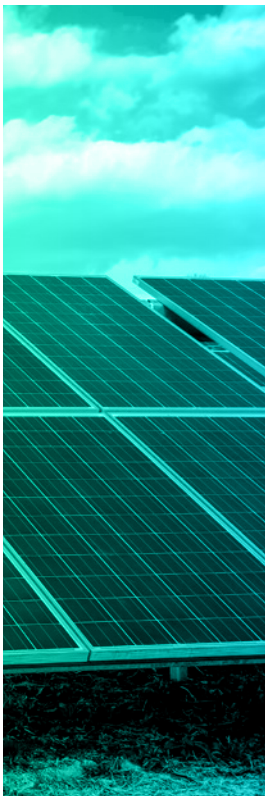
ACKNOWLEDGMENTS

The Canadian Renewable Energy Association (CanREA) wishes to recognize the following CanREA member companies who have provided financial support for the wider dissemination of CanREA's 2050 Vision.

We would also like to thank our members for their stalwart support. Since the association launched on July 1, 2020, more than 300 companies have signed up as CanREA members. A full member directory is available on the CanREA website. www.renewablesassociation.ca/member-directory

ABOUT THE CANADIAN RENEWABLE ENERGY ASSOCIATION



The Canadian Renewable Energy Association (CanREA) is the voice for the wind energy, solar energy and energy storage industries in Canada. CanREA represents more than 300 companies active in these industries across the country, including manufacturers, installers, developers, service providers and supply-chain partners. Through stakeholder advocacy and public engagement, CanREA works to create the conditions for a modern energy system, in which clean, low-cost, reliable, flexible and scalable solutions play a central role in transforming Canada's energy mix.

For more information about CanREA, please visit renewablesassociation.ca

STAY CONNECTED:

Follow us:

Subscribe to *"Power Together,"* CanREA's bimonthly e-newsletter, here.

Obtain more information on becoming a member here.

TABLE OF CONTENTS

INTRODUCTION

A word from Robert Hornung, CanREA President and CEO

"Powering Canada's Journey to Net-Zero: CanREA's 2050 Vision" is a wake-up call, an urgent call to action for governments, utilities, regulators, electricity system operators and the renewable energy industry, to get Canada started on the path to meeting its commitment to achieve net-zero greenhouse gas emissions by 2050.

In recent years, there have been many reports and studies looking at various pathways to reduce greenhouse gas emissions, many of which informed CanREA's 2050 Vision. While there is broad consensus around the critical role wind energy, solar energy and energy storage must play in any successful journey to meet a net-zero target, there has been little public discussion about the scale of action required and the speed at which it must occur.

CanREA's 2050 Vision document makes it clear that we have no time to waste. Canada must decarbonize and double its electricity production in less than 30 years. We will need an almost ten-fold expansion of Canada's wind energy, solar energy, and energy storage capacity, in addition to significant investments in other forms of electricity generation and electricity infrastructure. Such investments are historically unprecedented, but nonetheless essential if Canada is to successfully address climate change.

The wind, solar and energy storage industries are ready to take on the challenge, but immediate action is required from legislators, regulators, and other key decision makers, to enable these industries to deliver the results Canada needs.

For these technologies to make the greatest possible contribution to Canada's net-zero objective, federal and provincial governments must collaborate to address climate-change imperatives by creating clear policy signals to guide investors and those responsible for operating and regulating electricity markets.

This document identifies some of the specific measures needed, such as a national clean-electricity standard, full carbon pricing in the electricity sector, modernization of electricity markets and regulatory frameworks in response to disruptive technologies, investment in new transmission and non-wires alternatives, and distinct and comprehensive strategies to both electrify the economy and facilitate the use of green hydrogen.

Designing and implementing these measures will take time and effort. CanREA calls for increased collaboration among Canada's electricity stakeholders and is committed to working with them to help our country achieve net-zero by 2050 at the lowest possible cost, while providing the greatest possible benefit for Canadians.

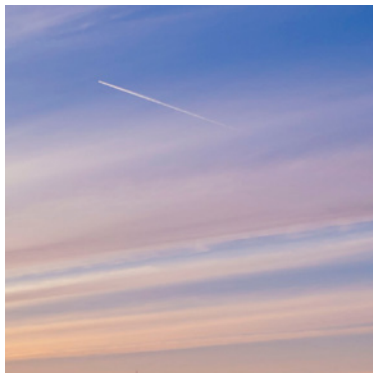
CanREA's 300-plus members are leaders in the field of wind, solar and energy storage in Canada. They are ready to capitalize on the synergies between these powerful technologies and accelerate their deployment to deliver practical, achievable, real-world solutions to the crisis of climate change.

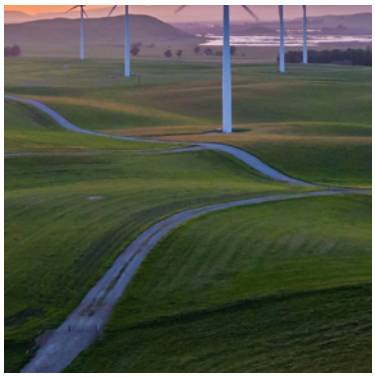
I know that all CanREA's members look forward to doing their part to realize the Vision described here. Together, we can help Canada meet its 2050 targets and, ultimately, preserve a climate in which our children and grandchildren can not only survive, but thrive.

-Robert Hornung, CanREA's President and CEO

EXECUTIVE SUMMARY








"Powering Canada's Journey to Net-Zero: CanREA's 2050 Vision" explains why Canada needs a powerful boost from wind energy, solar energy and energy-storage technologies as we set out on a transformative journey to reach net-zero GHG emissions by 2050.

Informed by a growing body of research on net-zero pathways for Canada, this Vision makes it clear that Canada will need to decarbonize and double its electricity production. It presents an illustrative scenario where wind and solar energy accounts for two-thirds of the new electricity required, growing to provide at least a third of Canada's total electricity supply by 2050.

This scenario requires Canada to deploy 3,800 MW of wind energy and 1,600 MW of solar energy annually for the next 29 years–resulting in an almost ten-fold expansion of Canada's wind- and solar-energy capacity. The scale and speed of this deployment is unprecedented. Canada must take immediate action to accelerate its efforts to start on the journey to net-zero.

As the wind, solar and storage industries expand throughout Canada, it will be important to ensure community support and customer satisfaction, create economic advantages for Canada and its communities, and contribute to sustainability and environmental protection.

CanREA's 2050 Vision outlines 5 key tasks and 15 immediate actions required from governments, utilities, system operators and regulators who must collaborate to deploy these critical technologies on a massive scale, and in a responsible and sustainable manner.

Canada's to-do list: An urgent call to action for electricity decision makers

Task 1: Decarbonize Canada's electricity production by 2035.

Task 2: Modernize Canada's electricity markets and regulatory structures to enable the lowest-cost pathway to grid decarbonization and expansion.

Task 3: Build new wind, solar and energy storage in Canada, ensuring cost-effective outcomes from procurement processes for new, decarbonized electricity generation.

Task 4: Rethink Canada's electricity infrastructure investments and seek to minimize the cost of new transmission and distribution infrastructure needed to expand electricity production.

Task 5: Use decarbonized electricity to reduce greenhouse gas emissions in Canada's transportation, buildings, and industry sectors.

1

Decarbonize Canada's electricity production by 2035:

- Adopt a Clean Electricity Standard that puts in place GHG-emission limits that will require Canada's electricity grid to be decarbonized by 2035.
- Ensure that existing natural gas-fired generation faces steadily increasing exposure to the carbon price, within federal and provincial carbon pricing frameworks, and is fully exposed to the carbon price by 2030.
- Consider the potential interaction between these measures and reflect this in their design.

2

Modernize Canada's electricity markets and regulatory structures to enable the lowest-cost pathway to grid decarbonization and expansion:

- Define and provide economic value for services that maintain grid stability and security
- Encourage innovation and experimentation with respect to deployment of and compensation for technologies that provide these services
- Remove barriers to the participation of these technologies in the electricity system
- Create the conditions to enable the largest number of service providers to compete for delivery of these services

3

Build new wind, solar and energy storage in Canada, ensuring cost-effective outcomes from procurement processes for new, decarbonized electricity generation:

- In Alberta's deregulated market, pursue market and regulatory reforms to remove barriers to the deployment of disruptive technologies, such as energy storage and distributed energy resources.
- In Canada's other markets, ensure that procurement processes are designed to ensure cost-effective outcomes for ratepayers by maximizing competition and providing quality information for competitive bids.
- In all markets, explore innovative procurement approaches that meet growing customer-driven demand and respect unique provincial electricity market structures.

4

Rethink Canada's electricity infrastructure investments and seek to minimize the cost of new transmission and distribution infrastructure needed to expand electricity production:

- Use existing infrastructure more efficiently by reducing peak demand to avoid/defer the need for new investment through consideration and deployment of non-wires alternatives (e.g., energy storage technologies and distributed energy resources)
- Where new transmission investment is required, consider such investment from a regional perspective, and not solely from a provincial perspective.
- Increase regional collaboration and co-operation with respect to electricity grid infrastructure and operations to reduce the costs of meeting Canada's greenhouse gas emission reduction targets.

5

Use decarbonized electricity to reduce greenhouse gas emissions in Canada's transportation, buildings, and industry sectors:

- Develop and implement comprehensive electrification strategies for these sectors that send a clear signal to investors that more decarbonized electricity will be required.
- Develop hydrogen strategies to ensure that Canada is well prepared to compete in future markets that will put an increasing value on the lowest carbon intensity green hydrogen.

The urgent actions described in this document will enable Canada's wind energy, solar energy, and energy storage industries, working with many stakeholders, to build and deliver the largest portion of significant new electricity capacity required for this country to fully capitalize on its massive untapped potential for decarbonized electricity production—while supporting Canada's net-zero goals reliably and in a least costly manner.

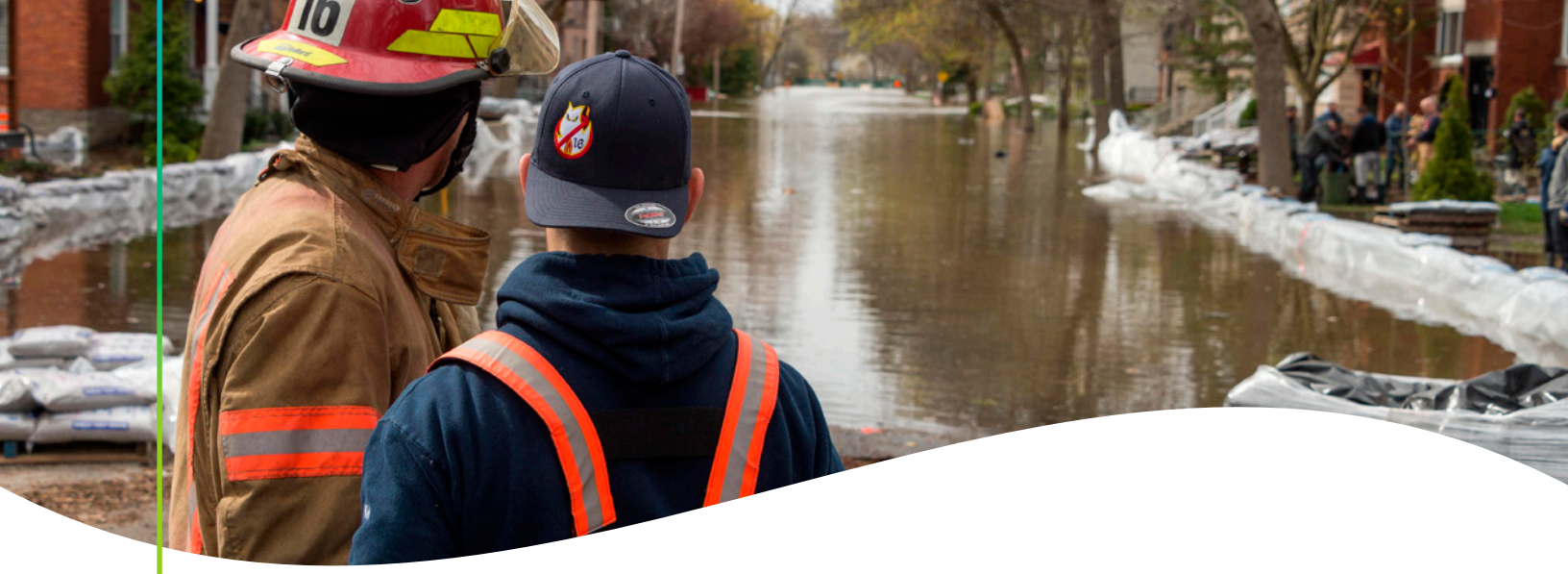
CHAPTER 1

The Challenge: Canada needs to take the best path to net-zero GHG emissions.

Canada is facing a climate change crisis. This chapter will make it clear that electricity can power much of Canada's path to net-zero GHG emissions by 2050, but that Canada is currently falling far short of what it needs to do to enable that outcome. Decarbonizing and significantly expanding electricity production is one of the most important keys to success on Canada's net-zero journey. The lowest cost way to do this is through a heavy reliance on a greatly expanded fleet of wind energy, solar energy, and energy storage facilities. These technologies are an absolutely essential component of any successful journey to net-zero.

The clock is ticking. Now is the time to act.

IN THIS CHAPTER:



CHALLENGE 1: FACING THE CLIMATE-CHANGE CRISIS

KEY TAKE-AWAYS

- Climate change is the biggest threat facing humanity.
- Canada has made commitments to reduce its GHG emissions by 40-45% from 2005 levels by 2030 and to achieve net-zero GHG emissions by 2050.
- Canada has succeeded in stabilizing GHG emissions, but not in reducing them. Canada's 2019 GHG emissions were only one percent below 2005 levels.

Canadians are increasingly concerned about climate change. Even as we fought against COVID-19, we also experienced a growing number of heat waves, droughts, forest fires, flooding, hurricanes and other extreme weather events in Canada and around the world.

In August 2021, the Intergovernmental Panel on Climate Change (IPCC) released a report stating that human-induced climate change is already affecting weather patterns and climate extremes in every region across the globe. All the future scenarios identified by the IPCC were characterized by increases in the frequency and intensity of extreme heat, marine heatwaves, heavy precipitation, agricultural and ecological droughts in some regions and intense tropical cyclones, as well as parallel reductions in Arctic sea ice, snow cover and permafrost. The UN Secretary General called the report a "Code Red for Humanity."

At the same time, however, the IPCC concluded that these trends could be stabilized if deep reductions in carbon dioxide emissions were made rapidly, along with strong reductions in other greenhouse gas (GHG) emissions. We are starting to see a response to this global call for action.

The federal government has now passed the Canadian Net Zero Emissions Accountability Act which legislated a national target of net-zero greenhouse gas emissions by 2050 and established a process to set five-year emission reduction targets for 2030, 2035, 2040 and 2045.

According to the Energy and Climate Intelligence Unit (ECIU), Canada is now one of 12 countries that have a legislated target to achieve net-zero by a specific date (usually 2050), while another four have proposed such legislation. Thirty-seven additional countries have now publicly made net-zero commitments but have not yet legislated them. Jurisdictions that have made such legislative or policy commitments include the United States, China, Japan, the European Union, the United Kingdom, South Korea, South Africa, Brazil, Argentina and Indonesia. The ECIU has also found that 20% of the world's 2,000 largest public companies have also made net-zero GHG emission commitments.

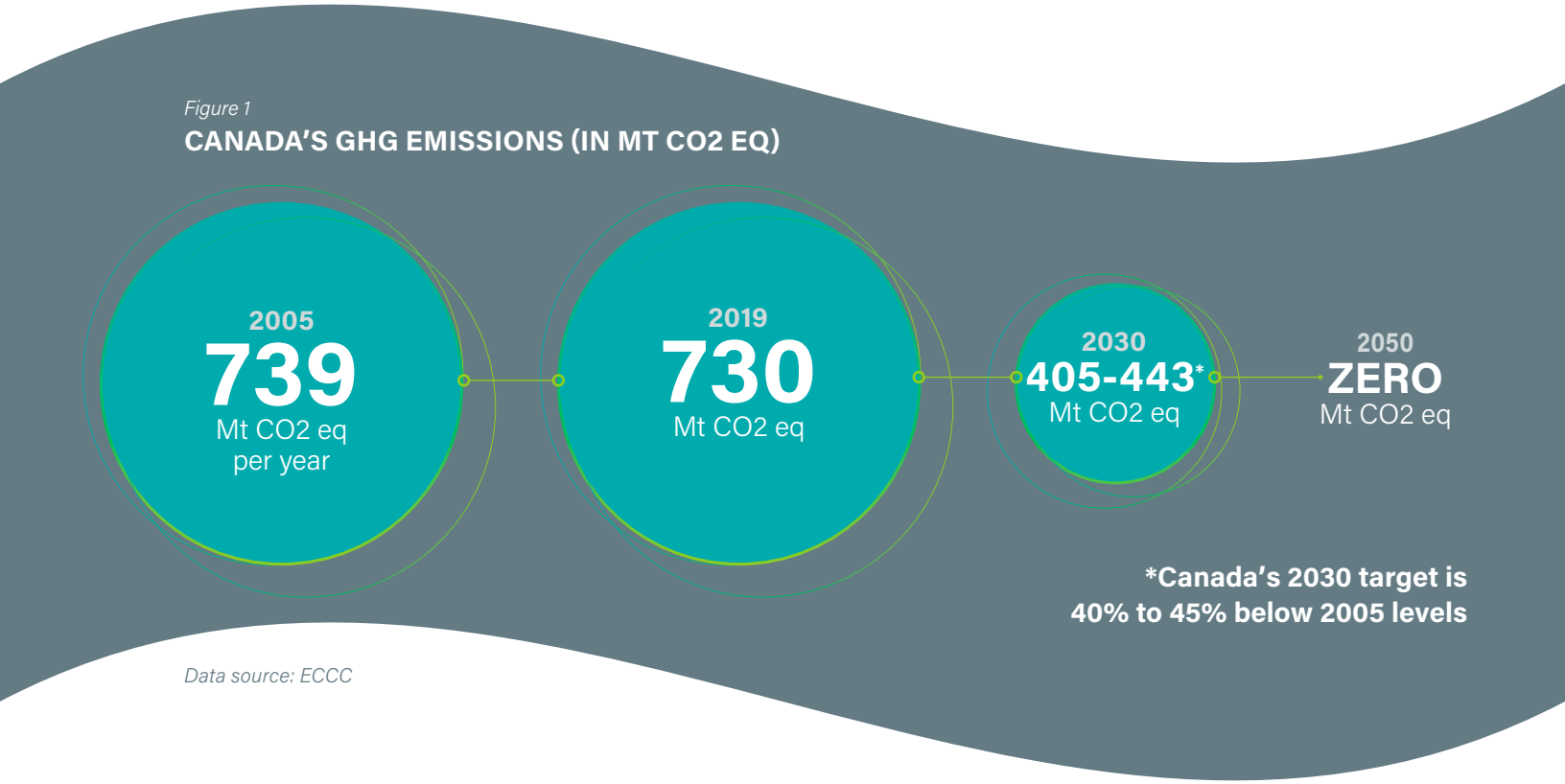
Targets are one thing, action is another. Canada has been making commitments to reduce greenhouse gas emissions since the early 1990s. Our most recent commitment is to reduce GHG emissions by between 40% to 45% below 2005 levels by 2030. And yet, in 2019, Canada's GHG emissions were 730 MT, just 1% below 2005 levels. Over the last 30 years, Canada has succeeded in stabilizing its GHG emissions, but it has not succeeded in reducing them.

The IPCC has demonstrated that we must reduce the world's net GHG emissions to zero in the next 30 years to restrict global temperature increases to 1.5 degrees Celsius above pre-industrial levels and avoid the most significant impacts of climate change. Canada must play its part. Based on our limited progress to date, the task is daunting. Nonetheless, multiple pathways have been identified that could get us to net-zero GHG emissions, key among them decarbonization of the electricity grid and increased electrification.

We know what must be done. But we must act now.

Figure 1

CANADA'S GHG EMISSIONS (IN MT CO2 EQ)



Data source: ECCC

CHALLENGE 2: DECARBONIZING ELECTRICITY PRODUCTION

KEY TAKE-AWAYS

- Canada's electricity production is 80% non-GHG emitting today and represents only 8.4% of Canada's GHG emissions. Emissions have been reduced 48% from 2005 levels.
- Wind and solar energy accounted for 52% of all new electricity generation capacity built in Canada between 2010 and 2018.
- According to the International Energy Agency, countries like Canada must move to a net-zero electricity grid by 2035 to reach net-zero GHG emissions across the economy by 2050.

Canada clearly has a lot of work to do to meet its GHG emission reduction targets. Much of this work can be accomplished through decarbonizing, and greatly expanding, Canada's electricity production. Decarbonized electricity will be a key climate change solution for Canada.

Canada is starting from a strong position. In 2019, more than 80% of Canada's electricity was already generated by non-GHG emitting sources.

Most of this non-emitting generation is hydroelectricity (59% of Canada's electricity), with contributions also provided by nuclear power (15%), wind energy (5%), and solar energy (0.5%).

Between 2005 and 2019, GHG emissions from Canada's electricity sector fell by 48%, primarily a product of the phaseout of coal-fired electricity generation in Ontario and growth in electricity generation from non-emitting and less carbon intensive sources. Wind and solar energy accounted for 52% of all new electricity generation capacity built in Canada between 2010 and 2018.

Electricity production generated only 8.4% (61 Mt) of Canada's total greenhouse-gas emissions in 2019. Nonetheless, if Canada is to meet its 2050 net-zero target, it will need to fully decarbonize its electricity production.

In fact, this needs to happen well before 2050. The International Energy Agency's (IEA) recent Net-Zero by 2050 report found that, for industrialized countries like Canada to achieve net-zero GHG emissions across their economy by 2050, they must have a net-zero electricity grid by 2035.

CHALLENGE 3: EXPANDING ELECTRICITY PRODUCTION TO SUPPORT ELECTRIFICATION

KEY TAKE-AWAYS

- Decarbonized electricity represents the most cost-effective way to reduce GHG emissions in many applications within transportation, buildings, and industry.
- Many studies show that Canada will need to double electricity production to support the levels of electrification required to achieve net-zero GHG emissions by 2050.
- Decarbonized electricity can also produce green hydrogen, which is expected to become a cost-effective solution in some applications where electrification is more challenging.

The most cost-effective way to reduce GHG emissions in many applications within transportation, buildings and industry, is by using decarbonized electricity as a substitute for fossil fuels.

The electrification of significant portions of these sectors must be a core component of any country's net-zero strategy. In addition, decarbonized electricity can produce green hydrogen, which is expected to become a cost-effective solution in some applications where electrification is more challenging.

To meet this emerging demand for decarbonized electricity, a significant increase in production will be required.

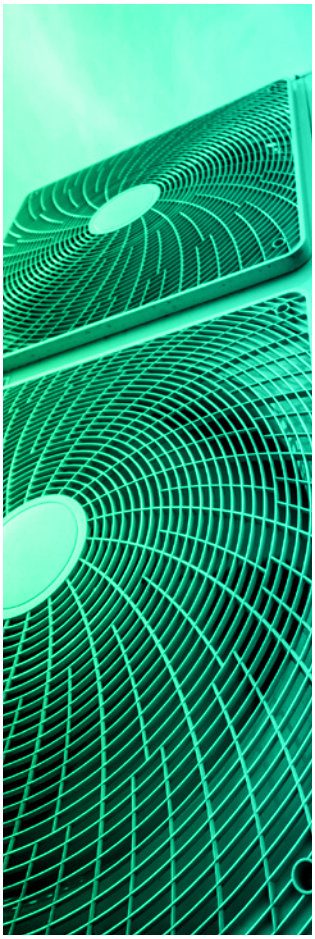
On a global scale, DNV's Energy Transition Outlook 2021 argues global electricity demand is already on a path to double by 2050 and finds electricity will meet 38% of global energy needs in 2050, compared to 19% today.

The IEA says that meeting net-zero by 2050 will require global electricity production to grow more than 2.5 times. By that calculation, electricity will account for almost 50% of the world's total energy consumption by 2050.

In Canada, numerous studies have reached similar conclusions about the critical need to increase the production of decarbonized electricity to get to net-zero. For instance, in 2021, the Canadian Institute for Climate Choices (CICC) examined more than 60 different pathways to net-zero GHG emissions by 2050.

The CICC concluded that Canada must prioritize and invest now in the "safe bets" that are required in all scenarios to reach net-zero. Among them: accelerating the decarbonization of the electricity grid, and increasing the electrification of transportation, buildings and industry. As a result, electricity production is required to increase by anything from 47 to 87% across the different scenarios.

Many other studies have identified an even larger role for decarbonized electricity in Canada. Work undertaken by Environment and Climate Change Canada, the Trottier Energy Futures Project, the UN Deep Decarbonization Pathways Project and SNC Lavalin has examined what would be required to reduce Canada's net GHG emissions by anywhere from 65% to 100% from 2015-2020 levels by 2050.



These studies all concluded that total electricity production in Canada would need to more than double to meet these GHG emission reduction targets[1].

SNC Lavalin's study envisaged a tripling of electricity demand and concluded that getting to net-zero will require Canada to add new generating capacity over the next 30 years on a yearly basis at roughly three times the rate at which Canada has built new electricity generating capacity, on average, over the last 50 years.

In the electricity sector, 30 years is not a long time. It can take many years to develop, approve and build new electricity generation and transmission infrastructure. If we are to meet the challenge of significantly expanding Canada's electricity production to support Canada's net-zero target, we need to get started now.

CHALLENGE 4: CHOOSING THE LOWEST-COST PATHWAYS

KEY TAKE-AWAYS

- To maintain the competitiveness of Canadian industry and to protect low-income Canadians, it is critical to minimize the costs associated with decarbonizing and expanding Canada's electricity production.
- Wind energy and solar energy will play a central role on any pathway to net-zero, as the lowest-cost sources of new electricity generation available today. They are expected to remain so through 2050.
- Cost, as well as benefit for the electricity system, must be the key considerations in determining which technologies should partner with wind, solar and energy storage on the path to net-zero.

Decarbonizing and doubling Canada's electricity production in less than 30 years will require significant investment. In 2018, the Conference Board of Canada estimated that Canada would need to invest $1.7 trillion in grid infrastructure (generation and transmission) to meet 2050 climate goals—which were less ambitious than our current net-zero target.

It is critical that we seek to find the most affordable way to decarbonize and expand electricity production to keep electricity costs low for Canadians as we move to net-zero. This is important to ensure the continued competitiveness of Canadian industry and to protect low-income Canadians, for whom energy costs are a larger portion of total expenses.

From a generation perspective, this can be achieved by relying heavily on wind and solar energy. In fact, a massive expansion of wind and solar energy is critical to ensuring the affordability of Canada's future electricity system. Why? Because these technologies now provide new electricity at the lowest cost, making them the dominant choice for new electricity generation around the world.

Solar & wind: lowest-cost new electricity generation

According to Lazard's 2020 Levelized Cost of Energy Analysis, the cost of solar energy has fallen 90% since 2009 and the cost of wind energy has fallen 71%. Solar and wind energy now have a levelized cost lower than any other form of new electricity generation in the United States.

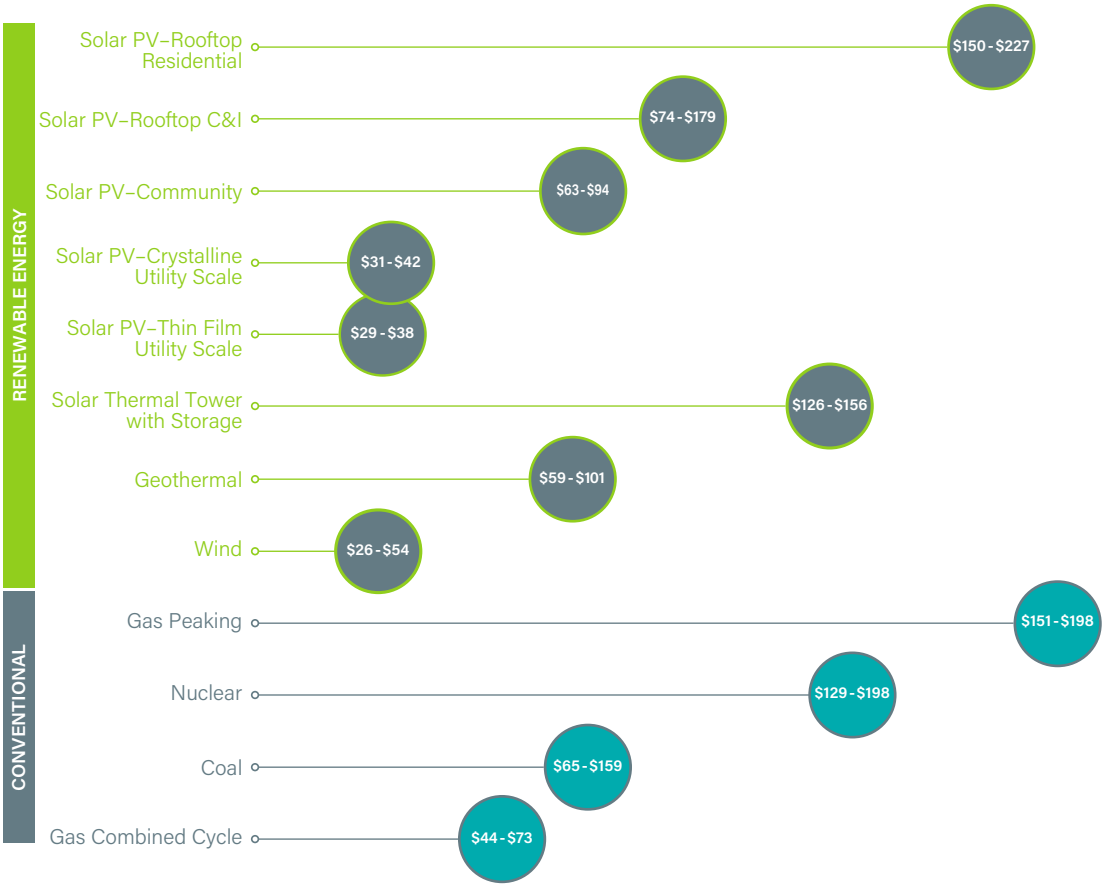
It's a similar situation in many other parts of the world. According to Bloomberg New Energy Finance (BNEF), either wind or solar energy is now the lowest-cost form of electricity generation in countries representing three-quarters of the world's economy. The IEA's 2020 World Energy Outlook calls solar energy "the new king of electricity supply," and the cheapest source of electricity in history.

Here in Canada, recent contracts for wind and solar energy in Alberta and Saskatchewan demonstrate that these technologies are already the lowest-cost form of new electricity generation, with per-MWh costs below those of new hydropower, nuclear or fossil fuel generation capacity on a levelized cost of energy basis.

While supply-chain challenges associated with the global COVID-19 pandemic put some upward pressure on costs in the short-term, these low costs are projected to fall still further thanks to continued technological evolution. BNEF projects that electricity from new wind and solar energy facilities will become cheaper than electricity produced from existing coal and natural gas-fired power plants as soon as the mid-2020s.

Figure 2

COMPARATIVE LEVELIZED COST OF UNSUBSIDIZED ENERGY GENERATION (IN US$/MWh)



Data source: Lazard's Levelized Cost of Energy Analysis 14.0 (2020)

The lowest-cost partnerships for net-zero

Some will argue that these costs are understated because the variability of wind and solar production means they will need to be paired with other technologies to achieve high levels of penetration in the electricity grid.

The reality, however, is that the electricity grid of the future will include multiple tools (e.g., energy storage[2], distributed energy resources) that will facilitate integration of these technologies into the grid.

In addition, increased interconnection of Canada's electricity grids will allow Canada's massive hydroelectric resources to fully capitalize on their potential to be an excellent, low-cost partner to facilitate wind and solar energy integration in many parts of the country[3].

Wind and solar energy, of course, will not be the only sources of new generation added to Canada's electricity grids in the next 30 years as Canada decarbonizes and expands the electricity system. Cost will be a key consideration in determining what other forms of generation are built. This must include consideration of generation costs, life-cycle costs, and the potential costs and benefits such technologies bring to the electricity system.

The costs of some emerging technologies (e.g., natural gas-fired generation with carbon capture and storage, or small modular nuclear reactors) are highly uncertain. Nonetheless, there is no expectation that they will turn out to be less costly than wind and solar energy.

The low cost of wind and solar energy, coupled with stronger linkages to hydropower, increasingly economical energy-storage options, and a variety of distributed energy resources, ensures that these technologies will play a central role in transforming Canada's energy mix and powering Canada's path to net-zero GHG emissions.

"Meeting our 2050 climate targets will not only require concerted effort in many industries, but also a paradigm shift. This is a crucial part of our responsibility to our children and future generations. A broad vision, a clear roadmap and quantified progress reports will enable renewable energy players to maintain their central role in the decarbonisation of our electricity grid and our economy."

-Jean Roy, Senior Vice President & Chief Operating Officer, Kruger Energy.

CHALLENGE 5: INVESTING IN NEW WIND ENERGY, SOLAR ENERGY AND ENERGY STORAGE

KEY TAKE-AWAYS

- Wind and solar energy will represent the largest source of new electricity generation in Canada over the next 30 years.
- An illustrative scenario, consistent with current analysis, would see wind and solar energy generation increase from 6% (37 TWh) of Canada's generation today to a minimum of 33% (430TWh) in 2050.
- This would require Canada to build, on average, 3,800 MW of new wind-energy capacity and 1,600 MW of new solar-energy capacity annually over the next 29 years.

Study after study, modelling results consistently show that least-cost pathways to net-zero rely on wind and solar energy as the primary sources of new electricity generation required to decarbonize and expand electricity production, with a more limited expansion of other decarbonized forms of electricity generation.

On a global level, the IEA's recent "Net-Zero by 2050" Report concluded that wind and solar energy will need to grow from 9% of global electricity generation in 2020 to 68% of global electricity generation in an electricity grid that is 2.5 times larger in 2050[4].

Further, the IEA argued that moving to net-zero by 2050 requires a 20-fold increase in solar energy capacity, plus an 11-fold increase in wind energy capacity, over the next 30 years. This would be accompanied by equally massive global growth in energy storage, from 18 GW of capacity in 2020 to 3,000 GW in 2050.

Potential growth in Canada's wind and solar energy

The growth of wind and solar energy in global studies are often higher than those cited in Canadian studies, because 60% of Canada's electricity already comes from non-emitting hydroelectricity.

Nevertheless, here in Canada, the CICC found that, across the 60 net-zero scenarios they studied, electricity generated from variable renewable energy in Canada—the clear majority of which is wind and solar energy

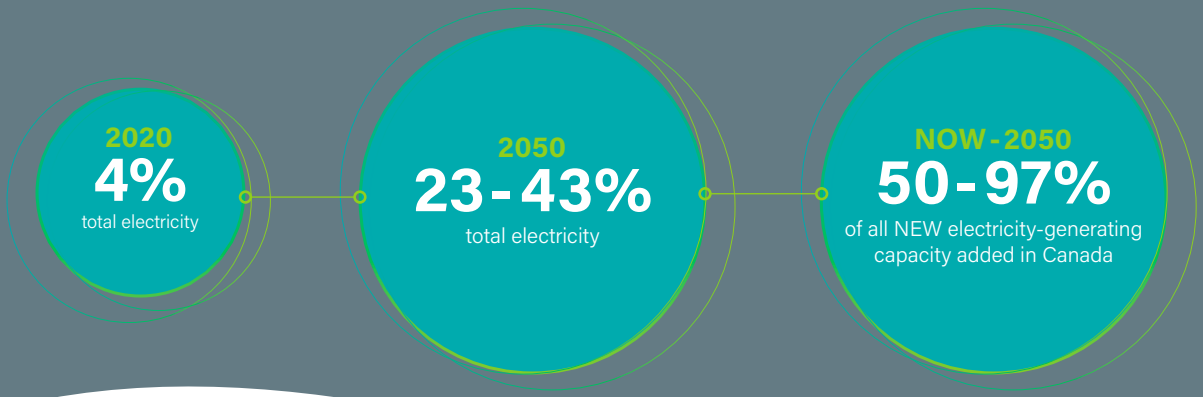
today and the overwhelming majority of which will be wind and solar energy in the future—would increase from 4% of total electricity in 2020 to between 23% and 43% of a much larger system in 2050[5].

The CICC found that electricity production from variable renewable sources would therefore increase between 12-fold and 19-fold over the next 30 years. Across all 60 scenarios, these sources are expected to account from anywhere between 50% and 97% of all new electricity-generating capacity added in Canada between now and 2050[6].

Studies consistently find that wind energy and solar energy are clearly going to be the foundation for decarbonizing and expanding Canada's electricity grid. To date, very few Canadian studies have quantified the potential contribution of energy storage to our electricity grid. While Canada's large hydroelectric reservoirs will reduce the need for energy storage here, relative to other countries, a range of energy storage technologies will still play an important role and will enable even larger buildouts of wind and solar energy. This is demonstrated by a growing body of work, such as the IEA study referenced above.

Figure 3

ELECTRICITY GENERATED FROM VARIABLE RENEWABLE ENERGY IN CANADA UNDER CICC NET-ZERO SCENARIOS



What will this mean on the ground in Canada?

Canada currently has 14,000 MW of wind energy capacity and 3,000 MW of solar energy capacity. How significantly must we expand Canada's wind and solar energy capacity to fully capitalize on the contributions these technologies can make to our net-zero journey? While different studies produce a range of results, they produce some relatively consistent findings that can be used for development of an illustrative scenario.

If achieving net-zero necessitates decarbonizing and doubling electricity supply in Canada to support electrification in other sectors, and if we assume that two-thirds of this new electricity will be produced from wind and solar energy, then these technologies will account for a minimum of 33% of Canada's total electricity generation in 2050, or 430 TWh of electricity production[7-8].

In comparison, wind and solar energy produced only 37 TWh of electricity in Canada in 2019: wind 34 TWh; solar 3 TWh.

If we assume that wind energy will produce six times as much electricity as solar energy in 2050[9], a conservative estimate would be that we will need approximately 109,000 new MW of wind-energy capacity (8X current levels) and approximately 47,000 MW of new solar energy capacity (16X current levels) by that time. Such growth rates fall within the range envisioned by many of the studies undertaken to date.

Figure 4

WIND AND SOLAR ENERGY CAPACITY GROWTH ESTIMATES IN CANREA'S ILLUSTRATIVE SCENARIO

CanREA's illustrative scenario would require Canada to install 3,800 MW of new wind energy capacity and 1,600 MW of new solar energy capacity every year for the next 29 years.

While most of this new capacity would be made up of utility-scale generation facilities, deployment of smaller scale projects (e.g., on-site solar energy) will also make a meaningful contribution. Although Canada has massive untapped wind and solar energy resources, well distributed across the country, this scenario would require a steep and unprecedented acceleration in Canada's deployment of these technologies.

This illustrative scenario is consistent with the range of studies undertaken on net-zero and deep decarbonization pathways. It is certainly possible to imagine different scenarios where wind or solar energy contributes somewhat more or less to the new decarbonized electricity supply Canada will require to get to net-zero.

None would, however, change the fundamental conclusion: Getting to net-zero requires a massive scaling up of wind and solar energy deployment in Canada–starting now.

CHALLENGE 6: GETTING ON TRACK FOR NET-ZERO

KEY TAKE-AWAYS

- Required build of wind and solar energy capacity, on average, over a five-year period for the next 29 years in our illustrative scenario: 27,000 MW.
- Most wind and solar energy capacity ever built in Canada over a five-year period (2011-2015): 9,200 MW.
- New wind and solar energy capacity build, on average, over a five-year period, for the next 30 years, per CER's (2020) evolving policy scenario: 7,375 MW.
- New wind and solar energy capacity built in Canada over the last 5 years: 3,292 MW.

Electricity, and in particular, wind and solar energy, working together with energy storge, can power Canada's path to net-zero GHG emissions. We are not deploying these technologies, however, at anywhere near the pace required to put us on a path to net-zero and we must rapidly accelerate the construction of new facilities across the country.

Between 2016 and 2020, Canada only installed a total of 3,292 MW of new wind and solar energy capacity. This is an average of only 658 MW a year–well below the illustrative scenario outlined earlier, where 5,400 MW of new capacity needs to be built every year between now and 2050 if Canada is to meet its net-zero GHG emissions commitment[10].

In fact, Canada installed only 389 MW of new wind and solar energy capacity in 2020 (166 MW wind; 233 MW solar), although this is expected to increase to 1,000 MW in 2021[11].

Canada is not on track

The fact that we are not on a net-zero pathway is clearly illustrated by the work of Canada's Energy Regulator (CER). Their 2020 report, Canada's Energy Future 2020, presents a reference scenario that projects the path forward given policies currently in place. Under this scenario, Canada's installed wind and solar energy capacity increases, on average, by only 555 MW a year between 2020 and 2050–slower than even the far-too-slow deployment of the last five years[12].

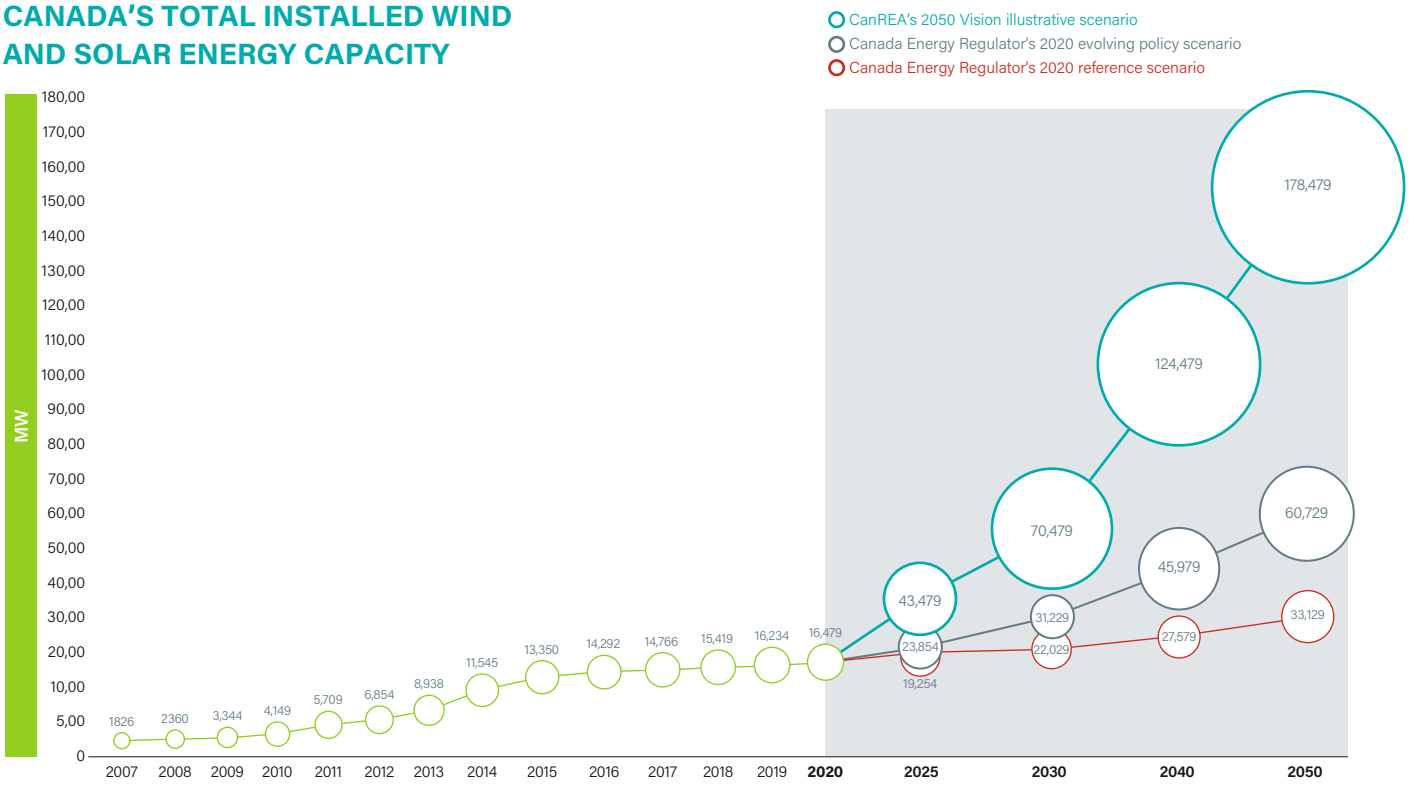
In fact, CER projected that natural gas-fired electricity generation, much of it built without any carbon capture and storage technology, would be the largest source of new electricity-generating capacity in Canada over the next 30 years.

There is no doubt that Canada is on track to see an expansion in GHG-emitting natural gas-fired generation in the short-term. In Alberta and Saskatchewan, coal-fired power plants are being converted to natural gas-fired plants, and/or new natural gas-fired generation is planned or under construction. Across the country in Ontario, the Independent Electricity System Operator (IESO) currently plans to rely primarily on increased natural gas-fired generation to avoid a looming electricity supply gap resulting from the refurbishment and retirement of nuclear generating stations.

Any increase in GHG-emitting, natural gas-fired electricity generation must be thoughtful and strategic and consistent with Canada's need to decarbonize electricity production by 2035 and achieve net-zero GHG emissions by 2050, as it has the potential to "lock in" GHG emissions for years to come.

Figure 5

CANADA'S TOTAL INSTALLED WIND AND SOLAR ENERGY CAPACITY



Data source: CanREA

While many pathways to net-zero envision a role for natural gas-fired electricity generation, they usually assume that much of this generation is either paired with effective carbon-capture and storage technology, or is renewable natural gas (e.g., produced from a landfill).

At this time, however, there are few examples of carbon-capture and storage technology being used with respect to electricity generation in Canada, and significant uncertainty on its cost-effectiveness as a GHG emission reduction tool in the sector. As a result, the CICC considers it a "wild card" technology because the scale of its potential contribution to a net-zero pathway remains highly uncertain.

Integrating carbon-capture and storage technology with natural gas-fired generation will increase the costs of such generation and make it less cost-competitive. As a result, most analysis of the lowest-cost pathways to net-zero finds natural gas playing an important, but much smaller role in future electricity generation than currently envisioned by the CER.

Canada has not yet put in place the policies required to enable the massive build-out of new wind and solar energy required to help us get to net-zero GHG emissions by 2050. Federal and provincial governments must take immediate action to put us on a path to success, as will be explained in Chapter Two.

"EDF Renewables would like to thank CanREA for its leadership in releasing the 2050 vision statement. We could not agree more: the time to invest in Canada's future electric grid starts today. As a developer, owner and operator of renewable energy generation globally, we know that the pathway to net zero starts with a deep decarbonization of the electricity system. EDF Renewables will continue to work diligently to bring experience and capital to deliver safe, reliable and affordable zero carbon energy facilities across Canada."

—Cory Basil, Vice-President, Development, EDF Renewables

CHAPTER 2

Canada's to-do list: An urgent call to action for electricity decision-makers

Canada has now legislated a commitment to achieve net-zero GHG emissions by 2050. Unfortunately, some of the most appropriate and cost-effective solutions available today are not being deployed, and are not currently envisioned to be deployed, at anything like the pace required to achieve our net-zero target.

Governments and electricity sector decision-makers must take actions NOW to accelerate our deployment of wind energy, solar energy and energy storage. Failure to do so puts our net-zero commitment at risk. And, as the impacts of climate change become increasingly apparent, inaction only makes our future challenge even larger and increases the risk of burdening future generations of Canadians with an unacceptable legacy.

Chapter Two of "Powering Canada's Journey to Net-Zero: CanREA's 2050 Vision," issues an urgent call to action for electricity decision-makers. It recommends several actions that will accelerate the growth of wind energy, solar energy and energy storage in Canada, a critical element of Canada's transformative journey to net-zero.

Success in this endeavour will also require governments to thoroughly inform and educate Canadians about the importance of our nation's net-zero GHG emission reduction objective, and why it is critical to massively expand Canada's wind, solar and energy storage capacity over the next 29 years to meet it.

IN THIS CHAPTER:

Task 1: Decarbonize Canada's electricity production by 2035

Task 2: Modernize Canada's electricity markets and regulatory frameworks

Task 3: Build new wind, solar and energy storage in Canada

Task 4: Rethink Canada's electricity infrastructure

Task 5: Use decarbonized electricity to reduce greenhouse gas emissions in Canada's transportation, buildings and industry sectors

"Northland Power stands with CanREA and its commitment to move the needle on climate change by leveraging the power of wind energy, solar energy and energy storage, as articulated in this 2050 Vision. As Northland works to build a sustainable and carbon-free world, we urge federal and provincial decision-makers to take those actions that give Canada the best chance to defeat climate change for the sake of future generations."

—Michelle Chislett, Managing Director, Canada & US Development, Northland Power

TASK 1: DECARBONIZE CANADA'S ELECTRICITY PRODUCTION BY 2035

CANADA'S TO-DO LIST FOR DECARBONIZING ELECTRICITY PRODUCTION:

- Adopt a Clean Electricity Standard that puts in place GHG emission limits that will require Canada's electricity grid to be decarbonized by 2035.
- Ensure that existing natural gas-fired generation faces steadily increasing exposure to the carbon price, within federal and provincial carbon pricing frameworks, and is fully exposed to the carbon price by 2030.
- Consider the potential interaction between these measures and reflect this in their design.

As discussed in chapter one, the IEA net-zero study concluded that all industrialized countries should decarbonize their electricity grids by 2035 to ensure we are on a net-zero trajectory by 2050 for the whole economy. But why?

It is broadly accepted that the electricity sector is an area where GHG emission reductions can occur most quickly because there are many proven, cost-competitive, non-GHG emitting technologies available today to produce electricity.

More important, however, is the fact that a decarbonized electricity grid is critical to successfully deploying the cost-effective electrification technologies that reduce GHG emissions in other sectors, such as transportation, buildings and heavy industry, to support our transition to a net-zero economy by 2050.

Canada's new federal government made a commitment in the recent federal election to a net-zero GHG emitting electricity system by 2035. This is similar to the Biden Administration's commitment in the United States to reach 100% carbon pollution-free electricity that same year.

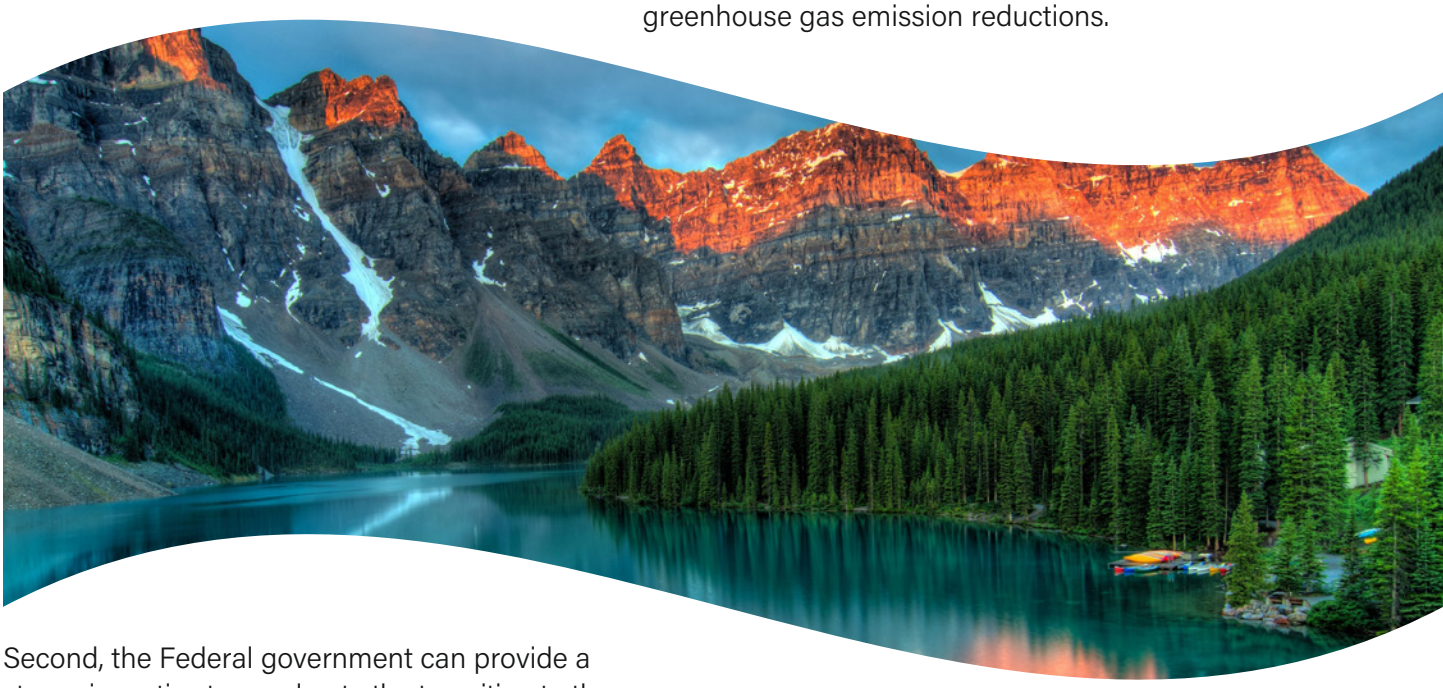
While Canada's electricity production is already 80% non-GHG emitting, significant work is required if we are to decarbonize the remaining 20% of Canada's electricity system by 2035. Indeed, the CER's 2020

reference scenario envisioned 19% of Canada's electricity still coming from natural gas (much of it without any complementary carbon capture and storage) by as late as 2050.

What does Canada need to do to ensure the accelerated decarbonization of its electricity production?

First, the Federal government needs to adopt a Clean Electricity Standard that puts in place GHG emission limits that will require Canada's electricity grid to be decarbonized by 2035. CanREA is committed to engaging with all stakeholders on the design of such a standard.

If required, the design of such a standard could potentially include some flexibility for generators to ensure the most efficient pathway to achieving such an objective.



Second, the Federal government can provide a strong incentive to accelerate the transition to the 2035 target by ensuring that the carbon price at the core of Canada's current greenhouse gas emission reduction strategy sends a clear pricing signal to the electricity sector that non-GHG emitting generation is preferred to GHG emitting generation in both federal and provincial carbon-pricing frameworks.

This is not currently the case. While new natural gas-fired electricity generation faces increasing exposure to the carbon price over time and will feel the full force of the carbon price in 2030, existing natural gas-fired electricity-generation facilities are largely sheltered from the Federal carbon price – providing no real incentive to reduce emissions from these facilities or explore alternative forms of generation.

The Federal government needs to ensure that existing natural gas generation faces steadily increasing exposure to the carbon price within federal and provincial carbon pricing frameworks and is fully exposed to the carbon price by 2030.

CanREA is prepared to participate in discussions exploring potential new mechanisms through which such carbon price payments could be directed to support additional, effective and measurable greenhouse gas emission reductions.

We also note that the efficiency and effectiveness of Canada's carbon price would be enhanced through greater integration and fungibility between the different carbon-pricing frameworks in place across the country.

The potential interaction between these measures needs to be considered and reflected in their design, but the objective to be achieved is clear–decarbonization of Canada's electricity production by 2035.

TASK 2: MODERNIZE CANADA'S ELECTRICITY MARKETS AND REGULATORY FRAMEWORKS

CANADA'S TO-DO LIST FOR ELECTRICITY MARKETS AND REGULATORY FRAMEWORKS:

- Define and provide economic value for services that maintain grid stability and security.
- Encourage innovation and experimentation with respect to deployment of and compensation for technologies that provide these services.
- Remove barriers to the participation of these technologies in the electricity system.
- Create the conditions to enable the largest number of service providers to compete for delivery of these services.

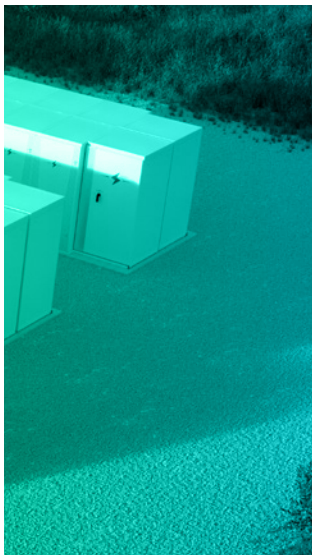
Decarbonizing and expanding Canada's electricity production will require us to transform our electricity system. A key part of the job is to modernize electricity markets and regulatory frameworks.

Canada is fortunate to be taking on the challenge of decarbonizing and expanding its electricity system at a time when disruptive technologies, including wind energy and solar energy, are poised to make our electricity system much more decentralized, distributed, digitalized, flexible and interconnected.

These technologies will, if we allow them, provide us with many more options to produce and manage electricity. While they will make our electricity system more complex, they will also provide enhanced flexibility for system operators. When deployed at the pace required to achieve net-zero, they will also increase competition, improve efficiency and reduce costs throughout the electricity system.

Unfortunately, we are not currently able to capture the full potential of these technologies within existing electricity market and regulatory frameworks that were not designed with these technologies in mind. In essence, technological change is proceeding at a rate that is making it extremely challenging for electricity markets and regulatory frameworks to keep pace.



As a result, the existing frameworks can make it very challenging for these technologies to connect, and provide services, to the electricity system—and to be compensated for doing so.

What do provinces need to do to modernize electricity markets and regulatory frameworks?

Provincial governments need to make it clear that the key objective of electricity market and regulatory frameworks should be to enable, from a system-wide perspective, the lowest cost pathway to the decarbonization of the electricity grid by 2035, and expansion of the electricity grid to support our net-zero GHG commitment for the entire economy by 2050.

They must also define and provide economic value for grid stability services—a variety of operations beyond generation and transmission that are required to maintain grid stability and security. Wind and solar energy themselves will be able to provide a number of these services.

In addition, provinces should encourage and facilitate innovation and experimentation with respect to the deployment of technologies that can provide these services, as well as review and remove barriers to the participation of these technologies in the electricity system.

And finally, market rules and regulations should create the conditions to allow the broadest range of potential service providers to compete for delivery of these services.

While some jurisdictions have started down the path of electricity market and regulatory reform that will facilitate increased deployment of disruptive technologies, like wind energy, solar energy and energy storage, this work must be significantly accelerated to ensure we are taking full advantage of the lowest-cost solutions on our journey to net-zero.

Energy-storage technologies

One important example of technological disruption is represented by energy-storage technologies that store electrical energy produced at one time for use at another time. Examples include batteries, flywheels, pumped hydro, compressed air and hydrogen. These technologies can store energy for periods of time ranging from minutes to hours to months. The costs of these technologies are falling rapidly (e.g., the cost of batteries have fallen 90% in ten years) and there is now a growing focus on long-duration energy storage technologies. All these technologies can quickly and accurately provide a variety of reliability services to the grid, such as renewable-energy generation profile-shaping, grid congestion management and voltage support. Canada's existing hydroelectric reservoirs also provide significant energy-storage potential.

Distributed energy resources

Another important example of technological disruption is represented by distributed energy resources (DERs). DERs are electricity producing resources or controllable loads that are connected to a local distribution system or connected to a host facility within the local distribution system. Examples include behind-the-meter (on-site) solar, electric vehicles, and demand-response technologies. DERs can transform our electricity system from a traditional one-way system, that sends power from large generating stations to consumers through the electricity grid, to a two-way system where electricity consumers can also produce electricity and/or provide a wide range of reliability services to the electricity grid.

"Bullfrog Power's community of businesses and individuals have shown that consumer demand can accelerate Canada's transition to renewable energy sources. But for our efforts to have the greatest impact, we need regulatory frameworks that remove barriers to decarbonization and prioritize new wind, solar, and battery storage projects. That's why we're proud to support CanREA's 2050 Vision and foster collaboration on the path to net zero emissions."

—Suha Jethalal, President, Bullfrog Power

TASK 3: BUILD NEW WIND, SOLAR AND ENERGY STORAGE IN CANADA

CANADA'S TO-DO LIST FOR BUILDING NEW WIND, SOLAR AND ENERGY STORAGE IN CANADA:

- In Alberta's deregulated market, pursue market and regulatory reforms to remove barriers to the deployment of disruptive technologies, such as energy storage and distributed energy resources.
- In Canada's other markets, ensure that procurement processes are designed to ensure cost-effective outcomes for ratepayers by maximizing competition and providing quality information for competitive bids.
- In all markets, explore innovative procurement approaches that meet growing customer-driven demand and respect unique provincial electricity market structures.

Another important step in transforming Canada's electricity system is to change the electricity supply mix to support a decarbonized and expanded electricity system. Wind and solar energy will represent the primary source of new electricity generation on any lowest-cost pathway to net-zero but expanding wind and solar energy generation capacity almost ten-fold over the next 30 years, coupled with a need for increased energy storage deployment, is a significant task.

Given the fact that electricity is primarily an area of provincial responsibility, the approach taken to facilitating the build out of wind, solar and energy storage will vary from province to province, reflecting unique electricity market and regulatory frameworks.

In Alberta's fair, efficient and openly competitive electricity market, new investment in these technologies will be driven primarily by demand from electricity consumers and foundational measures that provide market signals like a Clean Electricity Standard and carbon pricing. Private investment can be accelerated, however, if market and regulatory reforms can remove barriers to the deployment of disruptive technologies like energy storage and distributed energy resources[13].

Across most of Canada, however, investment will likely continue to be driven primarily through formal planning and procurement processes of Provincial Governments and Crown Utilities. We must ensure such procurement processes are designed to ensure cost-effective outcomes for ratepayers by seeking to maximize competition and provide project proponents with the quality information required to prepare competitive bids (see box).

How to ensure cost-effective outcomes from procurement processes for new decarbonized electricity generation:

- Identify multiple scheduled procurements over an extended period.
- Clearly define the services being procured and the relevant compensation mechanisms.
- Provide long-term and bankable revenue streams.
- Seek to maximize competition and provide a level and equitable playing field for potential participants.
- Have clear, consistent and transparent rules, timelines, and metrics.
- Increase the efficiency of permitting and approval processes without diminishing their effectiveness.

Customer-Driven Procurement

Customer-driven demand also has the potential to drive significant investment in wind and solar energy, but there are significant barriers that prevent that potential from being fully realized in Canada. Innovative procurement approaches that respect unique provincial electricity market structures could potentially unlock this opportunity to build new supply to meet customer-driven demand.

In the first half of 2021 alone, corporations signed contracts that will facilitate deployment of almost 800 MW of new wind and solar energy generation in Alberta[14]. While electricity market structures do not currently facilitate such contracting in other parts of Canada, a growing number of utilities are exploring new and innovative ways to respond to this customer-driven demand (e.g., Nova Scotia's Green Choice program).

On a smaller scale, net-metering and, to a lesser extent, net-billing frameworks currently provide an incentive for Canadians to pursue on-site renewable energy generation (e.g., rooftop solar), but market and regulatory barriers prevent us from capturing the full potential of these distributed energy resources. Changes that streamline connection processes and enable virtual net-metering and third-party financing of net-metered generation are examples of steps that can be taken to unlock this potential. Modifying building codes to ensure buildings are net-zero ready would also facilitate such deployment.

With the rapid growth of wind energy, solar energy and energy storage worldwide, Canada is increasingly competing for investment in these technologies. If we want to be a competitive destination for such investment, we need to clearly define and deliver on objectives for the future build-out of new wind, solar and energy storage, and the scale and timing of the path we are taking to get there.

Couple this with the removal of existing market and regulatory barriers to deployment of these technologies in response to customer demand, and we will then be on a path to maximizing the build out required to meet Canada's net-zero objectives.

TASK 4: RETHINK CANADA'S ELECTRICITY INFRASTRUCTURE

CANADA'S TO-DO LIST FOR RETHINKING ELECTRICITY INFRASTRUCTURE:

- Use existing infrastructure more efficiently by reducing peak demand to avoid / defer the need for new investment through consideration and deployment of non-wires alternatives (e.g., energy-storage technologies and distributed-energy resources)
- Where new transmission investment is required, consider such investment from a regional perspective, and not solely from a provincial perspective.
- Increase regional collaboration and co-operation with respect to electricity grid infrastructure and operations to reduce the costs of meeting Canada's GHG emission-reduction targets.

Doubling Canada's electricity production will require a significant increase in Canada's electricity transmission and distribution infrastructure. The costs are likely to be significant and should be minimized to the greatest extent possible. An important task for transforming Canada's electricity system is to rethink our approach to such infrastructure investment in two ways:

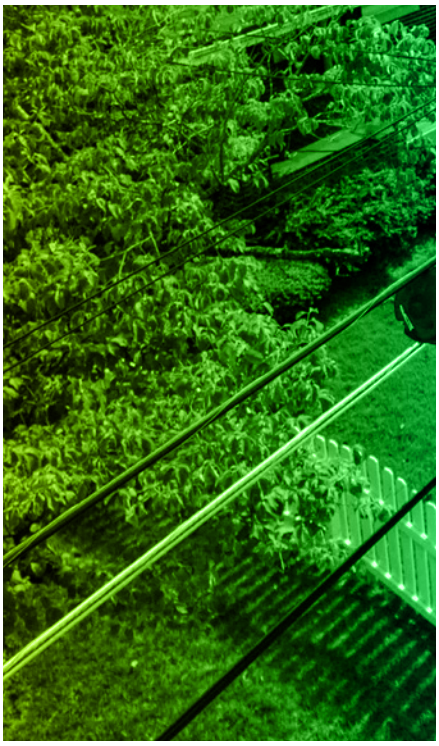
- First, focus on opportunities to enable more efficient use of existing infrastructure.
- Second, think of electricity infrastructure from a regional perspective and not from a provincial perspective.

The first step in minimizing transmission and distribution costs is to seek out alternatives to building new infrastructure by enabling the more efficient use of existing infrastructure. The electricity market and regulatory reforms recommended earlier should require consideration of "non-wires" alternatives and support their implementation in cases where they are more cost-effective and result in lower environmental and stakeholder impact than building new infrastructure.

Transmission and distribution lines are currently sized to meet peak needs for electricity demand. As a result, this infrastructure is underutilized most of the time.

Actions taken to reduce peak demand increase the capacity of existing infrastructure and can avoid or defer investments in expansion and reinforcement of transmission and distribution lines. This also reduces the social and environmental impacts associated with

such infrastructure. Energy-storage technologies and a range of distributed-energy resources can often provide this service at much lower cost than building new transmission[15].



Regional Approaches

Nonetheless, a significant amount of new transmission will need to be built. This new transmission will enable increased access to high-quality wind and solar energy resources, deliver this new generation to electricity consumers, and facilitate the efficient use and integration of these resources into the electricity grid by creating larger balancing areas, providing system operators with more options to manage variability.

In the context of our net-zero commitment, however, new transmission must be viewed from a regional perspective, and not solely from a provincial perspective. When all provinces seek to optimize investments in their own electricity systems, the net result is inevitably sub-optimal on a national basis.

Models consistently show that increased regional (and Canada-US) collaboration and cooperation with respect to electricity grid infrastructure and operations can make a significant contribution to reducing the costs of meeting Canada's GHG emission reduction targets[16].

Accordingly, Canada's plans to reduce greenhouse gas emissions through the electricity system must not be exclusively provincial in scope. We will only succeed in finding the lowest-cost pathways through increased collaboration and pursuit of regional approaches to the challenge of decarbonizing and expanding Canada's electricity production in the lowest-cost manner.

"The proposals laid out in CanREA's Vision 2050 are both critical and practical steps to accelerating Canada's journey to Net-Zero. The deployment of renewables must be accompanied by the transformation of the electrical infrastructure and regulatory frameworks that will turn this vision into reality."

—Dave Caroll, Chief Renewables Officer, ENGIE North America

TASK 5: USE DECARBONIZED ELECTRICITY TO REDUCE GHG EMISSIONS IN CANADA'S TRANSPORTATION, BUILDINGS AND INDUSTRY SECTORS.

CANADA'S TO-DO LIST TO INCREASE THE USE OF ELECTRICITY IN DIFFERENT SECTORS

- Develop and implement comprehensive electrification strategies that can send a clear signal to investors that more decarbonized electricity will be required in transportation, buildings and industry.
- Develop hydrogen strategies to ensure that Canada is well prepared to compete in future markets that will put an increasing value on the lowest-carbon-intensity green hydrogen.

It will not be possible for Canada to reach net-zero by 2050 without dramatically increasing the use of decarbonized electricity for transportation, buildings and industry. While decarbonized electricity is not a substitute for fossil fuels in all applications within these sectors, its use can and must be significantly expanded. The increased demand for electricity from these sectors will be the key driver for significant new investments in decarbonized electricity generation.

Accordingly, federal and provincial governments must take steps to design and implement comprehensive and detailed strategies to support electrification. Such strategies are critical to provide increased clarity to investors about the timing and scale of future investment in decarbonized electricity.

No government has yet put forth an electrification vision that will realize net-zero by 2050. Nonetheless, some governments, utilities and industries have already started to implement individual measures that can provide a foundation for a more comprehensive approach.

Such actions are most advanced in the transportation sector, where we see a growing number of industry commitments to increase electric vehicle production, and for which the Federal Government has announced a target that all cars sold in Canada as of 2035 will need to be non-GHG emitting (BC and Quebec have

similar types of targets). According to the IEA's Net Zero by 2050 report, ending the sale of new internal combustion engine cars by 2035 is a necessary step toward achieving net-zero emissions by 2050.

Some Canadian governments also offer financial incentives for electric-vehicle purchases, and there is an increasing amount of public and private investment directed toward electric-vehicle charging infrastructure. Significant new investments in electrified public transportation also are poised to provide important greenhouse gas emission reductions.

Beyond Transportation

Within buildings, opportunities for electrification are also significant. Electric heating is already standard in some provinces and technological advances are making electric heat-pumps an increasingly cost-competitive alternative to heating with natural gas.

In heavy industry, we have already seen government support for new initiatives, undertaken by leading companies in the steel and aluminum industries, to electrify production processes. A key driver for such investments is a desire to remain competitive in export markets, a growing number of which are stating a clear preference for less carbon-intensive products and considering the use of tools like carbon border adjustments to support that objective.

Hydrogen

Where direct electrification is not possible, the use of hydrogen represents a potential opportunity to reduce GHG emissions in several applications within transport, buildings, and industry. The Federal Government (and several provinces) have now developed high-level hydrogen strategies, believing that hydrogen can play an important role in reducing greenhouse gas emissions in heavy industry and some aspects of transportation, such as freight transport.

While green hydrogen produced with renewable electricity is the most climate-friendly form of hydrogen production, it is currently more expensive than hydrogen produced from other feedstocks, such as natural gas. It is, however, expected to become cost-competitive well before 2050, and this, coupled with customer preferences and the need to drive to net-zero greenhouse-gas emissions, has led experts like DNV and Bloomberg to agree that, by 2050, a majority of global hydrogen production will be from green hydrogen.

As a result, it is important that Canadian governments develop hydrogen strategies that ensure this country will also be well positioned to compete in the green hydrogen marketplace that will be increasingly important in a net-zero world.

"We fully support CanREA's 2050 Vision for our transformative journey to reach net-zero GHG emissions by 2050. Each of the measures identified in this document's "To-Do" list will help set us on the right path to reach that goal. Green hydrogen, for example, is vital to decarbonizing our economy, and by reducing greenhouse gas emissions from today's hydrogen production using renewable energy instead of fossil fuels, we will ultimately deliver a cleaner, more sustainable future."

—Shannon Sturgil, CEO, Onshore North America, Siemens Gamesa Renewable Energy

CHAPTER 3

Up for the challenge: Canada's wind, solar & energy storage industries

The wind energy, solar energy and energy-storage industries are eager to start building and delivering the significant new capacity required to enable Canada to achieve its net-zero goal.

Unlocking that investment requires immediate actions from governments, utilities, regulators and system operators, to start planning and building the electricity system we need to support Canada's net-zero objective, as per the tasks recommended in Chapter Two.

Success is not, however, wholly dependent on governments. Despite the impressive technological advances and cost-reductions seen in wind, solar and energy storage over the last decade, Canada's wind, solar and energy storage industries must also pursue continuous improvement to further reduce costs, maximize efficiencies and provide a broader range of services to support the electricity system.

More importantly, these industries must also take actions to ensure that, while they contribute productively to Canada's efforts to achieve net-zero GHG emissions by 2050, their work continues to be both responsible and sustainable.

Chapter Three of CanREA's Vision explores the role of these industries in ensuring a responsible, and sustainable transition to the electricity grid that will get us to net-zero GHG emissions by 2050.

IN THIS CHAPTER:

Up for the challenge: A responsible industry, earning community support and customer satisfaction

Up for the challenge: A growing industry, providing economic opportunities for Canadian communities

Up for the challenge: A sustainable industry, helping to protect the environment

As the wind, solar and storage industries expand throughout Canada, it will be important to ensure community support and customer satisfaction, create economic advantages for Canada and its communities, and contribute to sustainability and environmental protection.

"The global energy system is transitioning from molecules to clean electrons as our primary source of energy. Our ambitious net-zero goals and the electrification of transportation create massive need for new renewables and energy storage capacity. This is an opportunity to fundamentally re-invent energy and its relationship to society. Renewables projects like the ones developed by Greengate represent a rare alignment of environmental, financial, and social interests, which I am confident will help lead us to a cleaner and more sustainable future for all."

—Dan Balaban, CEO, Greengate Power Corporation

UP FOR THE CHALLENGE: A RESPONSIBLE INDUSTRY, EARNING COMMUNITY SUPPORT AND CUSTOMER SATISFACTION.

KEY TAKE-AWAYS:

- All new wind, solar and energy-storage projects need a strong base of community support and satisfied customers.
- Every community is unique. Understanding and addressing community perspectives requires early, meaningful and sustained community engagement.
- The number of wind, solar and energy-storage projects developed in partnership with Indigenous communities is growing rapidly.

Canada's wind energy, solar energy and energy-storage industries are more than ready to deliver the significant new capacity required to enable Canada to achieve its net-zero goal, counting on Canada's governments, utilities, regulators and system operators to take the actions recommended in Chapter Two.

It is the responsibility of these industries to earn and maintain public support for the deployment of wind, solar and energy storage technologies. Projects will not succeed without a strong base of community support and satisfied customers.

There are several hundred utility-scale wind, solar and energy storage projects currently operating in Canadian communities. To ensure success, such projects require early, effective, meaningful, and sustained community engagement with host communities. This is critical for building trust-based relationships. Every community is unique, and industry must ensure that host community perspectives are heard, understood and addressed.

Our industries must also, as standard practice, seek to engage Indigenous communities and ensure these communities both support and meaningfully participate in our wind, solar and energy storage projects.

According to Indigenous Clean Energy, 197 of Canada's medium-to-large renewable energy projects (more than one third of them solar or wind) are fully or partially owned by Indigenous people and benefit from Indigenous involvement, while approximately 2,000 small renewable energy systems have Indigenous leadership and partnerships in place. These numbers are poised to grow significantly over the next few years.

The CanREA document, "Wind Energy Development–Best Practices for Indigenous and Public Engagement," is intended to help industry members consult, engage, and communicate on wind energy development in host communities. A product of broad input, this resource guides CanREA members and provides stakeholders with a sense of what to expect if a project is proposed within their community.

For smaller-scale solar energy deployment, CanREA has also produced consumer guides to provide customers with the information required to make informed purchasing decisions.

UP FOR THE CHALLENGE: A GROWING INDUSTRY, PROVIDING ECONOMIC OPPORTUNITIES FOR CANADIAN COMMUNITIES

KEY TAKE-AWAYS:

- CanREA's illustrative scenario for the new wind and solar energy build needed to support Canada's net-zero objectives would result in $8 billion in investment and 28,000 direct and indirect person years of employment annually.
- A 100 MW wind energy project can deliver $1 million in property tax payments and $500,000 in lease payments to landowners on an annual basis.
- Clean-energy projects (the vast majority of which are renewable energy projects) are poised to provide $1.5 billion in Indigenous employment and contracting income over the next 10 years.

As a growing industry, wind, solar and energy storage can provide increasing economic opportunities for Canadian communities. This will contribute to development of a net-zero pathway that enables a just and equitable transition to a low-carbon future for workers and their communities.

Utility-scale wind, solar and energy-storage projects are big investments. BNEF projects that, between now and 2050, 80 percent of all global investment in new power-generating capacity will go to wind, solar and batteries, representing $12 trillion in new investment.

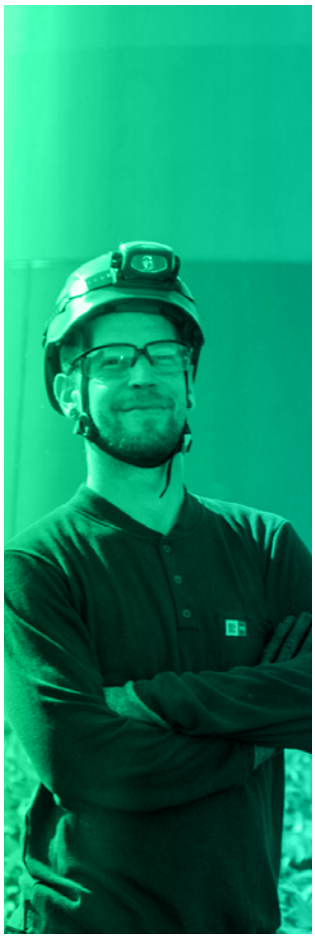
With its abundant, untapped, and high-quality solar and wind resources, Canada has an opportunity to position itself as a competitive destination for such investment.

The numbers are significant: building out 3,800 MW of new wind energy capacity and 1,600 MW of new solar energy capacity annually for the next 29 years, as our illustrative scenario suggests is needed to support our nation's legislated net-zero objectives, would represent $8 billion dollars of annual investment[17].

Significant new employment opportunities

The growing wind, solar and energy storage industries will create significant new employment opportunities. In the United States, wind turbine and solar technician jobs are among the fastest growing career opportunities. Our illustrative scenario would create more than 28,000 direct and indirect person-years of employment annually–or more than 800,000 direct and indirect person-years of employment over 29 years.






In pursuit of net-zero by 2050, Canada should also work to maximize deployment of smaller-scale wind, solar and energy storage projects. These projects are even more significant employment creators. A study by Dunsky Energy Consulting concluded that each MW of residential solar installed in Nova Scotia generates up to 35 full-time job-years of employment in such fields as manufacturing, equipment distribution, sales and marketing, engineering and design, project development and installation.

The wind, solar and energy-storage industries must work with post-secondary educational institutions to create more training opportunities for individuals keen to work in our industries so that we are prepared for the expanded workforce that will be required as we move to net-zero by 2050. We must also acknowledge that there is more work to do to ensure that our workforce better reflects the diversity within our society—and take actions to enhance its composition.

Economic benefits for communities

For the deployment of utility-scale wind and solar energy projects to be a sustained success, the industry must also provide meaningful economic opportunities and economic benefits for host communities. In addition to stimulating local investment and job opportunities, these projects can be an important source of property tax revenue for host communities and land lease income for the landowners hosting these projects.

An Alberta supply-chain study found that every 100 MW of wind provides approximately $1 million in annual property taxes for host communities and approximately $500,000 in royalty payments to landowners. Many projects also provide different forms of additional community benefit payments targeted at priority areas of interest to the community. Some communities also seek to become investors in the renewable energy projects they are hosting.

Indigenous communities across Canada are also working to access these economic opportunities. According to Indigenous Clean Energy, existing clean-energy projects (the overwhelming majority of which are renewable energy projects) are poised to provide $1.5 billion in Indigenous employment and contracting income over the next 10 years. These benefits are expected to grow significantly with the enhanced and accelerating renewable energy development required to get to net-zero by 2050.

On a smaller scale, the deployment of on-site solar energy also provides economic gains, in this case for host residences and businesses. While payback periods vary depending on local electricity prices, once the initial capital investment has been paid off through consistent annual savings in electricity costs, an on-site solar PV system can be expected to generate essentially free electricity for an additional 20 years or more, with minimal maintenance requirements.

When paired with battery storage, a solar PV system can also provide reliable back-up power in the event of a blackout–an increasingly important consideration in an era of more frequent and severe extreme-weather events.

"Leaving a legacy and making a difference in the communities where we live work and operate rests at the very heart of our company. We take great pride in building strong relationships based on trust and collaboration. As we engage with all of our key stakeholders – from the initial siting of a project and through the life of our operations – we work to create a shared future where renewable energy provides a direct complement to the energy and expertise that already exists within local communities."

—Grant Arnold, President and CEO of BluEarth Renewables.

UP FOR THE CHALLENGE: A SUSTAINABLE INDUSTRY, HELPING TO PROTECT THE ENVIRONMENT.

KEY TAKE-AWAYS:

- The generation of electricity through wind and solar energy does not emit greenhouse gases or air pollutants, consume large quantities of freshwater, or generate toxic, hazardous or radioactive waste.
- The wind, solar and energy-storage industries must go beyond simple compliance with environmental regulations, and proactively seek to find ways to enhance environmental sustainability and responsibility throughout the product and project lifecycle.
- CanREA supports the development of industry best practices, guidelines and reports, capacity building and information sharing, and hosts Canada's largest facility operations event on an annual basis.

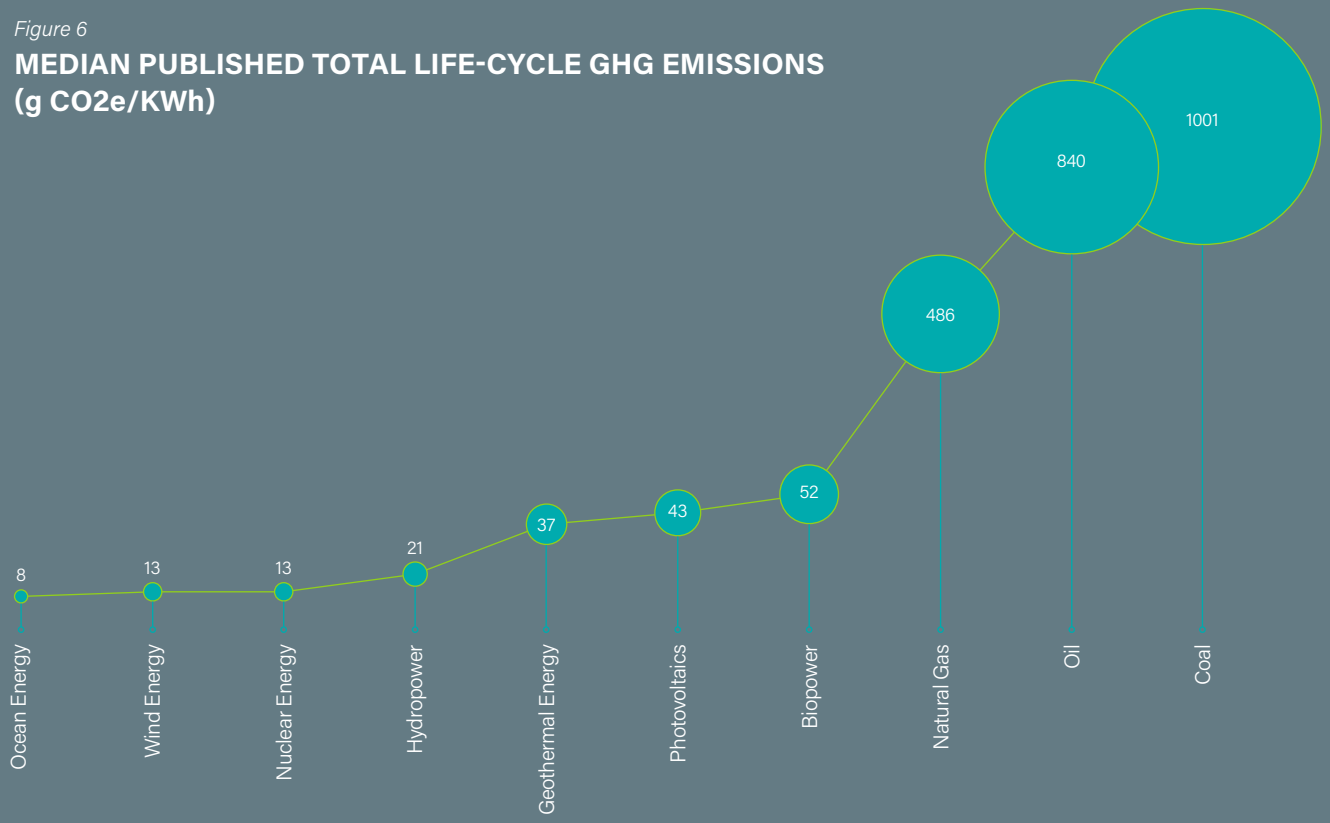
One of the important ways that the industry is up for the challenge of helping Canada achieve its net-zero by 2050 target is in its staunch commitment to sustainability and helping to protect the environment.

Canadians are increasingly concerned about the negative impact of fossil fuels on climate change, the environment and human health. In addition to producing GHG emissions, burning fossil fuels harms water quality, biodiversity, and habitats, and produces a large part of Canada's air pollution, including sulphur oxides, nitrogen oxides, particulate matter (soot) and mercury pollutants, which contribute to the formation of acid rain and smog. Air pollution alone causes 15,300 premature deaths and $120 billion in economic health impacts annually in Canada according to a 2021 Health Canada report.

While all forms of electricity generation will have an environmental impact, wind and solar are consistently identified as being the most environmentally friendly forms of electricity generation. Unlike many conventional power plants, the generation of electricity through wind and solar energy does not emit greenhouse gases or air pollutants, consume large quantities of freshwater, or generate toxic, hazardous or radioactive waste. It is important, however, to also consider the life-cycle environmental impacts associated with different forms of electricity generation, as illustrated for greenhouse-gas emissions in Figure 6.

Figure 6

MEDIAN PUBLISHED TOTAL LIFE-CYCLE GHG EMISSIONS (g CO2e/KWh)



Data source: NREL Life cycle assessment harmonization

Commitment to environmental sustainability

Where our industries do have environmental impacts, it is critical that we go beyond simple compliance with environmental regulations and proactively seek to find ways to enhance environmental sustainability and responsibility throughout the product and project lifecycle.

Conservation of avian species has been a significant focus for wind-energy developers, resulting in leading research and tools for the mitigation of impacts on birds and bats. In addition to Canadian resources, CanREA's members also partner with North American innovations in this area through the American Wind Wildlife Institute and the Bats and Wind Energy Cooperative.

Solar power continues to lead the way in establishing pollinator habitats within facilities and in using natural solutions, such as sheep grazing, to assist with vegetation management on site.

With sustainability at the core of the industry, responsible actions to decommission components and sites are also a priority. For example, industry leaders are implementing practical solutions for recovery of end-of-life batteries for almost complete waste diversion back into useful products, including new energy storage systems.

Wind turbine manufacturers are also tackling one of the industry's largest challenges by creating new, fully recyclable wind turbine blades. Planned material recovery efforts at wind sites are going so far as to capture the dust from cutting decommissioned blades to prevent traces of these inert materials from being left behind.

Solar PV recycling facilities can already claim 90-95% recovery of panel materials, with efforts to push this even further. This is in addition to a rapidly growing secondary market for end users that can accommodate certified, refurbished equipment and panels coming from non-traditional sources.

CanREA supports the responsible operations of renewable-energy assets at every phase of the project cycle. The Association provides forums to discuss emerging opportunities for supply chain resilience and sustainability, construction safety, reducing environmental impacts, a safe and healthy workforce, long-term site maintenance, and building out responsible decommissioning capabilities.

CanREA supports this through the development of industry best practices, guidelines and reports, capacity building and information sharing, as well as hosting Canada's largest facility operations event, held each year to convene our industries around these important topics. In addition, CanREA partners with organizations across Canada and the United States to expand its capabilities.

CONCLUSION

We need to act now, & we need to act together

In this document, CanREA has presented its Vision for how wind energy, solar energy and energy storage technologies can provide a powerful boost as Canada embarks on its transformative journey to reach net-zero greenhouse-gas emissions by 2050.

Canada faces a daunting challenge when it comes to climate change, and our federal and provincial electricity decision makers have their work cut out for them. But it is a challenge we can meet, by acting on the to-do list CanREA has outlined here, and relying on a responsible, growing and sustainable industry that is ready to act.

The science of climate change is clear. Urgent and immediate action is required to start Canada on a transformative voyage to an ambitious destination: net-zero GHG emissions by 2050. The challenge is enormous, but far from insurmountable. Failure to act will present us with much bigger challenges to address from a changing climate.

Our industries represent some of the technologies that will enable Canada to set out on this journey. We can achieve significant reductions in GHG emissions today, while at the same time laying the foundation for even greater GHG emission reductions tomorrow.

While Canada must continue to support further work to develop emerging and unproven technologies to reduce GHG emissions in some sectors, it is critical to accelerate deployment of existing, "safe bet", low-cost technologies, like wind energy and solar energy, that are critical to meeting Canada's 2030 GHG emission-reduction targets and achieving net-zero by 2050 under any scenario.

But to do so, Canada's electricity decision makers need to implement changes to policy, market and regulatory frameworks to address barriers that currently prevent Canada from capturing the full potential of these technologies.

"As Canada's leading integrated energy company, we recognize we are part of the country's emissions challenge and because of that, we have to be a part of the solution. To meet our own objective to be a net-zero company by 2050, Suncor invests and participates in different technologies, innovations and initiatives to reduce greenhouse gas emissions. These include expansion of our existing low-carbon power production through cogeneration and wind power, and working on future low-carbon power production through solar power and clean hydrogen as fuel for power generation. With CanREA, we embrace our role in shaping our shared and sustainable energy future."

—Kris Smith, Executive Vice President, Downstream, Suncor

This paper is a call to action.

CanREA is urging governments, utilities, system operators and regulators to:

- Agree on shared objectives: decarbonizing electricity production by 2035 and reaching net-zero GHG emissions across the economy by 2050
- Collaborate in pursuit of those objectives
- Commit to urgent action: We face a climate emergency and have less than 30 years to decarbonize, transform and dramatically expand our electricity system.

CanREA is committed to working with all stakeholders in a constructive and positive way in pursuit of net-zero solutions that ensure that Canada's future electricity system is decarbonized and expanded while prioritizing reliability and affordability. We are poised to support GHG-emission reductions throughout the Canadian economy.

CanREA believes that wind, solar and energy storage technologies are at the heart of Canada's future electricity system, but we know that many other technologies will also have important roles to play, and we are eager to realize the efficiencies and synergies of working together with our allies and contemporaries.

The time to act is now. There is not a moment to waste.

SUPPORTIVE STATEMENTS

CanREA's 2050 Vision, "Powering Canada's Journey to Net-Zero," states that Canada must rapidly expand its deployment of wind energy, solar energy and energy storage to address climate change. This view enjoys broad support across a diversity of sectors in Canada's economy and society. A sample of these views are reflected below. CanREA would like to thank the following companies and organizations for sharing their perspectives here. While the parties represented below are united around the common objective expressed in CanREA's 2050 Vision, they do not necessarily endorse any of its specific targets or recommendations.

"National Bank of Canada supports CanREA's 2050 Vision and is keen to play an active role in Canada's net-zero objective. Just recently, we announced our pledge to join the Net-Zero Banking Alliance as part of a global initiative to accelerate efforts to address climate change. We continue our long history of partnering with our clients, financing Canadian renewable energy projects and supporting innovative solutions that will drive the significant growth in sustainable energy that Canada needs."

—Iain Watson Managing Director, National Bank Financial

"As the world's leading insurance broker and risk advisor, Marsh has seen the growing impacts of climate change. Accelerated investment in wind, solar and energy storage assets will assist Canada in meeting aggressive NetZero targets and future energy demands. Marsh is supporting this transition by investing in specialist capabilities that provide insights and support to clients on their sustainability journey."

—Sarah Robson, President & CEO, Marsh Canada Limited

"Place is central to community. Land is the essence of culture. People are the power of abundance. These truths are groundings of an unequivocal and unencumbered embrace by Indigenous communities and peoples for a clean energy future, now! For resilient and reliable wind, hydro, solar and bioenergy are our best hope for meeting this century's energy demands affordably while also tackling climate change. The community of Indigenous Clean Energy (ICE) will continue to advance and advocate for deep and mutually supportive relationships between Indigenous Peoples and partners to be clean energy change agents. For this is an essential expression of our truths."

—Terri Lynn Morrison and Chris Henderson, Indigenous Clean Energy (ICE)

"Bell's strategic approach to managing climate change issues includes achieving carbon neutral operations starting in 2025, and reducing our absolute GHG emissions by 2030 in line with a 1.5°C emissions scenario in collaboration with the Science Based Targets initiative. Accelerating the adoption of decarbonized electricity production and storage, including wind and solar generation, is integral to Bell efficiently achieving our climate change goals."

—Marc Duchesne, Vice President, Corporate Security & Responsibility, Bell

"As Canada accelerates the development of zero carbon buildings and retrofits, more electricity generation and energy storage are going to be needed. Canada is a leader in clean energy, but needs to do more to bring renewable sources of electricity like solar and wind online quickly to keep the pace and ensure a zero-carbon electricity grid that can support the decarbonization of the building stock."

—Thomas Mueller, CEO, Canada Green Building Council

"Put simply, clean electricity will power Canada's transition to a net-zero economy. It will power our vehicles, our homes, our businesses. It's the spine that holds together the world's biggest action plan. There are many reasons why Canada needs to grow its supply of renewables and energy storage, from meeting our climate targets to growing our economic competitiveness. We also know it will create jobs across Canada, including for Indigenous nations and rural communities. And if that wasn't enough, it's how we finally escape the pain of global fossil fuel price shocks."

—Merran Smith, Executive Director, Clean Energy Canada

"While there are many uncertainties involved in the energy transition, we have absolute clarity on the need to significantly increase and accelerate the deployment of renewable energy and energy storage in Canada. In addition to the emissions reduction benefit, QUEST sees the integration of renewable energy and storage opportunities as a pathway to sustained and sustainable local economic prosperity and enhanced local energy resilience. Renewables and energy storage implementation enable local action on a global problem."

—Tonja Leach, Executive Director, QUEST

"The financial industry is critical to tackling climate change and achieving a net-zero carbon world. As a leading provider of risk protection for climate solutions, Swiss Re applauds the efforts of CanREA to accelerate production and adoption of renewable energy. We share your commitment by insuring projects such as offshore wind farms to guarantee their financial viability for the long-term. Together, the public and private sectors can advance the energy transition and make the world more resilient."

—Adrian Hall, CEO Canada, Swiss Re

"Electric Mobility and Renewable Energy: a great combination! Transportation accounts for 25% of Canada's GHG emissions and a significant part of its air pollution. Knowing that the impact of air pollution has been estimated at $120 billion and 15,300 deaths a year by Health Canada in 2021, the best way to significantly reduce our GHG and air pollution emissions is to combine electric mobility with renewable energy like wind and solar, among others. Not only will this great combination help save billions of dollars while creating hundreds of thousands of quality sustainable jobs, but it will also save thousands of Canadian lives. And that's priceless."

—Daniel Breton, President and CEO, Electric Mobility Canada

"Canada must decarbonize its electricity sector by 2035 and increase electrification in order to help keep global temperature rise within 1.5C and enable a net-zero economy by 2050. The Pembina Institute supports the rapid deployment of clean energy solutions including renewables, storage, demand response, efficiency, and transmission in a manner that takes advantage of their low costs and reliability services, and enables equitable transition for impacted communities. These measures can help attract jobs, investments and businesses with sustainability goals to Canada."

—Linda Coady, Executive Director, Pembina Institute

END NOTES

1. The range of results reflects different assumptions (including assumptions around energy efficiency) and the use of different modelling tools. Whether a 50% or 300% increase in electricity production is required, it will require an enormous effort to scale up Canada's electricity production to such levels in less than 30 years.

2. BNEF, Lazard, as well as DNV, also are reporting significant declines in the cost of energy-storage technologies. For example, BNEF found that the cost of lithium-ion batteries fell by almost 90% in the last decade, while DNV predicts these costs will drop another two-thirds by 2030.

3. It must be noted that large amounts of variable wind and solar energy are already being reliably integrated into electricity grids around the world. Approximately 7% of Canada's electricity demand is met by wind and solar today, although the contribution is much larger in PEI (25%) and Nova Scotia (13%). In the European Union, wind energy alone meets 15% of electricity demand, with wind energy representing more than 20% of generation in Ireland, Portugal, Germany, and Spain, and almost 60% of generation in Denmark. At the same time, solar energy now represents between 8% and 11% of electricity generation in Honduras, Italy, Greece, Germany and Chile.

4. This is consistent with the findings of DNV (69% in 2050) and Bloomberg's 2021 New Energy Outlook's net-zero scenarios (39%, 62% or 84% in 2050 depending on the scenario).

5. This is consistent with the findings of other studies on Canada. Wind and solar energy production increases significantly by 2050 in a net-zero study by SNC Lavalin (to 23% of total generation) and independently of net-zero by Bloomberg (to 32% of total generation).

6. Other studies examining pathways to major GHG emission reductions in Canada also see a massive build out in wind and solar energy capacity. The Trottier Energy Institute found that wind energy production would need to increase 15 – 34 times by 2050 across different scenarios and the North American Renewable Integration Study (NARIS) found that 90 – 95% of all new generation capacity built in Canada between now and 2050 would be wind or solar energy even without a net-zero target.

7. This is a minimum because wind and solar energy would also replace some of the generation existing today that will be decommissioned before 2050.

8. The remainder of new generation will likely come from many different established and emerging forms of electricity generation, including hydroelectricity, nuclear power, natural gas (e.g., renewable natural gas, natural gas with carbon capture and storage), biomass, geothermal, marine renewables, and so on. The final mix will reflect resource availability, generation cost, lifecycle costs and potential costs and benefits for the electricity system.

9. Most studies conducted to date find that wind energy will make a significantly larger contribution than solar energy to Canada's future electricity supply (e.g., NARIS 8.7:1, Bloomberg 6.3:1, SNC 4.75:1), although the continued cost-reductions expected for solar energy may reduce this gap.

10. For a short period of time between 2011 and 2015, Canada did install an average of 1,840 MW of new wind and solar energy capacity annually with a high of 2,607 MW in 2014. While still short of what is required, it shows that we have already demonstrated we can do much more than we are currently.

11. Several announcements and commitments have also been made in 2021 to procure new wind and solar energy resources over the next few years (e.g., Saskatchewan – 200 MW, Quebec – 300 MW, Nova Scotia – 350 MW, Alberta – 800 + MW of corporate procurement of renewables), but these new developments remain far below the pace required to put us on a path to net-zero by 2050.

12. The CER also presented an evolving policy scenario that considers the impact of continuing the historical trend of increasing global action on climate change. This envisions more substantial growth in wind and solar energy capacity between 2020 and 2050 - 1,475 MW / year on average – but it is acknowledged that this is not a scenario that delivers net-zero GHG emissions. In November 2021, the CER will release Canada's Energy Future 2021 which will include, for the first time, a scenario examining how the electricity grid could evolve to support Canada's net-zero by 2050 target.

13. https://www.qp.alberta.ca/documents/Regs/2009_159.pdf

14. In 2020, corporations signed contracts that will facilitate deployment of almost 24,000 MW of new wind and solar energy worldwide as they seek to reduce electricity costs and support their own greenhouse- gas emission-reduction targets. More than 300 such companies have come together as RE100 to signal their commitment to operate on 100% renewable electricity. According to Bloomberg New Energy Finance, these RE100 members will need to enable 93,000 MW of renewable energy in 2030 just to meet their existing commitments.

15. CanREA commissioned Power Advisory to quantify some of the benefits of distributed energy resources in the context of the Ontario energy system. The results suggested whole-system savings in the range of $250 million per year based on deployment of an additional 3 GW of behind-the-meter solar by 2030 under a $170/t carbon price.

16. This was illustrated in the Pan-Canadian Wind Integration Study, the North American Renewable Integration Study and studies under Natural Resources Canada's Regional Electricity Cooperation and Strategic Infrastructure Initiative (RECSI).

17. The investment and job creation estimates associated with CanREA's illustrative scenario were calculated using multipliers provided by American Clean Power. Canadian data is limited and studies have provided a range of results. The ACP numbers have been drawn from a much larger pool of studies.

KEY REFERENCE MATERIALS

American Wind Wildlife Institute. (n.d.). Information Hub for Wind Energy and Wildlife. https://awwi.org/

Bataille, C., et al. (2015). Pathways to deep decarbonization in Canada, SDSN - IDDRI. https://electricity.ca/wp-content/uploads/2017/05/DDPP_CAN.pdf

Bats and Wind Energy Cooperative. (n.d.). Home. https://www.batsandwind.org/

Bloomberg NEF. (2020). New Energy Outlook 2020. https://about.bnef.com/new-energy-outlook-2020/

Bloomberg NEF. (2021). New Energy Outlook 2021. https://about.bnef.com/new-energy-outlook/

Canada Energy Regulator. (2020, December 2). Canada's Energy Future 2020. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/index.html

Canadian Institute for Climate Change. (2021). Canada's Net Zero Future: Finding Our Way in the Global Transition. https://climatechoices.ca/reports/canadas-net-zero-future/

Canadian Solar Industries Association. (2020). Canada's Go Solar Guide and Directory. https://www.nxtbook.com/naylor/CSIB/CSIB0120/index.php#/p/Intro

Canadian Renewable Energy Association. (2017). Wind Energy Development: Best Practices for Indigenous & Public Engagement. https://renewablesassociation.ca/wp-content/uploads/2020/06/Wind-energy-development-best-practices_June-2020.pdf

Canadian Renewable Energy Association. (2021). By the numbers. https://renewablesassociation.ca/by-the-numbers/

Canadian Renewable Energy Association. (2021). Life Cycle. https://renewablesassociation.ca/life-cycle/

Coad, L., Gibbard, R., Macdonald, A. & Stewart, M. (2017). The Cost of a Cleaner Future: Examining the Economic Impacts of Reducing GHG Emissions The Conference Board of Canada. https://www.canadianfuels.ca/wp-content/uploads/2020/09/9021_cost-cleaner-future__rpt.pdf

Delphi Group. (2017). Alberta Wind Energy Supply Chain Study. https://renewablesassociation.ca/wp-content/uploads/2021/10/Delphi-AB-Wind-Supply-Chain-Study-Final-Report.pdf

DNV. (2021). Energy Transition Outlook 2021. https://eto.dnv.com/2021

Dunsky Energy Consulting. (2019). Nova Scotia Residential Solar: Market Outlook and Labour Force Study. https://renewablesassociation.ca/wp-content/uploads/2021/10/cansia_nova_scotia_residential_solar_market_outlook_and_labor_force_study_-_final_report__2019-04-09_.pdf

Energy & Climate Intelligence Unit. (2021). Net Zero Emissions Race: 2021 Scorecard. https://eciu.net/netzerotracker

Engineering Net Zero. (n.d.). Strategies and Solutions for a Net Zero Carbon Future. https://www.engineeringnetzero.com/

GE Energy Consulting. (2016). Pan-Canadian Wind Integration Study. https://renewablesassociation.ca/wp-content/uploads/2021/10/pcwis-fullreport.pdf

Government of Canada. (2016). Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy. https://unfccc.int/files/focus/long-term_strategies/application/pdf/canadas_mid-century_long-term_strategy.pdf

Government of Canada. (2021, July 26). Greenhouse gas sources and sinks: executive summary 2021. https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2021.html

Health Canada. (2021). Health Impacts of Air Pollution in Canada: Estimates of premature deaths and nonfatal outcomes. https://www.canada.ca/en/health-canada/services/publications/healthy-living/2021-health-effects-indoor-air-pollution.html

Indigenous Clean Energy. (2020). Accelerating Transition: Economic Impacts of Indigenous Leadership in Catalyzing the Transition to a Clean Energy Future Across Canada. https://icenet.work/attachment?file=HGQf2DFTWWhIlc6jcRtUCg%3D%3D

Institut de l'énergie Trottier. (2016, August 4). Trottier Energy Futures Project. https://iet.polymtl.ca/en/publication-en/trottier-energy-futures-project-2/

Institut de l'énergie Trottier. (2018, February 11). Canadian Energy Outlook 2018 – Horizon 2050. https://iet.polymtl.ca/en/publication-en/canadian-energy-outlook-2018-horizon-2050/

Institut de l'énergie Trottier. (2021, October 8). Canadian Energy Outlook 2021 – Horizon 2060. https://iet.polymtl.ca/en/energy-outlook/

Intergovernmental Panel on Climate Change. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

International Energy Agency. (2020). World Energy Outlook 2020. https://www.iea.org/reports/world-energy-outlook-2020

International Energy Agency. (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. https://www.iea.org/reports/net-zero-by-2050

Lazard. (2020). Lazard's Levelized Cost of Energy Analysis — version 14.0. https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf

National Renewable Energy Laboratory. (2021). North American Renewable Integration Study. https://www.nrel.gov/analysis/naris.html

Power Advisory LLC. (2021). Impact of Behind-the-Meter Solar in Ontario. https://renewablesassociation.ca/wp-content/uploads/2021/08/CanREA-study-Impact-of-BTM-Solar-in-Ontario-2021.pdf

RE100. (2021). RE100. https://www.there100.org/

Regional Electricity Cooperation and Strategic Infrastructure. (2018). Atlantic Region Summary for Policy Makers. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/clean/RECSI_AR-SPM_eng.pdf

Regional Electricity Cooperation and Strategic Infrastructure. (2018). Western Region Summary for Policy Makers. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/clean/RECSI_WR-SPM_eng.pdf

REN21. (2020). Renewables 2020 Global Status Report. https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf

Renewable Energy World. (2021, January 27). Global corporate clean energy purchasing up 18% in 2020. https://www.renewableenergyworld.com/solar/global-corporate-clean-energy-purchasing-up-18-in-2020/#gref

CREDITS

For media or interview requests, reprint permissions, comments, or more information, please contact CanREA's communications team, at communications@renewablesassociation.ca.

Canadian Renewable Energy Association

WIND. SOLAR. STORAGE.